THE AEROSHELL BOOK

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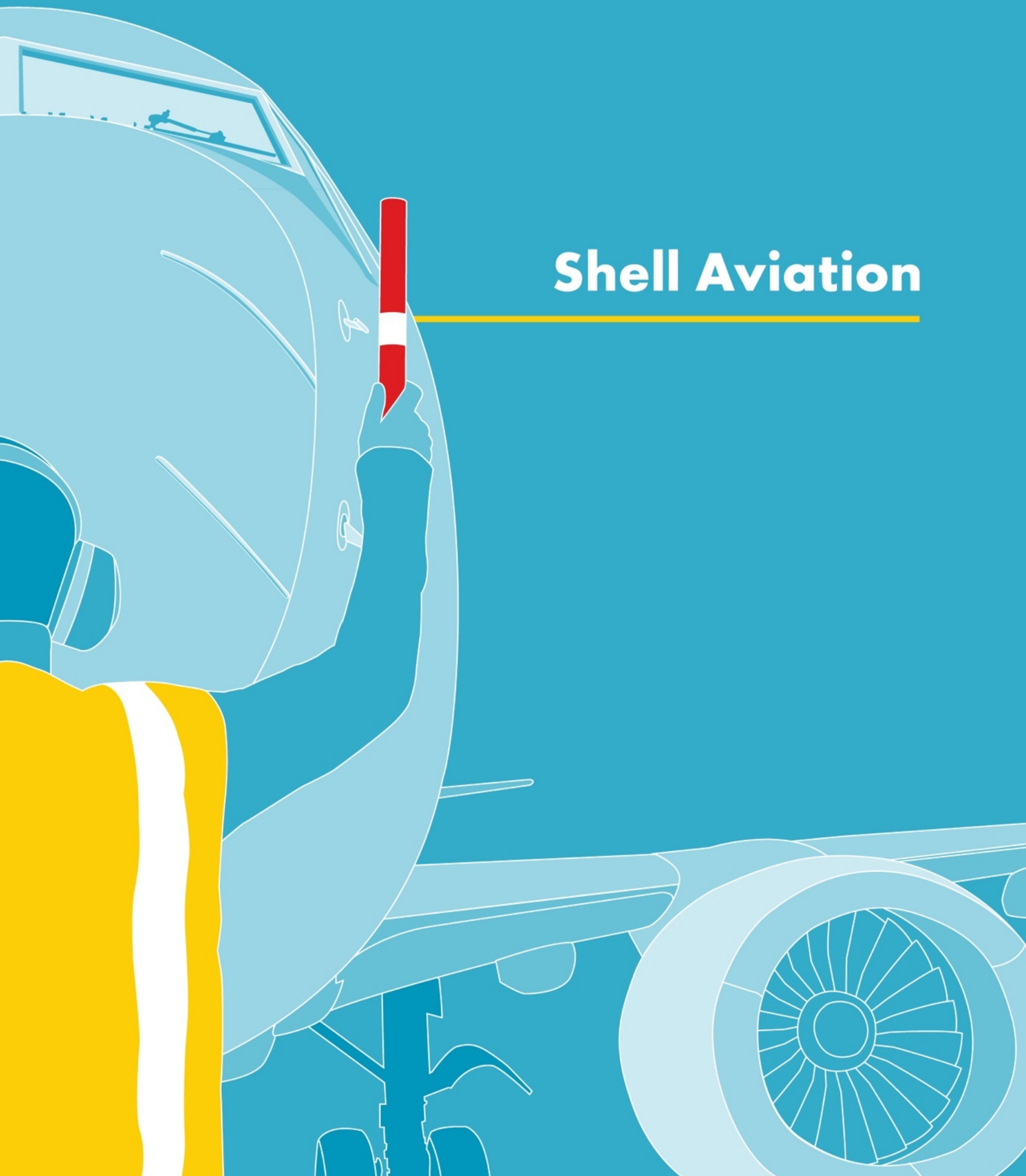

THE AEROSHELL BOOK

Twentieth Edition 2021

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This The AeroShell Book contains forward-looking statements (within the meaning of the U.S. Private Securities Litigation Reform Act of 1995) concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management’s current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management’s expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as “aim”, “ambition”, ‘‘anticipate’’, ‘‘believe’’, ‘‘could’’, ‘‘estimate’’, ‘‘expect’’, ‘‘goals’’, ‘‘intend’’, ‘‘may’’, ‘‘objectives’’, ‘‘outlook’’, ‘‘plan’’, ‘‘probably’’, ‘‘project’’, ‘‘risks’’, “schedule”, ‘‘seek’’, ‘‘should’’, ‘‘target’’, ‘‘will’’ and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this The AeroShell Book, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; (m) risks associated with the impact of pandemics, such as the COVID-19 (coronavirus) outbreak; and (n) changes in trading conditions. No assurance is provided that future dividend payments will match or exceed previous dividend payments. All forward-looking statements contained in this The AeroShell Book are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's Form 20-F for the year ended December 31, 2019 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward-looking statements contained in this The AeroShell Book and should be considered by the reader. Each forward-looking statement speaks only as of the date of this The AeroShell Book, January 1, 2021. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this The AeroShell Book.

We may have used certain terms, such as resources, in this The AeroShell Book that the United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our filings with the SEC. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov.

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NOTES

INTRODUCTION

1. INTRODUCTION

Shell companies manufacture and distribute throughout the world a full range of aviation products required for the operation and maintenance of aircraft of all types. This range includes:-

Aviation Turbine Fuels
Aviation Gasolines
AeroShell Turbine Engine Oils
AeroShell Piston Engine Oils
AeroShell Greases
AeroShell Hydraulic Fluids
AeroShell Fluids
AeroShell Preservatives

This manual contains information on the characteristics and specifications of these products and offers guidance on their application.

The Specification information provided is correct as known at the time of going to press. Due to the fact that commercial and military specifications for aviation products are subject to frequent changes, it is advisable to consult the local Shell company, whose representative will also give advice on availability (not all grades are always available worldwide), prices and packaging and will be glad to answer any other queries.

All reasonable care has been taken in the preparation of this publication; however, no responsibility can be accepted for the consequences of any inaccuracy which it may contain.

AEROSHELL TIMELINE

1940s

Launch of **AeroShell Grease** range

1950s

Developed **Shell Water Detector**

Launch of **AeroShell Oil W** range, first to use ashless dispersants for cleaner engines

Development of mineral and synthetic **AeroShell Turbine Oils**

1960s

1960 **AeroShell Grease 14** for helicopters approved to MIL-G-25537

1961 **Microgel®** grease thickener trademark filed

1964 Approval of high-temperature **AeroShell Grease 5** & launch of 5-cSt **AeroShell Turbine Oil 500**, approved to MIL-L-23699A

1965 Approval of **AeroShell Grease 6**

1967 Approval of **AeroShell Turbine Oil 555** for Rolls-Royce Olympus Engines (Concorde)

1970s

1972 **AeroShell Grease 7** approved to MIL-G-23827A

1976 Launch of advanced wheel-bearing grease **AeroShell Grease 22**

1980s

1980s Launch of **AeroShell Oil W 15W-50**, the 1st semi-synthetic multi-grade aviation oil

1984 Launch of **AeroShell Turbine Oil 560**, a 3rd generation 5-cSt oil, approved to MIL-PRF-23699 HTS

1985 Shell scientists develop new lithium soap thickener technology for aviation

2010s

2014 Launch of **AeroShell Grease 58**, a Li-Cx wheel-bearing grease exceeding SAE AMS3058 specification

2018 **AeroShell Grease 58** approved by Airbus under AIMS09-06-003

2000s

2000s **AeroShell Oil Sport Plus** 2 and **4** developed with ROTAX, the 1st oils specifically for light sport aircraft engines

2006 Launch of AeroShell Grease 33MS, renamed **AeroShell Grease 64** in 2015, an extreme pressure Li-Cx grease, approved to MIL-G-21164D;

AeroShell Oil Diesel 10W-40, now **AeroShell Diesel Ultra**, developed with SMA and Thielert, specifically for diesel aero engines

2007 Launch of **AeroShell Ascender**, world's 1st new TEO approved to SAE AS5780A HPC specification; **AeroShell Grease 33** approved by Airbus under AIMS09-06-002

2009 Shell celebrates **100 years** in aviation

1990s

1990s Launch of **AeroShell Oil W 100 Plus**

1995 Launch of **AeroShell Grease 33** – 1st lithium-complex (Li-Cx) grease approved to MIL-PRF-23827 Type 1 and BMS 3-33A

1997 **AeroShell LGF** & SSF approved to BMS 3-32

GENERAL NOTES ON AEROSHELL PRODUCTS

The notes contained in this section apply to the complete range of AeroShell products. Additional notes specific to each product group are given in the notes at the front of each chapter.

Notation

The brand names chosen for the range of AeroShell products comprise three parts: the name 'AeroShell' followed by the words 'Turbine Oil', 'Fluid', 'Grease', etc. and finally a number and/or letters designating each product. The numbers do not always follow a sequence. In the case of turbine and piston engine oils the number relates to the oil viscosity; for greases, fluids and compounds the numbers merely differentiate between products and gaps occur in the sequence due to obsolescence. Consequently an up-to-date version of this book should always be used for reference purposes.

Applications

Under this heading the more important and known representative aviation uses have been named for each AeroShell Grade, and these are intended to serve as a general indicator of the type of application for which the grade is normally suitable. Further consultation with the component manufacturer is recommended in case of doubt.

Whenever an aircraft is certified, all of the oils, greases and hydraulic fluids used on that aircraft 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 grades which are qualified to be used. The U.S. Federal Aviation Administration (FAA) regulations state that only grades 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 grades should be used.

Many AeroShell products are used in non-aviation applications especially where the operating requirements or properties are at the extreme for industrial lubricants (for example, high or low temperatures). Details are not included in this publication but further information is available from local Shell companies.

In selecting an AeroShell Grade for a non-aviation application the properties of the grade 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 the 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.

Specifications

The majority of AeroShell products are manufactured to comply with British or U.S. Government Specifications because these are acceptable to most aircraft manufacturers and airline operators. In certain cases where no suitable specification exists, Shell products have been developed to meet specific performance requirements.

Many of the British and U.S. Government Specifications (as well as those of other NATO countries) are interchangeable, although the specifications are not identical. The words ‘approved’, ‘meets’, ‘equivalent’ and ‘corresponding’ have been used in the text to define the relationship between products and specifications; the precise meaning of these terms is as follows:

Approved indicates that the product has been manufactured to meet the requirements of the specification, and against which it has been approved (where type approval is required).

Meets indicates that the product complies with the requirements of the specification and, either type approval is being obtained, or because the specification is now obsolete, it is not possible to obtain type approval (where type approval is required).

Equivalent indicates that the product complies with the major requirements of the specification but has not necessarily been manufactured to the specification.

Corresponding indicates that the product has not been manufactured to meet the specification and that it is the nearest product available.

The letters ‘DEF’, ‘DEF STAN’, ‘DTD’, ‘DED’, ‘D.Eng.R.D.’, ‘D.Eng.D’, ‘DERD’, ‘CS’, ‘TS’ and ‘BS’ refer to British Specifications; ‘MIL’ and ‘DOD’ refer to American Specifications.

As an aid to users, details of French and Russian Specifications are included but specifications of other countries are not included.

Over the years, changes were made to both U.S. and British Specifications. The U.S. authorities eliminated the older MIL specifications (e.g. H = hydraulic fluids; L = lubricating oils; G = greases) as they are currently known and replace them with performance specifications. These will be labelled MIL-PRF- followed by a number. Many MIL-PRF- specifications have now been issued and others will follow until all current MIL specifications have been converted. The numeric part of the MIL-PRF- designation is the same as the numeric part of the MIL specification it replaces; however, the letter which denotes the Revision level has also changed. MIL specifications which are cancelled or obsolete will not be changed. A small number of MIL specifications have been converted to MIL-DTL- specifications, where DTL represents 'detail'.

For certain products, the U.S. authorities have decided to no longer maintain military specifications; in these cases, they have been converted to civil specifications by the SAE (Society of Automotive Engineers).

Examples of these changes include:

MIL-H-5606G became MIL-PRF-5606H
MIL-L-23699E became MIL-PRF-23699F
MIL-G-23827B became MIL-PRF-23827C
MIL-T-83133D became MIL-DTL-83133E
MIL-G-4343C became SAE AMSG4343

British specifications are being standardised on Defence Standards (commonly referred to as DEF STAN). The changeover is virtually complete and all current DERD, DTD, CS and TS specifications have now been converted to DEF STAN specifications; in doing so, the numeric part has also been changed. Obsolete or Cancelled British Specifications will not be changed.

The British Ministry of Defence has also moved away from "qualifying" or "approving" products and no longer issues Qualified Products Lists (QPLs). Instead, the onus is put on the supplier under the new PCC (Product Conformity Certification) scheme to demonstrate that the product supplied is fit for purpose. Instead of QPLs, the Ministry of Defence now holds TAPLs (Technically Acceptable Products Lists).

On occasion, the specification on our AeroShell product labels may not always match that on the Certificate of Analysis (COA). In this instance we ask customers to please refer to the COA.

AeroShell products are approved to the relevant Military, Civil or Original Equipment Manufacturer (OEM) Specifications. Whenever a revision is made to a specification, there is a change typically in the last alphabet to denote the latest revision.

The COA changes are made earlier than the product label changes. This is because the labels are typically pre-printed on the packaging for supply chain and manufacturing efficiencies. As such, the affected products will have the preceding revision of the specification on the product label, until the pre-printed labels have been used up.

For example, the COA for AeroShell Fluid 41 will reflect MIL-PRF-5606J, while the product label will reflect MIL-PRF-5606H.

In such occurrences, please refer to the specification revision stated on the COA. This will be the latest revision.

Obsolete or cancelled specifications

Where specifications have been cancelled and superseded by another, the word "Obsolete" is shown after the specification. Even though the specification is obsolete, Shell may still manufacture the grade to meet the requirements of the obsolete specification and tests each batch of product against these requirements. In the majority of cases, test reports and product containers which normally include the specification number will also carry the annotation "(Obs)" or "(Obsolete)" after the specification.

Compatibility of Aeroshell grades with materials

Considerable care has to be exercised during selection of materials, including metals, paints, varnishes, insulation materials, plastics and elastomers, to ensure that they are compatible with the chosen lubricant whether it be an oil, fluid or grease. This is particularly important if the product has a synthetic oil component.

Since compatibility also depends upon the operating environment, it is impossible for lubricant suppliers to be aware of all possibilities of use. Therefore, it is most important that material or equipment manufacturers are consulted regarding compatibility of oils, fluids and greases with specific materials. Most elastomer manufacturers produce comprehensive tables of compatibility of their elastomers with a large range of products and these tables should therefore be consulted.

Where appropriate, more information on compatibility is given at the front of each product section in this book.

Rationalisation

For many years aircraft operators have been seeking to rationalise the oils and greases used on aircraft and to reduce the number of different products in their inventories.

It is possible to achieve this providing either the equipment manufacturer's approval has been obtained or the alternatives have been listed in the relevant manuals.

In some cases equipment manufacturers (e.g. Boeing) are taking steps to reduce the number of different grades required in support of their aircraft.

Use of alternative products

Apart from those products which are used for the same applications, but under different operating conditions, alternative grades should not be used as a substitute for grades which are not available.

Packages

Consumers are encouraged to obtain supplies of AeroShell products in the smallest packages commensurate with their use. Small packages which can generally be used as dispensers reduce the risk of product contamination. With larger containers it is usually necessary to decant the contents into smaller containers or jugs which may not always be perfectly clean. In addition, there is a possibility of contamination occurring through the lid or cap being left off or not being replaced properly.

Stocks

Every Shell company holds adequate stocks of those grades known to be in demand, based whenever possible on the offtake of the previous six months. For grades not in regular demand, special supply arrangements have usually to be made in advance.

Temperature and viscosity

All temperatures are quoted in Celsius with Fahrenheit referenced in parenthesis. Whilst the more recent British and U.S. Specifications are now based on Celsius temperatures, the earlier specifications are still based on Fahrenheit temperatures. In such cases, whilst it is acceptable to use and quote temperatures in degrees Celsius, the Fahrenheit temperature remains the reference temperature.

All viscosities are now shown as mm^2/s, (millimetres squared per second)

This unit is related to centiStokes as follows:

1 centiStoke (cSt) = 1 mm^2/s

Substitutes for Russian aviation lubricants

A number of AeroShell substitutes for Russian Grades are available for use in aircraft of Russian origin. Full details of these are included in the Specification Section of this publication and where appropriate the Russian equivalent is shown on each grade page. Further information is available from local Shell companies.

Typical properties

Typical properties as reported in this publication are determined by averaging actual batch data provided by the manufacturing facilities over a period of time. This data is therefore typical but obviously cannot be guaranteed to be identical to the batches of products provided at any specific time. In some instances, this averaging involves more than one manufacturing facility when products are supplied from a number of facilities.

The typical properties for each AeroShell product are also listed on a Technical Data Sheet (TDS). The most updated version of TDS can be found at **www.epc.shell.com**.

It must be emphasised that the data provided in this publication and individual TDS are presented only as a guide for the assistance of AeroShell product users. The actual test values can be found on the Certificate of Analysis (CoA) issued with each production batch.

Further information and publications

Additional information, changes in approval status, changes in specifications, user experience and other useful data is available from local Shell companies.

In addition, brochures and leaflets on particular topics are published from time to time. Copies of any brochure/leaflet are available from local Shell companies or online at **www.shell.com/aviation.**

NOTES

DISCONTINUED AEROSHELL GRADES

This table lists AeroShell grades which have been discontinued since 1975.

Also included are the U.S. and British specifications that the grades were approved to, a description of the grade, plus details about a suitable alternative AeroShell Grade.

AeroShell Grade	Specification	Description/Superseded by
Piston Engine Oils		
AeroShell Oil 65	SAE J1966	SAE Grade 30 straight mineral oil. No AeroShell alternative.
AeroShell Oil W65	SAE J1899	SAE Grade 30 ashless dispersant oil. No AeroShell alternative.
AeroShell Oil Diesel 10W-40	-	A fully synthetic, multigrade engine oil designed for use in compression ignition (Diesel) Aviation Piston Engines. Replaced by AeroShell Oil Diesel Ultra.
AeroShell Oil Sport Plus 2	-	For light sport 2-stroke engines such as the ROTAX ® air and water-cooled series engines. No AeroShell alternative. Proposed alternatives: Pennzoil 2-Cycle Oil for air-cooled engines (in USA); Shell Advance VSX 2 or any Shell Product on Rotax Service Instruction SI-2ST-008.
Turbine Engine Oils		
AeroShell Turbine Oil 3SP	MS-8P MK-8P MS-8RK	A 3mm2/s mineral turbine oil with improved anti-wear and antioxidant properties, as well as low temperature properties. Was approved for use in Russian engines which use the Russian grades MS-8P, MK-8P and MS-8RK. No AeroShell alternative.
AeroShell Turbine Oil 9	DEF STAN 91-097 (DERD 2479/0)	A 9mm2/s mineral turbine oil. No AeroShell alternative.
AeroShell Turbine Oil 9B	DEF STAN 91-097 (DERD 2479/1)	A 9mm2/s mineral turbine oil with an EP agent. No AeroShell alternative.
AeroShell Turbine Oil 529	MIL-PRF-23699F Grade STD	Standard grade 5cSt turbine engine oil. AeroShell Turbine Oil 500 is a direct replacement.
AeroShell Turbine Oil 530	MIL-PRF-23699F Grade C/I	Corrosion inhibited synthetic turbine engine oil. No AeroShell alternative.

AeroShell Grade	Specification	Description/Superseded by
Greases		
Shell Aviation Grease 7	MIL-G-23827B DEF STAN 91-053	A general purpose synthetic grease. Acceptable alternative is AeroShell Grease 7, but the two grades should not be mixed.
AeroShell Grease 8	DEF STAN91-054	A grease containing graphite. No direct replacement, although AeroShell Grease 17 may be suitable for some applications.
AeroShell Grease 11MS	-	High load aircraft grease. No AeroShell alternative.
AeroShell Grease 15	MIL-G-25013E DEF STAN 91-055 (Obsolete)	A special silicone grease for use over an extremely wide temperature range. No AeroShell alternative.
AeroShell Grease 15A	MIL-G-25013E DEF STAN 91-055 (Obsolete)	Was previously replaced by AeroShell Grease 15. No current AeroShell alternative.
AeroShell Grease 16	MIL-G-25760A (Obsolete) DTD.5579 (Obsolete)	Depending on application, AeroShell Greases 22, 33 or 58 may be suitable.
AeroShell Grease 17	MIL-G-21164D	Replaced by AeroShell Grease 64, but the two grades should not be mixed.
AeroShell Grease 22A	MIL-G-81322	Replaced by AeroShell Grease 22C, which in turn was replaced by AeroShell Grease 22CF.
AeroShell Grease 22C	MIL-G-81322	Replaced by AeroShell Grease 22CF.
AeroShell Grease 22CF	MIL-PRF-81322G	Advanced general purpose grease. AeroShell Grease 22 is direct replacement.
AeroShell Grease 23	MIL-G-81827A	High load capacity grease. Alternative grade was AeroShell Grease 23C.
AeroShell Grease 23C	MIL-G-81827A	Synthetic grease with molybdenum disulphide. No AeroShell alternative.
AeroShell Grease 33MS	MIL-G-21164D	Product re-named as AeroShell Grease 64.
AeroShell Grease 43C	SAE AMSG4343	Pneumatic system grease. No AeroShell alternative.
AeroShell Grease S.4768	DEF STAN 80-081	Anti-seize compound. No AeroShell alternative.
AeroShell Grease S.7108	SAE AMSG6032 DEF STAN 91-006	Gasoline and oil resistant grease. No AeroShell alternative.

AeroShell Grade	Specification	Description/Superseded by
Fluids		
AeroShell Fluid 1	DEF STAN 91-044	A light lubricating mineral oil containing, by specification, less than 0.10% mass stearic acid. AeroShell Turbine Oil 3 can be used as an alternative.
AeroShell Fluid 1AC	AAF.3580D	A special hydraulic fluid. No direct alternative although some equipment manufacturers have approved alternative grades.
AeroShell Fluid 2F	MIL-C-6529C Type II	An inhibited "flyaway" lubricating oil for the internal protection of piston engines during storage. Consists of three parts AeroShell Oil 100 with one part AeroShell Fluid 2XN.
AeroShell Fluid 2T	MIL-C-6529C Type III	Corrosion preventative for turbine engines. AeroShell Fluid 2XN is the concentrate from which AeroShell Fluid 2T was made.
AeroShell Fluid 2XN	MIL-C-6529C Type I	Corrosion preventive concentrate. No AeroShell alternative.
AeroShell Fluid 4	MIL-H-5606A	A mineral hydraulic fluid. MIL-H-5606A is obsolete and has been replaced by MIL-PRF-5606J. AeroShell Fluid 41 is approved to MIL-PRF-5606J.
AeroShell Fluid 5L-A	MIL-PRF-6086F Light Grade DEF STAN 91-112 Grade L	A highly refined, low viscosity mineral oil containing an extreme pressure additive and additives to provide good oxidation and corrosion protection. Also has good low temperature characteristics. No AeroShell alternative.
AeroShell Fluid 5M-A	MIL-PRF-6086F Medium Grade DEF STAN 91-112 Grade M	A highly refined, medium viscosity mineral oil containing an extreme pressure additive and additives to provide good oxidation and corrosion protection. No AeroShell alternative.
AeroShell Fluid 7	MIL-H-6083 DTD.5540	A preservative mineral hydraulic fluid. Was previously replaced by AeroShell Fluid 71, no current AeroShell alternative.
AeroShell Fluid 9	DEF STAN 91-040	A piston engine storage oil. No AeroShell alternative.
AeroShell Fluid 10	DTD.791C	A wax thickened piston engine storage oil. No AeroShell alternative.
AeroShell Fluid 14	DTD.445A	A cleaning fluid. No AeroShell alternative.
AeroShell Fluid 18	MIL-PRF-32033	Mineral based fluid with corrosion inhibitor & water displacing characteristics. No AeroShell alternative.
AeroShell Fluid 51	MIL-PRF-87257B	A synthetic hydrocarbon and ester based fluid for use in hydraulic systems. No AeroShell alternative.

AeroShell Grade	Specification	Description/Superseded by
Fluids *(continued)*		
AeroShell Fluid 61 Type II	MIL-H-46170B	Preservative synthetic hydrocarbon hydraulic fluid dyed red. Alternative is AeroShell Fluid 61 Type I which is undyed.
AeroShell Fluid 71	MIL-PRF-6083F DEF STAN 80-142	A preservative mineral hydraulic fluid of improved cleanliness. No AeroShell alternative.
AeroShell Fluid 602	MIL-PRF-87252C	A PAO-based fluid blended with additives. Widely used as a cooling fluid for aircraft avionics system. No AeroShell alternative.
AeroShell Fluid 634	MIL-PRF-63460D	Cleaning, preserving and lubricating fluid. No AeroShell alternative.
AeroShell Shock Strut Fluid (SSF)	BMS 3-32 Type I	A mineral hydraulic fluid (MIL-PRF-5606) to which additional additives have been added to improve the extreme pressure characteristics and the fluid's natural lubricity. No AeroShell alternative.
Others		
AeroShell Compound 01	-	A quick drying preservative fluid. In many cases, two coats of AeroShell Compound 02 can be used in place of Compound 01.
AeroShell Compound 02	MIL-PRF-16173E Grade 2 DEF.2331A	A quick drying lanolised fluid that provides temporary protection against corrosion. No AeroShell alternative.
AeroShell Compound 05	DEF STAN 80-085	A petroleum jelly/beeswax mixture for protecting metal parts against corrosion under temperate and tropical conditions. No AeroShell alternative.
AeroShell Compound 06	-	Denatured ethyl alcohol. Refer to AeroShell Compound 06A. No AeroShell alternatives, but 100% isopropyl alcohol could be used as replacement.
AeroShell Compound 06A	BS.1595	A de-icing fluid for windscreens, carburettors and propellers. No AeroShell alternatives, but 100% isopropyl alcohol could be used as replacement.
AeroShell Compound 08	SAE AMS2518A DEF STAN 80-080	Graphited anti-seize compound. No AeroShell alternative.
AeroShell Compound 09	MIL-M-7866C	Molybdenum disulphide powder. No AeroShell alternative.
Shell Compound S.7632	MIL-A-8243D	De-icing fluid. No AeroShell alternative.
Shell Aviation Fluid S.7229	-	A compressor wash fluid. No AeroShell alternative.
AeroShell Performance Additive 101	-	For military use of JP-8 as fuel stability improver. No AeroShell alternative.

ENVIRONMENTAL NOTES

In many countries there has been increasing interest in health, safety and environmental issues arising from the handling and use of oil products. Of late, legislation in many countries has changed, or is changing, with the result that information quickly becomes either out of date or is insufficient for a particular area.

- All AeroShell components registered in U.S. and Europe and increasingly in other countries such as Japan, China, Australia, Korea
- Safety Data Sheets are available for all grades
- Storage and handling information available to operators
- Labelling standards

Many countries now require Material Safety Data Sheets (MSDS) to be prepared for individual products and for these documents to be readily available to the users of the product.

Safety Data Sheets are available for all AeroShell grades and copies of these can be made available by local Shell companies. Where necessary, local Shell companies will ensure that any document they supply will comply with local legislation. If no local legislation exists then the data will be in accordance with the requirements of the European Community. These Safety Data Sheets contain information on:-

- Composition/information on ingredients
- Hazard identification/Dangerous Goods classification
- First Aid measures
- Fire Fighting measures
- Accidental release measures
- Exposure control/personal protection
- Toxicological information
- Ecological information
- Disposal considerations
- Regulatory information

These Safety Data Sheets are revised and re-issued whenever there is a change in the legal requirements and thus operators should always ensure that they are in possession of the latest edition. They can be accessed via **www.epc.shell.com.**

Safety Data Sheets are intended to act as a guide to users of Shell Aviation products and whilst the information is given in good faith, any remedial action must be the responsibility of the persons concerned and “Shell” cannot be responsible for any loss or damage resulting from any action taken.

QUALITY CONTROL, STORAGE, HANDLING AND RETESTING OF AEROSHELL PRODUCTS

Generally, AeroShell products are very stable and do not normally deteriorate if stored and handled correctly.

Owing to the nature of aviation there is a need to adopt procedures which enhance safety requirements and ensure product quality. Thus these recommendations must be considered as minimum requirements and any local requirements (e.g. ISO 9000, governmental and/or aviation authority requirements) which are more stringent take precedence.

Quality control

All AeroShell products are blended in batches with each batch composed of the identical formulation to all previous batches. A range of tests are performed on each batch to evaluate the physical, chemical and performance characteristics of the product. Historically, the batch-to-batch variations are minor and within the limits of test repeatability.

As each batch is prepared, a small quantity of product is set aside in sealed containers. These are then kept for a period of time in order to provide a reference base. Each released batch is then filled in the various pack sizes in which it is sold.

The date on the Certificate of Analysis (CoA) provided with the product is the date on which the product was tested and released by the laboratory. This date may not be exactly the same as the manufacturing date as some of the laboratory tests employed could be of a week or more duration.

Once the product is released, it is filled into those pack sizes required by our inventory control system necessary to maintain suitable stock levels.

A worked example is that 50% of the original batch may initially be filled off into 1 USQ tins and a fill date and batch number assigned. After a period of time the system may then require the remaining 50% of the batch to be filled off into 55 USG drums and again a fill and batch number is assigned with full traceability within our quality system to original batch number.

This may result in the filling date on the label of the container being slightly different to the testing date on the CoA. This is normally no more than two weeks difference at the most but occasionally could be as long as 4 weeks depending on the stock levels of various pack sizes in our warehouse.

Equally as important as good quality control during the blending and filling operation is correct storage and handling of the product prior to use. Customers can enhance the product storage by using first-in, first-out inventory procedures and maintaining the oil under normal storage conditions (i.e. indoors, protected from excessive heat, moisture and dust) and full details of the recommended storage, handling and retesting procedures are given in this section.

Product quality

In making any product which conforms to a military specification, a manufacturer can choose either to just barely meet the specification or to exceed the specification performance requirements. When a product exceeds the specification minimum requirements, the customer is provided with extra protection. The majority of AeroShell branded products exceed the specifications against which they are approved and have become acknowledged as industry standards. The products which Shell companies supply for military use are the same products supplied to commercial customers. The fact that the AeroShell products perform well in commercial operations further attests to the quality cushion which is provided to the military organisation using them.

Importance of correct storage and handling

The importance of correct storage and handling cannot be over emphasised.

Shell manufacturing plants pay particular attention to quality control throughout the entire manufacturing, blending and filling process of all aviation products. Rigorous checks take place during these operations and thorough testing before release of a product ensures that it meets the requirements of the specification and is fit to do the job for which it is intended.

It is therefore very important that operators and users of these products take equal care when handling and storing these products so that they remain in first class condition.

The most common problems

Deterioration of product quality arises mainly from contamination by water and/or dirt, and by temperature extremes during storage. In addition, deterioration can occur through the container being badly dented or damaged. Invariably, the sharp corners of dented or damaged containers are places of weakness where pinholes easily occur and rust readily forms.

Water contamination

Contamination by water can occur in two ways:

By 'breathing' of the container. In principal this happens when a container is stored in the open air. It may then be subjected to wide temperature changes (this includes, for example, the variation between daytime and night time temperature). At elevated temperatures the contents of the package will expand, and the layer of air above the oil will try to find a way out. With drums this is even possible through well sealed bungs. When cooling takes place, humid air often has the opportunity to penetrate into the drum, where the moisture then condenses out and the product becomes contaminated. Initially no more than a few droplets may be introduced, but with time the amount progressively increases and the contamination becomes significant and can lead to internal rusting of the container.

By penetration of water present on top of the container. Containers are carefully and thoroughly sealed after filling. However, if either breathing or if rusting (leading to pinholes in the container) has occurred, it is possible for water present on top of the container to penetrate the container and contaminate the product.

Preventing water contamination is simple: Store the product in a warehouse immediately after receipt. The warehouse should be dry, clean and not subject to wide temperature changes.

- Drums must be placed horizontally with the bungs at the 'quarter to three' position, to help ensure the gaskets are kept in contact with the oil in the drum.
- Pails and cartons must be stored in such a way that they cannot be damaged.

Contamination by dirt

Dirt cannot normally penetrate to the contents of a container until it has been opened. The dirt present in a dusty atmosphere will settle upon the surfaces of containers. Do not remove product from such containers without first having taken the proper precautions.

■ Prevention

AeroShell products should be stored in a dry, dust-free warehouse. Before a container is opened the top should be thoroughly cleaned. In the case of drums it is recommended that the whole top, and particularly the area around the bungs, should be thoroughly cleaned.

■ Greases

Greases require special precautions. Grease containers should never be opened in a dusty atmosphere. Before removing the contents, make sure that the equipment to be used for this is clean and free from dust and dirt. A wooden scraper is generally not recommended because it leaves small particles of wood mixed in with the grease which could affect the performance of the product.

In order to prevent oil separation into the hole from which grease has been removed, the surface of the product should be flattened out. Therefore: Always leave a smooth surface, and close the container after use!

Oil separation to a greater or lesser extent occurs with all greases. Unless the separation is excessive the grease can be used providing it is stirred well before use.

■ Superclean Hydraulic Fluids

Superclean hydraulic fluids, as the name implies, are hydraulic fluids which are exceptionally clean. This is achieved by extensive filtering of the fluid, thorough cleaning of containers, and packing in a clean room.

In view of this, particular care should be taken when opening the containers since it is all too easy for the fluid to lose its superclean properties. It is recommended that for superclean fluids a dispensing device, which includes fine filtration, is used.

Storage temperatures

Aviation lubricants should not be stored in the open air. Even inside warehouses, strong sunlight entering through windows and open doors can cause prolonged high temperatures on the surfaces of containers, which may affect product quality. Accordingly, containers should be kept in a shaded location. A constant ambient temperature between 0°C to 40°C (32°F to 104°F) is recommended.

Certain aviation products (in most cases for ground application) are affected by extremes of cold. Such low temperatures can inhibit the performance of these products and make them either difficult to pour, or difficult to use.

Shelf life, periodic inspection and re-testing

It is very important that no misunderstanding should ever arise over the contents of a container. Issue of an incorrect product from the warehouse should be prevented at all costs – especially for aviation applications. Great care must therefore be taken to ensure that the right product is received in the first instance. Furthermore, after products have been received, markings on containers and cartons should be kept legible; if necessary, they should be re-stencilled.

If a product is in store for a prolonged period of time, it is important to determine that it is still suitable for use. At regular intervals (exact time is for the user's decision, but it could be every quarter or every six months) a visual inspection of the outside of the cartons (for small packs) or containers (if drums or pails) should be undertaken checking for signs of leaks or damage. Those which are leaking or badly damaged should be downgraded for non- aviation use or destroyed in accordance with local environmental regulations.

If product is still in stock after a number of years, then it is necessary to take samples and test key properties to verify that the product continues to be fit for purpose. For the majority of AeroShell grades, representative samples from each batch should be re-tested after the specified time from date of manufacture or, if not known, date of order or date of receipt can be used instead.

Different products are subject to different re-test periods; similarly, the tests which need to be carried out on a product to verify its continued suitability for use depend on the type of product and field experience developed over the years. The re-test periods and the tests required for AeroShell products are based primarily on those specified in the latest issue of NATO Standard AFLP-4714 (Allied Fuels and Lubricants Publication) titled "Minimum Quality Surveillance for Lubricants and Associated Products". They are listed in the table below:

Product	**Initial Retest Period (years)**
All AeroShell piston engine oils	4
AeroShell Oil Sport Plus 4	4
AeroShell Oil Diesel Ultra	4
All AeroShell mineral turbine engine oils	4
All AeroShell synthetic turbine engine oils	6
AeroShell Fluids 4,41,31	3
AeroShell Fluids 61, LGF	4
AeroShell Fluids 2XN, 3, 5M-A, 12	4
AeroShell Fluids 602, S.8350	3
AeroShell Compound 07	2
AeroShell Calibrating Fluid 2	2

All AeroShell greases have a maximum shelf life of 6 years, no retest is required.
AeroShell Smoke Oil has a maximum shelf life of 10 years, no retest is required.

Note: In some countries, the local military authorities may adhere to re-test limits more stringent than those listed above, and these would need to be applied when supplying product to them.

The first re-test date shall be at the original frequency stated above. Subsequent re-tests shall follow at half that frequency. For example, the original re-test period for AeroShell Oil W100 is 4 years; thus the first re-test is due 4 years after date of manufacture with the next re-test 2 years later, with subsequent re-tests following every 2 years thereafter.

Normally there is no requirement to do a full specification test since in many specifications there are tests which are difficult/complex to do or which involve specialised hardware. Generally these can only be done by an oil products laboratory which specialises in aviation oils and greases. Instead, a reduced set of tests is specified for each product which focuses on those properties which would reveal any deterioration that has occurred in the product over the period in storage.

In some cases, the cost of re-testing can be higher than the value of the product in stock; in such situations it is doubtful that it makes economic sense to re-test the product and it should be downgraded or disposed of. Where re-testing is undertaken, then samples from each and every batch involved must be taken according to the cube root rule to determine how many containers need to be sampled.

All re-test results should be compared with the relevant specification requirements and, more importantly, with the original certificate of quality to assess if deterioration has occurred. Based on this comparison, a decision can then be made as to the suitability of the product for continued use or whether further testing is required, or if the product should be downgraded or disposed of according to local environmental regulations.

Note: As a best practice, in the NATO Standard for lubricants and associated products, the product is no longer authorised for servicing after 72 months from date of fill.

To sum up

In general, AeroShell products are inherently stable. If stored properly, their quality, properties and performance should not be affected by prolonged storage.

For greatest economic efficiency, it is recommended that products should be issued from the warehouse in the order in which they were received.

In other words: FIRST IN – FIRST OUT

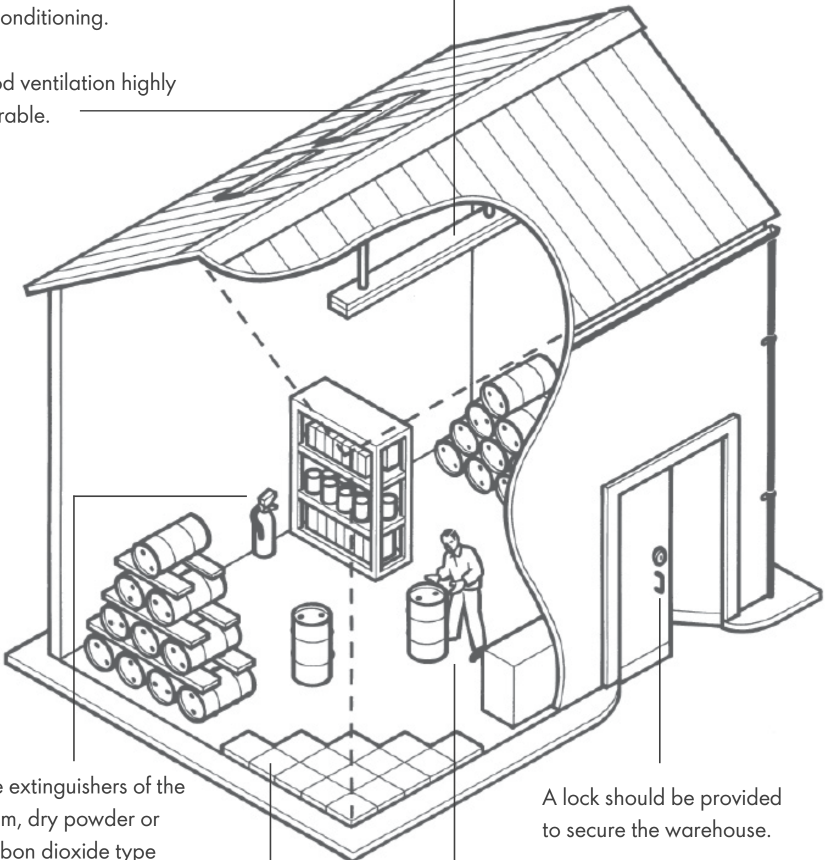
If, for some reason, a product has to be stored for longer than is economically desirable, and some doubt arises about its quality, it is recommended that Shell technical staff should be contacted for information about the product's continued suitability for aviation applications.

RECOMMENDED STORAGE

A constant temperature should be maintained throughout the year if necessary, by means of heating or air conditioning.

Good lighting should be provided also an electricity connection and a water supply.

Good ventilation highly desirable.



Fire extinguishers of the foam, dry powder or carbon dioxide type should be located at accessible spots.

A lock should be provided to secure the warehouse.

The room must be dust-free, accordingly it should be tiled or treated with a suitable paint.

The room must be spacious enough to permit the handling of drums and other containers, and such tasks as tapping oil and opening tins. It should be big enough to allow easy access to the stored containers.

A pump and other useful tools should be present.

SHELL AVIATION SERVICE

Shell Aviation is committed to meet or exceed industry standards at all locations. Aircraft operators may be assured that everyone concerned with the handling and dispensing of Shell Aviation fuels realises that the safety of each aircraft they refuel is dependent upon their skill, knowledge and ability. Fuels, fuelling methods and equipment are continually being developed and improved by Shell to meet the ever-increasing demands of modern aircraft and the aviation industry. Careful design of fuelling facilities, good operating procedures and thorough training of personnel are high on Shell's list of priorities. Included in this section are details of the care and attention paid by Shell to ensure that only clean, dry fuel to the correct specification is safely delivered into aircraft.

Types of aviation fuel

There are two categories of aviation fuel in common use today: aviation gasoline (known as Avgas) and turbine fuel or jet fuel. Details of these are given in the relevant fuels section in this handbook.

Identification of aviation fuels

The various grades of aviation gasoline are coloured to aid recognition. These colours have been established by international agreement. Turbine fuels, however, are not dyed and are generally colourless.

In addition to fuel identification by colour, a marking and coding system has been adopted to identify the various airport fuel handling facilities and pieces of equipment according to the fuel they contain. For example, leaded aviation gasolines are identified by name, using white letters on a red background; in contrast, turbine fuels are identified by white letters on a black background.

All parts of the fuelling facility and associated equipment where an error might occur, no matter how remote the possibility, are identified and labelled in the same marking and colour code. In addition, wherever possible, selective couplings are used to prevent the transfer of one grade into another.

Quality assurance

The Shell Aviation Service is designed to ensure that aviation fuels are at all times delivered into aircraft on specification and in a clean and dry condition. Shell operates throughout the world according to the standards set out in the Shell Aviation Quality System and the Shell Airport Operations Manual.

Regular audits by Shell Aviation personnel are made to ensure Shell's standards are maintained at all of Shell's locations worldwide.

SAFETY IN FUELLING OPERATIONS

Delivering the Correct Grade of Fuel

Before delivering any fuel into the aircraft, the fuelling crew need to confirm with certainty the correct grade and quantity of fuel required. This is particularly important when fuelling general aviation aircraft over-wing. There is a particular problem present when refuelling types of aircraft which are outwardly similar, but require different fuels – typically spark ignition piston engines that may require avgas, or similar aircraft with either compression ignition piston engines or turboprop engines that require jet fuel. They look similar and the spark ignition piston engine type may be turbo-charged, with large lettering on the cowlings saying "TURBO", bringing potential confusion between gasoline fuelled engine which is fitted with a turbocharger and jet fuelled turboprop.

To prevent misfuelling aircraft during over-wing fuelling, Shell Aviation requires that at least 2 out of the following criteria are satisfied for each and every fuelling:

1. A grade selective nozzle shall be fitted.
2. There shall be a decal next to the fuelling point on the aircraft specifying the grade of fuel required.
3. A Fuel Order Form has been completed and signed by an authorised member of the aircraft crew.

If the grade marking or Fuel Order Form is not available, no fuel will be delivered.

Aircraft operators should therefore make certain that all fuelling points on their aircraft are clearly marked with the correct grade of fuel.

Facilities

Shell sets high standards for the facilities used to handle aviation fuels. Storage depots are designed to store optimum quantities of fuel at the high standard required by the Shell quality assurance system. Mobile equipment used to deliver fuels to customers' aircraft is designed to ensure speedy, safe and efficient service. For both fixed and mobile equipment the emphasis is on achieving the correct balance between simplicity and sophistication. To help achieve this, Shell maintains contacts with equipment suppliers around the world and is active in international organisations responsible for equipment standards.

Good initial design and high standards of construction are complemented by regular testing and maintenance of all critical pieces of equipment.

Experience and Training

Shell has been in the aviation fuel business for more than 110 years and during that time it has built up a wealth of experience. This is communicated to all Shell locations by means of manuals, training courses and periodic publications and which is furthermore backed up by the extensive research facilities of Shell Group.

Shell staff are fully aware of all aspects of safety required for the storage, handling and dispensing of aviation fuels.

Fire

Aviation gasolines and Jet B are extremely hazardous unless handled correctly; jet fuel, although less volatile than gasoline, also requires safe handling to avoid hazard.

Shell refuelling crews are trained to handle fuels safely but, as a precaution, training in fire fighting is given, with regular fire drills held and crews made fully familiar with the operation of the fire extinguishers carried on all of Shell's fuelling vehicles.

The following points are worth remembering:

Fuel Vapour + Air + Spark or Flame = Fire

Every effort must be made therefore to prevent fuel spillage and subsequent vapour escape. Equally important are the procedures for the prevention of spark generation or naked flames near the airport apron or fuelling facilities. These are as follows:

1. No smoking or carrying of matches or lighters. This applies to all persons in the vicinity during fuelling operations.
2. Prevention of electrostatic sparks by careful bonding of fuelling equipment to aircraft.
3. Safe, well maintained equipment, e.g. motors and electrical circuits.
4. No fuelling whilst aircraft engines are running (unless special procedures are in force).
5. No fuelling whilst anti-collision strobe lights are operating (general aviation aircraft only).
6. Personnel must not wear nailed footwear or nylon clothing.
7. Care with mobile phones or any electrical equipment that could cause a spark.

Static Electricity

Matches, cigarette lighters, smoking, open flames and even backfires from vehicles or aircraft are obvious sources of ignition. Another source, not so visible or obvious, is the spark created by static electricity. Static electricity charges are generated in various degrees whenever one body passes through or against another. An aircraft in flight through the air, a fueller driving on a roadway, the rapid flow of fuel through a pipe or filter, and even the splashing of fuel into a fueller or aircraft during loading and fuelling operations, generates static electricity. A greater generation of static electricity may be expected when handling turbine fuels than when handling aviation gasoline; a basic reason for this is the higher viscosity of the fuel. Large turbine-powered aircraft demand large quantities of clean, dry fuel. The high-speed fuelling rates and the flow through ultra fine filter/separators required to meet this demand for cleanliness can create significant static electrical charges.

Some of the hazard from the charging of the fuel itself is reduced by the use of a static dissipator additive. However, it is worth noting that a static charge may still accumulate on the aircraft during flight or on the ground due to air friction and in this case the presence of a static dissipator additive in the fuel cannot help. To minimise this hazard, it is necessary to create an electrical circuit to equalise static electrical charges before they build up to a high enough potential to create a static spark. This can be accomplished by bonding the fuelling vehicle to the aircraft with a cable and allowing sufficient time for the charge to equalise before performing any act which may draw a spark.

The flow of an electrical charge from a body of fuel or an aircraft is not always an instantaneous act as is commonly believed. It may take several seconds to equalise all the charge from some fuels.

When handling all aviation fuels, the following procedures are adopted:

1. Connect the bonding wire from the fueller or cabinet to the aircraft.
2. In the case of overwing fuelling, connect the fuel nozzle bonding wire to the aircraft before the tank cover is opened (underwing couplings do not need to be individually bonded to the aircraft).
3. When disconnecting, reverse the order.

It cannot be emphasised too strongly the hazard present from static electricity when moving any hydrocarbon product. Many accidents outside airfield operations, in the home and at work, are caused by the mishandling of fuels.

Remember: If it's metal, bond it.
If it's plastic, don't use it!!!

NOTES

SHELL AVIATION FUELS

2. SHELL AVIATION FUELS

INTRODUCTION TO AVIATION FUELS

Shell Aviation fuels may be classified into two basic groups: aviation gasoline, for use in spark ignition piston engines; aviation turbine fuels (jet fuels), for use in turbofan, turbo jet,turboprop and turboshaft engines. Jet fuels are also certified by Aviation Authorities for use in compression ignition piston (diesel) engines, although the jet fuel specifications do not designed for this purpose. The various grades of each type available are described in this section.

All Shell Aviation fuels are produced to meet the stringent manufacturing requirements set out in the relevant specifications. At key stages between refinery and aircraft tank, fuel quality is checked by sampling and on-site or laboratory testing, to ensure that the fuel conforms to the requirements specified for the grade when it is delivered to the aircraft. The Shell Aviation Quality Assurance System is organised on a worldwide basis, made easier because Shell Aviation Service is provided directly in many countries of the world.

Aviation Turbine Fuel (Jet Fuel)

Today's kerosene 'Jet' fuels have been developed from the illuminating kerosene used in the early gas turbine engines. These engines needed a fuel with good combustion characteristics and a high energy content. The kerosene type fuels used in civil aviation nowadays are mainly Jet A-1 and Jet A. The latter has a higher freezing point (maximum −40°C (−40°F) instead of maximum −47°C (−53°F)) and is available only in the U.S.A.

Major Civil Jet Fuel grades

Jet A-1

Jet A-1 is a kerosene grade of fuel suitable for most turbine-engined aircraft. It has a flash point minimum of 38°C (100°F) and a freeze point maximum of −47°C (−52°F). It is widely available outside the U.S.A. The main specifications for Jet A-1 grade (see below) are the UK specification DEF STAN 91-091 (Jet A-1) NATO code F-35, (formerly DERD 2494) and the ASTM specification D1655 (Jet A-1).

Jet A

Jet A is a kerosene grade fuel, normally only available in the U.S.A. It has the same flash point as Jet A-1 but a higher freeze point maximum (–40°C/–40°F). It is supplied against the ASTM D1655 (Jet A) specification. Jet A is used within the United States by domestic and international airlines.

Jet B

Jet B is a distillate comprising naphtha and kerosene fractions. It can be used as an alternative to Jet A-1, but because it is more difficult to handle (higher flammability), there is minimal demand and availability for this grade of fuel. The only significant area of use is in very cold climates, such northern Americas, where its better cold weather performance can be preferred. Jet B is specified by ASTM D6615, but in Canada it is supplied against the Canadian Specification CAN/CGSB 3.23

TS-1

TS-1 is the main jet fuel grade available in Russia and the Commonwealth of Independent States. It is a kerosene type fuel with slightly higher volatility (flash point is 28°C (82°F) minimum) and lower freeze point (<–50°C/–58°F) compared with Jet A-1. It is supplied against the GOST 10227 specification.

No.3 Jet Fuel

No.3 Jet Fuel is the main Chinese grade which is essentially equivalent to Jet A-1.

American Civil Jet Fuels

The basic civil jet fuel specification used in the United States of America is ASTM Specification for Aviation Turbine Fuels ASTM D1655, which defines the requirements for the two grades of fuel – Jet A and Jet A-1 (Note: ASTM D1655 formerly included Jet B but this grade is now covered by a separate specification ASTM D6615).

Alternative and Sustainable Aviation Fuels

A recent development for jet fuels is the approval of alternative blend components. Unconventional blend components, including those derived from Fischer-Tropsch synthesis or some renewable bio-routes, are covered by a new specification, ASTM D7566. In this specification, blend components are defined and controlled in the Annex section, along with the blending limits. Once blended, the finished fuels must meet the test requirements in the main table of ASTM D7566, which includes all of the testing requirements of ASTM D1655 plus some additional parameters. Once a finished fuel is certified to ASTM D7566 it can be recertified as ASTM D1655, thereby allowing the fuel to be handled and mixed with conventional jet fuel batches and, furthermore, not requiring any change in the certification of either aircraft or engines.

Research and testing continues to prove the suitability of new processes and source materials for use in jet fuel and, as this work progresses, the scope of ASTM D7566 will continue to be expanded to accommodate these changes.

UK Jet Fuels

Although developed originally as a military jet fuel specification by the UK Ministry of Defence, DEF STAN 91-091 (originally DERD 2494) has been adopted as the standard UK civil jet fuel specification. It defines the requirements for a kerosene type fuel (Jet A-1 grade) having a maximum freeze point of –47°C (–52°F).

Jet A-1 according to the DEF STAN 91-091 specification is essentially the same as Jet A-1 defined by the ASTM D1655.

Russian and East European Jet Fuels

Russian kerosine type jet fuels are covered by a wide range of specification grades reflecting different crude sources and processing treatments used. The grade designation is T-1 to T-8, TS-1 or RT. The grades are covered either by a State Standard (GOST) number, or a Technical Condition (TU) number. The limiting property values, detailed fuel composition and test methods differ quite considerably in some cases from the Western equivalents.

The principle grade available in Russia and other members of the Commonwealth of Independent States (CIS) is TS-1 (written as TC-1 in Russian script).

The main differences in characteristics are that Russian fuels have a low maximum freeze point (equivalent to about –57°C (–70°F) by Western test methods) but also a low flash point (a minimum of 28°C (82°F) compared with 38°C (100°F) for western fuel). RT fuel (written as PT in Russian script) is the superior grade (a hydrotreated product) but is not produced widely. TS-1 (regular grade) is considered to be equivalent to Jet A-1 and is approved by most aircraft manufacturers.

In some locations in Russia and for exports, product may be supplied against the Russian Jet A-1 specification GOST 52050-2006 which is aligned with DEF STAN 91-091.

Eastern European countries have their own national standards with their own nomenclature. Many are very similar to the Russian standards, but others reflect the requirements of visiting international airlines and are similar to Jet A-1 in properties and test methods.

Chinese Jet Fuels

Five types of jet fuel are covered by current Chinese specifications. Previously, each grade was numbered with a prefix RP; however, they are now renamed No.1 Jet Fuel, No.2 Jet Fuel, etc. RP-1 and RP-2 are kerosenes which are similar to Russian TS-1. They both have low flash points (minimum 28°C/82°F). RP-1 maximum freeze point is –60°C (–76°F) and that of RP-2 is –50°C (–58°F).

RP-3 is essentially the same as Jet A-1. RP-4 is a wide-cut type fuel similar to Jet B and Russian T-2. RP-5 is a high flash point kerosene similar to that used in the west by naval aircraft operating on aircraft carriers. Virtually all jet fuel produced in China is now RP-3 (renamed No.3 Jet Fuel).

International Specifications - AFQRJOS Check List

As jet fuel supply arrangements have become more complex in the 1970s, involving co-mingling of product in joint storage facilities, a number of fuel suppliers developed a document which became known as the Aviation Fuel Quality Requirements for Jointly

Operated Systems, or AFQRJOS, Joint Fuelling System Check List. The "Check List" embodies the most stringent requirements of the DEF STAN 91-091 and ASTM D1655 specifications for JET A-1. By definition, any product meeting Check List requirements will also meet either DEF STAN or ASTM specifications.

The Check List is recognised by seven of the major aviation fuel suppliers - BP, Chevron, ENI, ExxonMobil, Kuwait Petroleum, Shell, and Total for use in joint venture locations.

Military Jet Fuel grades

JP-4

JP-4 used to be the primary jet fuel for the US Air Force but was phased out in the 1990s because of safety problems. A few air forces around the world still use it but there is very little production.

JP-4 is the military equivalent of Jet B with the addition of corrosion inhibitor and anti-icing additives; it meets the requirements of the U.S. Military Specification MIL-DTL-5624W Grade JP-4. The UK Military specification for this grade is DEF STAN 91-088 AVTAG/FSII (formerly DERD 2454), where FSII stands for Fuel System Icing Inhibitor.

NATO Code F-40.

JP-5

JP-5 is a high flash point kerosene meeting the requirements of the U.S. Military Specification MIL-DTL-5624W Grade JP-5. The UK Military specification for this grade is DEF STAN 91-086 AVCAT/FSII (formerly DERD 2452). This is primarily jet fuel for use in aircraft carriers.

NATO Code F-44.

JP-8

JP-8 is the military equivalent of Jet A-1 with the addition of corrosion inhibitor and anti-icing additives; it meets the requirements of the U.S. Military Specification MIL-DTL-

83133K. It is the dominant military jet fuel grade for NATO air forces. The UK also has a specification for this grade namely DEF STAN 91-087 AVTUR/FSII (formerly DERD 2453).

NATO Code F-34.

JP-8 +100

JP-8 +100 is JP-8 fuel to which has been added an approved thermal stability improver additive. It meets the requirements of the U.S. Military Specification MIL-DTL-83133K and has been widely used by the USAF in their fighter and trainer wings.

NATO Code F-37.

Aviation Gasoline (Avgas)

Aviation Gasoline (Avgas) is used in small piston engine powered aircraft within the General Aviation community, e.g. private pilots, flight training, flying clubs and crop spraying. Aviation spark ignition piston engines operate using the same basic principles as spark ignition engines in cars, but they have a much higher performance requirement. In today's General Aviation community there are only two main leaded Avgas grades (100 and 100LL low lead) - a rationalisation that has enabled fuel companies to continue supplying a market that would otherwise have become uneconomic. Worldwide, total Avgas volumes are low, since Avgas-fuelled aircraft, although they outnumber jet-fuelled aircraft, are generally much smaller.

Avgas grades

Avgas 100

This was the standard high-octane fuel for aviation piston engines and has a high lead content. There are two major specifications for Avgas 100. The ASTM D910 and UK DEF STAN 91-090. These two specifications are broadly the same, but differ over antioxidant content, oxidation stability requirements and max lead content.

Avgas 100 has a low market demand and is now only produced in a one or two locations in the world. Avgas 100 is dyed green.

Avgas 100LL

This grade is the lower lead version of Avgas 100. Low lead is a relative term. There is still up to 0.56 g/litre of lead in Avgas 100LL. This grade is listed in the same specifications as Avgas 100, namely ASTM D910 and UK DEF STAN 91-090.

Avgas 100LL is dyed blue and is the main grade of Avgas used worldwide.

Avgas 100VLL

This grade is the very low lead version of Avgas 100LL, containing a maximum lead concentration of 0.45 g/litre. It is effectively a variant of Avgas 100LL with a restraint on the max lead content. It could be made available as an interim measure prior to the introduction of an unleaded high octane fuel, should it be necessary to address environmental concerns about leaded fuels. This grade is listed in ASTM D 910 and, other than the lower lead content, is constrained by the same specification requirements as Avgas 100LL. It therefore meets the same aircraft approvals and operating limitation requirements as Avgas 100LL meeting ASTM D910.

Avgas 100VLL is dyed blue.

Avgas UL82 and UL87

These grades were intended to comply with the same aircraft approvals as the original motor gasoline (mogas) Supplementary Type Certificate (STC) approvals, but with better compositional and performance control. They were aimed at the low compression ratio engines, typically used within the light sport category, which do not need the high octane of Avgas 100LL and could be designed to run on automotive style unleaded fuels. Avgas UL82 and Avgas UL87 are specified in ASTM D6227. Unlike other Avgas specifications, ASTM D6227 allows the use of some non-hydrocarbon components used in mogas, such as ethers, but, unlike mogas specifications, alcohols are not permitted.

There has been no meaningful market demand for either Avgas UL82 or Avgas UL87 and so they are not known to be available in the market even though these remain active grade within an active specification and at the time of writing they remain as theoretical fuels only. Avgas UL82 and Avgas UL87 are both undyed grades.

Avgas UL91 and Avgas UL94

Compositionally Avgas UL91 somewhat comparable with Avgas 100LL but with a zero lead content, which results in a lower octane rating of 91MON. Avgas UL94 improves on this by including some more exotic high octane hydrocarbons such as mesitylene.

Avgas UL91 and Avgas UL94 are specified in ASTM D7547. Avgas UL91 differs principally from both Avgas UL87 and UL82 not only in the higher octane rating, but in lower vapour pressure (49kPa max compared with 60kPa max in ASTM D6227) and that oxygenates such as ethers are not permitted. In common with all other current Avgas specifications, ASTM D7547 does not permit the use of alcohols such as ethanol.

Avgas UL91 and Avgas UL94 are both undyed grades.

History of Avgas Grades

Avgas is gasoline fuel for spark ignition reciprocating piston engined aircraft. As with all gasolines, avgas is very volatile and is extremely flammable at normal operating temperatures. Procedures and equipment for safe handling of this product must therefore be of the highest order.

Avgas grades are defined primarily by their octane rating and lead content. Two octane ratings have historically been applied to aviation gasolines (the lean mixture rating and the rich mixture rating) which results in a multiple numbering system e.g. Avgas 100/130 (in this case the lean mixture performance rating is 100 and the rich mixture rating is 130). The aviation lean mixture rating is now obsolete due to a lack of test engines and has been replaced by the Motor Octane Number (MON) method, with a lean mixture rating of 100 equating to a MON of 99.6.

In the past, there were many different grades of aviation gasoline in general use e.g. 80/87, 91/96, 100/130, 108/135 and 115/145. However, with decreasing demand these were rationalised down to one principle grade, Avgas 100/130. (To avoid confusion and to minimise errors in handling aviation gasoline, it is now common practice to designate the grade by just the lean mixture performance rating; thus Avgas 100/130 becomes Avgas 100).

Some years ago, an additional grade was introduced to allow a common fuel to be used in engines originally designed for grades with lower lead contents as well as in those engines certified for higher lead contents. This grade is called Avgas 100LL, the LL standing for 'low lead'.

All equipment and facilities handling avgas are colour coded and display prominently the API markings denoting the actual grade carried. Currently, the two major grades in use internationally are Avgas 100LL and Avgas 100. To ease identification the fuels are dyed: Avgas 100LL is coloured blue, while Avgas 100 is coloured green.

In 1999 a new Avgas grade UL82 (UL standing for unleaded) was introduced as a low octane grade suitable for low compression engines. It has a higher vapour pressure than conventional Avgas and can be manufactured from motor gasoline components, but, notably, the specification does not allow alcohols such as ethanol to be used. It is particularly applicable to those aircraft which have Supplementary Type Certificates (STCs) to use automotive gasoline.

An extension of this has been the grade Avgas UL87, which was created in response to the higher octane demand of some light sport engines; notably the turbocharged Rotax® engines. UL87 is otherwise similar to UL82, using similar components, but again expressly excluding alcohols.

The relatively high vapour pressure of the ASTM D6227 specification when compared to more conventional Avgas grades makes UL82 and UL87 somewhat unsuitable for high altitude flight as engine failure from vapour lock can be an issue. In order to meet the demands from the military for an unleaded Avgas for use in high flying, unmanned aerial vehicles (UAVs), a new low vapour pressure UL91 grade was introduced, resulting in the requirement for a new specification, ASTM D7547. More recently this specification has been extended to include a higher octane Avgas UL94, with a minimum MON value of 94. This is estimated to be as high an octane as is practicable with the use of a hydrocarbon only composition without adversely affecting other properties required of such a fuel.

The ASTM D7457 specification is approved for light sport engines, such as Rotax®, and has also been approved in a wider range of general aviation engines of low to mid-octane demand.

However, it is clear that this will not be of high enough octane rating to be used safely in all general aviation engines and work continues in trying to find a true unleaded alternative to the almost ubiquitous Avgas 100LL. To meet this higher octane demand challenge without the use of Lead, research and testing work is underway by Shell and others using a number of relatively exotic high octane, non-hydrocarbon components and, through the oversight of the Federal Aviation Administration, it is hoped that these efforts will be successful in attracting fleet-wide approval at some point in the future.

NOTES

ACCESS TO AVIATION FUEL SPECIFICATIONS

Because it is important to refer only to the most recent issues of fuel specifications, their detailed requirements have not been tabulated in this AeroShell Book since they could quickly become out-of-date. Copies of the specifications cited above can be obtained from the following authorities:

DEF STAN Specifications

UK Defence Standardization
Kentigern House, Room 1138
65 Brown Street
GLASGOW
G2 8EX

phone +44 141 224 2531
email: enquiries@dstan.mod.gov.uk

NOTE: DEF STAN specifications are freely available from their web site at:
www.dstan.mod.uk

ASTM Specifications

ASTM specifications are published annually in the ASTM Book of Standards, Section 5 (on paper and CD). Copies are available from:

ASTM
100 Barr Harbor Drive
West Conshohocken
PA 19428-2959
USA

phone +1 610 832 9585
email: service@astm.org
ASTM website is: **www.astm.org**

NOTE: Specifications are available for a charge.

US Military Specifications

Department of Defense
DODSSP
Building 4/ Section D
700 Robins Avenue
PA 19111-5094
USA

phone +1 215 697 2667
fax +1 215 697 1462

NOTE: US Military specifications are freely available from their web site at:
https://quicksearch.dla.mil/qsSearch.aspx

IATA Guidance Material for Aviation Turbine Fuels Specifications

IATA issue an excellent guide covering commercial aviation fuels and additives. The latest edition can be obtained from:

Fuel Services IATA
800 Place Victoria
PO Box 113
Montreal Quebec
Canada H6Z 1M1

phone +1 514 874 0202
fax +1 514 874 9632

IATA website is: **https://store.iata.org/** where the document can be found under Publications > Safety & Operations > Turbine Fuel Specification Publication

AFQRJOS Check List for Jet A-1

The Joint Fuelling Systems Check List for Jet A-1 is maintained by the JIG Product Quality Committee on behalf of the industry. The latest edition can be accessed on the Joint Inspection Group's website: **www.jigonline.com** under the link 'Publications'.

AVIATION FUEL ADDITIVES

Aviation fuel additives are compounds added to the fuel in very small quantities, usually measurable only in parts per million, to provide special or improved qualities. The quantity to be added and approval for its use in various grades of fuel is strictly controlled by the appropriate specifications.

A few additives in common use are as follows:-

1. **Anti-knock additives** reduce the tendency of gasoline to detonate. Tetra-ethyl lead (TEL) is the only approved anti-knock additive for aviation use and has been used in motor and aviation gasolines since the early 1930s.

2. **Anti-oxidants** prevent the formation of gum deposits on fuel system components caused by oxidation of the fuel in storage and also inhibit the formation of peroxide compounds in certain jet fuels.

3. **Static dissipator additives** reduce the hazardous effects of static electricity generated by movement of fuel through modern high flow-rate fuel transfer systems. Static dissipator additives do not reduce the need for 'bonding' to ensure electrical continuity between metal components (e.g. aircraft and fuelling equipment) nor do they influence hazards from lightning strikes.

4. **Corrosion inhibitors** protect ferrous metals in fuel handling systems, such as pipelines and fuel storage tanks, from corrosion. Some corrosion inhibitors also improve the lubricating properties (lubricity) of certain jet fuels.

5. **Fuel System Icing Inhibitors (Anti-icing additives)** reduce the freezing point of water precipitated from jet fuels due to cooling at high altitudes and prevent the formation of ice crystals which restrict the flow of fuel to the engine. This type of additive does not affect the freezing point of the fuel itself. Anti-icing additives can also provide some protection against microbiological growth in jet fuel.

6. **Metal de-activators** suppress the catalytic effect which some metals, particularly copper, have on fuel oxidation.

7. **Biocide additives** are sometimes used to combat microbiological growths in jet fuel, often by direct addition to aircraft tanks; as indicated above, some anti-icing additives appear to possess biocidal properties.

8. **Thermal Stability Improver additives** are sometimes used in military JP-8 fuel, to produce a grade referred to as JP-8+100, to inhibit deposit formation in the high temperature areas of the aircraft fuel system.

FUEL PROPERTIES NOT IN SPECIFICATIONS

Fuel specifications do not list all the properties of aviation fuels; it would be impractical for them to do so because by no means all of these properties could be tested for at the creation of each new fuel batch. However, many of these properties not listed in official fuel specifications may nevertheless be important to the designers of aircraft engines and airframes because they describe certain aspects of the fuel's behaviour when in aircraft tanks and fuel systems.

Examples of these properties are:

Surface tension
Specific heat
Thermal conductivity
Enthalpy
Heat of vapourisation
Lubricity
Permittivity
Flammability limits
Autoignition temperature
Spark ignition energy
Bulk Modulus
Solubility of gases in fuel
Solubility of water in fuel

Information and typical values for these properties can be obtained from a variety of publications. The most useful one for designers of aircraft and engine fuel systems is probably the Coordinating Research Council (CRC) Report entitled "Handbook of Aviation Fuel Properties" (CRC Doc. No. 635). This was published in 2004 and is available from the Society of Automotive Engineers, Inc., General Publications Department, 400 Commonwealth Drive, Warrendale, Pennsylvania PA 15096 U.S.A.

Order via **http://aerospace.sae.org/** or by calling +1 724 776 4970. Available in hard copy and CD ROM format.

SHELL AEROJET

Shell AeroJet is a premium aviation fuel service, offering major benefits to pilots, operators and owners of turbine powered aircraft. The service is available at selected airports and countries worldwide.

Shell AeroJet minimises or eliminates some of the problems associated with the use of Jet A-1 in business jets, turbo-prop aircraft and helicopters and is mandated by some airframe manufacturers such as Pilatus.

Anti-Icing

The air inside fuel tanks contains moisture which can precipitate into the fuel as free water. This water has the potential to turn to ice during flight operation or even on the ground. Shell AeroJet contains a Fuel System Icing Inhibitor (FSII) that is an approved additive which dramatically lowers the freezing point of water and eliminates this problem to give added security in case of fuel heater system breakdown. It also creates an environment that inhibits the growth of bacteria and fungi which can pose a serious danger to the plane and passengers. This feature in Shell AeroJet can be particularly valuable for aircraft operating in hot and humid conditions.

Assurance

The practice of using aerosol cans to mix anti-icing additive while overwing refuelling often results in an uneven mix and incorrect additive concentration as well as posing health hazards to the user from possible contact with the neat additive. The major advantages of Shell AeroJet over this and other systems is the assurance that the fuel has been dosed with the additive at exactly the correct rate every time without any exposure to liquid splashes or harmful vapours.

AEROSHELL PERFORMANCE ADDITIVE 101

AeroShell Performance Additive 101, developed for the USAF JP-8 +100 programme by BetzDearborn (now GE Water & Power) for high temperature, high performance jet fuel, helps prevent the build up of carbon deposits in the engine.

AeroShell Performance Additive 101 is a unique, patented jet fuel additive designed to improve the thermal stability of military jet fuels.

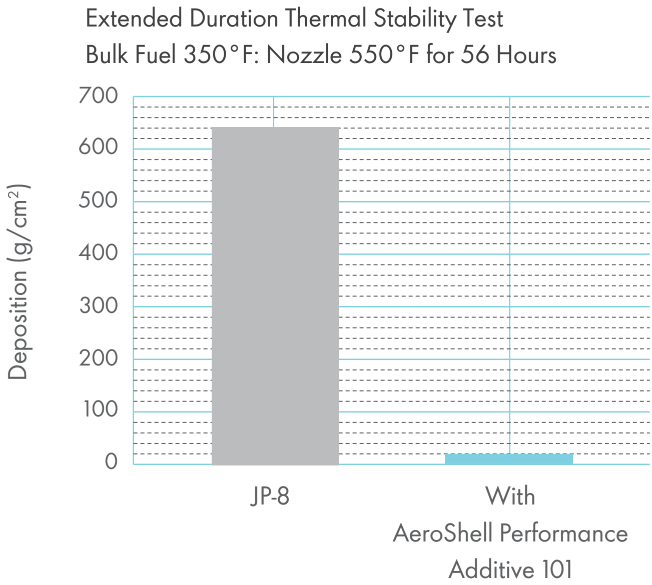
AeroShell Performance Additive 101 is approved for use in all military and civil engines manufactured by Pratt & Whitney and General Electric. Approval in Rolls-Royce and other manufacturers' engines is pending.

AeroShell Performance Additive 101 is designed to:

- provide greater fuel heat-dispersing capacity by allowing fuel temperatures to increase by as much as 56°C (100°F) without degradation.
- reduce deposits in turbine engines using all grades of jet fuel.
- prevent and clean up carbon in fuel system and combustion sections of turbine engines.

Improves Jet Fuel Thermal Stability

In today's military aircraft, standard jet fuel can break down and form deposits on metal surfaces, when thermally stressed to temperatures above 150°C (300°F). This severe environment requires substantially improved fuel stability. In a variety of static and dynamic laboratory tests, along with advanced simulator rigs, Shell Aviation's additive programme, in conjunction with GE, has already demonstrated a minimum of 56°C (100°F) improvement over today's jet fuel in both the bulk and wetted wall areas of aircraft fuel systems.



Reduces Fuel Manifold & Nozzle Coking

Carbon build-up (coking) can create back pressure in fuel manifolds, as well as distort fuel nozzle spray patterns. Altered flame patterns can contribute to metal fatigue in both the combustion and turbine sections of the engine. High engine cycle fatigue often occurs. In severe cases, turbine damage leading to catastrophic engine failure is possible.

Coke build up along the walls of the fuel manifold system can cause changes in hydraulic pressure and contribute to erratic fuel controller performance. In real world field testing and subsequent routine usage in JP-8 +100, AeroShell Performance Additive 101 has minimised equipment replacement costs by reducing coking, allowing optimum performance levels to be achieved.

Reduces Unscheduled Engine Removals

Reports of after-burner and other fuel related malfunctions usually trigger a mandatory inspection to duplicate and correct the malfunction before the engine can be put back into active service. These engine inspections are costly but necessary to ensure pilot safety and aircraft integrity. In military field testing, continuous use of AeroShell Performance Additive 101 dramatically reduced the frequency of these fuel related incidents.

Improves Engine Cleanliness

Following the introduction of JP-8 +100, hot engine sections, from the combustion zone through to the afterburner tail exhaust, previously covered with light carbon deposits, have actually cleaned up and remained clean. Visual inspection of aircraft tail sections, combined with field boroscope inspections of fuel manifolds and nozzles have confirmed this benefit.

Reduces Operational & Maintenance Costs

Keeping the fuel system and jet engine clean from carbon deposits caused by the thermal stressing of jet fuel can reduce overall engine maintenance costs. A detailed evaluation of these impacts has been carried out with over a decade worth of field experience. Reports are available from your Shell representatives.

Combine this with improved aircraft readiness, and the full benefit of AeroShell Performance Additive 101 can prove to be a wise investment.

Additive Injection

AeroShell Performance Additive 101 should be applied at the truck or vehicle refuelling operation using an injector system to meter the additive flow. Care should be taken if moving the injection point further up the refuelling process (such as into bulk storage tanks) in order to avoid deactivation of water coalescer systems by the detergent/dispersant action of the additive.

The recommended dose rate for AeroShell Performance Additive 101 in JP-8 is 256 ppm (mg/litre) or 1:4000. The product is oil soluble with good low temperature handling characteristics and can be injected undiluted in its delivered form.

Performance Evaluation

AeroShell Performance Additive 101 should be used in conjunction with a monitoring program designed to focus on fuel-related malfunctions. It is usual to measure the actual number of malfunctions, average time between occurrences, and the reduction in maintenance and labour costs. An additional measure is the effect on fleet readiness rate after treatment.

Caution: before using AeroShell Performance Additive 101, check with the aircraft/engine manufacturer to determine if the additive is approved for use in their equipment or, if not, under what terms and conditions the additive might be evaluated.

SHELL WATER DETECTOR

The Shell Water Detector is a device for determining the presence in jet fuels of finely dispersed undissolved water in concentrations lower than those normally detectable by visual examination. Water dispersions of this type can result from the emulsification of a water/fuel mixture during pumping, or from the precipitation of dissolved water due to a fall in fuel temperature.

Construction

The detector consists of two parts:

a) A standard polythene or nylon hypodermic syringe of 5 ml capacity with a Record type nozzle fitting.
b) A plastic detector capsule in which is fitted a disc of filter paper treated with water sensitive chemicals.

Use

Before use the detector capsule should be examined in order to confirm that the paper is of a uniform yellow colour. The detector capsule is fitted to the syringe, then the capsule and approximately half of the syringe is immersed in the sample under test and the plunger withdrawn until the fuel reaches the 5 ml mark. The capsule should be examined for any difference in colour between the inner wetted portion and the outer portion which is protected by the plastic moulding.

It is important to note that:

a) The screw cap should be replaced on the capsule container immediately the required capsule has been removed to prevent discolouration of the remaining capsules by atmospheric humidity. Unused capsules should not be left lying about or kept loose in the pocket.
b) A capsule should be used once only and then discarded because the sensitivity of the device is a function of the quantity of fuel passing through the paper.

Interpretation of results

The presence of undissolved water is indicated by a change in colour of the centre portion of the detector paper. The Shell Water Detector begins to react at very low levels of water contamination even below 10 ppm and the resulting colour change becomes progressively more noticeable with increasing water content until at approximately 30 ppm a distinct green colour is obtained giving a positive indication of water contamination. At lower water contamination levels a yellow/green colour is obtained which increases to blue/green and finally blue/black at very high levels of water contamination.

Application

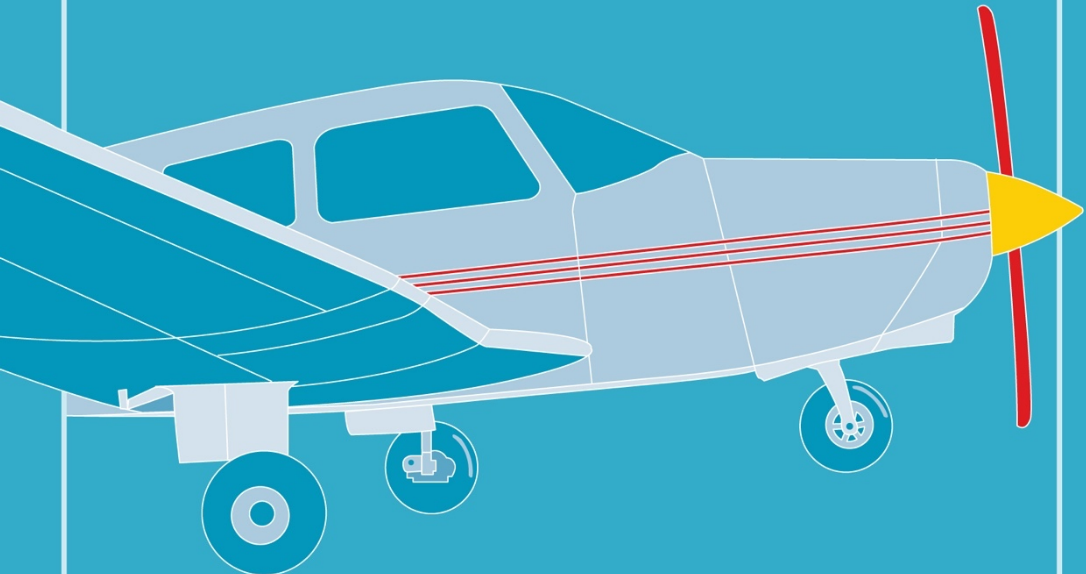
The Shell Water Detector should be used as follows to check samples of jet fuels immediately after they are drawn:

a) Road vehicle and RTW drain samples – before discharge into airport storage.
b) Bottom samples from airport tanks – immediately before release.
c) Fueller and trailer compartment drain samples – after each replenishment.
d) Hydrant dispenser filter drain samples – after each aircraft fuelling.
e) Fueller filter drain samples – after the first aircraft fuelling, after filling or topping up either fueller or trailer.
f) Drain samples from filtration equipment on hydrant delivery and fueller loading racks – daily.

Storage life and supply arrangements

The recommended life for Shell Water Detector capsules is nine months from time of manufacture. The life expiry date (month/year) is marked on the bottom of each tube of capsules and is also printed on one end of each box of ten tubes.

AEROSHELL PISTON ENGINE OILS



3. AEROSHELL PISTON ENGINE OILS

For many years the performance of aircraft piston engines was such that they could be lubricated satisfactorily by means of straight mineral oils, blended from specially selected petroleum base stocks. However, growing demand for oils to reduce sludge formation necessitated 'fortifying' them with the addition of small quantities of non-petroleum materials. The first additives incorporated in straight mineral piston engine oils were based on the metallic salts of calcium. In highly-rated engines the dispersant performance of these oils was excellent, but the combustion chambers of the majority of engines could not tolerate the presence of the ash deposits derived from these metal-containing additives.

To overcome the disadvantages of harmful combustion chamber deposits, a non-metallic, i.e. non-ash forming, polymeric additive was developed which was incorporated in blends of selected mineral oil base stocks, to give the range of AeroShell W Oils. Following extensive operational success in a wide range of civil engines, military specifications based on the general characteristics of AeroShell W Oils were prepared and issued.

AeroShell W Oils were in service with the world's airlines and aircraft operators for many years when they operated big transport piston-engined aircraft, during which time these oils became virtually the standard for all aircraft piston engines. Nevertheless, supplies of straight AeroShell Oils remained available primarily for running-in the aircraft piston engine and for the few operators who required them. Today these oils (both AeroShell W Oils and AeroShell Oils) are still required for the smaller piston-engined aircraft flying in air taxi operations, flying clubs or flown by private pilots. W is just a model designator to differentiate between AeroShell ashless dispersant AeroShell W oils and straight mineral AeroShell oils, which have no letter designator.

In the early 1980s a semi-synthetic multigrade W oil for piston engines (AeroShell Oil W 15W-50) was added to the range. This grade has become very popular amongst engine manufacturers and operators alike. In order to cater for those Lycoming engines which need improved load-carrying (i.e. those engine models which require the addition of Lycoming Additive LW 16702) AeroShell Oil W 15W-50 was upgraded in 1986 to include an antiwear additive.

In recent years utilisation of piston engine aircraft has decreased, resulting in the aircraft spending more time on the ground. This led to an increase in corrosion being seen inside the engine. In order to combat this, AeroShell Oil W 15W-50 was further upgraded in 1993 to include a very effective anti-corrosion additive package.

For those operators who prefer a single grade but still want the anti-wear and anti-corrosion benefits of the multigrade oil, AeroShell Oil W80 Plus and AeroShell Oil W100 Plus have been added to the range of ashless dispersant oils.

To cater for the demands of operators of light sport aviation piston engines, AeroShell Oil Sport Plus 2 (for 2-stroke engines, now discontinued) and AeroShell Oil Sport Plus 4 (for 4-stroke engines) were introduced in the 2000s.

With the development of compression ignition (Diesel) piston engines specifically for the aviation market, Shell Aviation worked closely with the OEMs to develop appropriate lubricants for this engine type. The result of these co-operative efforts was the development of AeroShell Oil Diesel 10W-40 (now discontinued), and AeroShell Oil Diesel Ultra.

SPECIFICATIONS

Since the 1940s, piston engine operators have relied on two U.S. Military Specifications for defining piston engine lubrication requirements. Beginning with the non-dispersant MIL-L-6082 oils and continuing through the MIL-L-22851 Ashless Dispersant products, the U.S. Military Specifications were the standards for oil performance worldwide. In military circles Grades 1065 and 1100 as well as Type II and III were familiar grade identifications, whilst in civil use Grades 65, 80, 100 and 120 were common. However, that has all changed.

The SAE Fuels and Lubricants Technical Committee 8 – Aviation Piston Engine Fuels and Lubricant Committee worked very closely with the U.S. Navy to convert these Military Specifications into SAE Standards. Also involved were oil manufacturers, engine builders, test laboratories and the American FAA. In due course agreement was reached on a new set of performance standards for piston engine oils. These current SAE Standards are J1966 Lubricating Oil, Aircraft Piston Engine (Non-Dispersant) and J1899 Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant), both of which have now been adopted for use. The adoption of these new SAE

Standards means that the two Military Specifications (MIL-L-6082 and MIL-L-22851) are now obsolete.

These new specifications include upgraded and improved tests and have been designed to meet current technology, and include the latest test methods and precision limits.

The most obvious change for users is the move from the old Grade or Type Number system to the more common SAE viscosity classification. Thus products in both SAE specifications are defined as SAE Grades 30, 40, 50 or 60. In addition, for the first time, multigrade aviation oils are included in the new specifications.

The U.K. has now cancelled DERD 2450 and DERD 2472 and adopted the SAE specifications.

FUNCTION OF PISTON ENGINE OIL

A piston engine oil's function inside a piston engine is to:

- reduce friction between moving parts
- provide necessary cooling to internal areas
- cushion moving parts against shock and help seal piston rings to cylinder walls
- protect highly finished internal parts of the engine from rust and corrosion
- keep interior of engine clean and free of dirt, sludge, varnish and other harmful contaminants

APPLICATION

AeroShell Oils and AeroShell W Oils are intended for use in four-stroke (four-cycle) aircraft reciprocating piston engines. They are not recommended for use in automotive engines converted for use in aircraft, and in these cases the conversion shop should be consulted for proper oil recommendations.

The term "ashless dispersant" was given to aviation oils to distinguish them from straight mineral aircraft piston engine oils. Automotive and heavy duty truck engine oils contain ashless dispersants and ash-containing detergents. They were traditionally called detergent oils (some aircraft operators incorrectly refer to ashless dispersant oils as "detergent oils").

Because of the negative effect of ash on aircraft engine performance, it is very important that ash-containing oils are NOT used in an aircraft piston engine.

Due to differences in metallurgy, operating conditions and fuel specifications, an aircraft oil will not meet all of the automobile/heavy-duty engine's requirements. In addition, the aviation oils are not qualified for this application and their use could result in voiding the warranty and/or reduction in engine life.

Thus automobile oils MUST NOT be used in aircraft engines which use or specify SAE J1899 or J1966 oils. Similarly aviation oils MUST NOT be used in automobile engines.

Selection of Right Grade of Oil

For the majority of aircraft piston engines the selection of the right grade is important to maximise engine performance and engine life.

Running-in	use	AeroShell Oils
Normal operation	use	AeroShell W or W Plus Oils

Selection of Correct Viscosity Grade

AeroShell Oils and AeroShell W Oils are each available in four grades. The grades differ only by viscosity and thus cover the needs of all reciprocating engines now in airline and general aviation operation. There is no general rule by which the correct grade for every engine type can be chosen, but the following table, based on recommendations from Lycoming, provides approximate guidance for selecting the most suitable grade, based on the average ambient outside air temperature at engine start-up.

AeroShell Oil (Single Grade)	65	80, W80 and W80 Plus	100, W100 and W100 Plus	120 and W120
Ambient air temperature °C (°F)	Below −12 (+10)	−17 to 21 (1 to 69)	16 to 32 (60 to 89)	Above 26 (78)
Corresponding SAE No.	30	40	50	60

AeroShell Oil (Multigrade)	W 15W-50
Ambient air temperature °C (°F)	All Temperatures
SAE Grade	SAE J1899 Grade Multigrade

N.B. For large engines the choice depends greatly upon the operator's preference and past experience. Traditionally the choice seems to be associated with climatic zones: AeroShell Oil W100 or W100 Plus is preferred for temperate regions and AeroShell Oil W120 for warmer climates.

UNDERSTANDING MULTIGRADES

Oil has many functions to perform in the engine, but the primary one is to reduce friction between moving parts by separating moving surfaces with a layer of oil. This oil must not only separate the two surfaces, but must also support any load that is being applied between them, so that the load can be transferred from one surface to the other.

If the oil did not support this applied load, then the two surfaces would force through the oil film until they came into contact, potentially causing significant and irreparable damage.

An important indication of how much load an oil can carry is the measurement of the oil's viscosity.

Viscosity is the resistance to flow of a particular fluid. Under the same conditions, a liquid with a low viscosity, such as water, will flow more quickly than a liquid with a high viscosity, such as syrup. However, in general, an oil with a high viscosity will support more load than one with a lower viscosity.

There is an obvious balance to be struck here between having the oil viscous enough to support the required amount of load whilst also being fluid enough to pump effectively.

The problem is further compounded by the fact that as an oil is heated, the viscosity drops and vice versa. This relationship between temperature and viscosity is known as the viscosity index; the higher the viscosity index of an oil, the less its viscosity changes with temperature.

The ideal situation is to have an oil where its viscosity does not change with temperature, so that it maintains the same load carrying ability as well as the ability to be pumped at all temperatures. Unfortunately, this is impossible to achieve, so we are left with certain compromises.

The majority of aviation piston engine oils on the market are mineral monogrades (both straight and monograde ashless dispersant or 'W' oils). The viscosity indices of these mineral oils are fairly uniform and relatively unimpressive due to the nature of the base oils used.

This means that whilst a higher grade oil (e.g. W 100) oil may be satisfactory for operation during warm weather, it may well become too thick to pump effectively at the lower temperatures, especially at start up. Conversely, if a lower grade oil (e.g. W 80) is used during hot weather, it may not be viscous enough to support the loads required at the elevated operating temperatures.

This is why many engine manufacturers advise that the oil grade is changed as climatic temperatures change. Note: you should always refer to your engine manufacturer's recommendations for clarification on which grade to use at which temperature.

The ideal solution to this is to produce an oil which has a higher viscosity index (i.e. viscosity changes less with temperature). In this way, it will pump effectively in cold weather, but still support high loads at high temperature.

This is the concept of the multigrade oil and there are two principle ways of achieving these objectives:

Mineral Multigrades

Mineral multigrades use a lightweight mineral oil (the same as a lightweight monograde oil), but include an additive called a Viscosity Index Improver. The best way to visualise this viscosity index improver is as a long chain molecule which curls up like a ball of string when cold, but then uncurls as the temperature increases.

Thus, when an oil is cold, the presence of the viscosity index improver has very little effect and the oil flows well as the base oil is a low viscosity oil. As the oil heats up, the viscosity index improver uncurls with the effect that it tends to restrict the motion of the oil, or 'thickens' it, which to some extent counteracts the decrease in viscosity of the base oil. This enables the oil to support more load than would otherwise be possible.

However, the viscosity of an oil which contains a viscosity index improver depends on the rate it is made to flow (or sheared). It may decrease rapidly if the oil is sheared rapidly, and this decrease can be temporary or permanent.

A temporary loss in viscosity develops when high shear rates (which frequently occurs in engines when one surface moves quickly past another) force the large viscosity index improver molecules to align themselves in the direction of flow. More seriously, a permanent loss of viscosity may occur if the shear rate is sufficient to physically break the large molecules into smaller units. This can happen in oil pumps and the like. Both of these scenarios reduce the oil's viscosity and therefore the load carrying ability.

The vast majority of 20W-50 aviation multigrades on the market are mineral multigrades.

One advantage of using the multigrade AeroShell W 15W-50 is that, not only does it pump quicker at low temperatures than the single grades – and even the 20W-50 multigrades on the market; it is also unusual in being a semi synthetic rather than a pure mineral oil.

Semi-Synthetic Multigrades

When Shell first started evaluating multigrade aviation piston-engine oils over 30 years ago, testing proved that multigrade oils formulated only with mineral base oils did not have adequate base oil viscosity (thickness) to properly lubricate all the high load points in the engine. Then we tested and flight evaluated a formulation made with all-synthetic base oils. This formulation had excellent anti-wear characteristics in all tests run. However, in the flight evaluations, some engines would reach 600 to 900 hours then lose oil consumption control and/or compression. When the engines were disassembled, we found that the piston rings were covered with a grey tacky substance that was primarily made up of the lead by-products of combustion (from the use of leaded aviation gasoline). Although synthetic oils are excellent lubricants with good high-temperature stability and very good low-temperature flow characteristics, they are relatively poor solvents. In an aircraft engine, the lead by-products of combustion must be dissolved by the base oil so they can be carried away from the ring belt area and removed from the engine when the oil is changed.

Semi-Synthetic oils use a blend of mineral oil and synthetic hydrocarbon oil. Due to the naturally high viscosity index of synthetic oil – its viscosity changes less with temperature as compared to mineral oils – there is no need to add a viscosity index improver.

Another advantage of using a semi-synthetic oil is that the synthetic component of the oil has a higher thermal stability and therefore degrades at a slower rate than mineral oils. This leads to the oil both performing as an effective lubricant for longer, and also producing less acidic compounds (by-products of oil degradation), which in turn reduces the risk of acid attack in the engine.

AeroShell Oil W 15W-50 is virtually the only approved semi-synthetic aviation mutigrade on the market at present, since its launch in the 1980s.

Unlike automotive engines, aviation engines run on 100LL (Avgas) which contains a much higher concentration of Lead than ordinary 4-star automotive fuels. The combustion of this fuel inevitably leads to Lead getting into the oil in the crankcase where it could form Lead deposits and may lead to subsequent failure. However, if the oil has a mineral oil content to it (either a fully mineral oil, or a semi-synthetic) then the Lead is dissolved by the oil, whereas a fully synthetic oil does not have the capacity to do this. This is why a fully synthetic oil is not feasible for aviation piston engines.

Are multigrade and single-grade AeroShell oils compatible?

The compatibility question covers two issues: mixing one grade of AeroShell oil with another, and the effects on the engine of changing from one AeroShell grade to another. If you typically run on AeroShell multigrade and find yourself in a place where only AeroShell single grades are available, you can safely add the AeroShell single grade to your engine. They are completely compatible.

If you run on an AeroShell single grade during the summer, but want to switch over to AeroShell Oil W 15W-50 Multigrade for the winter, you can safely replace the straight weight with the multigrade oil at your regular oil-drain interval. The idea that you have to stick with the type of oil you started with comes from the days of unusual chemistry when the resultant oils were incompatible. All approved SAE J1899 (former MIL-L-22851) and SAE J1966 (former MIL-L-6082) AeroShell oils are compatible. For example, if you have a high-run-time engine using ashless dispersant oils and need to replace a cylinder, you can switch to a mineral oil for 50 hours or so to break in the new cylinder. The only time Shell recommends against switching is in a high-run-time engine using straight mineral oil exclusively. Here, a switch to ashless dispersant oil can loosen the deposits left behind by the mineral oil.

UNDERSTANDING ADDITIVES

There are some aftermarket additives that claim to benefit engines and can be used in aviation piston engine oil. The general rule is that, unless they have been properly tested and approved for use in aircraft engines, they should not be used. Often these additives at best give no benefit at all, or can even cause the engine harm.

Most of the additives on the market have been developed for the automotive market, where conditions are much different to those found in aircraft engines. In automotive engines, cylinder head temperatures are much lower, the fuel is unleaded, the piston diameter to length ratio is much smaller, the mean power setting is much lower, etc.

These and other factors put different demands on the oil and have led to aviation engine oils being much different to their automotive cousins. If we take the cylinder head temperature for instance, aviation engines typically run around 100°C (212°F) hotter than automotive engines, and this leads to aviation oils needing to have specialised additives which do not form ash - hence the name ashless dispersant oils.

If an additive which has been developed for the automotive market is used, then it is likely to be an ash-forming compound which can cause combustion chamber deposits, leading to pre-ignition which can rapidly lead to a hole being burnt through the piston and you looking at a stationary propeller looking for somewhere to land.

Load Carrying/Anti-Wear Additives

Other additives, such as the Teflon type "anti-wear" additives, are sold as being able to improve engine lubrication. This type of additive is of dubious benefit and just coat the whole engine with a layer of Teflon, regardless of where it is needed. This can, at worst, restrict oil ways and limit lubricant flow, and at best is an expensive way of putting an unnecessary coating on the oil filter. These additives are not approved for use in aircraft engines, so using them is not only potentially dangerous, but also invalidates any warranty on the engine.

Using the additives present in the AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) to illustrate, the load carrying additive in this product works in a more subtle way. The compound is blended into the oil and does not react until it is needed. The way this works is that if two moving parts start to make contact, then friction causes heat to be produced – this heat causes the additive to alter its chemical structure and it then reacts with the metal surfaces, coating them with a protective layer.

If the two moving parts then try to make contact again, then they are separated by a layer of the additive even if no oil is present. In this way the additive is only deposited where it is needed. This is particularly useful in limiting wear when lubrication is marginal, such as on engine start up and on components which experience unusually high load – typically cams and cam followers.

This form of load carrying/anti-wear additive is so effective that the same type of compound used in all modern jet engine oils to improve their performance; without it these oils would not meet the demands put on them. This has also been recognised by Lycoming; they have adopted the additive under the name LW16702, and is mandated for use in their O-320H, O-360E's and TIO-541 series engines. Therefore, using AeroShell range of Plus Oil means that no additional additive needs to be used if you operate one of these engines.

Metal Passivators

Metals such as copper are normally a problem for oils as they cause oil to degrade quicker than they would otherwise. This can be a problem as many General Aviation engines contain copper – the largest area is normally found on cam shafts which is left over from the manufacturing process.

When cams are manufactured, the cam face is often hardened using a process called nitriding. This leaves a hard, but brittle surface – ideal for the cam face, but not for the rest of the shaft.

The rest of the shaft does not need to be hardened and it performs better if the surface is not brittle from the nitriding process. So to protect the rest of the shaft, a thin layer of copper plating is used to cover all the areas which do not need to be hardened.

Once the cam has been manufactured this copper serves no useful purpose, but it is not removed. This can be a problem for the oil in an engine because the copper acts as a catalyst to make the oil degrade faster than normal – and a degraded oil does not make a good lubricant.

This is where the "metal passivator" additive reacts with the surface of copper components forming a protective layer which separates them from the oil, thus preventing the copper from degrading the oil.

Corrosion Inhibitors

One more additive used in AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) is a corrosion inhibitor. This inhibits the formation of rust in the engine – a common root cause of engines not reaching TBO (Time Between Overhaul). Rust is often found in engines as used oil is acidic and, combined with dissolved water from the atmosphere, causes corrosion.

The reason why this problem is more pronounced in aviation piston engines than in automotive engines, is all due to how often they are used. The average General Aviation aircraft flies for around 100 hours per year, compared to your car, which is probably 4 times that figure.

OIL SERVICING

The pilot or mechanic should always review the manual for the proper procedures. An oil change may not only include draining the hot oil, changing and inspecting the filter and refilling the crankcase with the proper oil. For example, an inspection of the oil pan's suction screen is recommended at each oil change for most engines.

Converting from Straight Oils to 'W' Oils

Elaborate precautions are not needed when changing from straight mineral oil to AeroShell W Oils, since both types of oil are compatible with each other.

Experience has shown that AeroShell W Oils do not loosen or affect the hard carbonaceous material already deposited in high-time engines, and may therefore be introduced at any time during the operational life of an engine.

Many single- grade customers try AeroShell Oil W 15W-50 during the colder part of the year and then convert to using it year round. Others, however, alternate between single grade and multigrade, depending on the time of year. Either system works well because AeroShell oils are entirely compatible and can be interchanged as desired. In addition, if you need to replace a cylinder on a mid-time engine, you can switch from AeroShell Oil W single grade or AeroShell Oil W 15W-50 to a straight AeroShell mineral oil for one or two changes to break in the new cylinder. Then you can switch back to the ashless dispersant oil after the rings are properly seated.

The easiest and possibly the best way of converting a fleet of engines to an AeroShell W Oil is to 'top-up' with the oil commencing from a given date. The majority of operators use this method following procedures recommended by the engine's manufacturer.

However, other operators have drained engines and refilled them with AeroShell W Oil. If this procedure is adopted, the oil filters should be checked after a ground run and at short intervals during initial operation, because the fresh charge of AeroShell W Oil may disperse 'pockets' of partly oxidised straight mineral oil which may have bound together and retained flaky carbonaceous material during previous operation.

Similarly, if you have a mid-time engine that has been run exclusively on a straight mineral oil and wish to try an ashless dispersant oil, use caution. The introduction of an ashless dispersant oil into your engine could loosen some of the carbon deposits. So check your oil screens and filters often to guard against oil starvation and/or oil screen collapse.

Oil Draining

When draining oil, the engine should be hot. This can be very difficult on some aircraft, but it is recommended. The reason for changing oil when the engine is hot is to avoid the settling of dirt and water in a cold engine. When the engine is fully warm when it is drained, a higher percentage of contaminants is drained away with the old oil. When the engine is drained cold, more of these contaminants remain in the oil in the bottom of the pan, which results in more contaminants mixing with the new oil.

Oil Change Interval

Almost all oil change recommendations specify not only an engine hour time limit, but also a calendar time limit; typically 4 or 6 months depending upon engine manufacturer. On low usage aircraft the calendar time limit is usually more critical than the engine hour limit. The need for frequent oil changes in aircraft is not caused by the oil wearing out, but rather by the oil becoming contaminated with by-products of combustion, dirt, water both atmospheric as well as from condensation inside an engine) and unburnt fuel. This contamination can cause corrosion in the oil wetted areas of an engine and thus changing the oil removes these contaminants and helps to minimise corrosion. In order to minimise this corrosion inside low usage engines, calendar time changes are important.

Oil Change Extension

Many operators are interested in extending oil change intervals. As a general rule extensions are not recommended for the following reasons:

- many engine manufacturers do not approve extended intervals
- possibility of losing engine manufacturers' warranty on the engine
- possibility that extended intervals will shorten engine life

The initial enthusiasm in the U.S. for extended intervals has declined due to problems associated with lead sludge found in engines. Many operators have now reverted back to the engine manufacturers' oil change recommendations and found that these problems disappear. Operators are urged to follow the engine manufacturers' or rebuilders' recommendation for oil change interval.

Break-in Procedure

Most aircraft engine manufacturers and rebuilders/overhaul agencies suggest in their service bulletins the use of straight mineral oil in new or newly overhauled engines for break-in. These straight mineral oils are usually recommended for the first 25 to 50 or even 100 hours of operation, or until the oil consumption stabilises. Other rebuilders or manufacturers, especially for such engines as the Lycoming O-320H and O/LO-360E, allow either ashless dispersant or straight mineral oil for break-in, whereas ashless dispersant oils are mandated for break-in for all turbocharged Lycoming engines. Operators should check with engine manufacturers or rebuilders for the correct recommendation for the specific engine and application.

The following details the engine break-in concept for further understanding:

When a cylinder is new, the inner wall surface is not smooth as might be imagined. The objective of the break-in procedure is to rub off any high spots, both on the cylinder wall and the piston rings, so that the rings can create a tight gas seal for normal operation. This requires the piston ring to break through the oil film and allow a certain amount of metal-to-metal contact between the components. Once this matching has occurred, the break-in is considered to be complete and very little contact will occur thereafter.

The anomaly is that the lubricating oil is there to prevent metal-to-metal contact, but the process described requires that we rupture the oil film. Two actions by the pilot can critically impair this film rupture and therefore prevent adequate break-in – low power settings and the use of improper lubricating oils.

There are two main classifications of aviation piston engine oil on the market, Straight Oils and Ashless Dispersant (or 'W') oils. Ashless Dispersant oils contain additives, which becomes significant during break-in of most engines.

With the exception of some turbocharged engines (check the documents mentioned above), break-in should be conducted using straight oils. The first risk with using Ashless Dispersant oils used during break-in is that the higher film-strength will prevent the piston ring from rupturing the oil film and therefore the necessary abrasion on the cylinder wall will not occur.

Secondly, the frictional process creates unusually high surface temperatures on the cylinder wall and this can cause the additives in the Ashless Dispersant oils to form a glaze in the honing grooves on the surface of the cylinder wall. When a cylinder is manufactured, a cross-hatch hone is used to score a diamond pattern into the surface of the liner; this is necessary to allow an oil film to be held on the surface of the cylinder wall and lubricate the piston during operation.

If this glazing of these honing grooves occurs before the break-in period is complete then the piston ring will not seal properly, and the cylinder wall will no longer have the surface grooves necessary to carry lubricant, and the combination will result in a poor gas seal and high oil consumption. The only way to remove such a glaze is by re-honing the cylinder wall – meaning expensive and avoidable additional maintenance.

However, successful break-in not only means the use of a straight oil of the correct grade but also the use of high power settings. High power settings mean high combustion pressures which, due to the piston ring design, forces the piston ring out to rupture the oil film. This is the key to the break-in process.

Use a good quality Straight Oil, such as AeroShell Oil 65/80/100/120, and stay with it right through the break-in period (typically 50 hours but check your engine manual). Be sure to check the oil level frequently as oil consumption will be higher than under normal operation.

You should be aware that the engine will produce wear metal particles during the break-in process and the oil and filter should be changed more frequently to remove these particles so that they don't act as a grinding paste and cause additional, unwanted wear.

The oil and filter should be changed:

- Within the first 10 hours operation after overhaul
- Within 25 hours of the first oil change
- Within 50 hours of the 25-hour oil change for engines with full flow oil filters, or 25 hours for engines with pressure screen filters
- After 4 months since the last oil change regardless of engine hours

This is in line with the manufacturer's recommendations such as those found in Lycoming's Service Bulletin 480F.

As for engine operation, it is all about generating high cylinder pressure and maximising the engine cooling. Use full rated power and RPM for every take off and maintain these settings until at least 500 feet above the departed runway; at this point you can reduce power to 75% and continue the climb to your cruising altitude. Maintain 65% - 75% power for all cruise operations during the break-in period.

Avoid high altitude operation with non turbo- or supercharged engines as altitudes in excess of 8,000 feet will not permit sufficient cylinder pressure to be developed to overcome the spring force of the piston rings, preventing them from bedding in. Interrupt cruise power every 30 minutes or so with a smooth advance to full power for 30 seconds and then return to the original cruise settings. This allows the rings to flex and move in the piston groves.

Avoid long, low power descents as, again, there will be insufficient cylinder pressure force the piston rings out to form a gas seal and you will suffer from large amounts of combustion blow-by past the rings and also large amounts oil not being scraped from the cylinder wall. This combination can lead to excessive oil burn that can inhibit ring seating.

When descending, carry enough power to keep the cylinder head temperature (CHT) at least in the bottom of the green. For similar reasons, ground running should be kept to a minimum, particularly during hot weather. During break-in, it would be better to delay departure than to sit at the end of the runway for 15 minutes or so running in high ambient temperatures.

Be careful with engine cooling as the increased friction from the wear process will increase the cylinder wall and piston temperatures and so particular attention should be given to providing adequate engine cooling.

When climbing, keep the airspeed up, decreasing the angle of climb so that increased ram air is available for cooling. Be generous with the fuel mixture. Keeping a rich mixture will provide charge cooling of the combustion chamber and so all take offs should be made with fully rich mixture and at altitudes in excess of 5,000 ft.

The mixture should only be leaned sufficiently to restore power loss from an overly rich mixture. These procedures will help to hasten the break-in and ensure a good match of rings and bore.

To summarise, don't handle your engine gently, remember to check your oil level frequently and top up with only the correct oil during the break-in period and observe the oil change periods. Particularly with group-owned or rental aircraft, be sure that all those that fly the aircraft during the break-in period are aware of these 2 points.

How do you know when you have broken the engine in?

There are several clues that the engine will give you, and one key one is oil consumption, so you should really start to take note what the consumption is from the start. What you will find is that the consumption will probably be quite high initially, will reduce rapidly and then plateau at a certain value.

What this value is, is not really too important - it can be anywhere in the range of 1 litre every 4 to 20 hours - an indication of stabilisation is more the key. Too high an oil consumption indicates that the engine has not broken in yet (or has possibly glazed if it is over 100 hours operation).

Second indication to look out for is the exhaust stack. This will normally start being black and wet (due to the high level of oil burned during the initial stages of break-in). It will then turn to black soot and finally produce a tan / grey deposit, indicating that there is little oil being burned and the mixture setting is correct.

Another indication is that of crankcase pressurisation. If you fill the engine up to the maximum oil level indication and it rapidly loses the first half litre down the breather pipe, then many people just fill the engine with less oil next time. This is fine if it is an old, worn engine, but during break-in it is actually telling you something.

Assuming that it is not an aerobatic engine, the reason that the oil is being pushed down the breather is that the crankcase is being over-pressurised by exhaust gas getting past the ring pack. In other words, the engine is not effectively sealing itself and has not achieved a good gas seal between rings and bore – so the break-in process is not yet complete.

It is best to top oil up to the maximum and monitor whether it rapidly loses the first half litre or so.

Chrome Bores vs. Steel Bores

Most engines have nitrided steel cylinder liners and chrome-faced piston rings. Whilst this combination will often break-in quite easily, it would be good advice to fly as often as you can in the initial break-in period if your engine is fitted with steel liners rather than Channel Chrome bores.

The steel liners are particularly susceptible to surface corrosion in the early life of the engine, surface rust being quite common after only a few days of inactivity if the conditions are right. The straight oil is used for 50 hours in these engines more to create a thin protective film of lacquer on the bore rather than to hasten break-in; the break-in process tends to happen quite quickly with steel bores, but the potential for corrosion remains.

The Channel Chrome cylinders obviously do not suffer with the same corrosion problem, but the hard chrome surface is much more difficult to break-in – sometimes taking over 100 hours to break-in. Therefore it is very important to be patient to ensure proper ring matching with corrosion-resistant cylinders, as the hard surface of chrome bore engines is much more prone to cylinder glazing following improper break-in.

Long Term Operation on Straight Mineral Oils

It is possible to run engines permanently on straight mineral oils but, as straight mineral oils do not contain any additives, they tend to cause deposits to form in the engine. The "W" ashless dispersant oils contain an additive that is designed to keep particles separated so that they do not congregate to form a large mass.

If these particles are kept separated, then they are less likely to block an oil passage and deposit inside the engine. If the filter is of the relatively efficient cartridge type, then the small, dispersed debris will be removed by the filter element. It is these particles in suspension that makes an oil appear black.

If straight mineral oils are used, then the oil tends to appear relatively clean but carbon and other particulates deposit inside the engine on casings etc. This is not too much of a problem unless you later encourage these deposits to loosen.

Changing onto an ashless dispersant oil after a significant build-up of this deposit has occurred can cause this to happen. The dispersant additive can act like a detergent and clean out the inside of the engine. This normally results in an abnormally high level of filter deposits after the period of change over, so care should be taken to monitor this.

The critical time period for a significant deposit to occur inside an engine running on straight mineral oil depends on the individual engine type, operating temperature, flight profiles etc. but is normally around the 300 to 400 hour mark.

If your engine has run for this length of time on straight oil and you convert onto "W" (or ashless dispersant) oil, then take care to monitor your filter more frequently for signs of blockage. If your engine has not done this number of hours then you are reasonably free to choose whichever oil you see fit and don't worry too much.

There is therefore less risk carrying on with a straight oil for more than 50 hours if you are unsure whether or not the break-in is complete, than there is from having the cylinders glaze from changing to an ashless dispersant oil too early.

Oil Analysis

Routine oil analysis is now seen as a valuable part of a good maintenance programme. Increasingly, operators are adopting oil analysis programmes in order to help discover problems before they turn into major failures. Typically these programmes consist of spectrometric wear metal check, together with a few simple oil tests such as viscosity and acidity. Shell Companies can offer this service to operators.

As engines are used, small amounts of wear occurs all the time. This wear metal appears as minuscule amounts of metal held in suspension in the oil. These particles are much too small to be removed by the oil filter - and will do no abrasive damage to the engine - but by analysing the level of these particles in used oil, the operator has a means of assessing the condition of the engine.

The used oil sample can be analysed by a laboratory using a very sensitive technique known as spectrographic analysis, and particles can be detected down to levels of less than one part in every million of oil. It is not just wear metals that can be detected; water content, fuel dilution, acid content of the oil and other characteristics can be measured.

All engines produce a certain amount of wear metal - this is normal. The significant point about oil analysis is that the level of microscopic wear metal present in used oil will normally increase if a component starts to wear excessively. This will normally occur prior to any particles being present in the filter and is a good way of predicting a failure. The data can also can be an indication that the engine is not set up correctly, or a clue that the engine is being operated incorrectly. Here are some examples:

- High Aluminium content is usually from Gudgeon Pin end caps and is often an indication that the engine is not being properly warmed up prior to take off.
- High Silicon content is normally from the ingestion of dirt and dust, so the inlet filters should be checked.
- High Chrome content can be an indication of excessive piston ring or cylinder bore wear. This can be due to overloading the rings due to incorrect magneto timing.

- High Fuel dilution combined with high water content shows that the engine is being operated for too long on the ground at low idle speeds and the idling speed should be increased.
- Fuel dilution with high Lead content can be due to either worn piston rings which should be checked with a compression check, or poor fuel mixture adjustment (which should be checked and adjusted).

It is not only the engine that we can analyse by sampling used oil, we can also look at the condition of the oil.

As oil is used in an engine, several things happen to it to cause it to degrade. The best measure of the condition of the oil is what is known as the Total Acid Number, or TAN. When an oil is in contact with the air, especially at high temperature, it will degrade and a by-product of that process is the formation of organic acids. This is prevented to a certain extent by having anti-oxidant additives in the oil, but these additives are depleted over time and is one reason why oil changes are necessary.

Once the anti-oxidants have been consumed, the oil itself will start to oxidise, resulting in poorer lubricating properties. If the Total Acid Number of the oil is measured, then an assessment can be made as to whether the anti-oxidant has been used up and if the oil has started to degrade significantly in use. These are good clues as to whether the correct oil choice has been made, whether the oil has been thermally stressed in use, and may even be a sign that the oil change period needs to be reduced.

The viscosity characteristics of an oil can also give some indication of how effective it is in an engine. The viscosity of an oil is related to the size of the oil molecules - the bigger the molecules, the higher the viscosity and vice versa. If the oil has undergone severe shear stress, as can happen in gearboxes for example, then the molecules can be broken into smaller pieces with the result that the viscosity of the oil can reduce over time.

However, exposure to high heat can also make the molecules join together, or polymerise, to make large structures which can increase the viscosity. If both these processes happen at the same time, then the overall result may be no change in the viscosity, so measurement of viscosity alone does not give a complete picture - it must be considered in conjunction with TAN which should also increase with polymerisation.

There is a lot of practical information that can come out of oil analysis and it is an excellent way of limiting wear and preventing failures which increases aircraft safety and reduces the amount of expensive repair bills.

It is important to note that the information gained is only as good as the sampling procedure. A single test is not enough to reveal trends and significant changes, it can only tell an operator if there is already a serious problem, such as a scuffed piston. Operators should therefore:-

- **Take samples properly**
  For best results, take the sample about midway through the draining of hot oil from the sump. A sample pulled off the bottom may be dirtier than normal. The sample should be taken the same way every time. An improperly taken sample can lead to mistaken conclusions about engine problems.

- **Rely on a series of consistent tests over time**
  Operators should look for significant changes or trends over time, not just absolute values. Do not rely on just one very good result from just one report; it could have come from a 5- or a 10-hour sample. Relatively constant numbers from the last six oil changes are a far better indicator that the engine is in good condition. Your record of regular oil changes and analyses is also helpful when selling an aircraft.

- **Take samples consistently**
  Always take the sample the same way at the same time interval. If you change your oil after 50 hours and then after 25 hours the next time, the first sample may show twice the wear metals. (Expect higher wear metals during break-in or after some maintenance procedures, such as a cylinder replacement.) Always properly label the sample so that its identity is known.

Finally, always remember that oil analysis should be part of a good maintenance programme, not a replacement for one.

Understanding Your Oil Filters

Many people also throw a lot of useful information into the bin when they dispose of oil filters. These filters normally contain a lot of carbon deposits, but they will also hold any larger pieces of metallic debris that has come from the engine internals.

An engine may produce a small amount of metal which will be seen in the filter element, and this can be classed as normal. There is no defined level which is normal for an engine – each engine is different – but there will be a quantity which is usual for your engine.

This will vary not just from engine to engine, but will also depend on whether the engine has recently been overhauled. Engines which are still being broken in after overhaul will produce more wear metal than at other times. This is nothing to worry about as wear metals are inevitably produced as part of the abrasive break in process and is one of the reasons why the oil drain period is shorter during these times.

These filter deposits can be sent off to a qualified laboratory for analysis where the filter deposit weight and composition can be accurately assessed. Any metal deposits, even very small ones, can be analysed to see not only what the deposit is made of, but also what the exact alloy composition is. This means that not only can the laboratory tell that a particle is steel, for example, but also which steel alloy it is.

This is significant as different alloys are chosen by the engine manufacturers to perform different functions in the engine – so the steel alloy used in the cam shaft is different to that used in the valves and so on. This means that a small particle found in a filter can often be identified as coming from a particular component – so both you and your aircraft's engineer could know which component is wearing and you have the opportunity to work out why, or have the chance to replace it before complete failure occurs.

Again, this is a very powerful tool in preventing an in-flight engine failure and for reducing maintenance costs. Imagine that you know that a valve is worn and needs replacing. Your engineer knows which part he needs to replace before he dismantles the engine, so the labour costs are reduced, and he also needs to replace just one part rather than the whole engine, as might be the case if it failed. You also have the satisfaction of knowing that you have a reliable engine which is less likely to stop working when you need it most.

Even if you do not go to the extent of sending your filter off to a laboratory for analysis, there is some basic analysis that you can do yourself, instead of throwing the old oil filter away (or just cleaning it if you have a screen filter).

This will not be as accurate a technique as sending it off for analysis, but if you know what is the normal level of deposition is for your engine, and what types of particles are normally there when the oil is changed, then you may notice a change when things start to go wrong.

If you are going to analyse your own filters, use the proper tool to open the filter. Do not cut it open using a saw as the metal produced by sawing will contaminate the filter and give a false indication of deposits. There are tools available from aviation suppliers that work like a can opener and do not produce any metal swarf.

When looking at the results of either oil or filter analysis, the absolute values or quantity of deposit is less important than how the values have changed from previous samples - every engine will have a different level of what is normal and how this changes over time is the important factor. For this reason, the analysis of individual samples is of limited use; a long-term program of sampling is much more valuable.

Always wear protective clothing and gloves when dealing with used oil, as it can be carcinogenic and therefore represents a health hazard.

Changing of Oil Filters

It is necessary to change the oil filter at every oil change. If you do not change the filter each time, the new oil will automatically start with a retained amount of contaminated used oil. (Remember, the primary purpose for changing oil is to remove contaminants.) Old filters can serve as an excellent indicator of engine condition. An old filter that has been removed and cut open can indicate the engine’s condition by the amount and size of the particles in the filter. If your engine is not equipped with an oil filter, the pressure screen should be monitored.

Oil Colour

When a straight mineral oil turns dark or black, it usually means that the oil is starting to oxidise and needs to be changed. Because mineral oil does not absorb much of the dirt and sludge in your engine, the oil stays clean and the inside of your engine gets dirty. Ashless dispersant oils, however, are designed to get dirty so that the engine will stay clean. Just how quickly the oil turns black depends on several factors, including the condition of the engine, the dirt load, the oil temperature, the normal air/fuel mixture, the type of fuel, the time since the last service and the frequency and duration of your flights.

The important thing to remember is to change your ashless dispersant oil based on the recommended oil servicing requirement, not according to its colour. In addition, oil analysis can help ensure that the oil is still in good condition, even though it may have turned black.

Oil Consumption Rate

Oil can be consumed or lost by three different routes in an engine: the rings, leaks and the valve guides. In a good, tight engine, there should be very little oil consumption or loss via the guides and none through leaks. That leaves the rings as your primary concern. The amount of oil going past the rings will depend on the cylinder type and the break-in process. Assuming that the cylinders were broken in properly, the oil consumption may still vary according to the type of service and how the aircraft is flown.

Even two identical engines (such on a twin-engine aircraft) operated in the same way may have different oil consumption rates. Engine manufacturers state that oil consumption of up to a 0.26 gal/h (1 L/h) is acceptable on some models. (Some manuals for large radial engines say that anything over 6 gal/h (23 L/h) is excessive.) The best answer is that oil consumption will be at a certain level for each engine. Consumption changes should not be compared with an absolute level, but rather with the level that your engine sets historically.

Lower oil consumption is not necessarily better. Oil consumption due to leaks and loose guides is certainly bad. However, some oil consumption past the rings is beneficial. When the piston moves down on the intake stroke, the ring leaves a very thin layer of oil on the cylinder wall. This film helps the compression rings to seal properly. If the oil consumption is too low, the seal may be inadequate, which leads to increased blow-by, higher cylinder wall temperatures and accelerated cylinder bore wear. If you have a large or turbocharged engine, you will probably be better off if your engine uses a little oil past the rings.

LOW OIL TEMPERATURE

Low oil temperature can lead to excessive rusting and corrosion of critical engine parts. When an aircraft sits on the ramp or in a hangar, the engine heats up during the day and cools down at night. While the engine is cooling, some of the moisture in the air condenses on the engine walls and drops into the oil. This can form rust on internal engine components. The moisture can also react with by-products of combustion in the oil to form acids that may cause corrosion. The best way to remove this water is for the engine to boil it off during flight. Studies have shown that the temperature of your engine oil increases by about 33°C (50°F) as it circulates through the engine.

Therefore, unless the oil temperature reaches 77–82°C (170–180°F) during flight, the engine will not boil off the water that has accumulated in the crankcase. The result is rust and corrosion. Note that an excessively high oil temperature will also cause problems. Here are some tips to help avoid oil temperature problems:

- Check your oil temperature gauge for accuracy. It should read about 100°C (212°F) when the sensor is placed in boiling water.
- Monitor the oil temperature during flight. It should be about 82°C (180°F), even in winter. If it is lower, you may need a winterisation kit. Otherwise, check with your mechanic to see what is causing the excessively low oil temperature.
- The unique additive feature in anti-corrosion/anti-wear AeroShell Oil W 15W-50 can also help to control problems caused by rust and corrosion.

Why does my engine rust even though I fly often and with the gauges showing the correct temperature?

Pilots are always taught to “trust your gauges,” which is a critical lesson especially when flying instrument flight rules. Most of us apply this lesson to our engine as well.

However, another part of this lesson should be to check the calibration of all instruments periodically, including the oil temperature, tachometer and pressure gauges. Remember that quite a few general aviation aircraft are over 20 years old. So it is not surprising to hear numerous report of tachometers being off by several hundred revolutions per minute and temperature gauges being off by 5, 10, even 15 degrees. It is important to have you gauges checked and calibrated periodically.

One method used is to put marks on the oil temperature gauge so that the "preferred" range can be easily seen. (The "green" band on many oil temperature gauges starts at just over 38°C (100°F), which is okay for taking off but too low for normal cruising.) Remember, oil temperature is one of the most critical parameters to be measured and controlled.

As a rule, many naturally aspirated engines will run even at an oil temperature that is too low. This can lead to excess moisture in the crankcase and rusting or corrosion of critical engine parts. Conversely, many turbocharged engines run too hot and care must be taken to keep the cylinder and oil temperatures down. In most cases, a cruising oil temperature of 82–93°C (180–200°F) is preferred. Temperatures below 77°C (170°F) usually do not provide proper boiling off of water, which can lead to rusting. At the other extreme, cruising oil temperatures significantly above 100°C (220°F) can be an indication of inadequate cooling.

LEAD FOULING

Avgas 100LL contains a compound known as Tetra Ethyl Lead (TEL) which acts as an octane booster for the fuel. This results in a fuel which is commonly known as a 100 Octane lean mixture and 130 rich mixture Performance Number fuel.

In practice it is even better than this, with ratings more like 106 lean mixture & 130 rich mixture which are far in excess of the comparable 85 - 87 octane of road fuels. To achieve this, a lot of TEL is used – around 5 times the quantity that was used in the old Leaded automotive fuels.

This increase in octane allows aviation engines to produce more power through increased compression ratios or alternatively by increasing the inlet pressure by using a turbo or a supercharger. The problem with using Leaded fuels is that they will always burn with more deposits than unleaded fuels.

The Tetra Ethyl Lead used for octane boost in the fuel naturally degrades to form Lead Oxide when it is burned. In reality it is this oxide which gives the octane boost. The problem is that Lead Oxide is a solid up to about 900°C (1652°F), which is well within the wall temperatures inside a piston engine.

In order to prevent these deposits from forming, a Lead scavenging compound is added to Avgas 100LL – this compound is Ethylene Dibromide. This scavenger is designed to react with the Lead Oxide to form Lead Bromide which is more volatile – becoming a gas at around 200°C to 250°C (392°F to 482°F). This is a low enough temperature to ensure that the Lead is removed from the engine as a gas and it subsequently goes back to the solid phase as the exhaust gas cools in the atmosphere.

As a point of interest, the pale brown / ash coloured staining that is often seen leading from the exhausts of high-powered engines, such as those found on the warbirds, is in fact Lead Bromide.

To enable this reaction between the Lead Oxide and the scavenger to work, there needs to be a relatively high combustion temperature.

What a lot of people do is conduct the warm-up with the engine power lever on the idle stop, and this is inappropriate. The technique for the common Continental Motors and Textron Lycoming General Aviation engines is as follows.

After start-up, the engine should be operated at 1000 to 1200 rpm for the initial warm-up period and not at the 600 to 650 rpm idle speed. This serves a number of purposes.

The higher cylinder pressure encourages the rings to seal properly, not only limiting oil egress into the combustion chamber, but also reducing the amount of corrosive combustion by-products going the other way into the sump oil. This technique thus also helps reduce the risk of corrosion problems in the long term by reducing the amount of acids and Lead being pumped into the oil.

Meanwhile in the combustion chamber, Lead Oxides tend to form deposits because of the low combustion temperatures. The temperature for Lead deposits to form tends to be favourable around the spark plugs (as the whole mixture is quite cool before the flame starts to propagate) and on the exhaust valve stem (as the mixture cools after combustion).

The problem is that the deposits are electrically conductive, which shorts out the spark plug - and corrosive, which can start to attack the metal of the valve stems.

Temperature is a key factor in preventing Lead fouling and it is not just at start up, but also the correct shut down procedure should be carried out.

Engines that have been involved with long, low power descents, or have taxied for some distance, can have quite low cylinder temperatures and this - as we now know - can lead to lead fouling. Again the advice from Textron Lycoming and Continental Motors to remedy this is: once on the aircraft is on the stand, the engine speed should be kept between 1000 and 1200 rpm until the engine temperatures have stabilised.

Once the temperatures are stable, the engine speed should be increased to 1800 rpm for a period of 15 to 20 seconds, which should generate enough temperature to burn off any deposits. Once this period is past, the engine speed should be reduced to 1000 - 1200 rpm once again and then immediately shut down using the mixture control.

WATER INGESTION IN ENGINE OIL

When an engine is running, acids form in the oil from a combination of combustion gases dissolving in the oil and the oil's own natural degradation. The combustion gases enter the crankcase by 'blowing' past the piston rings and, once in the crank, they dissolve in the oil. Oil degradation is the inevitable and unavoidable oxidation process which occurs when an oil is at high temperature and in contact with air.

These by-products do not cause any problems until you also have water present in the oil, which then 'activates' them by hydrolysing them to form, predominantly, Formic and Nitric acids. It is these acids, along with any free water which may be present, which cause corrosion in an engine.

Water inevitably appears within the engine by condensing out of the atmosphere in much the same way as moisture condensing on the outside of the aircraft structure; the air getting into the engine internals though the crankcase breather. This is a continual process and occurs if the aircraft is in use or not.

The usual and most effective way of eradicating problems arising from this acid and water attack is to fly the aircraft. This heats up the oil and drives off any moisture in the oil, thus eliminating the water problem and deactivating the acids. The only way to get the oil hot enough to do this is to fly the aircraft; ground running will not get the oil hot enough to drive off the moisture. We usually suggest a minimum of 30 minutes cruising flight every 2 weeks.

One of the advantages of using AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) comes when the aircraft is not flown this frequently as the oil contains both a corrosion inhibitor and an anti-scuffing additive to help the occasional flyer.

If the aircraft cannot be flown with the frequency required to keep the oil 'dry' (a minimum of ½ hour cruise every 2 weeks), the corrosion inhibitor will suppress the formation of any corrosion during periods of inactivity, which would otherwise form due to the action of acids and water.

Furthermore, once the aircraft engine is started up after being inactive, the anti-scuffing additive will have coated all the internal metallic surfaces with a molecular layer so that metal to metal contact is prevented if there is no oil present. This is particularly important during the first few seconds after startup as the oil pump will not pump oil to all the extremities of the engine immediately.

PREPARATION FOR AIRCRAFT STORAGE

It is important that an aircraft be properly prepared if it is going to be inactive for an extended length of time, whether during winter storage, or in the middle of a major restoration or repair project. This extends to the oil you use.

When an aircraft sits unused, especially in humid conditions, it rusts. Rust forms in the engine on cams, lifters and cylinder bores. Rusting can cause pitting and the rust particles may act as a very fine grinding compound in your oil. This can lead to increased wear and reduced engine life.

Winterizing Your Aircraft

The best solution is to hangar your aircraft where it can be protected from winter elements and kept in a reasonably stable temperature environment. But even so, some precautions should be taken.

Many operators tend to fly their aircraft during summer, store over winter and then consider having the annual and routine maintenance carried out during spring, so that the aircraft is in perfect order for the new season.

This is fine to a certain extent, but we would recommend that if you do no other maintenance in autumn, then the old oil from your engine should be drained and have it filled with the appropriate grade.

The problem of leaving old used oil in the engine is that this used oil can be quite acidic which, when combined with water from the atmosphere, causes corrosion. This can lead to pitting of components like cam lobes, bearings etc. if left in the engine over a period of time.

This problem is then compounded when the rust particles that are formed get into the oil and act like a grinding paste when the engine is next started, causing further wear and damage. This all leads to increased maintenance bills and reduced reliability, all for the cost of an oil change.

The old oil, once drained, can be replaced by your normal grade if you intend to carry on flying for a minimum of half an hour cruise every fortnight. If however, like many, you fly less than this over the winter, then you have two choices.

AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) with its corrosion inhibitor and anti-wear additives is ideally suited for pilots who intend to fly through the winter, but do not manage to fly every 2 weeks. Alternatively, a mixture of 1 part of AeroShell Fluid 2XN to 3 parts of AeroShell Oil 100 can be used as an inhibiting oil (formerly AeroShell Fluid 2F) if the aircraft is to be stored for the winter period. Simply change the oil and the filter, then run the engine for approximately 15 minutes to circulate the product through the system. During this time, make sure the engine does not exceed its normal operating temperature.

This combination of AeroShell 2XN and AeroShell Oil 100 can be used in any certified aircraft engine, including Lycoming, Continental, Pratt & Whitney and most other radial, opposed or in-line engines, and can also be used as a flyaway oil for up to 50 hours during the time between overhaul of opposed engines. However, it is not recommended for two-cycle or adapted automotive engines.

Things to consider doing even if the aircraft is hangared are:

- **Change the Oil**.
- **Chock the wheels front and back, and release the parking brake**. This will prevent the brake seizing on, whilst keeping the aircraft static.
- **Blank the inlets exhaust and vents**. Pitot and static vent covers are essential to ensure that the orifices do not become blocked with insects or dirt, so as to prevent your ASI or altimeter from being inoperative. Blanking engine intakes and exhausts will also significantly reduce the amount of moisture from getting into the engine, which can cause the onset of corrosion.
- **Apply a canopy cover or at least tie a dust sheet over the cockpit area**. Not only does sunlight effect perspex, but bird droppings can be quite corrosive and etch the surface if not removed for a period of time.
- **Apply airframe grease**. Whilst doing storage checks, it is prudent to re-lubricate hinges and linkages. Most light aircraft use AeroShell Grease 6 as a general-purpose airframe grease, but do check with your maintenance engineer.
- **Check that the fuel cocks are closed and master switches off**. Also consider removing the battery to prevent any leakage current from draining it.
- **Fill the fuel tanks**. Ensuring that the fuel tanks are full prevents the build-up of condensation in the tanks over winter. This condensation is inevitable if air is present in the tank and will in turn will lead to the build-up of water in the bottom of the tank. This will again mean corrosion and potentially expensive tank repairs. This is particularly important if your aircraft is stored outside. If your aircraft is hangared, ensure that you have permission to

store your aircraft with full tanks – some hangar managers consider it to be a potential fire hazard and frown on such practice.

If your aircraft is metal skinned and your only option is to store it outside, the above suggestions still apply, but you should also consider the following:

- **Picket your aircraft down**. Ideally find a sheltered spot where the aircraft is not exposed to too much wind. The aircraft should be secured, using the correct tie down points, nose into the prevailing wind direction for that site. The tie down points should be secured to concrete blocks, screws, spikes or ideally dedicated hard points set into the ground. Ensure that the straps used are not too tight as they may alter in length in dry or damp conditions.
- **Apply control locks**. Use either external flying control surface locks or internal control braces to prevent the control surfaces from damaging themselves by crashing from one lock stop to the other whilst unattended.

No matter what you have added (control locks, engine blanks, pitot covers), or removed (battery), it is always good practice to placard the cockpit to remind you or others of the condition of the aircraft. In this way, when spring does finally come, the pre-flight walk around will be easier and you will take to the air with the peace of mind that you have done all you can for your aircraft.

Preparing Your Aircraft After Winter Storage

Activities that can be carried out to ensure that the first flight after storage will be a safe one:

- **First ensure that the battery is in good condition and fully charged**. It is not only the first start after a period of inactivity that may put a heavy demand upon the battery, but also it would be beneficial to have some enough battery power to help with some additional engine cranking as we shall see in later. The best way to ensure battery charge is to remove the battery from the aircraft and use a slow "trickle" charger rather than a rapid charger. This has less risk of damaging the battery. Slow charging of the battery has more chance of recovering a discharged battery and also rapid charging of a battery can sometimes cause damage by delaminating the cell plates.

- **Next check the fuel for water**. Condensation will form on the inside walls of a fuel tank and on the fuel surface, if the fuel temperature is below that of the dew point. This can cause some water to become suspended in the fuel as well as water to form in the bottom of the tank. What we need to think of when checking fuel drains is that as the temperature of fuel decreases, so does its ability to hold water in suspension. Hence the fuel will contain less water after being exposed to cold ambient temperatures – which tends to be overnight. It would also help if the aircraft has been stood still without any movement as agitation will encourage the mixing of water and fuel at the boundary where the two meets. This all means that the best time to check fuel drains is first thing in the morning before the aircraft is moved.
- **A full walk around.** This should also include the condition of the brakes. It is possible that the brakes could be seized if the aircraft has been left unused for a period, so care should be taken to make sure that the brakes are free. This is especially important if the brakes are seized off. It is best not to find out that the park brake is on in the cockpit, but the brakes are not actually on, after you have started the engine - this could be an expensive oversight. During the walk around, remove all the control locks, pitot and static blanks, and any engine blanks that you may have applied to exhaust, inlet etc. Once the blanks are removed, have a thorough check for any stowaways that you might have. Birds, animals and insects all find dormant aircraft a good place to make their home so have a good look in the engine bay, in accessible areas of the airframe and especially pitot and static vents. If there is any evidence of insect debris in the pitot and static vents do not be tempted to remove only the visible blockage, think what may be happening inside. Some insects use these vents as homes and use the pipe runs as small breeding areas. So what you found as a blockage at the vent opening may only be an indication that there is a further obstruction of insect larvae further down the line. If you find evidence of insect infestation at the vent opening, have an engineer check the whole line for obstructions. This is often not too complicated and better to find nothing on the ground than to be left in the air without pressure instruments.

- **Check on the engine**. If the engine has been stored for several months, it should have been inhibited with a storage oil and desiccant plugs put in place of one set of spark plugs to keep moisture out of the combustion chamber. We need to remove the desiccant plugs. If we do this and then leave the plug out, then the engine will not have any compression. With the cowling removed, the engine can then be turned over on the starter motor with the fuel turned off and the mixture lever in the idle cut off position, and magnetos in the "off" position. Without engine compression offering any resistance, the engine will turn over quite rapidly. This should allow the oil pump to rotate quickly enough to supply some oil to the oil gallery thus limiting the time that the engine will run without full lubrication after engine start. Now replace the spark plugs and start the engine for a brief ground run, just enough to warm the oil enough to make it more fluid to aid the drain.
- **Drain the preservative oil**, replacing the filter if necessary, and refill with an operating oil. If your aircraft is normally underutilised – perhaps you have periods of more than 2 weeks when the aircraft is not used – then consider using an oil with a corrosion inhibitor and anti-scuffing additive to reduce wear on start up. Oils such as the multigrade AeroShell Oil W 15W-50 or the monograde AeroShell Oil W100 Plus are two such oils.
- **Other areas of the aircraft that might need lubrication**: Light aircraft joints, such as flap and control surface operating linkages and other general-purpose applications are normally lubricated by AeroShell Grease 6. Often these grease application points go for long periods without adequate grease reapplication. The old grease appears dark and hard in nature and should be replaced. Some applications can be made by the pilot or operator, but perhaps it may be safer to ask your engineer to recharge these points with fresh grease. With applications that have grease nipples, fresh grease should be applied so that it flushes out the old product and fresh grease is seen emerging from the part being lubricated. With wiping applications, then the old grease should be cleaned off as far as possible and fresh grease applied and the joint cycled to help the grease to penetrate.
- **Perspex of the cockpit canopy**. Have any new surface marks developed over the winter period – scratches, abrasion marks or even

surface damage from bird droppings? These surface marks can be removed by using specialised Perspex blending and polishing kits which can significantly improve visibility especially when flying into a low sun, something that happens quite frequently in the early and late parts of the season.

- **Ensure full and thorough pre-flight run ups are completed**. If the aircraft has been in extended storage and not run for some months, then gums and lacquers could have formed in the fuel system which could restrict fuel flow – especially if Mogas has been used. So ensure that full power is available when doing the magneto checks and also check the throttle stop idle speed.
- **Pay attention to variable pitch propellers**. These are normally operated by engine oil pressure being fed to the propeller hub and, with the engine having had the oil changed, make sure that the propeller has full oil supply by cycling the pitch properly during the ground run.

RADIAL ENGINES

Radial engines utilise special parts and, depending upon the type of aircraft, application and climate are often subject to specific problems not seen in other types of piston engines.

In a radial engine each bank of cylinders has all of the cylinders in the same plane and transmits power through a single master rod bearing to the crankshaft. This master rod bearing is subjected to high loading and absorbs the shock and vibration from the cylinders and thus requires very good protection from the lubricant. Generally radial engines have greater piston and bearing clearances and thus require a higher viscosity oil.

As a result of all this heavy duty stress, it is recommended that for radial engines used in normal operation (all operations except agricultural spraying), an oil such as AeroShell Oil W 120 is used in moderate to temperate climates and AeroShell Oil W 100 in cooler climates (if breaking-in, then AeroShell Oil 120 and 100 respectively). Alternatively AeroShell Oil W 15W-50 could be used in those radial engines for which it is approved. None of these oils contain zinc additives which if used would quickly destroy the master rod bearing.

Agricultural operations represent a special problem for an oil used in radial engines. This is because of problems with high dirt and overspray ingestion into the oil. The best way to combat this is proper maintenance, good flying procedures and frequent oil changes.

VINTAGE AIRCRAFT

Vintage aircraft piston engines, including vintage radial engines, were approved on oils produced at the time the engine was originally manufactured. Many of these oils are no longer available. If the engine was approved on an aviation oil other than a MIL-L-6082 or a MIL-L-22851 oil then operators should consult with either the engine rebuilder or oil supplier. On no account assume that present oils are direct replacements for old vintage aircraft applications.

NON-AVIATION USE OF AEROSHELL PISTON ENGINE OILS

In selecting an AeroShell piston engine oil for a non-aviation application the properties of the oil 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.

STABILITY IN STORAGE

AeroShell W Oils are inherently stable and, providing they have been stored and handled correctly, prolonged storage does not have any effect on their quality, properties or performance.

AEROSHELL OILS 65, 80, 100 and 120

AeroShell straight mineral oils are blended from selected high viscosity index base stocks. These oils do not contain additives except for a small quantity of pourpoint depressant (which is added when improved fluidity at very low temperature is required) and an antioxidant.

APPLICATIONS

AeroShell Oils are available in four different viscosity grades:
AeroShell Oil 65 – AeroShell Oil 80 – AeroShell Oil 100 – AeroShell Oil 120

The suffix for each grade corresponds to the viscosity of the oil at 99°C (210°F) in Saybolt Universal Seconds.

The appropriate grades of these AeroShell Oils are approved for use in four-stroke (four-cycle) certified aircraft reciprocating piston engines (except Porsche) and other aircraft radial engines which use oil to specification SAE J1966 (MIL-L-6082) and which do not require use of an oil containing a dispersant additive. AeroShell Oils are used primarily during break-in of most new or recently overhauled four-stroke aviation piston engines. The duration and lubrication recommendations for break-in vary, so operators should refer to the original engine manufacturer and/or overhaul facility for specific recommendations.

SPECIFICATIONS

The U.S. Specification SAE J1966 replaces MIL-L-6082E.

Although it was planned to replace the British Specification DERD 2472 with a DEF STAN specification this has now been put into suspension and instead the SAE specification has been adopted.

AeroShell Oil	65	80	100	120
U.S.	Approved SAE J1966 Grade 30	Approved SAE J1966 Grade 40	Approved SAE J1966 Grade 50	Approved SAE J1966 Grade 60
British	-	Approved SAE J1966 Grade 40	Approved SAE J1966 Grade 50	-

Table continued

Table continued

AeroShell Oil	65	80	100	120
French	-	-	RO-117	-
Russian	-	MS-14	MS-20	-
NATO Code	-	-	-	-
Joint Service Designation	-	OM-170	OM-270	-

Typical Properties	65	80	100	120
SAE viscosity grade	30	40	50	60
Density @ 15°C (59°F) kg/m^3	882	884	888	890
API Gravity	28.8	28.3	27.8	27.2
Kinematic viscosity mm^2/s @ 100°C (212°F)	11	14	20.5	23.3
Viscosity index	> 94	> 95	> 94	> 96
Pourpoint °C (°F)	< –27 (–16)	< –21 (–5)	< –21 (–5)	< –12 (+10)
Flashpoint °C (°F)	> 250 (482)	> 250 (482)	> 250 (482)	> 250 (482)
Total acidity mgKOH/g	< 0.1	< 0.1	< 0.1	< 0.1
Sulphur %m	0.25	0.35	0.38	0.42
Copper corrosion 3hrs @ 100°C (212°F)	Passes	Passes	Passes	Passes
Ash content %m	< 0.005	< 0.005	< 0.005	< 0.005
Trace sediment ml/100ml	Passes	Passes	Passes	Passes
Foaming tendency	Passes	Passes	Passes	Passes

AEROSHELL OILS W80, W100 and W120

AeroShell W Oils were the first non-ash dispersant oils to be used in aircraft piston engines. They combine non-metallic additives with selected high viscosity index base stocks to give exceptional stability, dispersancy and anti-foaming performance. These additives leave no metallic ash residues that can lead to deposit formation in combustion chambers and on spark plugs, which can cause pre-ignition and possible engine failure.

APPLICATIONS

AeroShell W Oils are available in four different viscosity grades:

AeroShell Oil W80 – AeroShell Oil W100 – AeroShell Oil W120

The suffix for each grade corresponds to the viscosity of the oil at 99°C (210°F) in Saybolt Universal Seconds.

AeroShell W Oils are intended for use in four-stroke (four-cycle) certified reciprocating piston engines, including fuel-injected and turbocharged engines. AeroShell W Oils are not recommended for use in automotive engines. For automotive engines converted for use in aircraft, the specific engine manufacturer or the conversion agency should be consulted for proper oil recommendation.

Most radial engine operators use AeroShell Oil W120 in warm weather operations with AeroShell Oil W100 or AeroShell Oil W 15W-50 being used in cooler ambient temperatures.

AeroShell Oil W100 or AeroShell Oil W 15W-50 are the common choices for most operators of Lycoming and Continental flat engines but, during colder parts of the year, use of AeroShell Oil W80 in place of AeroShell Oil W100 would be an excellent choice.

Although some aircraft engine manufacturers and rebuilders/overhaul agencies suggest in their service bulletins the use of straight mineral oil in new or newly overhauled engines, other rebuilders or manufacturers, especially for such engines as the Lycoming O-320H and O/LO360E, allow either ashless dispersant or straight mineral oil for break-in, whereas ashless dispersant oils are mandated for break-in for all turbocharged Lycoming engines. Operators should check with engine manufacturers or rebuilders for the correct recommendation for the specific engine and application.

AEROSHELL W OILS

- Promote engine cleanliness
- Help keep engines sludge free
- Help reduce oil consumption
- Help engines reach TBO (Time Between Overhaul)
- Protect highly stressed engine parts against scuffing and wear

SPECIFICATIONS

The U.S. specification SAE J1899 replaces MIL-L-22851D.

Although it was planned to replace the British Specification DERD 2450 with a DEF STAN specification this has now been put into suspension and instead the SAE specification has been adopted.

AeroShell Oil	W80	W100	W120
U.S.	Approved SAE J1899 Grade 40	Approved SAE J1899 Grade 50	Approved SAE J1899 Grade 60
British	Approved SAE J1899 Grade 40	Approved SAE J1899 Grade 50	Approved SAE J1899 Grade 60
French	-	-	-
Russian	MS-14	MS-20	-
NATO Code	-	-	-
Joint Service Designation	OMD-160	OMD-250	OMD-370

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell W Oils are approved for use by the following engine manufacturers:-

Textron Lycoming	301F
Continental Aerospace Technologies	MHS 24B
Pratt & Whitney	Service Bulletin 1183
Curtiss Wright	Various Service Bulletins – refer to relevant Bulletin
Franklin Engines	Various Service Bulletins – refer to relevant Bulletin

Typical Properties		**W80**	**W100**	**W120**
SAE viscosity grade		40	50	60
Density @ 15 °C (59 °F)	kg/m^3	883	887	891
API gravity		28.6	27.8	27.2
Kinematic viscosity @ 100 °C (212 °F) @ 40 °C (104 °F)	mm^2/s	 14.5 139	 18.1 204	 23.8 306
Viscosity index		102	> 96	> 96
Pour point	°C (°F)	< –24 (–11)	< –21 (–5)	< –21 (–5)
Flash point	°C (°F)	> 240 (464)	> 250 (482)	> 260 (500)
Total acid number	mgKOH/g	< 0.4	< 0.5	< 0.5
Sulphur	%m	0.3	0.38	0.51
Copper corrosion 3 hrs @ 100 °C (212 °F)		1a	1a	1a
Ash content	%m	< 0.004	< 0.004	< 0.004
Trace sediment	ml/100ml	Passes	Passes	Passes
Trace metal content	ppm	Passes	Passes	Passes
Foaming tendency		Passes	Passes	Passes

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

NOTES

AEROSHELL OIL W 15W-50

AeroShell Oil W 15W-50 is a unique blend of high quality mineral oil and over 50% synthetic hydrocarbon base stocks, plus the AeroShell Oil W ashless dispersant additive system. This semi-synthetic blend offers high performance in a wide variety of applications and conditions. The synthetic base stock performance provides for better cold temperature pumping and protection than single grade oils. In addition, the blend of synthetic and high quality mineral base stocks provide high temperature performance superior to that of other fully approved aircraft piston engine oils. The mineral base stocks help disperse lead by-products of combustion, thereby keeping engines free of "grey paint" or lead sludge that can be a problem with some fully synthetic oils.

The anti-wear additive system in AeroShell Oil W 15W-50 provides outstanding wear protection for critical camshafts, lifters and other high wear components.

The anti-corrosion additive package in AeroShell Oil W 15W-50 helps protect low usage engines and engines in high humidity climates against rust and corrosion of critical engine parts such as camshafts and lifters.

AeroShell Oil W 15W-50 provides superior anti-corrosion protection for all types of certified aircraft piston engines. When used with proper maintenance procedures, the product provides maximum protection and improves the likelihood that aircraft engines will reach TBO. In addition, this product provides outstanding high temperature oxidation protection for hot running engines. It is designed to keep engines cleaner with less sludge and varnish build-up in critical ring belt and other areas.

APPLICATIONS

AeroShell Oil W 15W-50 is intended for use in certified four-stroke (four-cycle) aircraft piston engines. AeroShell Oil W 15W-50 is superior to single grade oils in almost every application. It offers easier starting, better lubrication after start-up, reduced wear, reduced corrosion and rusting, and improved cleanliness, with oil pressures and temperatures equal to that of single grade SAE 50 oils at fully warmed up conditions.

The anti-corrosion additive system is designed to prevent rust or corrosion in all types of aircraft piston engines. In comparative testing of camshaft rusting under high humidity conditions, AeroShell Oil W 15W-50 was almost entirely rust free while camshafts conditioned on other oils showed heavy rusting on some cam lobes and bearing surfaces.

These results indicate that AeroShell Oil W 15W-50 can provide maximum anti-corrosion protection for aircraft piston engines, when combined with proper maintenance practices and proper operating conditions.

Because of the improved flow characteristics of AeroShell Oil W 15W-50, operators may observe slightly lower oil temperatures in some aircraft. On larger aircraft, the oil cooler flap will normally compensate for this change. However, in small aircraft, oil temperature could be reduced slightly. Operators should always check the oil temperature to ensure that they are in the range specified by the manufacturer. Most manufacturers recommend cruising oil temperatures between 82 to 93°C (180 to 200°F). Oil temperatures significantly below this range can result in excessive water and fuel contamination in the crankcase.

AEROSHELL OIL W 15W-50

- Provides excellent rust and corrosion protection for aircraft engines
- Promotes engine cleanliness, fights wear, offers excellent anti-foam properties
- Helps reduce oil consumption by up to 50% and provides superior oil flow at low temperatures
- Compatible with other approved aircraft piston engine oils
- Functions as an all season oil, no seasonal changes needed
- Reduces fuel consumption by up to 5% over single grades
- Provides superior high temperature oxidation stability

Refer to General Notes at the front of this section for information on oil change recommendations and engine break-in.

AeroShell Oil W 15W-50 is not recommended for use in automotive engines. For automotive engines converted for use in aircraft, the specific engine manufacturer or the conversion agency should be consulted for proper oil recommendation.

SPECIFICATIONS

AeroShell Oil W 15W-50 was developed in co-operation with Textron Lycoming and Continental Aerospace Technologies (formerly Continental Motors) and conforms to their specifications 301F and MHS-24A respectively. This oil is also approved under Military Specification MIL-L-22851 which is now obsolete and has been replaced by the SAE J1899 specification. AeroShell Oil W 15W-50 is also approved for use in all Pratt & Whitney radial aircraft engines. In addition AeroShell Oil W 15W-50 meets the provisions of Lycoming Service Bulletin 446C and 471, plus Service Instruction 1409A and meets the American FAA Airworthiness Directive 80-04-03 R2 which specifies special anti-wear requirements for certain engine models.

AeroShell Oil W 15W-50 already contains, in the correct proportions, an anti-wear additive equivalent to the Lycoming additive LW 16702; operators who use AeroShell Oil W 15W-50 DO NOT need to add this Lycoming additive to the oil.

AeroShell Oil W 15W-50 is qualified for use in all Continental Aerospace Technologies ’ liquid cooled and air cooled aircraft piston engines.

U.S.	Approved SAE J1899 Grade Multigrade
British	Approved SAE J1899 Grade Multigrade
French	Approved DCSEA 262/A (XO-162)
Russian	-
NATO Code	-
Joint Service Designation	OMD-162

EQUIPMENT MANUFACTURERS’ APPROVALS

AeroShell Oil W 15W-50 is approved for use by the following engine manufacturers:

Textron Lycoming	301F Service Bulletins 446E and 471B Service Instruction 1409C
Continental Aerospace Technologies	MHS 24B SIL 99-2
Pratt & Whitney	Service Bulletin 1183
FAA	AMOC to Airworthiness Directive 80-04-03 R2 p.1b

Typical Properties		SAE J1899 Multigrade	TYPICAL
Oil type		–	Mixed synthetic hydrocarbon and mineral
SAE viscosity grade		Multigrade	Multigrade
Density @ 15°C (59°F)	kg/m^3	Report	857
API gravity		Report	33.4
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 – –	 18.2 137
Viscosity index		100 min	148
Viscosity dynamic @ –20°C (–4°F)		-	5561
Pour point	°C (°F)	Report	–36 (–32)
Flash point	°C (°F)	220 (428) min	> 240 (464)
Total acid number	mgKOH/g	1.0 max	< 0.1
Sulphur	%m	0.6 max	0.2
Copper corrosion 3hrs @ 100°C (212°F)		1 max	1a
Ash content	%m	0.011 max	< 0.006
Trace sediment	ml/100ml	Must pass	Passes
Foaming tendency		Must pass	Passes
Trace metal content	ppm	Must pass	Passes

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

AEROSHELL OILS W80 PLUS and W100 PLUS

AeroShell Oil W80 Plus and AeroShell Oil W100 Plus are new single grade oils that combine the single grade, ashless dispersant performance found in AeroShell Oils W80 and W100 and the anti-wear/anti-corrosion additives of AeroShell Oil W15W-50 Multigrade. They are the oils for pilots who prefer a single grade but who also want the extra protection and performance from the additive package.

APPLICATIONS

The advanced additives in AeroShell Oils W80 Plus and W100 Plus provide better rust and wear protection than conventional single grades. The additives work as a protective barrier to prevent critical parts from being slowly degraded by rust or wear, especially when an aircraft sits idle. This protection helps keep the camshaft and lifters coated, reducing the likelihood of premature damage and helping operators reach TBO.

- Blended from selected high viscosity mineral base oils
- Contains AeroShell's proven W Oils additive package
- Additional anti-wear additives (containing Lycoming additive LW 16702)
- Additional anti-corrosion additives
- Fully compatible with other approved aircraft piston engine oils

SPECIFICATIONS

Approved SAE J1899 Grade 40 (AeroShell Oil W80 Plus)
Approved SAE J1899 Grade 50 (AeroShell Oil W100 Plus)

AeroShell Oils W80 Plus and W100 Plus already contain, in the correct proportions, an anti-wear additive equivalent to the Lycoming additive LW 16702; thus complying with FAA Airworthiness Directive 80-04-03 R2. Operators who use AeroShell Oils W80 Plus and W100 Plus DO NOT need to add this Lycoming additive to the oil.

AeroShell Oils W80 Plus and W100 Plus are qualified for use in all Continental Aerospace Technologies' liquid cooled and air cooled aircraft piston engines.

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Oils W80 Plus and W100 Plus are approved for use by the following engine manufacturers:

Textron Lycoming	301F Service Bulletins 446E and 471B Service Instruction 1409C
Continental Aerospace Technologies	SIL 99-2
FAA	AMOC to Airworthiness Directive 80-04-03 R2 p.1b

Typical Properties		**W80 Plus**	**W100 Plus**
Density @ 15°C (59°F)	kg/m^3	886	891
API gravity		27.9	17.1
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		14.1	18.6
@ 40°C (104°F)		135	212
Viscosity index		> 101	> 96
Pour point	°C (°F)	< –24 (–11)	< –21 (–5)
Flashpoint	°C (°F)	> 250 (482)	> 255 (491)
Total acid number	mgKOH/g	< 0.2	< 0.6
Sulphur	%m	0.30	0.35
Copper corrosion 3 hrs @ 100°C (212°F)		1a	1a
Ash content	%m	< 0.004	< 0.008
Trace sediment	ml/100ml	Passes	Passes
Foaming tendency		Passes	Passes
Trace metal content	ppm	Passes	Passes

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

AEROSHELL OIL SPORT PLUS 4

Developed in conjunction with ROTAX®, AeroShell Oil Sport Plus 4 is the first oil specifically developed for light sport aviation piston engines such as the ROTAX® 912 & 914 series. A combination of low cylinder head temperature (compared with air cooled engines), low oil consumption and the engine internals requires a blend of high quality hydrocarbon base stocks, incorporating synthetic technology, which allows full performance with different fuel types. This oil can be used in all climates.

APPLICATIONS

AeroShell Oil Sport Plus 4 is intended for use in four-stroke (four-cycle) aircraft piston engines that are of an original automotive design and which cannot, therefore, use traditional Ashless Dispersant aircraft engine oil types. These engines include carburetted, fuel-injected and turbocharged types such as the ROTAX® 912 & 914 series.

AeroShell Oil Sport Plus 4 can be used in integrated gearbox and wet clutch systems.

AeroShell Oil Sport Plus 4 can be used in engines which operate on both unleaded gasoline and Avgas 100LL. The correct choice of additives and good solvent properties allow the oil to handle lead by-products that can form a semi solid sludge in the oil which can restrict oil passages and compromise lubrication. AeroShell Oil Sport Plus 4 is superior in this respect to those oil types intended for automotive/motorcycle application.

Please refer to Operators Handbook/Manual for the correct oil drain interval when operating on different fuels.

SPECIFICATIONS

No Aviation specifications yet defined.

Meets or exceeds the requirements of the highest international specifications:
API SL
JASO MA

Fully approved to ROTAX® RON 424 specification, listed in ROTAX® Service Instruction SI-912i-01/SI-912-016/SI-914-019 Selection of suitable operating fluids for ROTAX® engine type 912 & 914 (series).

Please consult Operating Handbook/Manual to confirm the correct lubricant specification before use.

FEATURES AND BENEFITS

- First specific oil for Light Sport and Very Light/Ultra light aircraft engines
- Promotes engine cleanliness
- Helps keep engines sludge and varnish free
- Helps reduce oil consumption
- Helps engines reach TBO (Time Between Overhauls)
- Protects highly stressed engines parts against scuffing and wear
- Anti-foaming additives to maximise lubrication effectiveness – especially for those engines operating an integrated gearbox
- Better cold flow characteristics for easier starts and quicker protection
- High thermal stability for longer-lasting and safer lubrication
- Can be used in any climate
- Advanced anti-rust and anti-wear package

DO NOT use AeroShell Oil Sport Plus 4 in engines that are designed to use Ashless Dispersant aviation piston engines oils such as AeroShell W oils. This includes air-cooled Continental Aerospace Technologies and Textron Lycoming engines.

Typical Properties		**Sport Plus 4**
SAE viscosity grade		10W-40
Density @ 15°C (59°F)	kg/m^3	868
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 14.2 94.2
Dynamic viscosity (CCS)@ −25°C (−13°F)	mPa.s	5975
Pourpoint	°C (°F)	−39 (−38)
Flashpoint	°C (°F)	228 (442)
Phosphorus	%m	0.196
Zinc	%m	0.220
Calcium	%m	0.284

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

AEROSHELL OIL DIESEL ULTRA

AeroShell Oil Diesel Ultra is a fully synthetic, multigrade engine oil designed for use in the new generation of compression ignition (Diesel) Aviation Piston Engines.

The formulation has been selected to be suitable in piston engines fuelled by Jet A or Jet A-1 and is designed for use in the latest highly rated turbocharged diesel engines under all operating conditions.

APPLICATIONS

AeroShell Oil Diesel Ultra is a fully synthetic engine oil containing a unique additive package to provide superior piston cleanliness, resulting in a clean, efficient and reliable engine. This package includes a powerful surface active additive, which bonds to the surface of highly loaded engine parts, protecting the engine from scuffing damage.

This oil has been developed to provide excellent component wear protection and engine cleanliness, based on substantial engine and component endurance tests with all the major diesel aero-engine manufacturers, and flight experience with diesel aero-engines in the field over recent years.

AeroShell Oil Diesel Ultra has been developed to be suitable for use in engines burning Jet fuel and its performance has been optimised to cope with the demands of this unique type of engine/fuel combination. Its key performance features include the ability to sustain high bearing loads, neutralisation of acid build up from the sulphur present in the fuel, and high dispersancy to allow for the relatively high particle loading produced when burning Jet fuel.

AeroShell Oil Diesel Ultra MUST NOT be used in spark ignition or Avgas powered aircraft engines.

ENGINE MANUFACTURERS' APPROVALS

AeroShell Oil Diesel Ultra is approved to Mercedes Benz Specification 229.5, recognised and required by the leading Diesel aero engine manufacturers AeroShell Oil Diesel Ultra is approved for use in the following engines. Whilst this is correct at the time of writing, testing is ongoing to extend this approval listing as new engines are produced.

Thielert/Centurion® Engines	1.7 & 2.0 Centurion® (Other models yet to be produced)
SMA	SR305-230E
Austro Engine	AE300

SPECIFICATIONS

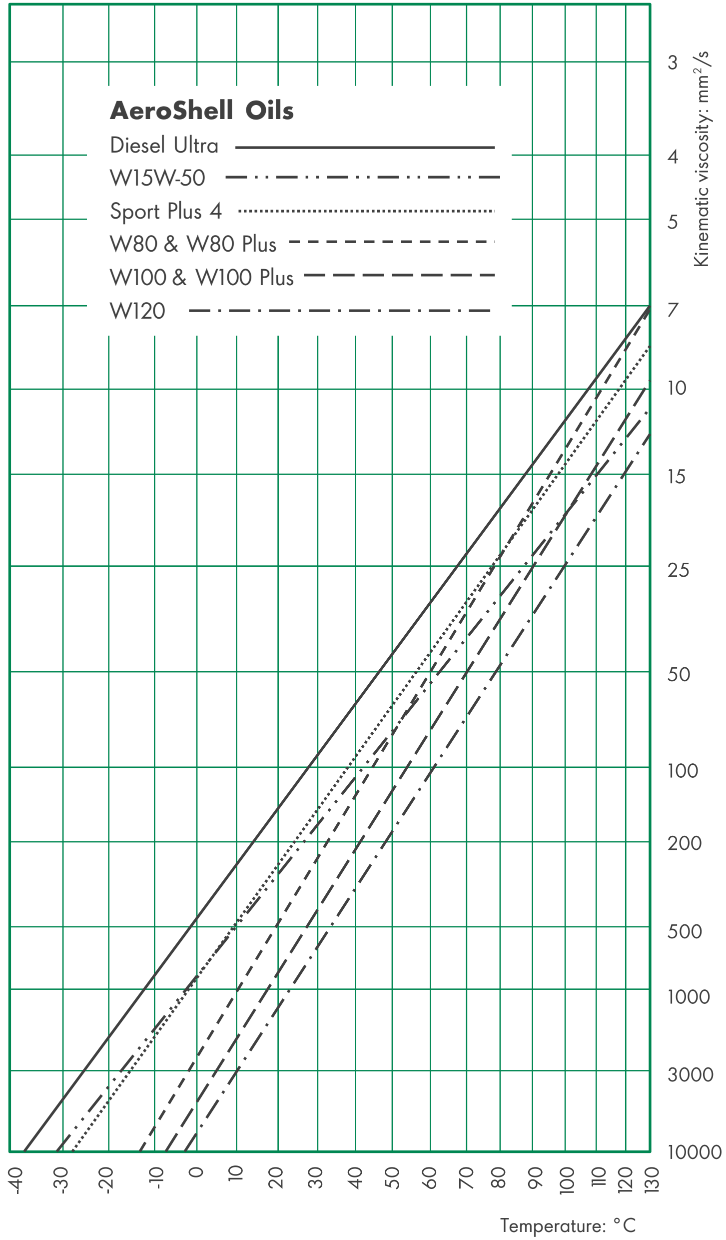
No Aviation specifications yet defined.

U.S.	-
British	-
French	-
Russian	-
NATO Code	-
Joint Service Designation	-
ACEA	Meets the requirements of A3/B4
API	Meets the requirements of SL/CF
Mercedes Benz	MB 229.5
SAE	Viscosity grade 5W-30

Typical Properties		**Diesel Ultra**
SAE viscosity grade		Multigrade 5W-30
Density @ 15°C (59°F)	kg/m^3	850
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 12.0 68.2
Pourpoint	°C (°F)	–39 (–38)
Flashpoint	°C (°F)	215 (419)
Dynamic viscosity @ –30°C (–22°F)	mPaS	 6043

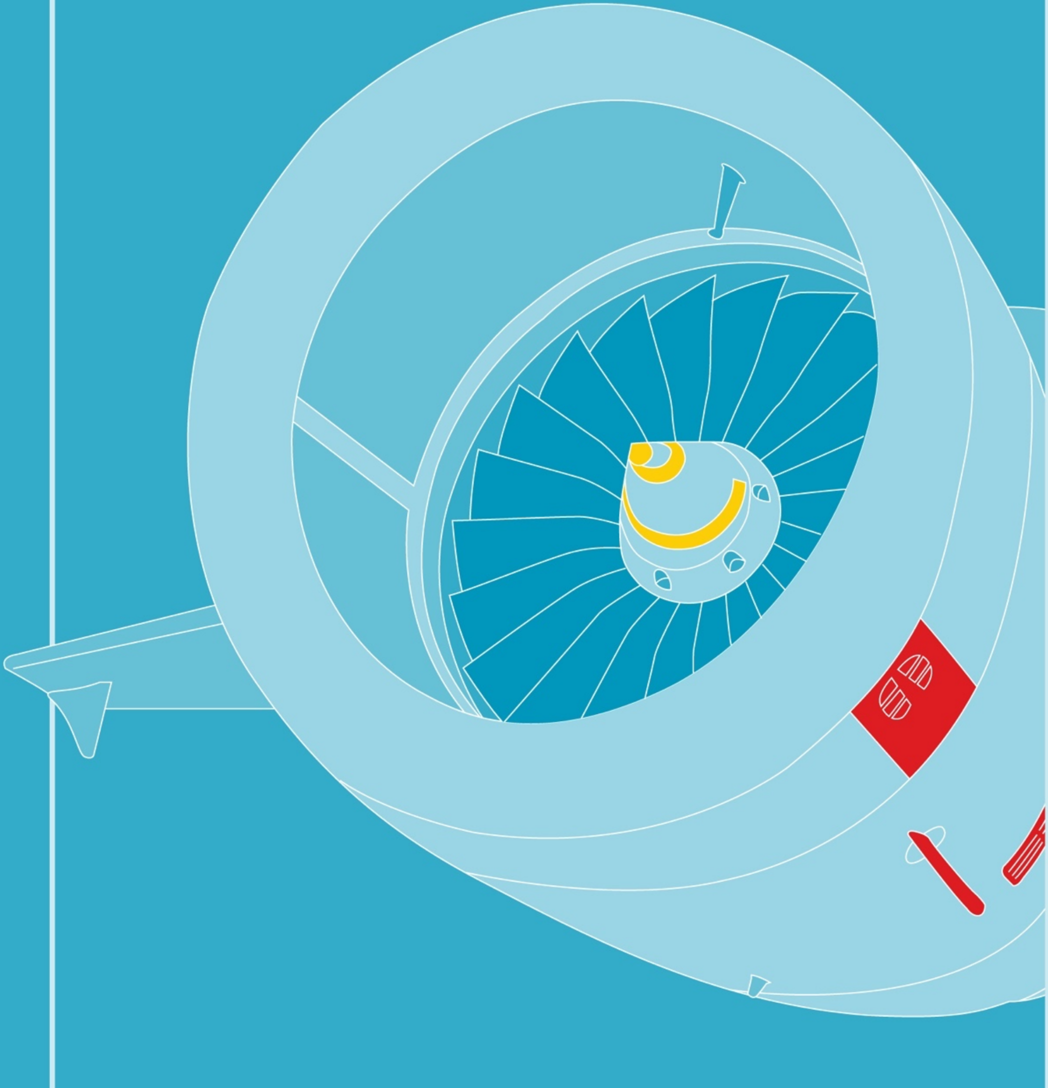
A viscosity/temperature chart is shown at the end of this section.

TYPICAL TEMPERATURE/VISCOSITY CURVES OF AEROSHELL OILS



NOTES

AEROSHELL TURBINE ENGINE OILS



4. AEROSHELL TURBINE ENGINE OILS

The earliest gas turbine engines were developed using straight mineral oils but the operational requirements for low temperature starting, either on the ground or at high altitude (re-lights) led to the development of a range of straight mineral oils with viscosities far lower than those of conventional aircraft engine oil of that time. For example, oils with viscosities between 2 mm^2/s and 9 mm^2/s at 100°C (212°F) became standard for gas turbine engines, compared with viscosities of 20 mm^2/s to 25 mm^2/s at 100°C (212°F) for piston engine oils.

Although demand for the low viscosity straight mineral turbine oils is diminishing, the following list tabulates the current range of specifications covered.

MIL-PRF-6081E Grade 1010/N - AeroShell Turbine Oil 2

DEF STAN 91-099 (DERD 2490) - AeroShell Turbine Oil 3

With the progressive development of the gas turbine engine to provide a higher thrust and compression ratio, etc., the mineral oils were found to lack stability and to suffer from excessive volatility and thermal degradation at the higher temperatures to which they were subjected.

At this stage, a revolutionary rather than evolutionary oil development took place concurrently with engine development and lubricating oils derived by synthesis from naturally occurring organic products found an application in gas turbine engines. The first generation of synthetic oils were all based on the esters of sebacic acid, principally dioctyl sebacate. As a class, these materials exhibited outstanding properties which made them very suitable as the basis for gas turbine lubricants.

However, these materials yielded a product with a viscosity of about 3 mm^2/s at 100°C (212°F) and alone had insufficient load carrying ability to support and transmit high gear loads. Therefore, to these materials were added thickeners (complex esters), which gave the required degree of load carrying ability and raised the final viscosity to about 7.5 mm^2/s at 100°C (212°F).

Unlike straight mineral oils, the synthetic oils had to rely on additives, and in later formulations on multi-component additive packages, to raise their performance. This was particularly necessary to improve resistance to oxidation and thermal degradation; important properties which govern long term engine cleanliness.

The two different basic grades of synthetic oil found favour on opposite sides of the Atlantic; in the U.S.A. 3 mm^2/s oils became standard while, in the U.K., 7.5 mm^2/s oils were used. AeroShell Turbine Oil 300 and AeroShell Turbine Oil 750 respectively were developed to meet these two separate requirements.

The situation persisted for some years until 3 mm^2/s oils were required for use in British pure jet engines. For many years AeroShell Turbine Oil 300 was the standard Shell 3 mm^2/s oil and rendered satisfactory airline service in many different types of British and American engines. However, to provide a more than adequate margin of performance and to allow for further increase of operational life, principally in Rolls-Royce engines, AeroShell Turbine Oil 390 was developed.

Although the use of 3 mm^2/s oils in aero-engines has declined, the use in auxiliary power units (APU) is increasing where, because of the low temperature viscometric properties, use of 3 mm^2/s oils gives improved cold starting reliability after prolonged cold soak.

Soon after the introduction of AeroShell Turbine Oil 390, American practice changed. With the almost continuous increases in engine size and power output, a demand developed in the U.S.A. for oils possessing improved thermal stability and high load carrying ability, with some sacrifice in low temperature performance, and the idea of introducing a "Type II", 5 mm^2/s oil was formed.

These 5 mm^2/s 'second generation', oils were usually based on 'hindered' esters and have since found wide application in American engines and subsequently in British, Canadian and French engines. AeroShell Turbine Oil 500 was developed to meet these requirements.

To meet the requirements to lubricate the engines of supersonic aircraft AeroShell Turbine Oil 555 was developed as an advanced 5 mm^2/s synthetic oil with high temperature and load carrying performance.

Changes which have taken place over the last two decades in engine performance (in terms of improved fuel consumption, higher operating temperatures and pressures) and in maintenance practices have resulted in increased severity in lubricant operating conditions. These types of changes stress the engine oil and thus the original Type II oils are becoming less suitable for use in modern aircraft engines. This has resulted in the need for engine oils with very good (and improved) thermal stability such as AeroShell Turbine Oil 560. This type of oil with better thermal stability is now generally known as "third generation" or "HTS".

In military aviation, the British Military initially standardised on the 7.5 mm^2/s oils as defined by DERD 2487 (now renumbered as DEF STAN 91-098), but then, in the mid 1980s switched and decided that future requirements will be met by the specification DERD 2497 (now renumbered as DEF STAN 91-100) covering high temperature performance oils.

In the U.S.A., the U.S. Air Force continues to prefer 3 mm^2/s oils, and, more recently,4 mm^2/s oils, and maintains their performance requirements by revisions to specification MIL-PRF-7808 (formerly MIL-L-7808). The U.S. Navy, with interest in turbo-prop engines and helicopter gearboxes, etc., has tended to use 5 mm^2/s oils and after a series of specifications have finalised their requirements in the MIL-PRF-23699 specification (formerly MIL-L-23699). The latest issue of this specification, MIL-PRF-23699G, now caters for four classes of 5 mm^2/s oils:

- Standard Class (STD)
- High Thermal Stability Class (HTS)
- Corrosion Inhibited class (C/I)
- Enhanced Ester (EE)

With the need to transmit more power and higher loads through helicopter gearboxes it has become apparent that MIL-PRF-23699 oils may not be completely satisfactory. With this in mind, many helicopter manufacturers (as well as the U.S. Navy) have turned to the advanced high load carrying 5 mm^2/s oil AeroShell Turbine Oil 555. This in turn has led to the development of a U.S. military specification DOD-PRF-85734A (formerly DOD-L-85734) which covers a helicopter transmission oil against which AeroShell Turbine Oil 555 is fully approved.

Historically, the aircraft engine original equipment manufacturers (OEMs) have used the MIL-PRF-23699 specification to control the performance and quality of turbine oils used in their commercial engines. Approval to this specification has always been the first, essential, step in the process of gaining OEM approval in different civil engine and APU types.

In subsequent years, it was recognised that hotter running engines with extended TBOs (Time Between Overhauls) meant that the military, MIL-PRF-23699 (HTS) specification was no longer adequate to define the type of oil needed in modern, commercial, engines. The SAE E-34 Propulsion Lubricants Committee was established to development a core TEO specification appropriate to civil aviation. In 2000, SAE AS5780 was ratified and issued. Since then there were several updates to the specification, now it is SAE AS5780D. SAE AS5780D defines two grades of oil:

- SPC – Standard Performance Capability
- HPC – High Performance Capability

The SPC grade is virtually identical to the STD grade defined by MIL-PRF-23699 but the HPC grade has more stringent performance requirements than the HTS grade of MIL-PRF-23699. AeroShell Ascender was the first formulation to be approved to the HPC category of SAE AS5780A specification in September 2007.

In summary, HPC oils will have:

- very low coking propensity (in both liquid phase and vapour/oil mist phase)
- higher oxidative stability
- higher thermal stability
- improved compatibility with a wide range of elastomers
- better defined load-carrying capacity

The AS5780 specification, as well as listing all the technical requirements for the two grades of oil, also defines the procedure whereby oils can obtain qualification approval. This approval activity is managed by the QPG (Qualified Products Group), a section of the PRI (Performance Review Institute), the stand-alone division of SAE that is responsible for product qualifications to SAE specs and the issue of QPLs. The QPG associated with AS5780 comprises only OEMs and specification authorities; oil suppliers cannot be members. This activity is supported by all the major OEMs and approval to AS5780 will henceforth become the essential first step to obtaining approvals in individual engine models. Individual engine approvals remain necessary to ensure the continuing safe and reliable operation of today's modern gas turbine engine.

VINTAGE AIRCRAFT

Vintage aircraft turbine engines were approved on oils available when the engine was originally manufactured and in many cases these oils were specific blends of mineral oils, such oils being no longer available. If the engine was approved on a mineral turbine oil other than MIL-L-6081 or DEF STAN 91-099 (formerly DERD 2490) oils then operators should consult with either the engine manufacturer/rebuilder or oil supplier. In some cases it is possible to switch to a synthetic turbine oil but such a move can only be considered on a case by case basis. On no account assume that present turbine oils (both mineral and synthetic) are direct replacements for old vintage aircraft applications.

OIL ANALYSIS

Routine oil analysis is now seen as a valuable part of a good maintenance programme. Increasingly operators are adopting oil analysis programmes in order to help discover problems before they turn into major failures. Typically these programmes consist of spectrometric wear metal check, together with a few simple oil tests such as viscosity and acidity. Shell Companies can offer this service to operators.

It is important to note that the information gained is only as good as the sampling procedure. A single test is not enough to reveal trends and significant changes, it can only tell an operator if there is already a serious problem. Operators should therefore:

- **Take samples properly**

For best results, take the sample immediately after engine shutdown. The sample should be taken the same way every time. An improperly taken sample can lead to mistaken conclusions about engine problems.

- **Rely on a series of consistent tests over time**

Operators should look for significant changes or trends over time, not just absolute values.

- **Be consistent**

Always take the sample the same way at the same time interval. Always properly label the sample so that its identity is known.

APPLICATIONS

Whenever an aircraft is certified, all of the engine oils 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 engine oils which are qualified to be used. The U.S. Federal Aviation Administration (FAA) regulations state that only engine oils 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 engine oil should be used.

OIL APPROVALS

The oil approvals listed in this section are believed to be current at time of printing, however, the respective engine manufacturer's manuals and service bulletins should be consulted to ensure that the oil conforms with the engine manufacturer's latest lubricant approval listing.

TYPICAL PROPERTIES

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

COMPRESSOR WASHING

Some turbine engine manufacturers permit or even recommend regular compressor washing. In this, water and/or special wash fluid is sprayed into the compressor during either ground idle running or during the final stages of engine shut down. The purpose of this washing is to restore the performance of the compressor by washing off any salt/sand/dirt/dust which may have collected on the compressor blade thereby causing deterioration in the performance of the compressor.

Operators should strictly follow the engine manufacturers' requirements for performing the compressor wash and in particular any requirement for a drying run since incorrect application of the wash/drying cycle could lead to contamination of the oil system by water and/or special wash fluid.

OIL CHANGE INTERVAL

For many gas turbine engines there is no set oil change interval, this is because the oil in the system changes over through normal consumption in a reasonable number of hours. For some engines, particularly smaller engines, the engine manufacturer recommends regular oil changes. Operators should therefore adhere to the recommendations for the specific model of engine they operate. Depending upon the condition of the oil and the oil wetted areas of the engine, the engine manufacturer may be prepared to authorise oil change extensions.

For gas turbines used in coastal operations (e.g. off-shore helicopter operations) where there is salt in the atmosphere, in high temperature/high humidity areas or in sandy/dusty areas regular oil changes can be beneficial because it allows removal of any salt/sand/dust/dirt/water contamination from the oil.

OIL CHANGEOVER

Generally synthetic turbine oils in one viscosity group are compatible and miscible with all other synthetic oils in the same viscosity group (and in many cases other viscosity groups as well). However, in changing from one synthetic turbine oil to another, an operator must follow the engine manufacturers' recommendations.

Change by top-off (mixing) allows the change over to take place slowly and there is increasing evidence that this is less of a shock to the engine and engine oil system. Whilst most engine manufacturers e.g. Rolls Royce, GE, P&W, CFMI, etc., allow change by top-off (mixing), other engine manufacturers e.g. Honeywell, do not and only allow changeover by either drain and refill or drain, flush and refill.

It is Shell's policy to always recommend that the engine manufacturer's recommendations are followed. In addition it is recommended that for the initial period during and after change over the oil filters are inspected more frequently.

COMPATIBILITY WITH MATERIALS

The advent of synthetic oil for gas turbine engine lubrication permitted greater extremes of temperature to be safely encountered (far in excess of those possible with mineral oils), and brought with it the problem of compatibility, not only of elastomers, but of metals, paints, varnishes, insulation materials and plastics. In fact all materials associated with lubricants in aircraft have had to be reviewed and new materials evolved, in some cases, to enable maximum benefit to be obtained from the use of synthetic turbine oils.

Much of this evaluation has been undertaken by the manufacturers in the industries concerned, and may be summarised under the general heading of the materials groups.

ELASTOMER COMPATIBILITY

When using a synthetic ester turbine 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 here can only be considered as a guideline.

Elastomer/Plastic	Mineral Turbine Oils	Synthetic Ester Turbine Oils
Fluorocarbon (Viton)	Very good	Very good
Acrylonitrile	Good	Poor to Good (high nitrile content is better)
Polyester	Good	Poor to Fair
Silicone	Poor to Good	Poor to Fair
Teflon	Very Good	Very Good
Nylon	Poor to Good	Poor
Buna -S	Poor	Poor
Perbunan	Good	Fair to Good
Methacrylate	Good	Poor to Fair
Neoprene	Fair to Good	Poor
Natural Rubber	Poor to Fair	Poor
Polyethylene	Good	Good
Butyl Rubber	Very Poor to Poor	Poor to Fair
Poly Vinyl Chloride	Poor to Good	Poor

Compatibility Rating:

Very Good – Good – Fair – Poor – Very Poor

PAINTS

Epoxy resin paints have been found to be practically the only paints entirely compatible giving no breakdown or softening or staining in use, except for the very light colour shades, which are susceptible to staining due to the actual colour of the anti-oxidant inhibitor contained in practically all ester based lubricants.

PLASTICS

Only the more common plastics can be considered for evaluation of compatibility.

The best from chemical and physical aspects is polytetrafluoroethylene, as might be expected from its generally inert properties. This is closely followed by higher molecular weight nylon. Polyvinyl chloride is rapidly softened by the hot oil and is not recommended. Currently, polythene and terylene are also suspect in this respect, but have not been extensively evaluated.

VARNISHES

Many commonly used phenolic impregnated varnishes are softened by contact with the hot oil, but a few of the harder grades show moderate to good resistance. Silicone varnishes and TS 188 are considerably softened.

Modified alkyd type varnishes, when baked, possess good resistance to oil but have poor resistance to water. When good resistance to water is also required, it is recommended that the varnish be coated with a water resistant finish.

MINERAL AND VEGETABLE OILS

Ester based synthetic oils are incompatible with mineral and vegetable oils. In no circumstances should these products be used together and, if changing from one type to another, then particular care is needed to ensure that all traces of the previous product are removed prior to ester lubricant application.

METALS

Copper and alloys containing copper

As in mineral oil applications, pure copper has a marked catalytic effect at sustained high oil temperatures on the break down of the esters to acid derivatives, and its use in engines or other equipment is thus most undesirable. Copper alloys such as brass and bronze do not possess this property to any great degree and can be used with safety.

Aluminium and steel and their alloys

These materials are not affected.

Cadmium

Cadmium, in the form of plating as a protective treatment for storage of parts destined to be in contact with oil in service, experiences a tendency at the higher temperatures to be taken into solution by synthetic oils. This solvent action does not harm the lubricant, but the slow removal of cadmium plating after many hours of service will detract from its efficiency as a subsequent protective.

Lead and alloys containing lead

Lead and all alloys containing lead are attacked by synthetic lubricants. The way the lubricant reacts with the lead differs according to the type of lubricant, but in general, all lead compounds should be avoided. The most common forms of lead are lead abradable seals and lead solder used particularly in filters and mesh screens. In these cases the mesh screen should be brazed.

OTHER METALS

Magnesium is not affected except where hydrolysis occurs. Thus magnesium should not be used if there is any likelihood of hydrolysis occurring or alternatively the magnesium could be coated with epoxy to protect it.

Monel and Inconel are not affected.

Tungsten accumulates a very thin soft black film after prolonged immersion in synthetic oils under static conditions. It is readily removed by wiping, leaving no sign of corrosion. Under the scrubbing conditions normally associated with circulatory oil systems this film does not materialise and its effect may be ignored.

Zinc, as galvanised protective, is attacked by synthetic lubricants leading to the formation of zinc soaps and thus should not be used. Storage of synthetic oils is best achieved in tinned mild steel cans or failing this, bright mild steel.

Titanium is not affected.

Silver and silver plating is generally not affected. However, in some synthetic ester oils, the additive pack, especially high load additives, react with the silver and blacken or even de-plate the silver.

Chromium plating is not affected.

Nickel and alloys are generally satisfactory.

Tin plating is generally satisfactory.

For aircraft oil tanks the recommended material is light alloy or stainless steel.

NON-AVIATION USE OF AEROSHELL TURBINE ENGINE OILS

In selecting an AeroShell turbine engine oil for a non-aviation application, the properties of the oil 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.

The main use of AeroShell turbine engine oils in non-aviation applications is in aero-derived industrial and marine gas turbine applications. Such engines have found application in:

- electrical power generation
- large pumps and compressors, especially in pipeline applications and in petrochemical process industry
- marine propulsion

In an aero-engine, essential design features are its size and weight, which results in compact units. Such designs place heavy demands on the engine components and lubricants to ensure total reliability in the high temperatures within the engine.

The land and sea based derivatives of the aero-engines retain the essential design elements of their aviation versions and thus have similar lubrication requirements.

Engine manufacturers therefore approve the use of aircraft synthetic turbine oils in these engines. Only these lubricants have the characteristics required to provide the unit lubrication and cooling within the severe operating environment.

There is a full range of AeroShell turbine oils approved by the major engine manufacturers for use in their industrial and marine derivatives of aero-engines and a quick reference table is included at the end of this section.

AEROSHELL TURBINE OIL 2

AeroShell Turbine Oil 2 is a 2 mm^2/s mineral turbine oil blended from mineral base stocks to which a pour-point depressant and an anti-oxidant have been added.

APPLICATIONS

AeroShell Turbine Oil 2 is widely used for inhibiting fuel systems and fuel system components during storage.

AeroShell Turbine Oil 2 is an analogue to the Russian Grade MK-8 and can therefore be used in engines which require the use of MK-8.

SPECIFICATIONS

U.S.	Approved MIL-PRF-6081E Grade 1010 and 1010N
British	-
French	Equivalent to AIR 3516/A
Russian	Analogue to MK-8
NATO Code	O-133
Joint Service Designation	OM-10 (Obsolete)

PROPERTIES		MIL-PRF-6081E Grade 1010/N	TYPICAL
Oil type		Mineral	Mineral
Colour		5.5 max	< 1.5
Density @ 15°C (59°F)	kg/m^3	–	878 to 893
Kinematic viscosity @ 37.8°C (100°F) @ –40°C (–40°F)	mm^2/s	 10.0 min 3000 max	 10.2 to 12.7 2305 to 2634
Viscosity stability 3hrs @ –40°C (–40°F)		 2 max	 0.12 to 0.5
Pourpoint	°C (°F)	–57 (–70) max	–75 to <–57 (–103 to <–70)
Flashpoint	°C (°F)	132 (269) min	136 to 142 (277 to 287)
Total acid number	mgKOH/g	0.10 max	0.02 to 0.04
Copper corrosion 3hrs @ 100°C (212°F)		 1 max	 Passes
Trace sediment	ml/200ml	0.005 max	< 0.005
Corrosion & oxidation stability 168 hrs @ 121°C (250°F) - metal weight change - change in viscosity @ 37.8°C (100°F) - acid number change	 % mgKOH/g	 Must pass –5 to +20 0.2 max	 Passes Passes < 0.2

AEROSHELL TURBINE OIL 3

AeroShell Turbine Oil 3 is a 3 mm^2/s mineral turbine oil blended from mineral base stocks to which a anti-corrosion additive has been added.

APPLICATIONS

AeroShell Turbine Oil 3 was developed for early pure jet engines and is still approved for some versions of these engines plus the Safran Helicopter Engines (formerly Turbomeca) Artouste, Marbore 2 and Marbore 6.

AeroShell Turbine Oil 3 is widely used for inhibiting fuel systems and fuel system components during storage.

AeroShell Turbine Oil 3 is an analogue to the Russian Grade MK-8 and can therefore be used in engines which require the use of MK-8. It is also used as the mineral turbine oil component in the mixture of mineral turbine oil and piston engine oil used in Russian turboprop engines.

AeroShell Turbine Oil 3 can also be used as an alternative to the discontinued AeroShell Fluid 1, which was used where a light anti-freezing oil is required, e.g. on aircraft instruments, gun mounting buffers, hydraulic coupings, controls, door hinges, etc. It was also used as a preservative oil for Stromberg carburetors and some fuel systems.

SPECIFICATIONS

U.S.	-
British	Approved DEF STAN 91-099 Meets DEF STAN 91-044 (Obsolete)
French	Equivalent to AIR 3515/B
Russian	Analogue to MK-8
NATO Code	O-135
Joint Service Designation	OM-11

PROPERTIES		DEF STAN 91-099	TYPICAL
Oil type		Mineral	Mineral
Density @ 15°C (59°F)	kg/m^3	–	875
Kinematic viscosity @ 40°C (104°F) @ –25°C (–13°F)	mm^2/s	 12.0 min 1250 max	 12.28 1112
Pourpoint	°C (°F)	–45 (–49) max	Below –45 (–49)
Flashpoint Pensky Martin Closed Cup	°C (°F)	144 (291) min	146 (294)
Total acidity	mgKOH/g	0.30 max	0.15
Strong acid number	mgKOH/g	NIL	NIL
Copper corrosion 3hrs @ 100°C (212°F)		 1 max	 Passes
Saponification matter	mgKOH/g	1 max	0.25
Ash	% m/m	0.01 max	0.001
Aromatic content	%	10 max	6.0
Oxidation - total acid number increase - asphaltenes	 mgKOH/g % m/m	 0.7 max 0.35 max	 0.24 0.09

AEROSHELL TURBINE OIL 308

AeroShell Turbine Oil 308 is a 3 mm^2/s synthetic ester oil incorporating additives to improve resistance to oxidation and corrosion and to minimise wear.

APPLICATIONS

AeroShell Turbine Oil 308 was developed specifically for use in particular models of aircraft turbo-prop and turbo-jet engines for which a MIL-PRF-7808 (formerly MIL-L-7808) oil is required.

AeroShell Turbine Oil 308 contains a synthetic ester oil and should not be used in contact with incompatible seal materials and it also affects some paints and plastics. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	Approved MIL-PRF-7808L Grade 3
British	-
French	-
Russian	-
NATO Code	O-148
Joint Service Designation	OX-9

PROPERTIES		MIL-PRF-7808L Grade 3	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Density @ 15°C (59°F)	kg/m^3	–	956
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		3.0 min	3.1
@ 40°C (104°F)		11.5 min	12.0
@ –40°C (–40°F)		–	2400
@ –51°C (–60°F)		17000 max	12000
Viscosity stability		Must pass	Passes
Pourpoint	°C (°F)	–	Below –62 (–79°F)
Flashpoint Cleveland Open Cup	°C (°F)	210 (410) min	235 (455)
Total acidity	mgKOH/g	0.3 max	0.15
Trace metal content		Must pass	Passes
Evaporation 6.5 hrs @ 205°C (401°F)	%m	30 max	20
Silver - bronze corrosion @ 232°C (450°F)			
- silver	gm/m^2	+ 4.5 max	0.01
- bronze	gm/m^2	+ 4.5 max	0.05
Deposit test			
- deposit rating		1.5 max	0.8
- neutralisation number change	%	20 max	2.0
- viscosity change @ 40°C (104°F)	%	100 max	12.0
Storage stability		Must pass	Passes
Compatibility		Must pass	Passes

Table continued

Table continued

PROPERTIES		**MIL-PRF-7808L Grade 3**	**TYPICAL**
Elastomer compatibility			
SAE AMS3217/1, 168 hrs			
@ 70°C (158°F)	% swell	12 to 35	27
SAE AMS3217/4, 72 hrs			
@ 175°C (347°F)	% swell	2 to 25	16
- tensile strength change	%	50 max	30
- elongation change	%	50 max	3.5
- hardness change	%	20 max	9.0
SAE AMS3217/5, 72 hrs			
@ 150°C (302°F)	% swell	2 to 25	Passes
- tensile strength change	%	50 max	Less than 50
- elongation change	%	50 max	Less than 50
- hardness change	%	20 max	Less than 20
Static foam test			
- foam volume	ml	100 max	30
- foam collapse time	secs	60 max	15
Dynamic foam test		Must pass	Passes
Corrosion and oxidation stability		Must pass	Passes
Bearing deposition stability			
- deposit rating		60 max	< 60
- filter deposit weight	g	2.0 max	< 2
- viscosity change @ 40°C (104°F)		−5 to +25	Passes
- acid number change	mg/KOH/g	1.0 max	< 1
- metal weight change	mg/cm^2	+ 0.2 max	Passes
Gear load carrying capacity		Must pass	Passes

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

NOTES

AEROSHELL TURBINE OIL 390

AeroShell Turbine Oil 390 is a 3 mm^2/s synthetic diester oil incorporating a carefully selected and balanced combination of additives to improve thermal and oxidation stability and to increase the load carrying ability of the base oil.

APPLICATIONS

AeroShell Turbine Oil 390 was developed primarily as an improved 3 mm^2/s oil for British turbo-jet engines. AeroShell Turbine Oil 390 is fully approved for a wide range of turbine engines.

More recently, because of the low temperature characteristics of AeroShell Turbine Oil 390, there is interest in using this oil in auxiliary power units (APU) in order to overcome the effects of cold soak. Normal practice is to shut down the APU during cruise, the APU then experiences cold soak, often prolonged, and when the unit is started there is considerable difficulty resulting in the unit not coming up to speed in the given time, thus causing a hung start.

In such cases where the APU is subject to a long cold soak the viscosity of standard 5 mm^2/s oils used in the APU will increase from 5 mm^2/s at 100°C (212°F) to typically 10,000 mm^2/s at −40°C (−40°F). At this much higher viscosity the oil cannot flow easily leading to a large viscous drag within the APU, thereby contributing to the difficulty in starting. AeroShell Turbine Oil 390 on the other hand experiences a much smaller viscosity increase (typically 2000 mm^2/s at −40°C) with a reduction in viscous drag which is often sufficient to overcome hung start problems.

All experience to date shows a considerable improvement in cold reliability of the APU when AeroShell Turbine Oil 390 is used.

SPECIFICATIONS

U.S.	-
British	Approved DEF STAN 91-094
French	-
Russian	Analogue to IPM-10, VNII NP 50-1 4f and 4u, and 36Ku-A
NATO Code	-
Joint Service Designation	OX-7

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Turbine Oil 390 is approved for use in all models of the following engines:

Honeywell	APU Series: 131, GTCP 30, 36, 85, 331 and 660; RE100, 220; HGT 400, 750 and 1700
Pratt & Whitney AeroPower (formerly Hamilton Sundstrand)	APS 500, 1000, 2000, 3000, 5000
Pratt & Whitney Canada	PW901A/C and PW980 APUs
Rolls-Royce	Conway, Spey, Tay, M45H
Safran Helicopter Engines (formerly Turbomeca)	Artouste III, Bastan, Turmo, AST 950. Approved with restrictions*: Ardiden, Arriel, Arrius, Artouste, TM333, AST 600, Astazou, Makila, Marbore 6

*Please refer to Safran Helicopter Engines manual for details.

PROPERTIES		DEF STAN 91-094	TYPICAL
Oil type		–	Synthetic ester
Density @ 15 °C (59 °F)	kg/m^3	–	924
Kinematic viscosity	mm^2/s		
@ 40 °C (104 °F)		16.0 max	12.9
@ 100 °C (212 °F)		4.0 max	3.4
@ –54 °C (–65 °F)		13000 max	< 13000
Pourpoint	°C (°F)	–60 (–76) max	–68 (–90)
Flashpoint Cleveland Open Cup	°C (°F)	225 (437) min	225 (437)
Foam characteristics		Must pass	Passes
Trace metal content		Must pass	Passes
Elastomer compatibility, swell tests			
- nitrile	%	14 to 26	Within range
- viton	%	15 to 25	Within range
- silicone	%	16 to 24	Within range
Solid particle contamination			
- sediment	mg/l	10 max	< 10
- total ash of sediment	mg/l	1 max	< 1
Corrosivity		Must pass	Passes
High temperature oxidative stability		Must pass	Passes
Load carrying ability		Report	Passes

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

NOTES

AEROSHELL TURBINE OIL 500

AeroShell Turbine Oil 500 is a 5 mm^2/s synthetic hindered ester oil incorporating a carefully selected and balanced combination of additives to improve thermal and oxidation stability and metal passivation.

APPLICATIONS

AeroShell Turbine Oil 500 was developed essentially to meet the requirements of Pratt & Whitney 521 Type II and MIL-L-23699 specifications and is entirely suitable for most civil and military engines requiring this class of lubricant. AeroShell Turbine Oil 500 is approved for use in a wide range of turbine engines as well as the majority of accessories.

With the advent of the new civil turbine oil specification, SAE AS5780, which has more stringent requirements than the military specification MIL-PRF-23699, AeroShell Turbine Oil 500 was approved as a SPC (Standard Performance Capability) oil.

AeroShell Turbine Oil 500 contains a synthetic ester oil and should not be used in contact with incompatible seal materials and it also affects some paints and plastics. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	Approved MIL-PRF-23699G Grade STD Approved SAE AS5780D Grade SPC
British	Approved DEF STAN 91-101 Grade OX-27
French	Meet DCSEA 299/A
Russian	-
NATO Code	O-156
Joint Service Designation	OX-27
Pratt & Whitney	Approved 521C Type II
General Electric	Approved D-50 TF 1
Allison	Approved EMS-53 (Obsolete)

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Turbine Oil 500 is approved for use in all models of the following engines:

Honeywell	APU series: 131, GTCP 30, 36, 85 (except -99), 331 and 660; RE100, 220; HGT 400, 750 and 1700; TSCP 700. Engine series: TPE 331, TSE 331, ALF 502, LF507, LTS101, LTP101, T53, T5508D, AL5512, CTS800
Engine Alliance	GP7200
Eurojet	EJ200
General Electric	CF34, CF6, CF700, CJ Series, CT7, CT64, Catalyst, H Series
Motorlet	M601D, E and Z
Pratt & Whitney	JT3, JT4A, JT8D, JT9D, JT12A, PW4000, PW6000, F117-PW-100
Pratt & Whitney AeroPower (formerly Hamilton Sundstrand)	APS 500, 100, 2000, 3000
Pratt & Whitney Canada	Engine series: JT15, PT6 Series, ST6, PW100 (except PW150), PW200, PW300, PW500 & PW600 Series APU series: PW901A/C, PW980
Rolls-Royce	250 Series, 501, AE2100 & 3007 Series, BR700 Series, RB211-22/524/535, Tay, Gem, Gnome, Spey, Adour, M45H, Viper (Series MK 301, 521, 522, 526, 535, 540, 601, 623 and 632)
Safran Helicopter Engines (formerly Turbomeca)	Ardiden, Arriel, Arrius, Arrius 1D, AST 600, Astazou XVI, Larzac, Makila, MTR390, RTM322, TM333, 526, 535, 540, 601, 623 and 632. Approved with restrictions*: Artouste, AST 950, Astazou, Turmo, Bastan

Full details of the approval status of AeroShell Turbine Oil 500 in APUs and other engines/accessories is available.

*Please refer to Safran Helicopter Engines manual for details.

PROPERTIES		MIL-PRF-23699G Grade STD SAE AS5780D Grade SPC	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		4.90 to 5.40	5.11
@ 40°C (104°F)		23.0 min	25.40
@ −40°C (−40°F)		13000 max	9215
Flashpoint Cleveland Open Cup	°C (°F)	246 (474) min	264 (507)
Pourpoint	°C (°F)	−54 (−65) max	<−54 (−65)
Total acidity	mgKOH/g	1 max	0.05
Evaporation loss 6.5 hrs @ 204°C (399°F)	%m	10.0 max	2.5
Foaming tendency		Must pass	Passes
Thermal stability/corrosivity 96 hrs			
- metal weight change	mg/cm^2	± 4.0 max	Passes
- viscosity change	%	5.0 max	1.42
- total acid number change	mgKOH/g	6.0 max	1.9
Swelling of standard synthetic rubber SAE AMS3217/4 72 hrs @ 204°C (399°F)	swell %	5 to 25	Within limits 15%
Elastomer compatibility, % weight change after 24/120 hours:			
Fluorocarbon @ 200°C (392°F)		10/15 max	Passes
LCS Fluorocarbon @ 200°C (392°F)		10/20 max	Passes
Nitrile @ 130°C (266°F)		19.5/22 max	Passes
Silicone @ 175°C (347°F)		16.5/16.0 max	Passes
Perfluoroelastomer @ 200°C (392°F)		N/A	Passes

Table continued

Table continued

PROPERTIES		MIL-PRF-23699G Grade STD SAE AS5780D Grade SPC	TYPICAL
Corrosion & oxidation stability			
72 hrs @ 175°C (347°F)		Must pass	Passes
72 hrs @ 204°C (399°F)		Must pass	Passes
72 hrs @ 218°C (424°F)		Must pass	Passes
HLPS dynamic coking @ 375°C (707°F) @ 20hrs	Deposit mg	4.0 max	1.75 average
Ryder gear test, relative rating Hercolube A	%	102 min	Passes
Bearing Test Rig Type 1 ½ conditions			
- Overall deposit demerit rating (100hrs)		80.0 max	Passes
- Viscosity change @ 40°C (104°F)	%	–5 to +30	Passes
- Total acid number change	mgKOH/g	2 max	Passes
- Filter deposits	g	3.0 max	Passes
Sonic shear stability viscosity change at 40°C (104°F)	%	4 max	0.19
Trace metal content		Must pass	Passes
Sediment	mg/l	Must pass	Passes

AeroShell Turbine Oil 500 is also approved for use in the industrial and marine versions of the Siemens Trent, Avon, SGT-A05 (formerly 501K) and 570K, Honeywell TF35, Mitsubishi Power GG3/FT3, GG4/FT4, GG12/FT12, all General Electric LM Series of units, Safran Helicopter Engines industrial engines and certain Solar gas turbine engines.

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

AEROSHELL TURBINE OIL 555

AeroShell Turbine Oil 555 is an advanced 5 mm^2/s synthetic hindered ester oil incorporating a finely balanced blend of additives to improve thermal and oxidation stability and to increase the load carrying ability of the base oil.

APPLICATIONS

AeroShell Turbine Oil 555 was specifically developed to meet the high temperatures and load carrying requirements of SST engines and the DEF STAN 91-100 (formerly DERD 2497) and XAS-2354 specifications. AeroShell Turbine Oil 555 was also designed to give enhanced performance in current engines.

More recently with the need to transmit more power and higher loads through helicopter transmission and gearbox systems (many helicopters use a synthetic turbine engine oil in the transmission/gearbox system) it has become apparent that the use of a very good load carrying oil, such as AeroShell Turbine Oil 555 is necessary. This in turn has led to the development of a U.S. Military Specification, DOD-L-85734 (now DOD-PRF-85734A), which covers a helicopter transmission oil against which AeroShell Turbine Oil 555 is fully approved.

AeroShell Turbine Oil 555 contains a synthetic ester oil and should not be used in contact with incompatible seal materials and it also affects some paints and plastics. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	Approved DOD-PRF-85734A
British	Equivalent DEF STAN 91-100
French	-
Russian	-
NATO Code	O-160
Joint Service Designation	OX-26
Pratt & Whitney	Approved 521C Type II
General Electric	Approved D-50 TF 1
Allison	Approved EMS-53 (Obsolete)

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Turbine Oil 555 is approved for use in all models of the following engines:

Honeywell	APU series: 131, GTCP 30, 36, 85 (except -99), 331 and 660; RE100, 220; HGT 400, 750 and 1700; TSCP 700. Engine series: T53, AL5512, ALF502, LF507, TPE331, CTS800.
General Electric	CT58, CT64, CF700, CJ610
Motorlet	M601D, E and Z
Pratt & Whitney	JT3, JT4A, JT8D, JT9D, JT12A, PW4000
Pratt & Whitney Canada	ST6
Rolls-Royce	Adour, Gem, LiftFan, M45H, Olympus, RB199, Tyne
Safran Helicopter Engines (formerly Turbomeca)	MTR390, RTM322. Approved with restrictions*: Artouste (some models) Astazou, AST 950, Bastan

*Please refer to Safran Helicopter Engines manual for details.

AeroShell Turbine Oil 555 is also approved for use in the industrial and marine versions of the Siemens (formerly Rolls-Royce) RB211-22 and Olympus engines, General Electric LM 100, 250, 350, 1500 and 2500 engines.

EQUIPMENT MANUFACTURERS' APPROVALS – HELICOPTER TRANSMISSIONS

AeroShell Turbine Oil 555 is approved for an increasing number of helicopter transmissions, whilst details are listed below, it is important that operators check latest status with the helicopter manufacturer. In all cases it is important to check compatibility with seals used in the transmission/gearbox.

U.S. Military	Approved for helicopter transmission specification DOD-PRF-85734A
Eurocopter	Approved for Super Puma, for other helicopters check with Eurocopter
Agusta	Approved for A109 and A129 models, for other models check with Agusta
Bell Helicopter Textron	Approved for all Bell turbine engine powered helicopters
Boeing Vertol	Approved for Chinook
McDonnell Douglas	Approved
MBB	Approved
Sikorsky	Approved for S-61N (note other types such as the S-70 and S-76 do not use synthetic turbine oils in the transmission)
Leonardo Helicopters (formerly Westland Helicopters)	Approved for some models

PROPERTIES		DOD-PRF-85734A	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		4.90 to 5.40	5.2
@ 40°C (104°F)		23.0 min	26.5
@ –40°C (–40°F)		13000 max	11000
Flashpoint Cleveland Open Cup	°C (°F)	246 (474) min	258 (496)
Pourpoint	°C (°F)	–54 (–65) max	< –60 (–76)
Total acidity	mgKOH/g	0.75 max	0.4
Evaporation loss 6.5 hrs @ 204°C	%m	10 max	1.5
Foaming characteristics	ml	Must pass	Passes
Swelling of standard synthetic rubber			
SAE AMS3217/1			
72 hrs @ 70°C (158°F)	swell %	5 to 25	14
SAE AMS3217/4			
72 hrs @ 204°C (399°F)	swell %	5 to 25	14
Thermal stability/corrosivity (96 hrs)			
- metal weight change @ 274°C (525°F)	mg/cm^2	4.0 max	Passes
- viscosity change	%	5.0 max	1.4
- Total acid number change	mgKOH/g	6.0 max	2.6

Table continued

Table continued

PROPERTIES		DOD-PRF-85734A	TYPICAL
Corrosion & oxidation stability			
72 hrs @ 175°C (347°F)		Must pass	Passes
72 hrs @ 204°C (399°F)		Must pass	Passes
72 hrs @ 218°C (424°F)		Must pass	Passes
Ryder gear test, relative rating			
Hercolube A	%	145 min	Passes
Bearing Test Rig Type 1 ½ conditions			
- Overall deposit demerit rating		80.0 max	Passes
- Viscosity change @ 40°C (104°F)	%	0 to +35	Passes
- Total acid number change	mgKOH/g	2.0 max	Passes
- Filter deposits	g	3 max	Passes
Sonic shear stability			
- viscosity change at 40°C (104°F)	%	4 max	0.3
Trace metal content	ppm	Must pass	Passes
Sediment	mg/l	10 max	Passes
Ash	mg/l	1 max	Passes

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

NOTES

AEROSHELL TURBINE OIL 560

AeroShell Turbine Oil 560 is a third generation, high performance, low coking 5 mm^2/s synthetic hindered ester oil incorporating a carefully selected and finely balanced combination of additives to improve thermal and oxidation stability.

APPLICATIONS

Changes which have taken place over the last twenty years in engine performance (in terms of improved fuel consumption, higher operating temperatures and pressures) and maintenance practices have resulted in increased severity in lubricant operating conditions.

AeroShell Turbine Oil 560 was developed to withstand the hostile environments of today's high powered, high compression engines in which the older generation of oils can be stressed up to and beyond their thermal limits, as evidenced by oil coking in the high temperature bearing areas.

By overcoming the problems associated with using old technology oils in new technology engines, AeroShell Turbine Oil 560:

- maintains a cleaner engine
- provides improved load carrying capacity
- reduces maintenance costs
- prolongs bearing life

in both new and existing engines.

In order for military authorities to take advantage of this better performance in military engines the specification MIL-PRF-23699 was re-written to include a "High Thermal Stability" (HTS) grade as well as the Standard (STD) and Corrosion Inhibited (C/I) grades. AeroShell Turbine Oil 560 is fully approved as an HTS oil. With the advent of the new civil turbine oil specification, SAE AS5780, which has more stringent requirements than the military specification, AeroShell Turbine Oil 560 was approved as a SPC (Standard Performance Capability) oil.

With effect from January 1st 2002, AeroShell Turbine Oil 560 has been manufactured with an improved formulation to further enhance its anti-coking performance.

AeroShell Turbine Oil 560 contains a synthetic ester oil and should not be used in contact with incompatible seal materials and it also affects some paints and plastics. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	Approved MIL-PRF-23699G Grade HTS Approved SAE AS5780D Grade SPC
British	Equivalent DEF STAN 91-101 Grade OX-27
French	Equivalent DCSEA 299/A
Russian	Analogue to VNII NP 50-1-4F, B3V, LZ-240, VNII NP 50-1-4U and 36/Ku-A
NATO Code	O-154
Joint Service Designation	OX-27
COMAC	Approved QPL-CMS-OL-202
Pratt & Whitney	Approved 521C Type II
General Electric	Approved D-50 TF 1
Allison	Approved EMS-53 (Obsolete)

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Turbine Oil 560 is approved for use in all models of the following engines:

Honeywell	APU series: 131, GTCP 30, 36, 85 (except -99), 331 and 660; RE100, 220; HGT 400, 750 and 1700 Engine series: TPE 331, LTS 101, LTP 101, ALF 502, LF 507, AS907, AS977
CFM International	CFM 56 and LEAP series
Collins Aerospace	All IDGs and VSFGs
Engine Alliance	GP7200
General Electric	CF34, CF6, CJ610, CF700, GE90, GEnx, Passport
IAE	V2500
Pratt and Whitney AeroPower (formerly Hamilton Sundstrand)	APS 500, 1000, 2000, 3000
Pratt & Whitney	JT3D, JT8D, JT9D, PW4000 Series (cleared for flight evaluation in PW2000 engines), F117-PW-100
Pratt & Whitney Canada	Engine series: JT15D, PT6 Series, PW100 Series (except PW150), PW200 Series, PW300 Series, PW500 Series, PW600 Series APU series: PW901A/C, PW980
Rolls-Royce	250 Series, Avon, BR700 Series, Spey, Tay, Tyne, RB199, RB211 Series
Safran Helicopter Engines (formerly Turbomeca)	Ardiden, Arriel, Arrius, Arrius 1D, AST 600, Astazou XVI, Makila, TM333. Approved with restrictions*: Artouste, AST 950, Bastan, Turmo

*Please refer to Safran Helicopter Engines manual for details

PROPERTIES		MIL-PRF-23699G Grade HTS SAE AS5780D Grade SPC	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		4.90 to 5.40	5.21
@ 40°C (104°F)		23.0 min	26.7
@ –40°C (–40°F)		13000 max	10229
Flashpoint Cleveland Open Cup	°C (°F)	246 (474) min	262 (503)
Pourpoint	°C (°F)	–54 (–65) max	–60 (–76)
Total acidity	mgKOH/g	1.00 max	0.20
Evaporation loss 6.5 hrs @ 204°C (399°F)	%m	10 max	2.0
Foaming tendency		Must pass	Passes
Swelling of standard synthetic rubber SAE AMS3217/4 72 hrs @ 204°C (399°F)	swell %	5 to 25	12.9
Elastomer compatibility, % weight change after 24/120 hours:			
Fluorocarbon @ 200°C (392°F)		10/15 max	Passes
LCS Fluorocarbon @ 200°C (392°F)		10/20 max	Passes
Nitrile @ 130°C (266°F)		19.5/22 max	Passes
Silicone @ 175°C (347°F)		16.5/16.0 max	Passes
Perfluoroelastomer @ 200°C (392°F)		N/A	Passes
Thermal stability/corrosivity 96 hrs @ 274°C (525°F)			
- metal weight change	mg/cm^2	± 4.0 max	Passes
- viscosity change @ 37.8°C (100°F)	%	5.0 max	0.3
- Total acid number change	mgKOH/g	6.0 max	1.5

Table continued

Table continued

PROPERTIES		MIL-PRF-23699G Grade HTS SAE AS5780D Grade SPC	TYPICAL
Corrosion & oxidation stability			
72 hrs @ 175°C (347°F)		Must pass	Passes
72 hrs @ 204°C (399°F)		Must pass	Passes
72 hrs @ 218°C (424°F)		Must pass	Passes
HLPS dynamic coking @ 375°C (707°F)			
@ 20hrs	Deposit mg	4.0 max	0.17
Ryder gear test, relative rating			
Hercolube A	%	102 min	Passes
Bearing Test Rig Type 1 ½ conditions			
- Overall deposit demerit rating	200 hrs	40 max	Passes
- Viscosity change @ 40°C (104°F)	%	0 to 30	Passes
- Total acid number change	mgKOH/g	2 max	Passes
- filter deposits	g	1.5 max	Passes
Sonic shear stability			
viscosity change at 40°C (104°F)	%	4.0 max	0.3
Trace metal content		Must pass	Passes
Sediment		Must pass	Passes

AeroShell Turbine Oil 560 is also approved for use in the industrial and marine versions of the Siemens (formerly Rolls-Royce) RB211-22, Avon, Spey, Olympus and Tyne engines, Mitsubishi Power GG3/FT3, GG4/FT4, GG12/FT12, GG8/FT8 engines, all General Electric LM Series of units, some Honeywell and Safran Helicopter Engines industrial engines and certain Solar gas turbine engines.

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

NOTES

AEROSHELL TURBINE OIL 750

AeroShell Turbine Oil 750 is a 7½ mm^2/s synthetic mixed ester oil containing a thickener and additives which provide excellent load carrying, thermal and oxidation stability.

APPLICATIONS

AeroShell Turbine Oil 750 was developed to meet the requirements of DERD 2487 (now DEF STAN 91-098) and to provide a high standard of lubrication in British civil gas turbines, particularly turbo-prop engines where a good load carrying oil was required for the propeller reduction gearbox.

AeroShell Turbine Oil 750 is also approved by the Russian authorities as an analogue to MN-7.5u and for those Russian turbo-prop applications which require the use of mixtures of mineral turbine oil and aircraft piston engine oil.

AeroShell Turbine Oil 750 contains a synthetic ester oil and should not be used in contact with incompatible seal materials and it also affects some paints and plastics. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	-
British	Approved DEF STAN 91-098 (replaces DERD 2487)
French	Equivalent to AIR 3517/A
Russian	Analogue to TU 38.1011722-85 Grade MN-7.5u
NATO Code	O-149 (equivalent O-159)
Joint Service Designation	OX-38

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Turbine Oil 750 is approved for use in all models of the following engines:

Honeywell	Auxiliary Power Units (some models)
Pratt & Whitney Canada	PT6 (some models)
BMW-Rolls-Royce	Dart, Tyne, Avon (some early models only), Gnome, Pegasus, Palouste, Nimbus, Proteus, Orpheus, Olympus 200 and 300
Sikorsky	S-61N transmissions
Soloviev	D30 engine
Safran Helicopter Engines (formerly Turbomeca)	Turmo. Approved with restrictions*: Arriel, Artouste, Astazou, Bastan, Malika

*Please refer to Safran Helicopter Engines manual for details

PROPERTIES		DEF-STAN 91-98	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Density @ 15°C (59°F)	kg/m^3	Report	947
Kinematic viscosity	mm^2/s		
@ 40°C (104°F)		36.0 max	32
@ 100°C (212°F)		7.35 min	7.47
@ –40°C (–40°F)		13000 max	10140
@ –40°C after storage @ –54°C (–65°F) for 12 hr		-	10800
Flashpoint Cleveland Open Cup	°C (°F)	216 (420) min	242 (467)
Pourpoint	°C (°F)	–54 (–65) max	Below –54 (–65)
Total acidity	mgKOH/g	Report	0.03
Foaming characteristics		Must pass	Passes
Sediment	mg/l	10 max	Less than 10
Total ash of sediment	mg/l	1 max	Less than 1
Trace metal content		Must pass	Passes
Elastomer swell tests		Must pass	Passes
Corrosivity, metal weight change		Must pass	Passes
Gear machine rating		Must pass	Passes
Shear stability			
- viscosity change @ 40°C (104°F)	%	2 max	Less than 2
- condition of oil		Must pass	Passes
Compatibility and miscibility		Must pass	Passes
Homogeneity			
@ 210°C (410°F)		Must pass	Passes
@ –40°C (–40°F)		Must pass	Passes

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

NOTES

AEROSHELL ASCENDER

AeroShell Ascender is a "fourth generation" turbine engine oil developed with a high performance, low coking, 5 mm^2/s synthetic hindered ester basestock combined with a state of the art additive system, to both improve thermal and oxidation stability and provide superior elastomer compatibility.

FEATURES & BENEFITS

The value of AeroShell Ascender lies in its ability to deliver both low coking and elastomer compatibility/seal integrity. Until recently, it had been commonly accepted that the two are mutually exclusive, so that improving the oil's properties in one regard meant compromising the other.

For airline operators, this problem can be expensive in terms of prematurely degraded seals. With AeroShell Ascender, Shell Aviation has developed a product that now deals with this problem so operators no longer have to choose between coking performance and elastomer compatibility.

FEATURES	BENEFITS
Excellent elastomer seal compatibility	Reduced chance of seal swell or degradation leading to high oil consumption and cost of changing the seals
Low coking performance	Less chance of oil coke build-up in bearing chambers and service pipes resulting in lower maintenance and cleaning costs
Improved oxidation and thermal stability	Extended oil life during arduous engine conditions
Excellent compatibility with other approved oils	No issues or concerns when changing from one approved oil to AeroShell Ascender
A 'High Performance Capability' grade oil	Improved performance over traditional 'standard' grade oils can help reduce maintenance costs and extend engine life

APPLICATIONS

AeroShell Ascender was developed for the latest generation of gas turbine engines as a low-coking, high compatibility product. Its improved thermal and oxidative stability will ensure negligible coke formation in engines, so any traditional engine problems associated with coke should never occur. It has also been tested extensively for elastomer compatibility, which is a known service problem. AeroShell Ascender therefore offers the customer the balance of low coking performance with excellent elastomer compatibility.

AeroShell Ascender will also deliver performance benefits in today's existing high powered, high compression engines in which the older generation of oils can be stressed up to and beyond their thermal limits, as evidenced by oil coking in the high temperature bearing areas.

SPECIFICATIONS

U.S.	Approved SAE AS5780D Grade HPC Approved MIL-PRF-23699G Grade HTS
British	Equivalent DEF STAN 91-101 Grade OX-27
French	Equivalent DCSEA 299/A
Russian	-
NATO Code	O-154
Joint Service Designation	OX-27
Pratt & Whitney	Approved 521C Type II
General Electric	Approved D-50 TF 1

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Ascender is approved for use in all models of the following engines:

General Electric	GEnx, Passport, Catalyst
GE Honda	HF120 series
Pratt & Whitney AeroPower	APS 500, 1000, 2000, 3000
Pratt & Whitney Canada	PW307A/D
Rolls-Royce	Trent series, RB211 series, BR700 series
Siemens (Industrial Gas Turbines)	SGT-A05 (501K), SGT-A65 (Trent 60)

For latest engine approval status, please contact your Shell Aviation representative.

PROPERTIES		**SAE AS5780D Grade HPC MIL-PRF-23699G Grade HTS**	**TYPICAL**
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		4.90 to 5.40	5.02
@ 40°C (104°F)		23.0 min	25.77
@ –40°C (–40°F)		13000 max	< 12000
Flashpoint Cleveland Open Cup	°C (°F)	246 (475) min	266 (511)
Pourpoint	°C (°F)	–54 (–65) max	< –54 (–65)
Total acidity	mgKOH/g	1.0 max	0.26
Evaporation loss 6.5 hrs @ 204°C (399°F)	%m	10.0 max	2.0
Swelling of standard synthetic rubber SAE AMS3217/4 72 hrs @ 204°C (399°F)	swell %	5 to 25	16.24
Foaming tendency		Must pass	Passes

Table continued

Table continued

PROPERTIES		SAE AS5780D Grade HPC MIL-PRF-23699G Grade HTS	TYPICAL
Elastomer compatibility, % weight change after 24/120 hours:			
Fluorocarbon @ 200°C (392°F)		11/15 max	Passes
LCS Fluorocarbon @ 200°C (392°F)		12/20 max	Passes
Nitrile @ 130°C (266°F)		19/19.5 max	Passes
Silicone @ 175°C (347°F)		14.5/14.5 max	Passes
Perfluoroelastomer @ 200°C (392°F)		2/2 max	Passes
Thermal stability/corrosivity 96 hrs			
- metal weight change	mg/cm^2	± 4.0 max	Passes
- viscosity change	%	± 5.0 max	0.2
Total acid number change	mgKOH/g	6.0 max	1.4
Corrosion & oxidation stability			
72 hrs @ 175°C (347°F)		Must pass	Passes
72 hrs @ 204°C (399°F)		Must pass	Passes
72 hrs @ 218°C (424°F)		Must pass	Passes
Ryder gear test, relative rating			
Hercolube A	%	102 min	Passes
Bearing test rig Type 1 ½ conditions			
- Overall deposit demerit rating	200 hrs	40 max	Passes
- Viscosity change @ 40°C (104°F)	%	0 to +35	Passes
- Total acid number change	mgKOH/g	2.0 max	Passes
- filter deposits	g	1.5 max	Passes
HLPS dynamic coking @ 375°C (707°F)			
@ 20 hours, Deposit mg		0.4 max	0.23
@ 40 hours, Deposit mg		0.6 max	0.32
Sonic shear stability			
- viscosity change at 40°C (104°F)	%	4 max	0
Trace metal content		Must pass	Passes
Sediment		Must pass	Passes

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

AERO DERIVED IGTs: APPROVED STATUS OF AEROSHELL TURBINE OILS

ENGINE MANUFACTURER	ENGINE MODEL	AEROSHELL TURBINE OIL 390	500	555	560	750	Ascender
General Electric	LM100, 150, 250 and 350		✓	✓	✓		
	LM2500		✓	✓	✓		
	LM5000		✓		✓		
	LM6000		✓		✓		
	LMS100		✓		✓		
Honeywell	TF-25, -35, -40		*		*		
Mitsubishi Power (formerly Turbo Power & Marine (P&W))	GG3 / FT3		✓		✓		
	GG4 / FT4		✓		✓		
	GG12 / FT12		✓		✓		
	GG8 / PT8				✓[5]		
Mitsubishi Power (formerly Pratt & Whitney Canada)	ST6-75, -76		✓		✓		
	ST6-73		✓	✓[1]	✓		
	ST6A, ST6B, ST6J, ST6K, ST6L		✓		✓		
Siemens (formerly Rolls-Royce)	Trent (SGT-A65)						✓
	Avon	✓	✓		✓		
	Gnome					✓	
	Olympus			✓	✓	✓	
	Proteus					✓	
	RB211-22 (SGT-A35)			✓[2]	✓[3]		✓
	RB211-24 (SGT-A35)				✓[3]		✓
	Spey Industrial	✓					
	Spey Marine				✓		
	Tyne				✓	✓	

Table continued

Table continued

ENGINE MANUFACTURER	ENGINE MODEL	AEROSHELL TURBINE OIL 390	500	555	560	750	Ascender
Siemens (formerly Allison)	501K (SGT-A05)		✓				✓
	570K		✓				
	571K		✓				
Solar Turbine	Centaur		✓[4]		✓[4]		
	Mars		✓[4]		✓[4]		
	Saturn		✓[4]		✓[4]		
Safran Helicopter Engines (formerly Turbomeca)	Astagaz XII & XIV	✓	✓			✓	
	Astazou IV	✓				✓	
	Bastangaz IV, VI, VII	✓	✓				
	Oredon IV	✓	✓				
	Turmagaz III	✓				✓	

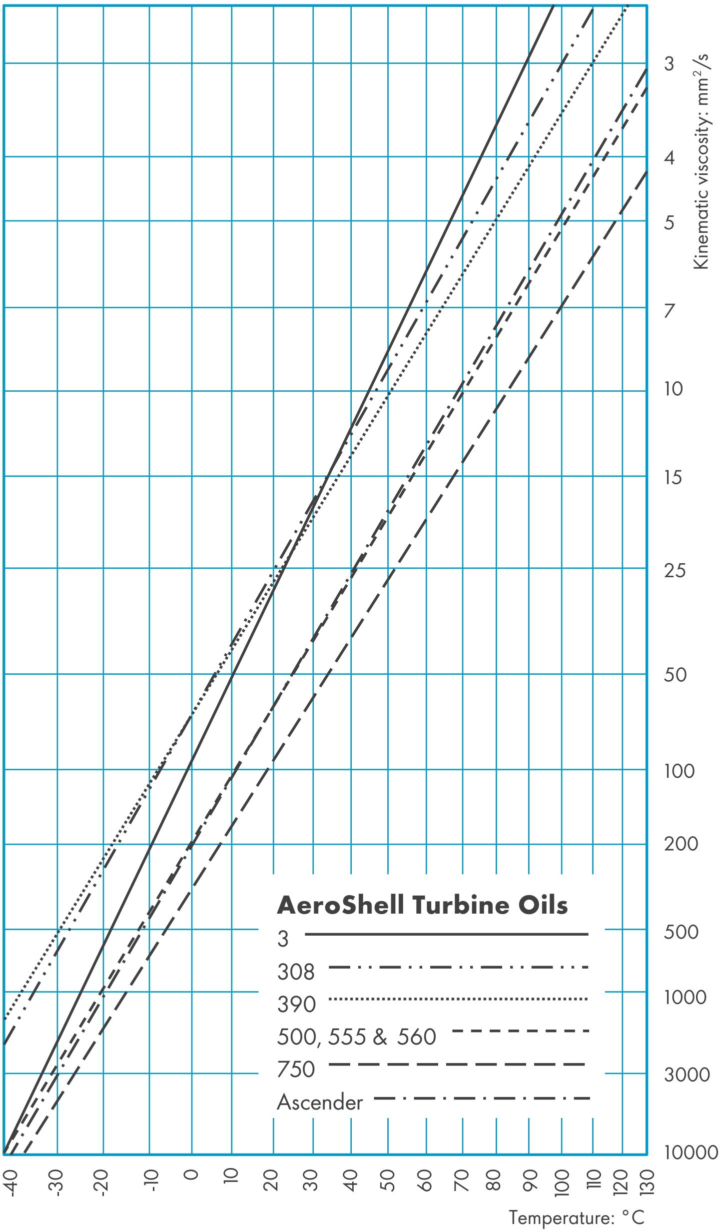
NOTES:

✓ Approved

* Consult the engine manufacturer for details on latest approvals.

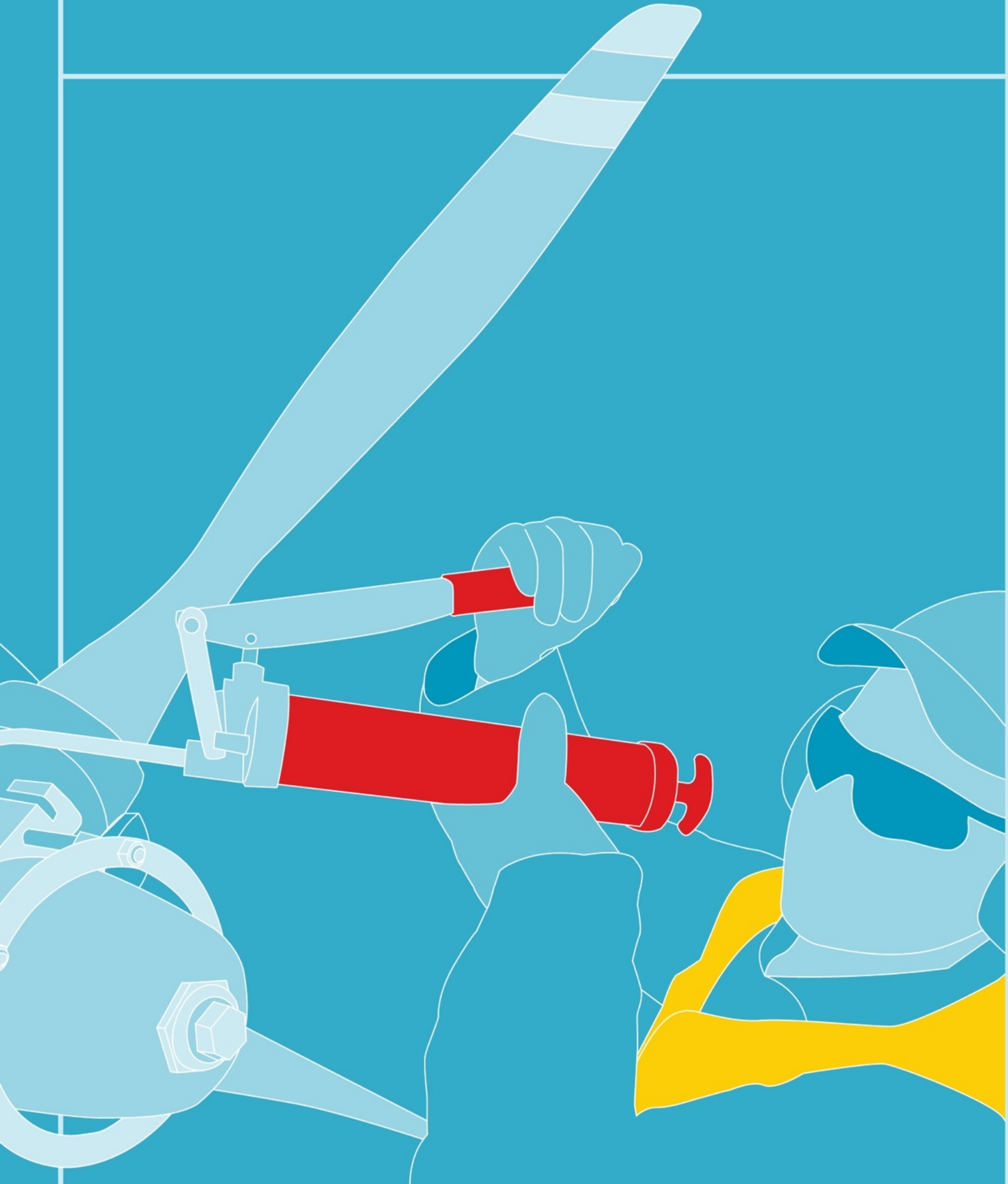
(1) AeroShell Turbine Oil 555 can be used if SB 49-59 has been incorporated
(2) 22/Mk1 lube system combinations only
(3) 10,000 hours max. on Viton "O" seals (Pre-Mod.1017)
(4) Oils approved on a unit by unit basis, not all units can use synthetic oils thus the manual for specific unit must be consulted or the unit manufacturer contacted.
(5) Service evaluation required.

TYPICAL TEMPERATURE/VISCOSITY CURVES OF AEROSHELL TURBINE OILS



NOTES

AEROSHELL GREASES



5. AEROSHELL GREASES

ABOUT GREASES

The definition of a grease is "A solid or semi-solid lubricant comprising a dispersion of a thickening agent in a liquid lubricant to which various additives have been added to improve particular properties".

So how is a grease made?

All greases consist basically of a base oil, a thickener (essentially a lattice which gives the stable semi solid consistency) and performance improving additives. Varying these three basic ingredients leads to different greases suitable for a vast range of applications. However, in broad terms, a typical grease would consist of about 80% - 90% base oil, 10% - 15% thickener and about 5% - 10% additives.

When they are used as lubricants, greases behave like oils in many ways. They reduce friction by providing a film which separates moving surfaces and it is actually oil that carries out this lubrication rather than the grease itself. However, unlike oils, greases have the advantage that they tend to stay where they are put.

They are less likely than oils to leak out of a machine and less likely to flow away from the surface that they lubricate under the effect of gravity or centrifugal forces. At the same time, and this can be significant in many airframe applications, greases can form an effective seal against moisture and solid contaminants.

Within the aviation industry, there are many grease lubricated applications covering a very wide range of performance requirements. Those requirements are being increasingly stretched through new technology developments and extended service intervals.

Many different grease formulations have been developed to meet specific requirements. One of Shell's recent objectives, as a major supplier of aviation greases, has been the development of wide performance range products where a single grease can cover a multitude of applications.

Greases, depending on the thickening agent, are broadly classified as either soap-based or non-soap-based. The soap-based greases include, for example, aluminum, calcium, sodium or lithium soaps; the non-soaps silica gel, clay and substituted urea.

The low melting points and water solubility of some soap greases limit their usefulness. As a result alternative thickening agents have been developed – soap-complex thickened greases, and non-soap greases with a much higher or no melting point. These thickening agents were developed for greases needing superior high temperature performance characteristics. Shell's search for thickeners without the limitations of the simple soap-type, led to a family of proprietary technologies including our 'Microgel®' and Lithium-Complex systems.

Microgel® greases rely on an inorganic grease thickening agent, based on hectorite clay, which has several advantages over simple soap-type thickeners. It provides the AeroShell greases in which it is used with excellent physical properties, as shown below. Those properties make them particularly suitable for multi-purpose as well as specialised applications.

1. No melting point, within any conceivable temperature range for aircraft greases.
2. Very little change in consistency with variation in temperature.
3. Extremely good load carrying ability without the need for extreme pressure additive.
4. Excellent water resistance due to the use of tenacious waterproofing agents developed by Shell.
5. Low oil separation or 'bleeding', because of the high gelling efficiency.

During recent years, the number of greases required for aircraft lubrication/maintenance has been reduced by more extensive use of multi-purpose greases. However, because of commercial and technological limitations, special greases are still required. Most aircraft grease requirements are covered by the products in the AeroShell grease range.

To minimise the number of greases required per aircraft, the most widely used specification in the aviation industry today is the general purpose grease to MIL-PRF-23827.

In the early 2000's the Boeing Company introduced a multi-purpose grease specification (BMS 3-33) to replace many of the different greases previously required in support of Boeing aircraft. This has led to the development of the accompanying specification SAE AMS3052. The only grease to meet the most challenging set of requirements of the initial BMS 3-33A specification has been AeroShell Grease 33.

This ground breaking grease, based on a Lithium-Complex thickener system, has a superior capacity to accommodate a wide range of proprietary performance additives. This thickener system now forms the basis for future grease developments in the AeroShell grease family.

Detailed information for each AeroShell grease is given in this section.

Base Oils

Aeroshell Grade	Base Oil		
	Mineral	Synthetic	
		Hydrocarbon	Ester
AeroShell Grease 5	✓		
AeroShell Grease 6	✓		
AeroShell Grease 7			✓
AeroShell Grease 14	✓		
AeroShell Grease 22		✓	
AeroShell Grease 33		✓	✓
AeroShell Grease 58		✓	
AeroShell Grease 64		✓	✓

Choosing a base oil for a grease is essentially determined by the type of application the grease will be used for. For example, with mineral oil based greases, if the application involves heavy load conditions a heavy viscosity base oil will be used (for example in AeroShell Grease 5 which is commonly used in General Aviation as an undercarriage wheel bearing grease).

However, high viscosity mineral oils do not perform well at low temperature as they become too thick, and so for more general use a lighter base oil will be used. This is the case with the general purpose AeroShell Grease 6 which has an operating temperature range of –40°C to +121°C (–40°F to +250°F) compared with–18°C to +149°C (–0.4°F to +300°F) for AeroShell Grease 5.

There are few airframe applications which exceed the 121°C (250°F) limit of AeroShell Grease 6, but wheel bearings using AeroShell Grease 5 will sometimes be exposed to high temperatures with high rolling friction and hard braking which takes into account the 149°C (300°F) upper limit for this grade.

It is therefore important to use the correct grade for the correct use.

Greases which are required to operate over a very wide temperature range are often base on synthetic oils, often derived from esters rather then mineral oils. However, these oils are more aggressive to seal materials and should not be used unless specified for your aircraft. An example of a grease with a synthetic base oil is another multipurpose grease, AeroShell Grease 7, which is used extensively on commercial aircraft where there is frequent exposure to extremely low temperatures at altitude. AeroShell Grease 7 has an operating temperature range of –73°C to +121°C (–99°F to 250°F)002E

Although not normally part of the specification requirements, typical base oil viscosities have been quoted for the majority of AeroShell Greases.

Thickening Agents

Aeroshell Grade	Thickener		
	Microgel	Lithium Complex	Calcium Soap
AeroShell Grease 5	✓		
AeroShell Grease 6	✓		
AeroShell Grease 7	✓		
AeroShell Grease 14			✓
AeroShell Grease 22	✓		
AeroShell Grease 33		✓	
AeroShell Grease 58		✓	
AeroShell Grease 64		✓	

The amount and type of thickening agent used in making a grease has the biggest effect on its consistency, that is its softness or stiffness. The thickener does not perform any lubrication - that is the job of the oil - but it does hold the oil in a lattice rather like a sponge. Again like a sponge, when pressure or stress is applied, oil is released which then lubricates the mechanism and, when the stress is released, the thickener and oil return to a semi-solid state.

The consistency of greases can vary from very soft, semi-fluid cream like consistencies through to hard wax-like solids. The consistency is measured by allowing a standard metal cone to sink into the grease and measuring its penetration. This is often called the Unworked Penetration value of the grease.

Most greases tend to soften slightly when heavily worked and the ability of the grease to resist changes in consistency during working is an important characteristic, particularly if vibration is present. This "Working Stability" is quantified by working the grease with perforated mechanical plunger and measuring it penetration value afterwards, the result often being referred to as the "Worked Penetration" value of the grease. The difference between the worked and unworked penetration values gives an indication of the working stability of the grease.

The majority of aviation greases have unworked penetration values of around 260 to 320, which is the normal consistency suitable for roller bearings, but also can be suited to fretting and sliding type applications as demonstrated by AeroShell Grease 14, the leading multi purpose Helicopter grease.

The common types of thickeners are generally "soap" based or "clay" based. A soap is a salt formed when a metal hydroxide, or alkali, is reacted with a fatty acid; a kind of organic acid derived from fats. The first greases were made with Calcium and Sodium soaps but Lithium soaps, and less commonly Aluminium and Barium soaps, are now also being used.

Calcium soaps have a smooth texture and have good water resistance, but have very low operating temperatures normally not more that 60°C (140°F). This can be improved by reacting the Calcium soap with organic acids to form a Calcium Complex thickener. It is a Calcium Complex thickener that is used in the helicopter grease AeroShell Grease 14 which has a temperature range of –54°C +75°C (-65°F to 167°F).

Sodium soaps have a higher melting point than plain Calcium soaps, have a fibrous texture and have good adhesive properties. However, they have relatively poor water resistance and risk suffering water washout in very wet conditions.

Lithium soaps have a butter like texture, relatively high temperature (up to about 135°C/275°F) and have good water resistance.

However, all of the soap thickeners are limited by their high temperature performance as the thickeners tend to melt and the grease softens markedly.

COMPATIBILITY WITH MATERIALS

When using greases containing a synthetic oil, particularly an ester oil, the compatibility with sealing materials, plastics or paints has to be examined.

Greases with a silicone oil base should not be used when silicone elastomers are present.

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.

Elastomer/ Plastic	Mineral Oil Based Greases	Synthetic Hydrocarbon Based Greases	Synthetic Ester Based Greases
Flurocarbon (Viton)	Very Good	Very Good	Very Good
Acylonitrile	Good	Good	Poor to Good (high nitrile content is better)
Polyester	Good	Good	Poor to Fair
Silicone	Poor to Good	Poor to Good	Poor to Fair
Teflon	Very Good	Very Good	Very Good
Nylon	Poor to Good	Poor to Good	Poor
Buna-S	Poor	Poor	Poor
Perbunan	Good	Good	Fair to Good
Methacrylate	Good	Good	Poor to Fair
Neoprene	Fair to Good	Fair to Good	Poor
Natural Rubber	Poor to Fair	Poor to Fair	Poor
Polyethylene	Good	Good	Good
Butyl Rubber	Very Poor to Poor	Very Poor to Poor	Poor to Fair
Poly Vinyl Chloride	Poor to Good	Poor to Good	Poor

Compatibility Rating:
Very Good - Good - Fair - Poor - Very Poor

COMPATIBILITY AND INTERMIXING OF GREASES

What is grease incompatibility? The National Lubricating Grease Institute (NLGI) definition states that two greases show incompatibility when a mixture of the products shows physical properties or service performance which are markedly inferior to those of either of the greases before mixing. Performance or properties inferior to one of the products and superior to the other may be due to simple mixing and would not be considered as evidence of incompatibility; this is sometimes referred to as "performance dilution".

In general, mixing of greases made with different thickener types should be avoided; thus Microgel® or clay thickened greases should not be mixed with soap thickened (e.g. lithium complex) greases as this can lead to breakdown of the thickener structure. Incompatibility between greases can also arise from additive interactions. In some cases, different greases approved to the same specification may be incompatible with each other; to account for this, the MIL-PRF-23827C specification was amended to divide approved greases into Type I (soap-based) and Type II (clay-based).

GREASE SERVICING

Oil Separation

Oil separation to a greater or lesser extent occurs with all greases. Unless the separation is excessive the grease can be used providing it is stirred well before use.

Grease Changeover

Airframe and grease manufacturers do not recommend intermixing different types or brand names of grease, even if they are considered optional to each other, because of possible incompatibility.

When changing over from one type or brand name grease to another, the recommended practice is to remove all of the old grease from the bearing surfaces and internal cavities of the lubricated mechanism prior to application of the new grease. If this is not possible or practicable, then the "purging" technique should be employed.

Generally, "purging" is defined as "the process of injecting grease into the grease fitting until the old grease has been visibly exhausted from the mechanism and only the new grease is coming out." It is advisable to seek information from the aircraft manufacturers and their maintenance manuals for their recommendations regarding purging procedures.

Note: The definition of purging is not specific to the substitution of greases and applies equally to routine re-greasing with the same grease where the object in this case is to expel contaminants such as wear debris, dust, dirt and water which may have accumulated in the grease during service. That is, purging should always be done where the design of the lubricated component is amenable to this purging process.

Always consult the Aircraft Maintenance Manual, Maintenance Planning Document or Component Overhaul Manual, and any associated Service Bulletins for advice on the correct grade of grease to be used in a particular mechanism and on the method of application and/or replacement of that grease. The latest issues of the following publications can be consulted for advice:

- Boeing Service Letter 707-SL-20-012-C/727-SL-20-022C/737-SL-20-027-C/747-SL-20-044-C/757-SL-20-022-C/767-SL-20-022-C/777-SL-20-006-C "Summary of Most Commonly Used Greases on Boeing Airplanes"
- Airbus Service Information Letter SIL 12-008 "General Purpose Aviation Greases Functional Interchangeability"
- FAA Flight Standards Information Bulletin for Airworthiness FSAW 02-02C "The Potential Adverse Effects of Grease Substitution"

After changing from one type or brand of grease to another, operators may choose to shorten the re-greasing interval by 50% for the following period and then revert to the normal re-greasing interval specified in the Aircraft Maintenance Manual. This will help to ensure that the new type or brand of grease has fully replaced the old.

It is not good practice to randomly or intermittently alternate between grease types or brands, even though they may be approved to the same grease specification. Grease manufacturers carefully balance the components in their greases for optimum performance. Therefore even if two different greases are not incompatible, it is unlikely that all mixtures of the two greases will maintain the same optimal performance as the individual greases ("performance dilution"). Once an action has been taken to change grease types or brands, then the chosen grease should always be used for subsequent re-greasing.

Wherever possible, use of a grease gun or grease in cartridges is recommended. If grease is used directly from tins or pails, it is important that wooden scrapers are not employed and that the tin lid is replaced firmly immediately the grease has been removed in order to prevent contamination by airborne dust, dirt and atmospheric moisture.

Operational Advice for Re-Greasing

When re-greasing a bearing with a grease gun, always apply enough grease for fresh, clean grease to be seen coming out of the bearing. This ensures that the bearing purged of the old, degraded grease which can then be wiped off and discarded.

The inspection or assembly of new bearings should be as follows:

- Wear protective gloves - not just for your own safety but also to prevent oil from your fingers from effecting the lubrication of the raceway.
- Remove the old bearing, clean off the old grease and rinse in a degreasing bath. Remove traces of old grease from the bearing housing and grease channels. If old grease cannot be removed from nipples, drillings and cut outs by cleaning alone, then apply fresh grease to the grease nipple and purge the channels whilst the bearing is removed.
- Inspect the old bearing and replace if outside limits.
- Having inspected the new or serviceable bearing, rinse the bearing through with Iso Propyl Alcohol (IPA) or a similar solvent to remove any traces of finger marks. The grease from your fingers can prevent some of the grease additives from bonding effectively with the bearing surfaces and so should be removed.
- Pack the bearing with fresh grease prior to assembly. Ensure that the race is full and wipe off any excess.
- Assemble the bearing to the manufacturer's instructions and using the correct tooling. Remember more bearings fail through improper assembly or misalignment than for any other reason.

APPLICATIONS

Whenever an aircraft is certified, all of the greases 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 greases which are qualified to be used. The U.S. Federal Aviation Administration (FAA) regulations state that only greases 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 greases should be used.

The majority of aviation grease specifications call for greases to be evaluated in the following tests:

- Drop point
- Penetration at 25°C (77°F), unworked/worked
- Evaporation loss in 22 hours (temperature varies according to specification)
- Corrosion, copper strip at 100°C (212°F)
- Water resistance at 40°C (104°F)

- Anti-friction bearing performance (temperature varies according to specification)
- Mean Hertz load
- Oil separation in 30 hours (temperature varies according to specification)
- Bomb oxidation pressure drop (conditions vary according to specification).

In addition most aviation grease specifications call up other tests which are either specific to the type of grease or to the intended application.

Useful Operating Temperature Range

The useful operating temperature ranges are quoted for guidance only. Continuous operation of equipment, with bearing temperatures at or in excess of these maximum and minimum limits for the grade in use, is not recommended.

AeroShell Greases in Non-Aviation Applications

In selecting an AeroShell Grease for a non-aviation application the properties of the greases 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.

Grease Selection

In selecting a grease for a particular application, the following should be considered:

- **Lubrication Requirements**
  - friction requirements
  - wear control
  - penetration
  - cooling (heat dissipation)
  - sealing
  - corrosion resistance
- **Engineering Component**
  - type of component
  - nature of contact (rolling, sliding, etc.)
  - load, speed and size
  - metallurgy/chemistry of component
  - geometrics/space constraints
- **Environment Factor**
  - temperature
  - atmosphere conditions (humidity, dirt/dust contamination)
  - ingress of water or other fluids
  - seal materials
  - health and safety
- **Endurance and Application**
  - method of application
  - re-lubrication interval
  - life expectancy of lubricant
  - life expectancy under exceptional conditions
  - life expectancy of component
  - need for protection against unexpected event
  - performance versus cost

NOTES

AEROSHELL GREASE 5

AeroShell Grease 5 is a high temperature grease composed of a mineral oil thickened with Microgel®, possessing good load-carrying ability. It is inhibited against oxidation and corrosion and has excellent resistance to water. The useful operating temperature range is –18°C to +149°C (–0.4°F to +300°F).

APPLICATIONS

AeroShell Grease 5 is particularly effective for use as a wheel bearing grease, especially when landing speeds are high, and is suitable for the lubrication of aircraft and engine accessories operating at high speeds and at relatively high temperatures, e.g. magnetos, generators and starters. For the lubrication of rolling bearings which are required to start at temperatures as low as –18°C (–0.4°F) an adequate period should be allowed for the grease to channel.

SPECIFICATIONS

U.S.	Meets MIL-G-3545C (Obsolete)
British	Meets DTD.878A (Obsolete)
French	Equivalent DCSEA 359/A
Russian	-
NATO Code	G-359
Joint Service Designation	XG-277 (Obsolete)

PROPERTIES		MIL-G-3545C	TYPICAL
Oil type		-	Mineral
Thickener type		-	Microgel
Base oil viscosity	mm^2/s		
@ 40°C (104°F)		-	500 to 525
@ 100°C (212°F)		-	32
Useful operating temperature range	°C (°F)	Up to 149 (300)	–18 to +149 (–0.4 to +300)
Drop point	°C (°F)	177 (350) min	260+ (500+)
Worked penetration @ 25°C (77°F)		250 to 300	284
Bomb oxidation pressure drop @ 99°C (210°F)			
100 hrs	psi	10 max	5
500 hrs	psi	25 max	9
Oil separation @ 100°C (212°F), in 30 hrs	%m	5 max	2.6
Water washout @ 41°C (105°F)	%m	20 max	3.6
Copper corrosion 24 hrs @ 100°C (212°F)		Must pass	Passes
Colour		-	Amber

AEROSHELL GREASE 6

AeroShell Grease 6 is a general purpose grease composed of a mineral oil thickened with Microgel®, possessing good all-round properties within a limited range. It is inhibited against oxidation and corrosion and has good water resistance and low noise capability.

The useful operating temperature range is –40°C to +121°C (–40°F to +250°F).

APPLICATIONS

AeroShell Grease 6 is a general purpose airframe grease for use in anti-friction bearings, gearboxes and plain bearings within the temperature range of –40°C to +121°C (–40°F to +250°F).

SPECIFICATIONS

U.S.	Approved MIL-PRF-24139A Meets MIL-G-7711A (Obsolete)
British	Meets DEF STAN 91-012 (Obsolete)
French	Equivalent DCSEA 382/A
Russian	-
NATO Code	G-382 (Aircraft Grease), G-450 (Naval Grease, obsolete)
Joint Service Designation	XG-271 (Obsolete), XG-274 (Obsolete)

PROPERTIES		MIL-PRF-24139A	TYPICAL
Oil type		Mineral	Mineral
Thickener type		-	Microgel
Base oil viscosity @ 40°C (104°F) @ 100°C (212°F)	mm^2/s	 - -	 35 5.5
Useful operating temperature range	°C (°F)	-	−40 to +121 (−40 to +250)
Drop point	°C (°F)	149 (300) min	> 300 (572)
Worked penetration @ 25°C (77°F)		265 to 300	295
Unworked penetration @ 25°C (77°F)		-	287
Worked stability (100,000 strokes)		355 max	270
Bomb oxidation pressure drop @ 99°C (210°F) 100 hrs 500 hrs	 lb/in^2 lb/in^2	 10 max 25 max	 4 15
Oil separation @ 100°C (212°F), in 30 hrs	%m	-	0.7
Water resistance / washout @ 38°C (100°F)	%m	5 max	3.2
Evaporation loss in 22 hrs @ 121°C (250°F)	%m	-	1.3
Mean Hertz Load	kg	30 min	35
Anti-friction bearing performance @ 121°C (250°F)	hrs	2000	2000+
Copper corrosion 24 hrs @ 100°C (212°F)		Must pass	Passes
Apparent viscosity @ 0°C ± 0.5°C (32°F ± 1°F)		250 max	121
Dirt count		Must pass	Passes
Low temperature torque @−6.7°C (+20°F) Starting Running	g-cm	 4500 max 1500 max	 Below 3100 Below 380
Bearing protection 2 days @ 51°C (124°F)		Must pass	Passes
Colour		-	Golden Yellow

AEROSHELL GREASE 7

AeroShell Grease 7 is an advanced multi-purpose grease, composed of a synthetic oil thickened with Microgel®, possessing good load carrying ability over a wide temperature range. It is inhibited against corrosion and has excellent resistance to water.

The useful operating temperature range is –73°C to +121°C (–99°F to 250°F).

APPLICATIONS

AeroShell Grease 7 satisfies nearly all the airframe grease requirements of turbine engine aircraft and also those of piston engined aircraft provided that seal incompatibility does not occur. Most civil aircraft manufacturers approve AeroShell Grease 7 as a general purpose grease either by brand name or by specification. It is recommended for lubricating highly loaded gears, actuator screw mechanisms, etc., also for instrument and general airframe lubrication within the temperature range of –73°C to +121°C (–99°F to 250°F).

AeroShell Grease 7 contains a synthetic ester oil and should not be used in contact with incompatible seal materials. Refer to the General Notes at the front of this section.

AeroShell Grease 7 is a clay-based grease approved to MIL-PRF-23827C Type II; it should not be mixed with soap-based greases approved to MIL-PRF-23827C Type I.

SPECIFICATIONS

U.S.	Approved MIL-PRF-23827C (Type II)
British	-
French	-
Russian	-
Joint Service Designation	-
COMAC	Approved to QPL-CMS-OL-302

PROPERTIES		MIL-PRF-23827C (Type II)	TYPICAL
Oil type		Synthetic	Synthetic ester (Diester)
Thickener type		Clay	Microgel
Base oil viscosity @−40°C (−40°F) @ 40°C (104°F) @ 100°C (212°F)	mm^2/s	 - - -	 1150 10.3 3.1
Useful operating temperature range	°C (°F)	-	−73 to +121 (−99 to +250)
Drop point	°C (°F)	165 (329) min	300+ (572+)
Worked penetration @ 25°C (77°F)		270 to 310	296
Unworked penetration @ 25°C (77°F)		200 min	283
Bomb oxidation pressure drop @ 99°C (210°F) 100 hrs 500 hrs	 kPa kPa	 70 max 105 max	 62 96.5
Oil separation @ 100°C (212°F), in 30 hrs	%m	5 max	3
Water resistance / washout test @ 38°C (100°F)	%m	20 max	2.5
Evaporation loss in 22 hrs @ 100°C (212°F)	%m	2.0 max	1.3
Mean Hertz Load	kg	30 min	43
Anti-friction bearing performance @ 121°C (250°F)	hrs	-	2460
Copper corrosion 24 hrs @ 100°C (212°F)		Must pass	Passes
Rust preventive properties 48 hrs @ 52°C (125°F)		Must pass	Passes
Low temperature torque @ −73°C (−99°F) Starting Running 1 hr	 Nm Nm	 1.00 max 0.1 max	 0.30 0.03
Dirt count		Must pass	Passes
Colour		-	Beige
Worked stability		270 – 375	Average 285

AEROSHELL GREASE 14

AeroShell Grease 14 is a helicopter multi-purpose grease composed of a mineral oil thickened with a calcium soap, possessing outstanding anti-fret and anti-moisture corrosion properties. It is oxidation and corrosion inhibited.

The useful operating temperature range is –54°C to +75°C (–65°F to +167°F).

APPLICATIONS

AeroShell Grease 14 is the leading helicopter multi-purpose grease and is approved by all helicopter manufacturers. Owing to its anti-fret properties, AeroShell Grease 14 is particularly suitable for the lubrication of helicopter main and tail rotor bearings, splines, etc.

SPECIFICATIONS

U.S.	Approved MIL-G-25537C
British	Approved DEF STAN 91-051
French	-
Russian	-
NATO Code	G-366
Joint Service Designation	XG-284

PROPERTIES		MIL-G-25537C	TYPICAL
Oil type		-	Mineral
Thickener type		-	Calcium Soap
Base oil viscosity @ 40°C (104°F) @ 100°C (212°F)	mm^2/s	 - -	 12.5 3.1
Useful operating temperature range	°C (°F)	-	−54 to +75 (−65 to +167)
Drop point	°C (°F)	140 (284) min	147 (297)
Worked penetration @ 25°C (77°F)		265 to 305	284
Unworked penetration @ 25°C (77°F)		200 min	276
Bomb oxidation pressure drop @ 99°C (210°F) 100 hrs 400 hrs	 MPa MPa	 0.0345 max 0.1378 max	 0.0192 0.113
Oil separation @ 100°C (212°F), in 30 hrs	%m	5.0 max	4.2
Water stability / washout	dmm	-	51
Evaporation loss in 22 hrs @ 100°C (212°F)	%m	7.0 max	6.5
Low temperature torque @ −55°C (−67°F) Starting Running	Nm	 1.47 max 0.196 max	 0.53 0.03
Copper corrosion 24 hrs @ 100°C (212°F)		Must pass	Passes
Dirt count		Must pass	Passes
Colour		-	Tan

AEROSHELL GREASE 22

AeroShell Grease 22 is a versatile advanced general-purpose grease composed of a synthetic hydrocarbon oil thickened with Microgel®. Appropriate additives are included to achieve the necessary oxidation and corrosion resistance, anti-wear properties and load carrying properties.

The useful operating temperature range is –54°C to +177°C (–65°F to +350°F).

APPLICATIONS

AeroShell Grease 22 is especially recommended for use wherever severe operating conditions are encountered as in high bearing loads, high speeds, wide operating temperature range, and particularly where long grease retention and high resistance to water washout are required.

The wide range of applications include aircraft wheel bearings, engine accessories, control systems, actuators, screw-jacks, servo mechanisms and electric motors, helicopter rotor bearings, instruments, airframe lubrication, hinge pins, static joints, landing gears.

AeroShell Grease 22 contains 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.

SPECIFICATIONS

U.S.	Approved MIL-PRF-81322G Approved DOD-G-24508A
British	Meets DEF STAN 91-052 (Obsolete)
French	Approved DCSEA 395/B
Russian	Analogue of CIATIM 201 and 203, VNII NP 207, ERA (VNII NP 286M) and ST (NK-50)
NATO Code	G-395
Joint Service Designation	XG-293
COMAC	Approved to QPL-CMS-OL-301

PROPERTIES		MIL-PRF-81322G NLGI Grade 2	TYPICAL
Oil type		-	Synthetic Hydrocarbon
Thickener type		-	Microgel
Base oil viscosity	mm^2/s		
@ –40°C (–40°F)		-	7500
@ 40°C (104°F)		-	30.5
@ 100°C (212°F)		-	5.7
Useful operating temperature range	°C (°F)	-	–54 to +177 (–65 to +350)
Dropping point	°C (°F)	232(450) min	> 300 (572)
Worked penetration @ 25°C (77°F)		256 to 320	283
Bomb oxidation pressure drop @ 99°C (210°F)			
@ 100 hrs	kPa (psi)	83 (12) max	27 (4)
@ 500 hrs	kPa (psi)	172 (25) max	69 (10)
Oil separation @ 177°C (350°F), in 30 hrs	%m	2.0 to 8.0	5.8
Water washout @ 41°C (106°F)	%m	20 max	2.0
Evaporation loss in 22 hrs @ 177°C (350°F)	%m	10 max	1.1
Anti-friction bearing performance @ 177°C (350°F)	hrs	400 min	> 400
Load carrying capacity	kg	30 min	40
Copper corrosion 24 hrs @ 100°C (212°F)		Must pass	Passes
Colour		-	Amber

AEROSHELL GREASE 33

AeroShell Grease 33 is a synthetic universal airframe grease composed of a lithium complex thickened synthetic base oil with corrosion and oxidation inhibitors and load carrying additives.

The useful operating temperature range is –73°C to +121°C (–99°F to +250°F).

APPLICATIONS

For many years, aircraft operators have been seeking to rationalise the greases used on aircraft and to reduce the number of different greases in their inventories. Recently Boeing began research on a new, general purpose, corrosion-inhibiting grease. The aim was for a non-clay based grease that would provide longer life for components and mechanisms and possess improved wear and corrosion resistance. This led to the introduction of the Boeing Specification BMS 3-33.

Owing to the wide range of operating temperatures, loads and other environmental conditions required for various aircraft components, several different types of grease with different desirable properties are used during routine lubrication of aircraft components. Boeing, in developing their BMS 3-33 specification, took account of the properties of the different grease types used on aircraft and wrote a specification for a grease which would provide improved performance and which could be used in the widest possible range of grease applications. That performance level has largely been adopted as the SAE AMS3052 specification, which is in turn the basis for the Airbus AIMS 09-06-002 specification.

AeroShell Grease 33 is approved to BMS 3-33C and offers the improved performance properties required by this specification and the other specifications mentioned above. AeroShell Grease 33 can be used for routine lubrication on Boeing aircraft where MIL-PRF-23827C is specified and where the obsolete BMS 3-24 is specified.

AeroShell Grease 33 can also be used for routine lubrication in applications where MIL-PRF-23827C and BMS 3-33C are specified on aircraft manufactured by McDonnell Douglas, Airbus, BAe Regional Aircraft, Canadair, Lockheed, Embraer, Fokker and Gulfstream (except for wheel bearings, applications above 121°C (250°F) and sliding applications requiring molybdenum disulphide).

Other aircraft manufacturers are evaluating AeroShell Grease 33 with the aim of approving it for use on their aircraft. Operators should regularly check with these manufacturers for the latest status.

Use of AeroShell Grease 33 can provide operators with the following benefits:

- Reduced inventories
- Easier maintainability (one major grease for most applications)
- Reduced maintenance labour costs
- Less chance of product mis-application

AeroShell Grease 33 contains a synthetic oil and must not be used with incompatible seal materials. Refer to the General Notes at the front of this section for further information.

SPECIFICATIONS

U.S.	Approved MIL-PRF-23827C (Type I)
British	-
French	Equivalent DCSEA 354/B
Russian	-
NATO Code	G-354
Joint Service Designation	-
SAE	Exceeds AMS3052A
Boeing	Approved BMS 3-33C
Airbus	Approved AIMS 09-06-002
COMAC	Approved QPL-CMS-OL-302

PROPERTIES		BMS 3-33C AIMS 09-06-002 SAE AMS3052A	TYPICAL
Oil type		Synthetic Hydrocarbon/Ester	Synthetic Hydrocarbon/Ester
Thickener type		Lithium Complex	Lithium Complex
Base oil viscosity	mm^2/s		
@ −40°C (−40°F)		-	1840
@ 40°C (104°F)		-	14.2
@ 100°C (212°F)		-	3.4
Useful operating temperature range	°C (°F)	−73 to +121 (−99 to +250)	−73 to +121 (−99 to +250)
Dropping point	°C (°F)	205 (401) min	227 (440)
Worked penetration @ 25°C (77°F)		265 to 315	297
Bomb oxidation pressure drop from 758 kPa (110 psi) @ 99°C (210°F)			
@ 100 hrs	kPa (psi)	70 (10) max	3.5 (0.5)
@ 500 hrs	kPa (psi)	105 (15) max	34 (5)
Oil separation @ 100°C (212°F), in 30 hrs	%m	8 max	2
Water washout @ 79°C (174°F)	%m	7.5 max	< 6
Evaporation loss 500 hr @ 121°C (250°F)	%m	10 max	< 10
Anti-friction bearing performance @ 121°C (250°F)	hrs	1000 min	> 1200
Load carrying capability LWI @ 27°C (80°F)	kg	60 min	> 60
Copper corrosion 24 hrs @ 100°C (212°F)		1B max	Passes
Colour		Blue-green	Green

NOTES

AEROSHELL GREASE 58

AeroShell Grease 58 is an advanced general purpose and wheel bearing grease composed of a synthetic base fluid and a lithium complex soap thickener. AeroShell Grease 58 possesses outstanding combination high performance characteristics including high load carrying, corrosion protection, mechanical stability, oxidation resistance and wear resistance.

The useful operating temperature range is –54°C to +175°C (–65°F to +347°F).

APPLICATIONS

AeroShell Grease 58 has been developed to exceed the requirements of the SAE AMS3058 Wide Temperature Range Lithium Complex Aircraft Wheel Bearing Grease specification. It is recommended for use wherever severe operating conditions are encountered as in high bearing loads, high speeds, wide operating temperature range, and particularly where long grease retention and high resistance to water washout and corrosive fluids are required.

AeroShell Grease 58 is the latest member of the AeroShell Lithium Complex Grease portfolio which includes AeroShell Greases 33 and 64.

The wide range of applications include aircraft wheel bearings, engine accessories, control systems, actuators, screw-jacks, servo mechanisms and electric motors, helicopter rotor bearings, instruments, airframe lubrication, hinge pins, static joints, landing gears.

SPECIFICATIONS

U.S.	Approved SAE AMS3058
British	-
French	-
Russian	-
NATO Code	-
Joint Service Designation	-
Airbus	Approved AIMS 09-06-003

PROPERTIES	SAE AMS3058	TYPICAL
Oil type	Synthetic Hydrocarbon/Ester	Synthetic Hydrocarbon/Ester
Thickener type	Lithium/ Lithium Complex	Lithium Complex
Base oil viscosity mm²/s @ 100°C (212°F) @ 40°C (104°F)	 Report 165 max	 12 100
Useful operating temperature range °C (°F)	-54 to +175 (-65 to +347)	-54 to +175 (-65 to +347)
Drop point °C (°F)	250 (482) min	265 (509)
Worked penetration @ 25°C (77°F)	265 to 305	295
Bomb oxidation pressure drop @ 99°C (210°F) @ 100 hrs kPa (psi) @ 500 hrs kPa (psi)	 35 max 105 max	 15 40
Oil separation 30 hrs @ 175°C (347°F) %m	 8 max	 4
Copper corrosion 24 hrs @ 100°C (212°F) %m	 1b max	 1b
Evaporation loss in 22 hrs @ 175°C (347°F) %m	 10 max	 4.9
Water washout @ 79°C (174°F) %m	15 max	5
Dynamic rust prevention @ 25°C (77°F) 3% NaCl 7 days	1/1 max	0/0
Extreme pressure weld load kg	315 min	350
Colour	-	Yellow
Low temperature torque dry @ -54°C (-65°F) Starting torque Nm Running torque Nm	 2.0 max 0.5 max	 0.7 0.15
Roll stability 10% water 1/10 mm	-20 to +50	0

AEROSHELL GREASE 64

AeroShell Grease 64 comprises AeroShell Grease 33 fortified with 5% molybdenum disulphide. It possesses the enhanced anti-wear and anti-corrosion properties of AeroShell Grease 33 with the added EP (Extreme Pressure) properties provided by the addition of a solid lubricant.
The useful operating temperature range is –73°C to +121°C (–99°F to +250°F).

NOTE: AeroShell Grease 64 was previously branded as AeroShell Grease 33MS. Responding to customer requests, to avoid confusion with AeroShell Grease 33 it was decided to rebrand AeroShell Grease 33MS as AeroShell Grease 64.

APPLICATIONS

AeroShell Grease 33 has established itself as the answer to most of the airframe's General Purpose, airframe greasing requirements, being approved for use in Boeing, Airbus and many other aircraft types. It sets the standard with exceptional anti-corrosion and anti-wear performance while allowing aircraft operators to shrink their grease inventory and reduce the risk of misapplication. However, there remains a small number of highly loaded, sliding applications on the airframe where the additional boost of molybdenum disulphide will always be required. To address this need, Shell Aviation has developed AeroShell Grease 64. Sharing the same advanced grease technology as its parent, AeroShell Grease 64 also possesses the extreme pressure (EP) characteristics provided by molybdenum disulphide.

AeroShell Grease 64 contains a synthetic oil and must not be used with incompatible seal materials.

SPECIFICATIONS

U.S.	Approved MIL-G-21164D
British	Equivalent DEF STAN 91-057
French	Equivalent DCSEA 353/A (Obsolete)
Russian	-
NATO Code	G-353
Joint Service Designation	XG-276
COMAC	Approved QPL-CMS-OL-311

PROPERTIES	MIL-G-21164D	TYPICAL
Oil type	-	Synthetic Hydrocarbon/Ester
Thickener type	-	Lithium Complex
Base oil viscosity mm²/s @ −40°C (−40°F) @ 40°C (104°F) @ 100°C (212°F)	 - - -	 1840 14.2 3.4
Useful operating temperature range °C (°F)	-	−73 to +121 (−99 to +250)
Drop point °C (°F)	165 (329) min	234 (453)
Worked penetration @ 25°C (77°F)	260 to 310	289
Unworked penetration @ 25°C (77°F)	200 min	281
Worked stability (100,000 strokes)	260 to 375	305 to 310
Bomb oxidation pressure drop from 758 kPa (110 psi) @ 99°C (210°F) @ 100 hrs kPa (psi) @ 500 hrs kPa (psi)	 68.9 (10) max 103.4 (15) max	 19 (2.75) 34.5 (5.0)
Oil separation @ 100°C (212°F), in 30 hrs %m	5 max	1.5
Water resistance test loss @ 40°C (104°F) %m	20 max	3.39
Evaporation loss in 22 hrs @ 100°C (212°F) %m	2 max	0.81
Low temperature torque @ −73°C (−99°F) Starting Nm Running 1 hr Nm	 0.98 max 0.098 max	 0.5 0.06
Anti-friction bearing performance @ 121°C (250°F) hrs	1000 min	> 1000 (on all four runs)

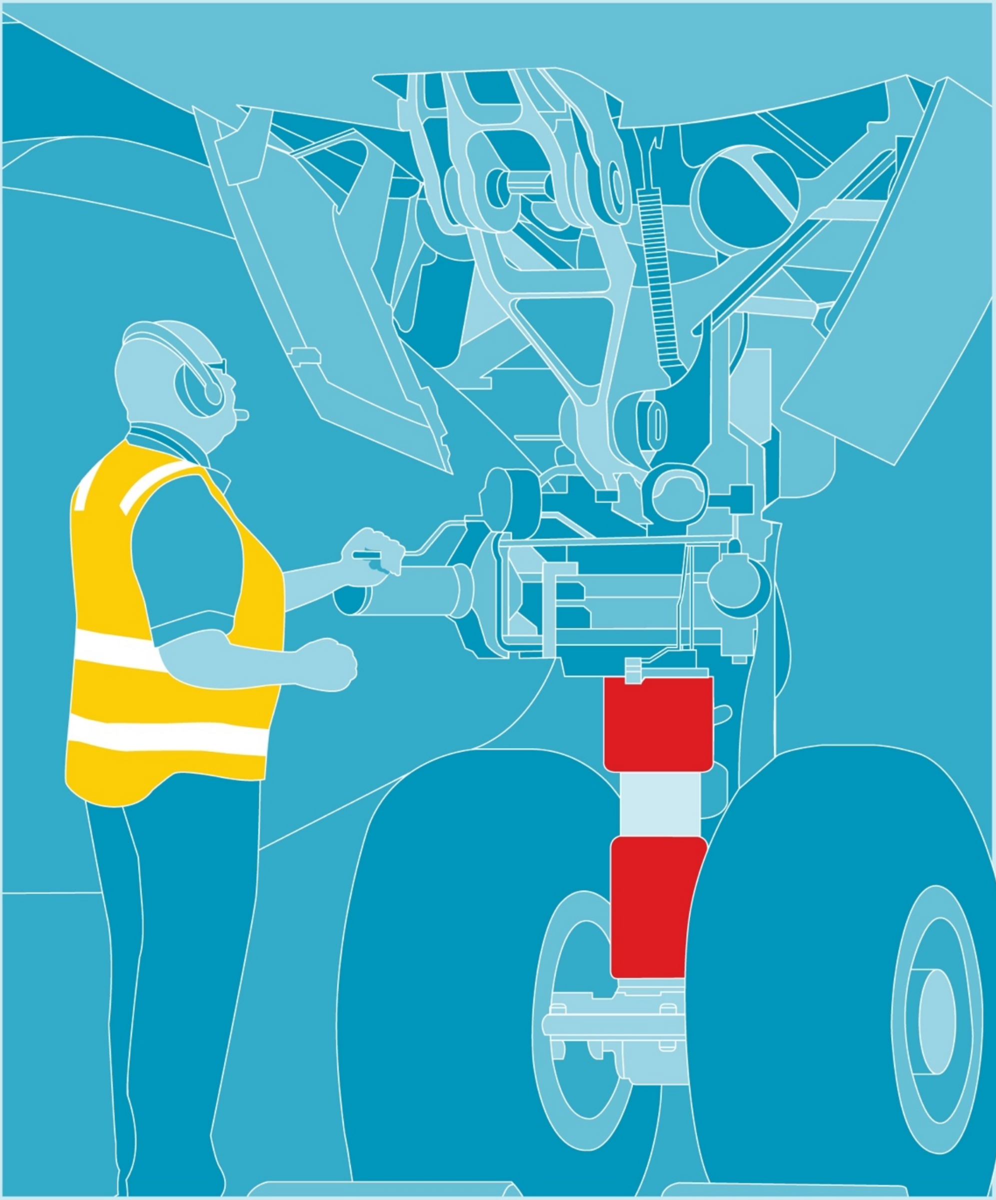
Table continued

Table continued

PROPERTIES	MIL-G-21164D	TYPICAL
Extreme pressure properties load wear index	50 min	81.7
Copper corrosion 24 hrs @ 100°C (212°F)	1b max	1b
Rust prevention/bearing protection 2 days @ 52°C (125°F)	Must pass	Passes, no corrosion
Storage stability 6 months @ 40°C (104°F) Unworked penetration Worked penetration Change in penetration from original	 200 min - 30 max	 226 289 8
Colour	-	Dark grey

NOTES

AEROSHELL HYDRAULIC FLUIDS



6. AEROSHELL HYDRAULIC FLUIDS

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

AeroShell Fluid 4
AeroShell Fluid 41
AeroShell Fluid 31
AeroShell Fluid 61
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 31 is a synthetic hydrocarbon fire resistant hydraulic fluid. This type of fluid is increasingly replacing mineral hydraulic fluids.

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

AeroShell LGF is a hydraulic fluid specifically for landing gear shock struts of some aircraft.

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°C to 135°C (–65°F to 275°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 x 107 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.

Elastomer/Plastic	Mineral Oil Based Hydraulic Fluids	Synthetic Hydrocarbon Based Hydraulic Fluids
Flurocarbon (Viton)	Very Good	Very Good
Acylonitrile	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

Mineral
AeroShell Fluid 4
AeroShell Fluid 41
AeroShell Fluid LGF

Synthetic Hydrocarbon
AeroShell Fluid 31
AeroShell Fluid 61

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 gotten smaller while operating pressures have increased. As a result, particulates in the hydraulic fluid are more likely to cause system failures through valve sticking, erosion by impingement, wear, or blockages of nozzles and tubes. Thus, these specifications include very tight limits on particulates.

Typically for MIL-PRF-5606J and MIL-PRF- 83282D the requirement is of the order:

Particle Size	**MIL-PRF-83282D**		**MIL-PRF-5606J**
	Microscopic Count	**Automatic Count**	**Automatic Count**
5 to 15 µm	2500	10000	8000
16 to 25 µm	1000	1000	1425
26 to 50 µm	250	150	253
51 to 100 µm	25	20	45
over 100 µm	10	5	8

MIL-PRF-5606J allows automatic method only
MIL-PRF-83282D allows both methods

Shell applies special process controls including multistage filtration, container cleaning just before filling, and 'clean room' packaging conditions in order to manufacture fluids that meet these stringent limits.

However, it would be pointless for Shell manufacturing plants to go to these extreme lengths if customers/operators do not handle the fluids in a manner that ensures 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, MILPRF-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.

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 good low temperature flow properties, anti-wear properties, antifoam characteristics, and oxidation stability.

AeroShell Fluid 4 is dyed red.

The useful operating temperature range unpressurised is –54°C to +90°C (–75°F to +194°F).
The useful operating temperature range pressurised is –54°C to +135°C (–75°F to +275°F).

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. It 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 and 61, 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

U.S.	Meets MIL-H-5606A (Obsolete - see AeroShell Fluid 41)
British	Meets DTD.585 (Obsolete - see AeroShell Fluid 41)
French	Approved DCSEA 415/A
Russian	Analogue to AMG-10
NATO Code	-
Joint Service Designation	-

PROPERTIES		MIL-H-5606A (Obsolete)	TYPICAL
Oil type		-	Mineral
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		-	5.30
@ 40°C (104°F)		-	14.1
@ −40°C (−40°F)		500 max	491
@ −54°C (−65°F)		-	2300
Flashpoint	°C (°F)	93.3 (200) min	105 (221)
Pourpoint	°C (°F)	−59.4 (−75) max	−60 (−76)
Total acid number	mgKOH/g	0.20 max	0.01
Relative density @ 15.6/15.6°C (60°F)		-	0.87
Evaporation @ 100°C (212°F)	%m	-	10
Colour		Red	Red
Copper corrosion		-	Passes
Low temperature stability		Must pass	Passes
Shear stability		Must pass	Passes
Foaming characteristics		-	Passes
Phosphorus content	% m/m	0.035 to 0.050	Passes
Oxidation & corrosion stability (168 hrs)			
- metal weight change @ 121.1°C ± 1°C (250°F ± 2°F)		Must pass	Passes
- change in viscosity @ 40°C (104°F)	%	-	+2.0
- change in acid number	mgKOH/g	0.20 max	+0.1
Anti-wear properties, scar diam	mm	-	0.95
Rubber swell 168 hrs @ 70°C (158°F) Vol change	%	19 to 26.5	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, anti-wear, 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°C to +205°C (–40°F to +401°F).

APPLICATIONS

AeroShell Fluid 31 is recommended for use in aircraft, ordnance, and missile systems operating from –40°C to +205°C (–40°F to +401°F). 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 the 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 and 61 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

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

PROPERTIES		MIL-PRF-83282D	TYPICAL
Oil type		Synthetic Hydrocarbon	Synthetic Hydrocarbon
Kinematic viscosity	mm^2/s		
@ 205°C (401°F)		1.0 min	1.1
@ 100°C (212°F)		3.45 min	3.53
@ 40°C (104°F)		14.0 min	14.2
@ −40°C (−40°F)		2200 max	1937
Flashpoint Cleveland Open Cup	°C (°F)	205 (401) min	225 (437)
Fire point	°C (°F)	245 (473) min	248 (478)
Total acidity	mgKOH/g	0.10 max	0.04
Evaporation loss 6.5 hrs @ 150°C (302°F)	%m	20 max	17
Relative density @ 15.6°C (60°F)		Report	0.850
Pour point	°C (°F)	−55 (−67) max	−78 (−108)
Low temperature stability 72hrs @ −40°C (−40°F)		Must pass	Passes
High temperature stability 100 hrs @ 205°C (401°F)		Must pass	Passes
Gravimetric filtration	mg/100ml	0.3 max	0.1
Filtration time	minutes	15 max	5
Particle count, automatic	per Lt		
5 to 15 µm		10000 max	Passes
16 to 25 µm		1000 max	Passes
26 to 50 µm		150 max	Passes
51 to 100 µm		20 max	Passes
>100 µm		5 max	Passes
Water content	ppm	100 max	Passes
Foam resistance	ASTM Seq 1	Must pass	Passes
Flame propagation	cm/s	Must pass	Passes
Rubber swell, NBR-L	%	18 to 30	Passes

Table continued

Table continued

PROPERTIES		MIL-PRF-83282D	TYPICAL
4-Ball wear, 1 hr @ 75°C (167°F)			
scar dia	mm		
1 kg load/1200 rpm		0.21 max	0.20
10 kg load/1200 rpm		0.30 max	0.25
40 kg load/1200 rpm		0.65 max	0.55
Oxidation & corrosion stability			
168 hrs @ 121°C (250°F)			
- metal weight change		Must pass	Passes
- change in viscosity @ 40°C (104°F)	%	10 max	Passes
- change in acidity	mgKOH/g	0.2 max	Passes
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 good low temperature fluidity, 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°C to 90°C (–65°F to 194°F) and pressurised between –54°C to 135°C (–65°F to 275°F).

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, 61 and 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.

Due to its properties, it is also used in several industrial applications.

SPECIFICATIONS

U.S.	Approved MIL-PRF-5606J
British	Approved DEF STAN 91-048 Grade Superclean* (European production only) Meets DEF STAN 91-048 Grade Normal (European production only) Equivalent to DEF STAN 91-048 Grades Superclean* & Normal (U.S. production only)
French	Approved DCSEA 415/A
Russian	Analogue to AMG-10
NATO Code	H-515* (equivalent H-520 (Obsolete))
Joint Service Designation	OM15* (equivalent OM-18)
COMAC	Approved QPL-CMS-OL-104

*Superclean grades

The British specification DEF STAN 91-048 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-5606J	TYPICAL
Oil type		Mineral	Mineral
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F) @ –40°C (–40°F) @ –54°C (–65°F)	mm^2/s	 4.90 min 13.2 min 600 max 2500 max	 4.9 – 5.30 13.2 – 14.3 460 – 600 2200 – 2500
Flashpoint	°C (°F)	82 (179) min	90 – 95 (194 – 203)
Pourpoint	°C (°F)	–60 (–76) max	–60 (–76) max
Total acid number	mgKOH/g	0.20 max	0.02 – 0.05
Evaporation loss 6 hrs @ 71°C (160°F)	%m	20 max	10 – 15.4
Water content	ppm	100 max	50 – 75
Relative density @ 15.6°C (60°F)		Report	0.868 – 0.873
Colour		Red	Red
Particle contamination, number of particles per 100ml in size range 5 to 15 µm 16 to 25 µm 26 to 50 µm 51 to 100 µm over 100 µm		 8000 max 1425 max 253 max 45 max 8 max	 1200 max 1425 max 253 max 45 max 8 max
Particle count		5	5 max
Copper corrosion		2e max	2b
Steel on steel wear scar diam	mm	1.0 max	0.6 – 0.95
Rubber swell, L rubber 168 hrs @ 70°C (158°F)	%	19 to 30	Passes
Low temperature stability 72hrs @ –54°C (–65°F)		Must pass	Passes
Gravimetric analysis	mg/100ml	1.0 max	Passes
Foaming tendency		Must pass	Passes
Barium content	ppm	10 max	Nil

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

NOTES

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.

AeroShell Fluid 61 has an operating temperature range of –40°C to +204°C (–40°F to +399°F).

APPLICATIONS

AeroShell Fluid 61 is designed for use where a fire-resistant preservative grade hydraulic fluid is required and is suitable for operational use from –40°C to +204°C (–40°F to +399°F) as well as preservation of components during storage and shipment.

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

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

U.S.	Approved MIL-PRF-46170E Type I*
British	-
French	-
Russian	-
NATO Code	H-544
Joint Service Designation	-

*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-46170E Type I	TYPICAL
Oil type		-	Synthetic Hydrocarbon
Kinematic viscosity	mm^2/s		
@ 100°C (212°F)		3.4 min	3.71
@ 40°C (104°F)		19.5 min	15.43
@ –40°C (–40°F)		2600 max	2488
@ –54°C (-65°F)		-	15022
Flashpoint Cleveland Open Cup	°C (°F)	218 (424) min	233 (451)
Fire point Cleveland Open Cup	°C (°F)	246 (475) min	248 (478)
Acid or Base number	mgKOH/g	0.2 max	0.07
Evaporation loss 22 hrs @ 149°C (300°F)	%m	5.0 max	2.39
Relative density @ 15.6°C (60°F)		-	0.859
Pourpoint	°C (°F)	–54 (–65) max	Below –54 (–65)
Water content	ppm	500 max	278
Auto-ignition temperature	°C (°F)	343 (649) min	354 (669)
Colour		Undyed	Undyed
Particle count, automatic	per Lt		
5 to 25 µm		10000 max	1414
26 to 50 µm		250 max	390
51 to 100 µm		50 max	4
> 100 µm		10 max	0
Trace sediment	mg/l	0.005 max	0.001
Rubber swell 168 hrs @ 70°C (°F)	% swell	15 to 25	21.5
4-Ball wear, 75°C (167°F) - scar dia	mm		
147N load/1200 rpm		0.3 max	0.23
392N load/1200 rpm		0.65 max	0.38

Table continued

Table continued

PROPERTIES		MIL-PRF-46170E Type I	TYPICAL
Galvanic corrosion		Must pass	Passes
Corrosiveness & oxidation stability 168 hrs @ 121°C (250°F) - metal weight change - viscosity change @ 40°C (104°F) - change in acidity	 % mg/KOH/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.

NOTES

AEROSHELL LGF

AeroShell Landing Gear Fluid (LGF) is a mineral hydraulic fluid (MIL-PRF-5606) 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 LGF is AeroShell Fluid 41 plus additives, and is straw yellow in colour.

APPLICATIONS

The better low temperature properties of AeroShell LGF make it particularly suitable in areas of low temperature operations.

AeroShell LGF is compatible with AeroShell Fluids 4 and 41.

EQUIPMENT MANUFACTURERS' APPROVALS

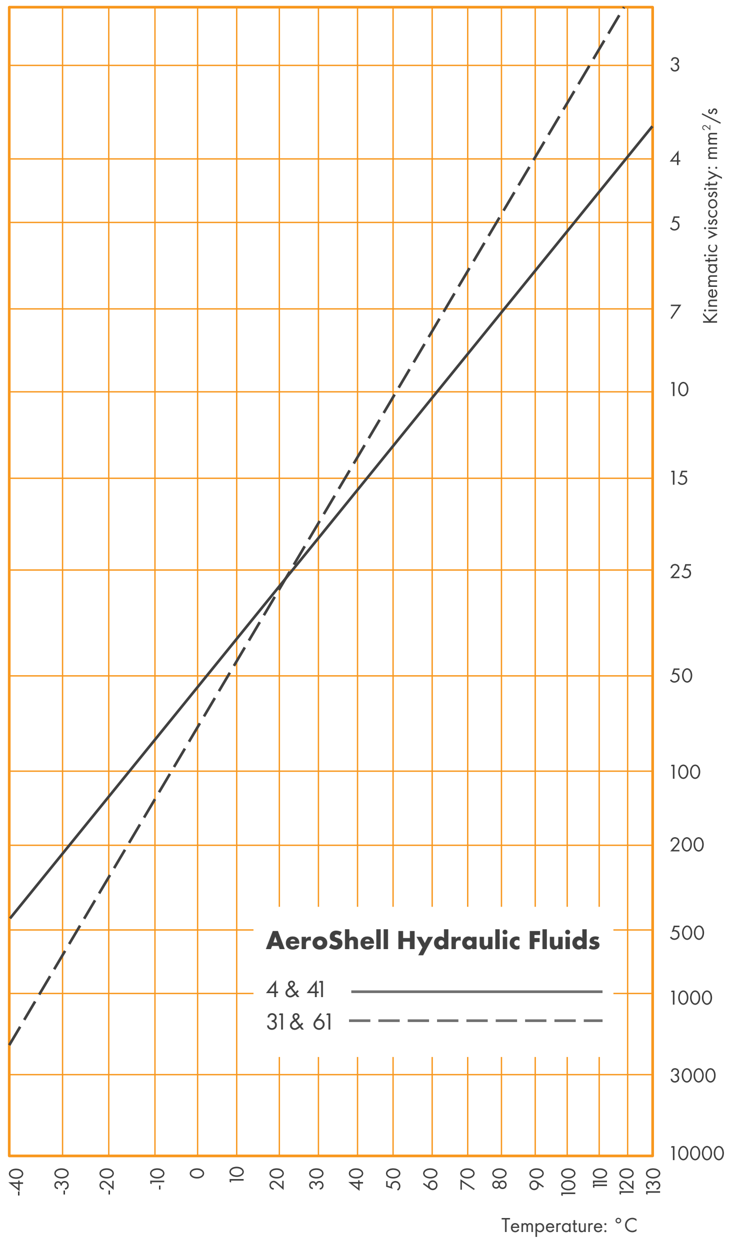
Boeing	Approved BMS 3-32C Type II
Lockheed	L1011 Tristar
McDonnell Douglas	Approved DPM-6177 (DC-8, DC-9, DC-10, MD-80, MD-11

AeroShell LGF is not covered by any military specification.

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

PROPERTIES		BMS 3-32C	LGF TYPICAL
Base hydraulic fluid specification		MIL-PRF-5606J	MIL-PRF-5606J
Colour Yellow		1.0 – 2.0	L1.5
Density @ 15.6°C (60°F)	kg/m^3	-	879
Kinematic viscosity @ 40°C (104°F)	mm^2/s	13.2 min	14.5
Flashpoint	°C (°F)	-	110 (230)
Total acid number	mgKOH/g	1.5 to 5.0	3.1
Evaporation 6 hrs @ 71°C (160°F)	%m	-	18.0
Pourpoint	°C (°F)	-	<–60 (–76)
Foaming tendency		-	Passes
Zinc	ppm	1700 ± 300	1620

TYPICAL TEMPERATURE/VISCOSITY CURVE OF AEROSHELL HYDRAULIC FLUIDS



NOTES

AEROSHELL PRESERVATIVES

7. AEROSHELL PRESERVATIVES

When the winter period comes bringing shorter days and worse weather than is enjoyed during the summer months, many owners decide to hanger their aircraft and not fly until spring. An integral part of the process of preparing an aircraft for storage should be to use a preservation oil to give protection against corrosion, which greatly accelerates the rate of wear in an engine.

When an engine stands idle for long periods, the oil absorbs water from the atmosphere and, combined with condensation on the internal engine components, causes rust to form. Once the rust has formed it remains in the oil and acts as a grinding paste, causing increased wear, reduced engine life and potentially higher maintenance bills.

If an aircraft is flown frequently (at least once every two weeks) then this water evaporates as the engine temperature rises and therefore does not cause a problem. However, if the aircraft is not flown as often as this, then the owner should consider using a preservation oil.

AeroShell Preservatives are used for the preservation and protection of aircraft, aircraft engines and aircraft components.

Two classes of corrosion preservatives are used on aircraft, those for protecting engine interiors and those for exterior application.

Corrosion protectives (internal-engines)

AeroShell Fluid 2F

AeroShell Fluid 2XN

Piston engine corrosion protective fluids

Corrosion protection fluids are used for preventing cold corrosion which would occur during the storage or shipment of engines, principally because of the action of fuel combustion products trapped in piston engine cylinders after shut-down. In addition to the protection given by the compound they contain, these fluids neutralise the acid products of combustion resulting from the use of leaded fuel, e.g. hydrobromic acid.

British and American methods for inhibiting engines differ as is shown by the following specifications prescribing the official procedures:

	American	**British**
Piston engine practice:	MIL-E-6058B (Obsolete)	D.Eng.R.D. 2027 (Obsolete)
Turbine engine practice:	MIL-E-5607F (Obsolete)	D.Eng.R.D. 2028 (Obsolete)

For inhibited engine oils in piston engines the British procedure was to motor the engines cold using a 'storage' oil (DEF STAN 91-040 [Obsolete]) in the engine oil system, followed by spraying of various parts internally with a wax thickened oil/petrol mixture (DTD.791C [Obsolete]).

The U.S. procedure differs according to whether the storage period is short term or for an extended period. For short term protection only one type of product is required and this is a 'flyaway' oil (1 part AeroShell Fluid 2XN mixed with 3 parts AeroShell Oil 100, formerly AeroShell Fluid 2F), which is added to the engine oil system while the engine is run-up under its own power. Immediately before shutdown it is sprayed into various parts of the engine as in the British procedure.

If you intend to carry on flying throughout the year, but may have a few periods of several weeks inactivity, then use the AeroShell Oil W 15W-50 to take advantage of the anti-wear and anti-corrosion additives.

However, if you intend to lay the aircraft up for several months (winter or summer) and perhaps enjoy the occasional flight during this period, then you should use AeroShell Fluid 2XN mixed with AeroShell Oil 100 (formerly AeroShell Fluid 2F). Finally, if you have an engine which will lie idle for an indefinite period, such as a spare engine, then you should use AeroShell Fluid 2XN in its pure form.

By using these simple solutions, no matter how often you fly, you can be sure that you are giving your engine the best protection possible.

Turbine Engine Corrosion Protective Fluids

Corrosion protective fluids to MIL-C-6529C Type III are suitable for the internal protection during storage of turbine engines which normally use mineral lubricating oil to MIL-PRF-6081E.

Corrosion protective fluids to MIL-PRF-8188D are suitable for the internal protection during storage of turbine engines which normally use synthetic lubricating oils to MIL-PRF-7808L.

More recently there has been increasing concern regarding corrosion inside turbine engines which use synthetic oils to MIL-PRF-23699 (formerly MIL-L-23699). In order to address these concerns the specification MIL-PRF-23699G has been revised to include a corrosion inhibited (C/I) grade alongside the standard (STD) grade and high temperature grade (HTS).

AEROSHELL FLUID 2XN

AeroShell Fluid 2XN is a corrosion preventative concentrate from which AeroShell Fluid 2F is blended; the blending proportions are one part AeroShell Fluid 2XN to three parts Aeroshell Oil 100. This blended oil is the inhibited "flyaway" lubricating oil for the internal protection of piston engines during storage.

AeroShell Fluid 2F may be used in conjunction with Shell VPI 260 or VPI 280 if protection for extended periods is required.

APPLICATIONS

AeroShell Fluid 2XN is primarily used as an ingredient of AeroShell Fluid 2F, but can be used undiluted to provide additional protection for piston engines after run-out on AeroShell Fluid 2F, by spraying exhaust ports, rocker arms, accessories. This blend of AeroShell Fluid 2XN and AeroShell Oil 100 can be used in any certified aviation engine, although we do not recommend its use in 2-stroke or automotive derived engines.

A period of 15 minutes engine running under idling conditions is required to ensure adequate distribution of the blended oil throughout the engine. It can also be applied to other parts of the engine and its accessories by spraying. Once the engine has cooled, it is also worth blanking off the intake and exhaust if possible, to reduce the flow of air (and therefore moisture) through the engine. However, remember to placard the cockpit to remind yourself and other pilots that this has been done. The ashless anticorrosion additive package and highly refined mineral base oils protect the engine by minimising the effects of humidity and neutralising the acidic components of engine oil oxidation and combustion by-products.

After storage and before operating the engine, rotate the crankshaft by hand and drain off the preservative oil. An additional optional precaution is to flush the engine with the correct grade of AeroShell oil before draining and re-filling with fresh oil.

Operation of engines containing "flyaway" oils is limited to 50 hours maximum. Note that this is 50 hours during the total TBO cycle, not 50 hours every time you use the oil. This means that if you want to fly then you still can without needing to drain the oil and replace it with your usual AeroShell grade; but remember that this oil is a 100 weight oil and so if the temperature is too low for this weight of oil in your engine then the oil should be preheated. Extensive flying on this oil will not harm the engine, but engine cleanliness may be effected as the preservation oil does not contain an ashless dispersant additive as the AeroShell W series of oils do. Detailed instructions for inhibiting piston engines are given in specifications MIL-E-6058B and MIL-E-6059A and in relevant engine manufacturer's publications.

For aircraft gas turbine engines a mixture of one part of AeroShell Fluid 2XN to three parts of AeroShell Turbine Oil 2 is required. Detailed instructions for inhibiting turbines are given in specification MIL-E-5607F.

SPECIFICATIONS

U.S.	Approved MIL-C-6529C Type I
British	(Has adopted MIL-C-6529C Type I) Meets DTD900/4913A (Obsolete)
French	Equivalent to AIR 1503/B Type B Concentrate (Inactive)
Russian	-
NATO Code	C-608
Joint Service Designation	ZX-21 (Obsolete)

Properties are controlled only for the finished blends using AeroShell Fluid 2XN.

PROPERTIES		MIL-C-6529C Type I	TYPICAL
Oil type		-	Mineral
Kinematic viscosity @ 37.8°C (100°F) @ 98.9°C (210°F)	mm^2/s	 Report Report	 285 22
Density @ 15°C (59°F)	kg/m^3	-	900
Volatility	%	3 max	< 0.52
Viscosity (after elimination of volatile content)	mm^2/s	90 – 110	105
Flashpoint Cleveland Open Cup	°C (°F)	 204 (399) min	 270 (518)
Pourpoint	°C (°F)	–12.2 (+10) max	–17 (1.4)
Carbon residue	%m	2.0 max	0.5
Lead corrosion 4 hrs @ 149°C (300°F)	mg/in^2	 70 max	 30
Ash	%m	0.015 max	0.01
Copper corrosion @ 100°C (212°F)		2A max	Passes
Rust protection (humidity cabinet)		Must pass	Passes
High / Low Temperature Stability		Must pass	Passes
HBr Neutralisation		Must pass	Passes

NOTES

OTHER AEROSHELL FLUIDS

8. OTHER AEROSHELL FLUIDS

ABOUT THE FLUIDS

Other AeroShell Fluids are used for special applications on aircraft, aircraft engines and auxiliary equipment, and can be subdivided under the following headings:

Lubricating oils
Gearbox oils
Calibrating fluids
De-icing fluids
Avionic cooling fluids

Lubricating Oils

AeroShell Fluid 3
AeroShell Fluid 12

AeroShell Fluid 3 and AeroShell Fluid 12 cover the two types of aircraft general purpose and instrument oils in use today i.e. mineral oil (MIL-PRF-7870) and synthetic oil (MIL-PRF-6085) respectively. They are recommended for the lubrication of delicate instruments and general aircraft lubrication by oil can application, etc.

Gearbox Oils

AeroShell Fluid 5M-A
AeroShell Fluid S.8350

AeroShell Fluid 5M-A is of medium viscosity and is recommended for the lubrication of gears where high tooth loadings exist e.g. helicopter gearboxes and constant speed alternator drives.

AeroShell Fluid S.8350 is an extreme pressure gear oil and recommended for lubrication of gears where the use of a 90 EP gear oil is required.

Calibrating Fluid

AeroShell Calibrating Fluid 2

This fluid is used for calibrating the aircraft fuel system components of turbine engines.

De-icing Fluids

AeroShell Compound 07

Various alcohols, or mixtures of these with other materials, are used for de-icing windscreens, propellers, carburettors and wing surfaces. The most common requirement, for de-icers for windscreens and propellers, is met by AeroShell Compound 07. AeroShell Compound 07 is also an approved wing de-icing fluid.

Avionic Cooling Fluids

AeroShell Fluid 602

AeroShell Fluid 602 is a cooling fluid for aircraft avionic systems.

Smoke Oil

AeroShell Smoke Oil

AeroShell Smoke Oil is used in both piston engine and jet engine powered aviation aerobatic flight displays.

NOTES

AEROSHELL FLUID 3

AeroShell Fluid 3 is a general purpose mineral lubricating oil recommended for general lubrication of aircraft parts that require a light oil with good low temperature characteristics and a low freezing point. It is inhibited against oxidation and corrosion. AeroShell Fluid 3 is a relatively low viscosity product with good resistance to evaporation.

APPLICATIONS

AeroShell Fluid 3 is recommended for general lubrication of aircraft parts that require a light oil, e.g. hinges, pivot joints, shaft joints, linkage pins and bearings, pulleys, cables, camera mechanisms, radio and radar gear and instruments. AeroShell Fluid 3 is normally applied by means of an oil can or brush. For this reason it is also described as 'an oilcan lubricant'.

Operating temperature range of AeroShell Fluid 3 is –54°C to +121°C (–65°F to 250°F).

For high temperature applications where no provision is made for frequent re-lubrication the synthetic oil, AeroShell Fluid 12, should be used in place of the mineral oil, AeroShell Fluid 3; however in this case care should be taken to ensure that there is no incompatibility between AeroShell Fluid 12 and seals, paints etc.

SPECIFICATIONS

U.S.	Approved MIL-PRF-7870E
British	Meets DEF STAN 91-047 (Obsolete)
French	-
Russian	-
NATO Code	O-142
Joint Service Designation	OM-12 (Obsolete)

PROPERTIES		MIL-PRF-7870E	TYPICAL
Oil type		-	Mineral
Kinematic viscosity @ 38°C (100°F) @ –40°C (–40°F)	mm^2/s	 10 min 4000 max	 10 < 4000
Flashpoint Cleveland Open Cup	°C (°F)	 130 (266) min	 155 (311)
Pourpoint	°C (°F)	–57 (–70) max	< –57 (–70)
Evaporation @ 99°C (210°F), 22 hrs	%m	25 max	19
Total acid number	mgKOH/g	Report	0.68
Density @ 15°C (59°F)	kg/m^3	-	890
Low temperature stability 72 hrs @ –54°C (–65°F)		 Must pass	 Passes
Corrosion & oxidation stability 168 hrs @ 121°C (250°F) - metal weight change - viscosity change @ 37.8°C (100°F) - acid number change	 % mgKOH/g	 Must pass –5 to +20 0.2 max	 Passes 10 0.06
Corrosivity		Must pass	Passes
Precipitation number	ml	0 max	Passes
ASTM colour		-	< 0.5

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

AEROSHELL FLUID 5M-A

AeroShell Fluid 5M-A is a highly refined, medium viscosity mineral oil containing an extreme pressure additive as well as additives to provide good oxidation and corrosion protection.

APPLICATIONS

Aeroshell Fluid 5M-A is used for the lubrication of gears where high tooth loadings exist. AeroShell Fluid 5M-A is particularly recommended for the lubrication of translation units of contra-rotating propellers, radar gearboxes, constant speed alternator drives. AeroShell Fluid 5M-A is also used in those helicopter transmissions (gearboxes) which require use of a MIL-PRF-6086 oil.

AeroShell Fluid 5M-A is also suitable as an extreme pressure lubricant for heavily loaded pins, bushes and gear mechanisms.

AeroShell Fluid 5M-A must not be used in engines.

SPECIFICATIONS

U.S.	Approved MIL-PRF-6086F Medium Grade
British	Approved DEF STAN 91-112 Grade M
French	-
Russian	-
NATO Code	O-155
Joint Service Designation	OEP-70

PROPERTIES		MIL-PRF-6086F Medium Grade	TYPICAL
Oil type		-	Mineral
Kinematic viscosity @ 37.8°C (100°F) @ 98.9°C (210°F)	mm^2/s	 60 to 82 -	 72 8.7
Viscosity index		80 min	102
Flashpoint	°C (°F)	154.5 (310) min	181 (358)
Pourpoint	°C (°F)	−28.9 (−20) max	−39 (−38)
Precipitation number	ml	0.1 max	< 0.05
Total acid number	mgKOH/g	1.0 max	< 0.1
Relative density @ 15.6°C (60°F)		-	0.92
Load wear index	kgf	40 min	47
Colour ASTM		8 max	1.5
Foaming tendency		Must pass	Passes
Copper corrosion 3 hrs @ 100°C (212°F)		Must pass	Passes

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

AEROSHELL FLUID 12

AeroShell Fluid 12 is a low volatility synthetic ester oil used in aircraft instruments and also for the general lubrication of aircraft. It is oxidation and corrosion inhibited, and possesses good high and low temperature characteristics.

APPLICATIONS

AeroShell Fluid 12 is used for general aircraft lubrication as well as for aircraft gyro instrument gimbal bearings, separately lubricated high speed turbines and compressors, aircraft air cycle equipment and electronic equipment. AeroShell Fluid 12 is particularly suitable for use when an oil with a low evaporation rate is required at high and low temperatures.

AeroShell Fluid 12 is a synthetic oil and it should not be used in contact with incompatible seal materials such as neoprene or natural rubber. Suitable seal material include Fluorocarbon (Viton). AeroShell Fluid 12 may also affect certain paints and plastics. It is recommended that components are evaluated for compatibility if there is any question.

SPECIFICATIONS

U.S.	Approved MIL-PRF-6085E
British	Equivalent DEF STAN 91-049
French	Approved AIR 3511/A
Russian	-
NATO Code	O-147
Joint Service Designation	Equivalent OX-14
COMAC	Approved QPL-CMS-OL-204

PROPERTIES		MIL-PRF-6085E	TYPICAL
Oil type		-	Synthetic ester
Colour ASTM		5.0 max	< 1.5
Density @ 15°C (59°F)	kg/m^3	-	925
Kinematic viscosity @ 54.4°C (130°F) @ –54°C (–65°F)	mm^2/s	 8 min 12000 max	 9 11000
Pourpoint	°C (°F)	–57 (–70) max	< –60 (–76)
Flashpoint Cleveland Open Cup	°C (°F)	185 (365) min	> 220 (428)
Total acid number	mgKOH/g	Report	0.20
Relative density @ 15.6°C (60°F)		-	0.925
Evaporation loss in 22 hrs @ 120°C (248°F)	%m	1.80 max	0.6
Corrosion & oxidation stability 168 hrs @ 121°C (250°F) - metal weight change - viscosity change - total acid number change - insolubles	 mg/cm^3 % mgKOH/g mg/100ml	 Must pass ± 5 0.5 max Must pass	 Passes 1 0.2 Passes
Low temperature stability 72 hrs @ –54°C (–65°F)		Must pass	Passes
Precipitation number	ml	0 max	0
Corrosivity		Must pass	Passes

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

AEROSHELL FLUID 602

AeroShell Fluid 602 synthetic base fluid is composed of highly branched, compact and very stable molecules known as polyalphaolefins (PAO), blended with additives to provide long term storage stability.

AeroShell Fluid 602 offers exceptional performance over a wide temperature range between –54°C to 200°C (–65°F to 392°F) and does not react with water, resulting in clean systems and long fluid and component life.

APPLICATIONS

AeroShell Fluid 602 is most widely used as a cooling fluid for aircraft avionic systems, whose benefits include lower initial cost, longer fluid life, lower weight and lower toxicity when compared with other types of avionic system coolants. Since AeroShell Fluid 602 does not react with water, no reclamation equipment is required, adding further to the cost advantage.

SPECIFICATIONS

U.S.	Approved MIL-PRF-87252E
British	-
French	-
Russian	-
NATO Code	S-1748
Joint Service Designation	-

PROPERTIES		MIL-PRF-87252E	TYPICAL
Relative density @ 15.6°C (60°F)		-	0.799
Viscosity	mm^2/s		
@ 100°C (212°F)		1.65 min	1.77
@ 40°C (104°F)		5.0 min	5.29
@ –40°C (–40°F)		300 max	280
@ –54°C (–65°F)		1300 max	1094
Flash point	°C (°F)	150 (302) min	160 (320)
Fire point	°C (°F)	160 (320) min	171 (340)
Total acid number	mgKOH/g	0.2 max	< 0.01
Water content, Karl Fischer	ppm	50 max	35
Dielectric breakdown Voltage	kv	35 min	47
Volume resistivity @ 25°C (77°F)	ohm-cm	1.0×10^{10} min	2.9×10^{15}
Particle count, automatic			
5 to 15 µm		8000 max	2664
16 to 25 µm		1425 max	345
26 to 50 µm		253 max	86
51 to 100 µm		45 max	10
< 100 µm		8 max	0
High temperature stability @ 200°C (392°F)		Must pass	Passes
Corrosiveness and oxidation stability		Must pass	Passes

AEROSHELL FLUID S.8350

AeroShell Fluid S.8350 is an SAE 90 extreme pressure gearbox oil.

APPLICATIONS

AeroShell Fluid S.8350 is used for helicopter rotor gears, drive-shafts and pitch control mechanisms and wherever high loads and slow speeds in gears require the use of a 90 EP gear oil. AeroShell Fluid S.8350 is approved for use in various Westland helicopter gearboxes.

AeroShell Fluid S.8350 must not be used in engines.

SPECIFICATIONS

U.S.	-
British	-
French	-
Russian	-
NATO Code	-
Joint Service Designation	OEP-215

PROPERTIES		OEP-215	TYPICAL
Oil type		-	Mineral
Kinematic viscosity	mm^2/s		
@ 40°C (104°F)		-	182
@ 100°C (212°F)		16.26 to 17.42	17.0
Viscosity index		85 min	97
Flashpoint Cleveland Open Cup	°C (°F)	177 (350) min	228 (442)
Pourpoint	°C (°F)	–18 (–0.4) max	–21 (–5.8)
Total acid number	mgKOH/g	0.2	0.15
Density @ 15°C (59°F)	kg/m^3	-	895
Evaporation loss @ 150°C (302°F)		5 max	3.0
Precipitation loss	ml	0.05 max	0.01
Copper corrosion		Must pass	Passes
Foaming, sequence I, II, III		Must pass	Passes

AEROSHELL CALIBRATING FLUID 2

AeroShell Calibrating Fluid 2 is composed of Specially Run Stoddard Solvent and is used for calibrating aircraft fuel system components.

APPLICATIONS

AeroShell Calibrating Fluid 2 is intended for the calibration of fuel system components of aircraft turbine engines.

SPECIFICATIONS

U.S.	Approved MIL-PRF-7024F Type II
British	-
French	-
Russian	-
NATO Code	-
Joint Service Designation	-

PROPERTIES		MIL-PRF-7024F Type II	TYPICAL
Oil type		-	Mineral
Relative density @ 15.6°C (60°F)		0.77 ± 0.005	0.766
Colour (Saybolt)		-	30
Kinematic viscosity @ 25°C (77°F)	mm^2/s	1.17 ± 0.05	1.2
Flashpoint	°C (°F)	38 (100) min	43 (109)
Distillation:			
Initial boiling point	°C (°F)	149 (300) min	152 (305)
Final boiling point	°C (°F)	210 (410) max	196 (385)
Recovery	%	98.5 min	99
Total acid number	mgKOH/g	0.015 max	0.003
Copper corrosion 3 hrs @ 100°C (212°F)		Must pass	Passes
Aromatics	% vol	20 max	< 7
Existent gum	mg/100ml	5.0 max	< 5
Olefin content	%v	5.0 max	< 5
Particulate matter	mg/l	2.0 max	< 1
Benzene	%vol	0.01 max	< 0.01
Mercaptan sulfur (Doctor Test)		Sweet	0-29

AEROSHELL COMPOUND 07

AeroShell Compound 07 is a de-icing fluid composed of ethylene glycol, isopropyl alcohol and distilled water.

Specification DTD.406B requires the product to have the following approximate composition:

Ethanediol (BS.2537) 85% volume
Isopropanol (BS.1595) 5% volume
Distilled water 10% volume

APPLICATIONS

AeroShell Compound 07 is used for in-flight de-icing of windscreens, propellers, wings, tailplanes, etc. on suitably equipped aircraft.

AeroShell Compound 07 is also recommended for removing hoar frost and light snow/ice from parked aircraft. AeroShell Compound 07 can be sprayed undiluted or mixed with up to 50% volume of water, depending upon the severity of the icing conditions, the efficiency of the spraying technique and whether it is applied hot or cold.

SPECIFICATIONS

U.S.	-
British	Meets DTD.406B (Obsolete)
French	-
Russian	-
NATO Code	S-745
Joint Service Designation	AL-5

PROPERTIES		DTD.406B (Obsolete)	TYPICAL
Flashpoint Cleveland Open Cup	°C (°F)	-	54.4 (130)
Kinematic viscosity @ 20°C (68°F)	mm^2/s	11.0 to 13.0	11.4
Cold test @ −40°C (−40°F)		No deposition	Complies
pH value		6.0 to 7.5	6.9
Conductivity	micromho/cm	5.0 max	0.5
Density @ 15°C (59°F)	kg/l	1.092 to 1.097	1.094
Miscibility with water @ 15°C (59°F)		Must pass	Passes

AEROSHELL SMOKE OIL

AeroShell Smoke Oil is a hydrocarbon fluid based on Shell Gas-to-Liquid Technology. It is fully saturated with a high degree of iso paraffinic structures.

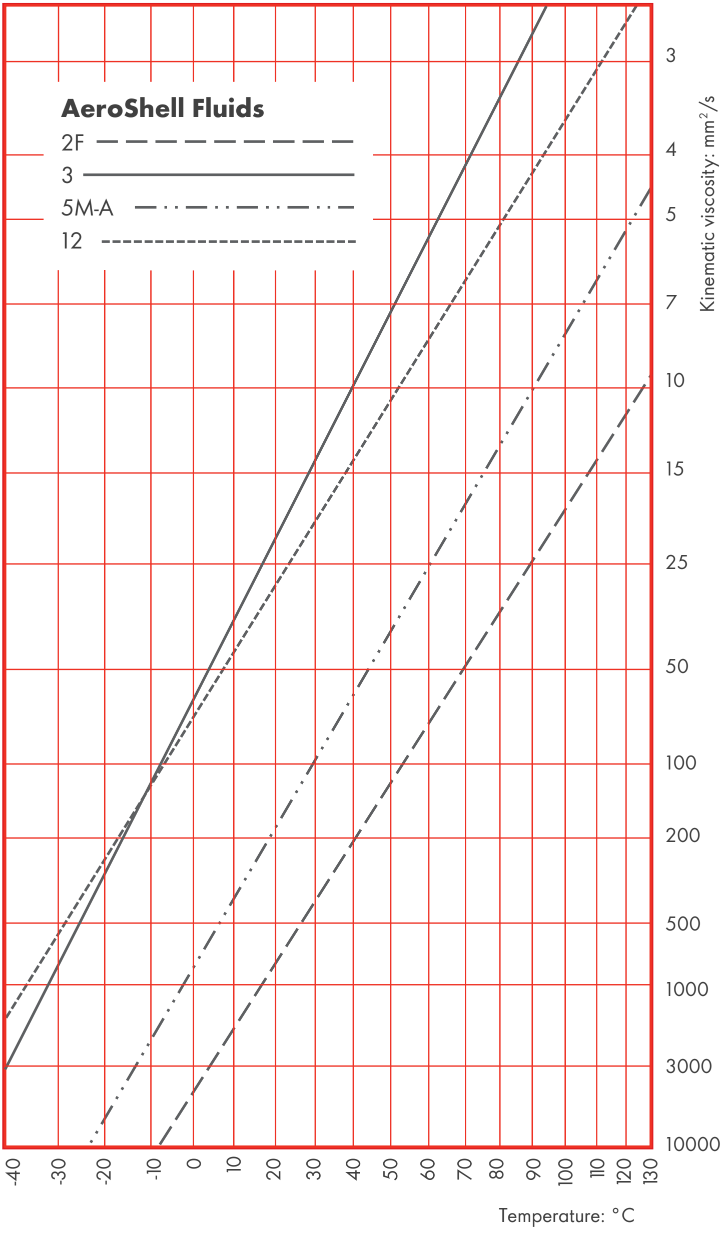
AeroShell Smoke Oil has low viscosity and good low temperature properties. It can be readily vaporized and fulfils the stringent international pharmacopoela purity.

APPLICATIONS

AeroShell Smoke Oil is used in both piston engine and jet engine powered aviation aerobatic flight displays.

PROPERTIES		TYPICAL
Colour (Saybolt)		30
Density @ 15°C (59°F)	kg/m^3	806
Refractive index @ 20°C (68°F)		1.45
Viscosity index		118
Flashpoint Cleveland Open Cup	°C (°F)	200 (392)
Pour point	°C (°F)	–45 (–49)
Kinematic viscosity	mm^2/s	
@ 20°C (68°F)		19
@ 40°C (104°F)		9.8
@ 100°C (212°F)		2.7
Aniline point	°C (°F)	114 (237)
Evaporation loss 22h/107°C (224°F)	%m	0.75
Noack volatility 1h/250°C (482°F)	%m	40
Medicinal white oil		
EU Pharm.		Meet
US Pharm.		Meet
FDA 21CFR172.878		Meet
21CFR178.3620		Meet

TYPICAL TEMPERATURE/VISCOSITY CURVE OF OTHER AEROSHELL FLUIDS



CONVERSION TABLES

9. CONVERSION TABLES

TEMPERATURE CONVERSION CHART

The central figure in each column is the temperature in degrees Celsius or Fahrenheit which require conversion. If this is in terms of degrees Celsius, the corresponding Fahrenheit temperature will be found to the right of it; if the given temperature is in terms of Fahrenheit, the corresponding Celsius temperature is to the left.

°C		°F	°C		°F	°C		°F
-73.3	**-100**	-148.0	-6.7	**20**	68.0	10.0	**50**	122.0
-67.8	**-90**	-130.0	-6.1	**21**	69.8	10.6	**51**	123.8
-62.2	**-80**	-112.0	-5.6	**22**	71.6	11.1	**52**	125.6
-56.7	**-70**	-94.0	-5.0	**23**	73.4	11.7	**53**	127.4
-51.1	**-60**	-76.0	-4.4	**24**	75.2	12.2	**54**	129.2
-45.6	**-50**	-58.0	-3.9	**25**	77.0	12.8	**55**	131.0
-40.0	**-40**	-40.0	-3.3	**26**	78.8	13.3	**56**	132.8
-34.4	**-30**	-22.0	-2.8	**27**	80.6	13.9	**57**	134.6
-28.9	**-20**	-4.0	-2.2	**28**	82.4	14.4	**58**	136.4
-23.3	**-10**	14.0	-1.7	**29**	84.2	15.0	**59**	138.2
-17.8	**0**	32.0	-1.1	**30**	86.0	15.6	**60**	140.0
-17.2	**1**	33.8	-0.6	**31**	87.8	16.1	**61**	141.8
-16.7	**2**	35.6	0.0	**32**	89.6	16.7	**62**	143.6
-16.1	**3**	37.4	0.6	**33**	91.4	17.2	**63**	145.4
-15.6	**4**	39.2	1.1	**34**	93.2	17.8	**64**	147.2
-15.0	**5**	41.0	1.7	**35**	95.0	18.3	**65**	149.0
-14.4	**6**	42.8	2.2	**36**	96.8	18.9	**66**	150.8
-13.9	**7**	44.6	2.8	**37**	98.6	19.4	**67**	152.6
-13.3	**8**	46.4	3.3	**38**	100.4	20.0	**68**	154.4
-12.8	**9**	48.2	3.9	**39**	102.2	20.6	**69**	156.2
-12.2	**10**	50.0	4.4	**40**	104.0	21.1	**70**	158.0
-11.7	**11**	51.8	5.0	**41**	105.8	21.7	**71**	159.8
-11.1	**12**	53.6	5.6	**42**	107.6	22.2	**72**	161.6
-10.6	**13**	55.4	6.1	**43**	109.4	22.8	**73**	163.4
-10.0	**14**	57.2	6.7	**44**	111.2	23.3	**74**	165.2
-9.4	**15**	59.0	7.2	**45**	113.0	23.9	**75**	167.0
-8.9	**16**	60.8	7.8	**46**	114.8	24.4	**76**	168.8
-8.3	**17**	62.6	8.3	**47**	116.6	25.0	**77**	170.6
-7.8	**18**	64.4	8.9	**48**	118.4	25.6	**78**	172.4
-7.2	**19**	66.2	9.4	**49**	120.2	26.1	**79**	174.2

°C		°F	°C		°F	°C		°F
26.7	**80**	176.0	48.9	**120**	248.0	71.1	**160**	320.0
27.2	**81**	177.8	49.4	**121**	249.8	71.7	**161**	321.8
27.8	**82**	179.6	50.0	**122**	251.6	72.2	**162**	323.6
28.3	**83**	181.4	50.6	**123**	253.4	72.8	**163**	325.4
28.9	**84**	183.2	51.1	**124**	255.2	73.3	**164**	327.2
29.4	**85**	185.0	51.7	**125**	257.0	73.9	**165**	329.0
30.0	**86**	186.8	52.2	**126**	258.8	74.4	**166**	330.8
30.6	**87**	188.6	52.8	**127**	260.6	75.0	**167**	332.6
31.1	**88**	190.4	53.3	**128**	262.4	75.6	**168**	334.4
31.7	**89**	192.2	53.9	**129**	264.2	76.1	**169**	336.2
32.2	**90**	194.0	54.4	**130**	266.0	76.7	**170**	338.0
32.8	**91**	195.8	55.0	**131**	267.8	77.2	**171**	339.8
33.3	**92**	197.6	55.6	**132**	269.6	77.8	**172**	341.6
33.9	**93**	199.4	56.1	**133**	271.4	78.3	**173**	343.4
34.4	**94**	201.2	56.7	**134**	273.2	78.9	**174**	345.2
35.0	**95**	203.0	57.2	**135**	275.0	79.4	**175**	347.0
35.6	**96**	204.8	57.8	**136**	276.8	80.0	**176**	348.8
36.1	**97**	206.6	58.3	**137**	278.6	80.6	**177**	350.6
36.7	**98**	208.4	58.9	**138**	280.4	81.1	**178**	352.4
37.2	**99**	210.2	59.4	**139**	282.2	81.7	**179**	354.2
37.8	**100**	212.0	60.0	**140**	284.0	82.2	**180**	356.0
38.3	**101**	213.8	60.6	**141**	285.8	82.8	**181**	357.8
38.9	**102**	215.6	61.1	**142**	287.6	83.3	**182**	359.6
39.4	**103**	217.4	61.7	**143**	289.4	83.9	**183**	361.4
40.0	**104**	219.2	62.2	**144**	291.2	84.4	**184**	363.2
40.6	**105**	221.0	62.8	**145**	293.0	85.0	**185**	365.0
41.1	**106**	222.8	63.3	**146**	294.8	85.6	**186**	366.8
41.7	**107**	224.6	63.9	**147**	296.6	86.1	**187**	368.6
42.2	**108**	226.4	64.4	**148**	298.4	86.7	**188**	370.4
42.8	**109**	228.2	65.0	**149**	300.2	87.2	**189**	372.2
43.3	**110**	230.0	65.6	**150**	302.0	87.8	**190**	374.0
43.9	**111**	231.8	66.1	**151**	303.8	88.3	**191**	375.8
44.4	**112**	233.6	66.7	**152**	305.6	88.9	**192**	377.6
45.0	**113**	235.4	67.2	**153**	307.4	89.4	**193**	379.4
45.6	**114**	237.2	67.8	**154**	309.2	90.0	**194**	381.2
46.1	**115**	239.0	68.3	**155**	311.0	90.6	**195**	383.0
46.7	**116**	240.8	68.9	**156**	312.8	91.1	**196**	384.8
47.2	**117**	242.6	69.4	**157**	314.6	91.7	**197**	386.6
47.8	**118**	244.4	70.0	**158**	316.4	92.2	**198**	388.4
48.3	**119**	246.2	70.6	**159**	318.2	92.8	**199**	390.2

°C		°F	°C		°F	°C		°F
93.3	**200**	392.0	204.4	**400**	752.0	315.6	**600**	1112.0
98.9	**210**	410.0	210.0	**410**	770.0	343.3	**650**	1202.0
104.4	**220**	428.0	215.6	**420**	788.0	371.1	**700**	1292.0
110.0	**230**	446.0	221.1	**430**	806.0	398.9	**750**	1382.0
115.6	**240**	464.0	226.7	**440**	824.0	426.7	**800**	1472.0
121.1	**250**	482.0	232.2	**450**	842.0	454.4	**850**	1562.0
126.7	**260**	500.0	237.8	**460**	860.0	482.2	**900**	1652.0
132.2	**270**	518.0	243.3	**470**	878.0	510.0	**950**	1742.0
137.8	**280**	536.0	248.9	**480**	896.0	537.8	**1000**	1832.0
143.3	**290**	554.0	254.4	**490**	914.0	315.6	**600**	1112.0
148.9	**300**	572.0	260.0	**500**	932.0			
154.4	**310**	590.0	265.6	**510**	950.0			
160.0	**320**	608.0	271.1	**520**	968.0			
165.6	**330**	626.0	276.7	**530**	986.0			
171.1	**340**	644.0	282.2	**540**	1004.0			
176.7	**350**	662.0	287.8	**550**	1022.0			
182.2	**360**	680.0	293.3	**560**	1040.0			
187.8	**370**	698.0	298.9	**570**	1058.0			
193.3	**380**	716.0	304.4	**580**	1076.0			
198.9	**390**	734.0	310.0	**590**	1094.0			

$°C = {}^5/_9\,(°F - 32)$

$°F = ({}^5/_9 \times °C) + 32$

MISCELLANEOUS CONVERSION CHART

Some useful conversion factors are listed below. For a full range, consult **www.onlineconversion.com**

TO CONVERT FROM:	TO:	MULTIPLY BY:
Calorific Value. SI units - mass basis-Joule/kilogramme (J/kg); volume basis-Joule/cubic metre (J/m^3)		
MJ/kg	Btu/lb	4.299×10^2
Btu/lb	kWh/kg	6.461×10^{-4}
cal/g(kcal/kg)	Btu/lb	1.8
Concentration (mass/volume) and **Density**. SI unit - kilogramme/cubic metre (kg/m^3)		
kg/m^3(g/litre)	kg/litre	10^{-3}
lb/1000 UK gal	mg/litre	99.78
lb/1000 US gal	mg/litre	1.198×10^2
g/US gal	g/litre	0.264
kg/litre	lb/UK gal	10.02
kg/litre	lb/ft^3	62.43
Concentration (volume/volume). SI unit - cubic metre/cubic metre (m^3/m^3)		
ml/UK gal	ml/litre or litre/m^3	0.22
ml/US gal	ml/litre or litre/m^3	0.264
ppm	% vol	10^{-4}
Energy/Heat/Work. SI unit - Joule (J)		
Btu	kJ	1.055
Btu	kWh	2.9307×10^{-4}
therm	MJ	1.055×10^2
cal	J	4.1868
kWh	MJ	3.6
Force. SI unit - Newton (N)		
lbf	N	4.448
pdl	N	1.38255×10^{-1}
dyne	mN	0.01
Length. SI unit - metre (m)		
in	mm	25.4
ft	m	0.3048

TO CONVERT FROM:	TO:	MULTIPLY BY:
Mass. SI unit - kilogram (kg)		
kg	lb	2.2046
lb	g	4.536×10^2
UK ton (2240 lb) long	tonne(t)	1.016
UK ton (2000 lb) short	tonne(t)	0.907
Power/Heat Flow. SI unit - Watt (W)		
h.p.	kW	0.7457
ft.lbf/s	W	1.3558
Btu/hr	W	0.2931
Pressure. SI unit - Newton/square metre (N/m^2)		
N/m^2 (Pascal)	Bar	10^{-5}
lbf/in^2(psi)	N/m^2 (Pa)	6.895×10^3
lbf/in^2	mbar	68.948
kgf/cm	$2N/m^2$	9.807×10^4
kgf/cm^2	lbf/in^2	14.223
in Hg	mbar	33.864
atmosphere	mbar	1013.25
lbf/in^2(psi)	Pa	6.894757×10^3
lbf/in^2(psi)	Bar	0.06894
Bar	Pa (N/m^2)	105
Volume. SI units - cubic metre (m^3)		
m^3	ft^3	35.315
in^3	cm^3	16.387
UK gal	m^3	4.546×10^{-3}
US gal	m^3	3.785×10^{-3}
UK gal	litre	4.546
US gal	litre	3.785

Relative Density) Specific Gravity/API conversion

(Relative Density) Specific Gravity 15.6/15.6°C (60°F) = $\dfrac{141.5}{°API + 131.5}$

Kinematic viscosity

mm^2/s = 1cSt

AVIATION SPECIFICATIONS

10. AVIATION SPECIFICATIONS

AVIATION SPECIFICATIONS GUIDE

British, U.S., French and Russian Military Specifications for aviation fuels, engine oils, hydraulic fluids, greases and other aviation products used on aircraft.

Foreword

This part of the AeroShell Book contains five lists relating to British and U.S. Military Aviation specifications, NATO Code Numbers, Joint Service Designations and Shell Aviation Products. The lists are inter-related in that they contain the same data arranged in different forms for easy reference. In each list or table, the title data is given in the first column in numerical order.

Further lists provide details of French and Russian Military Aviation Specifications and Shell Aviation Products. Specifications of other countries have not been included for reasons of space and their more limited application.

Details of the precise relationship between the various items on each line are given in the introductions preceding each list.

The significance of the letters incorporated in the various specification numbers and reference symbols are given in the key in the following page.

In the column headed "Product and Application" only the most important and representative known uses have been named, and these are intended to serve as an indication of the type of application for which each grade is suitable.

A range of substitutes to Russian grades have been developed for use in aircraft manufactured in Russia, some of which have been approved by the Russian Authorities and full details of these approvals are given in the list of Russian Specifications.

Some AeroShell products are manufactured at more than one location. It is possible that the approval status will vary according to the source of material.

The specification information provided is believed correct at time of going to press. However, commercial and military specifications for aviation products are subject to frequent changes, and where applications require compliance of AeroShell grades to new or revised specifications, consultation with the local Shell company is advised.

In many cases where an AeroShell grade is not listed an unbranded, specification grade may be available; for further details please consult your local AeroShell supplier.

U.S. Specifications

AAF	U.S. Army Air Force
AN	U.S. Air Force Navy Aeronautical
JAN	Joint Army/Navy
MIL	U.S. Military Specification
DOD	Department of Defense
PRF	Performance Standard
DTL	Detail Standard
VV	U.S. Federal Specification
JJJ	U.S. Federal Specification
TT	U.S. Federal Specification
SS	U.S. Federal Specification
O	U.S. Federal Specification
P	U.S. Federal Specification

British Specifications

DTD DEF	Procurement Executive Ministry of Defence (Director of Materials Research)
D.Eng.R.D. DERD D.Eng.D	Procurement Executive Ministry of Defence (Director General Engine Development)
DEF STAN	Directorate of Standardisation, Ministry of Defence
CS	Procurement Executive Ministry of Defence (Materials Quality Assurance Directorate)
BS	British Standards Institution
TS	Technical Specification

British Joint Service Designation

Oils

OM	Oil mineral
OEP	Oil extreme pressure
OMD	Oil mineral detergent
OF	Oil fatty
OC	Oil compound
OX	Oil miscellaneous

The number following represents the approximate viscosity at 40°C (104°F).

Greases

LG	Lime base grease
XG	Miscellaneous grease

This covers greases made from less common soaps, e.g. aluminium, lithium, etc., unspecified soaps or mixture of soaps. The group also includes greases containing fatty oils, synthetic oils, graphite or other non-soap additives.

The number following represents the approximate worked penetration.

Miscellaneous Products

PX	Protective, miscellaneous. Materials for temporary protection against corrosion of metal equipment in storage
ZX	Speciality, miscellaneous
AL	Coolants, anti-freezing and de-icing agents The number following is merely an arbitrary serial number

NATO Symbols

F	All fuels
O	All oils except those developed for some other primary function other than lubrication
H	All oils where the hydraulic properties are the main consideration
G	All greases except those developed for a special function
C	All products possessing anti-corrosion properties
S	All products which were developed for special functions, i.e. speciality products
P	All products for use as propellants

U.S. AVIATION SPECIFICATIONS

Scope of list

This list is comprised of U.S. Military Specifications which cover aviation fuels, engine oils, hydraulic fluids, greases and allied products.

The U.S. authorities have decided to eliminate MIL specifications as they were previously known and replaced them by Performance specifications. These are labelled MIL-PRF- followed by a number. Many MIL-PRF- specifications have now been issued and others will follow until all current MIL specifications have been converted. The numeric part of the MIL-PRF- designation is the same as the numeric part of the MIL specification it replaces; however, the letter which denotes the Revision level has also changed. Some other MIL specifications have been converted to Detail specifications denoted by MIL-DTL- followed by a number. MIL specifications which are cancelled or obsolete will not be changed.

For certain products, the US authorities have decided to no longer maintain military specifications; in these cases, they have been converted to civil specifications by the SAE (Society of Automotive Engineers).

Examples of this change include:

MIL-L-7808K has become MIL-PRF-7808L
MIL-L-23699F has become MIL-PRF-23699G
MIL-T-83188D has become MIL-DTL-83188E
MIL-G-4343C has become SAE AMSG4343

U.S. Military specifications can be downloaded free of charge as Acrobat documents from U.S. Department of Defense ASSIST database site:

https://quicksearch.dla.mil/qsSearch.aspx

Qualified Products Lists (QPLs) are held electronically in the Qualified Products Database (PQD) and can be downloaded from there on the ASSIST website.

Interpretation of list

In the column headed "Alternative British Specification", only those specifications which are equivalent, or acceptable alternatives, to the U.S. Specification are shown.

Where an asterisk* appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses of the official specifications, but is the nearest product marketed by Shell.

For easy reference, obsolete specifications are shown in both the current and superseded specification columns. In the former case, a suitable comment is made, namely, "OBSOLETE - superseded by..."

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-P-116J (Obsolete)	MIL-P-116H	-	Refer to MIL-STD-2073-1D Standard Practice for Military Packaging	-	-
MIL-PRF-372F	MIL-PRF-372E	-	Solvent cleaning compound for automatic weapons	-	-
MIL-PRF-680C	MIL-PRF-680B	 S-752 S-753 S-760 - -	Degreasing solvent Type I Type II Type III Type IV Type V	-	-
MIL-PRF-907H	MIL-PRF-907G	-	High temperature anti-seize thread compound	-	-
MIL-S-3136B (Obsolete)	-	-	OBSOLETE - superseded by TT-S-735	-	-
MIL-PRF-3150E	MIL-PRF-3150D	O-192	Preservative Lubricating Oil - Medium	-	-
MIL-G-3278A (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-23827A	-	-
MIL-G-3545C (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-81322 (AeroShell Grease 5 is still available meeting MIL-G-3545C and NATO Code G-359)	-	AeroShell Grease 5*
MIL-PRF-3572C	MIL-PRF-3572B	-	Lubricant, colloidal graphite in oil	-	-
MIL-DTL-3918B (Obsolete)	MIL-L-3918A	-	Jewel bearing instrument oil - Specification cancelled without replacement	-	-
MIL-DTL-4339E (Inactive for new design)	MIL-C-4339D	C-630	Soluble corrosion preventive oil - INACTIVE	-	-
MIL-G-4343C (Obsolete)	MIL-G-4343B	G-392	Grease for pneumatic systems - superseded by SAE AMSG4343	(SAE AMSG4343A)	-
MIL-DTL-5020F	MIL-DTL-5020E	S-712 (Obsolete)	Aircraft compass liquid	-	-
MIL-T-5542E (Obsolete)	-	-	Specification cancelled. Use MIL-PRF-27617	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-T-5544C (Obsolete)	MIL-T-5544B	S-720	Graphite-petrolatum anti-seize thread compound - superseded by SAE AMS2518	DEF STAN 80-080	-
MIL-C-5545C (Obsolete)	AN-C-178 MIL-C-5545B	C-612 (Obsolete)	Corrosion preventive compound for aircraft engines, heavy oil type	-	-
MIL-G-5572F (Obsolete)	-	-	Specification cancelled. Use ASTM D910	-	-
MIL-H-5606A (Obsolete)	MIL-O-5606	-	Hydraulic aircraft oil, petroleum base. Remains available for civil use.	DTD.585 (Obsolete)	AeroShell Fluid 4*
MIL-PRF-5606J	MIL-PRF-5606H	H-515	Hydraulic aircraft oil, petroleum base, of improved cleanliness and performance	DEF STAN 91-048 Grade Superclean	AeroShell Fluid 41
MIL-E-5607F (Obsolete)	MIL-E-5607E	-	Process for preparation for storage and shipment of gas turbine engines	-	-
MIL-DTL-5624W Grade JP-4 Grade JP-5	MIL-DTL-5624V	- F-40 F-44	Aircraft turbine engine fuel Wide cut, gasoline type with FSII High flash point, kerosine type with FSII	- DEF STAN 91-086 DEF STAN 91-088	- - Shell JP-5
MIL-G-6032D (Obsolete)	AN-G-14a MIL-L-6032C	G-363	Gasoline and oil resistant grease - superseded by SAE AMSG6032	DEF STAN 91-006	-
MIL-E-6058B (Obsolete)	AN-R-11a MIL-P-5894 MIL-E-6058A	-	Procedure for preparation of aircraft reciprocating engines for storage and shipment	D.Eng.R.D. 2027 (Obsolete)	-
MIL-E-6059A (Inactive for new design)	AN-E-50	-	Processes for corrosion protection, pre-oiling and ground operation of aircraft reciprocating engines	D.Eng.R.D. 2027 (Obsolete)	-
MIL-PRF-6081E Grade 1005 Grade 1010 Grade 1010N	MIL-PRF-6081D	 O-132 (Obsolete) O-133 -	Aircraft mineral turbine oil Grade 1005 Grade 1010 Grade 1010N	-	 - AeroShell Turbine Oil 2 AeroShell Turbine Oil 2
MIL-L-6082E (Obsolete)	-	-	OBSOLETE - superseded by SAE J1966. See later in this section.	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-PRF-6083G	MIL-PRF-6083F	C-635	Preservative oil of improved cleanliness for hydraulic equipment	DEF STAN 80-142	-
MIL-PRF-6085E	MIL-PRF-6085D	O-147	Low volatility aircraft instrument lubricating oil	DEF STAN 91-049	AeroShell Fluid 12
MIL-PRF-6086F Grade L - Light Grade M - Medium	MIL-PRF-6086E	 O-153 O-155	Lubricating gear oil, petroleum base Low viscosity Medium viscosity	DEF STAN 91-112 Grade L (OEP-30) Grade M (OEP-70)	 - AeroShell Fluid 5M-A
MIL-A-6091C (Obsolete)	-	-	Denatured ethyl alcohol for aircraft use	BS 3591:1985	-
MIL-C-6529C (Inactive for new design)	MIL-C-7853 MIL-C-6529B	 C-608 C-609 C-610	Non metallic aircraft engine corrosion preventive compounds Type I - concentrate Type II - ready mixed material for aircraftpiston engines Type III - ready mixed material for jet aircraft engines	 (MIL-C-6529C) - -	 AeroShell Fluid 2XN - -
MIL-S-6625A (Obsolete)	MIL-S-6625	-	Anti-icing spray equipment for aircraft windshield	-	-
MIL-C-6708 (Obsolete)	-	-	OBSOLETE - superseded by MIL-C-16173E, Grade 1 and MIL-C-11796C	-	-
MIL-G-6711 (Obsolete)	-	-	OBSOLETE - superseded by SS-G-659A	-	-
MIL-L-6880B (Obsolete)	-	-	General Specification for lubrication of aircraft. OBSOLETE – superseded by MIL-STD-838	-	-
MIL-PRF-7024F	MIL-PRF-7024E	-	Calibrating fluid for aircraft fuel systems and components Type I - normal heptane Type II - special run Stoddard solvent Type III - high flashpoint fluid	-	 - AeroShell Calibrating Fluid 2 -

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-G-7118A (Obsolete)	-	-	OBSOLETE - superseded by MIL-PRF-23827C	-	-
MIL-G-7187 (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-21164D and MIL-G-23549	-	-
MIL-G-7421B (Obsolete)	-	-	OBSOLETE - superseded by MIL-PRF-23827C	-	-
MIL-G-7711A (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-81322 (AeroShell Grease 5 is still available meeting MIL-G-3545C and NATO Code G-359) AeroShell Grease 6 still available for civil market meeting MIL-G-7711A and NATO Code G-382	-	AeroShell Grease 6*
MIL-PRF-7808L Grade 3 Grade 4	MIL-L-7808K	 O-148 O-163	Synthetic lubricating oil for military gas turbines Normal grade Higher viscosity/greater thermal stability grade	 (MIL-PRF-7808L Grade 3) -	 AeroShell Turbine Oil 308 -
MIL-M-7866C (Obsolete)	MIL-M-7866B	S-740	Molybdenum disulphide powder - superseded by SAE AMSM7866	DEF STAN 68-062	-
MIL-PRF-7870E	MIL-PRF-7870D	O-142	General purpose low temperature lubricating oil	DEF STAN 91-047	AeroShell Fluid 3
MIL-PRF-8188D	MIL-C-8188C	C-638	Synthetic corrosion protective oil for aircraft gas turbines	-	-
MIL-A-8243D (Obsolete)	MIL-A-8243C	-	De-icing and defrosting fluids. Superseded by SAE AMS1424	-	-
MIL-H-8446B (Obsolete)	MIL-H-8446A	-	Aircraft non-petroleum hydraulic fluid	-	-
MIL-S-8660C (Obsolete)	MIL-I-8660B	S-736	Silicone compound - superseded by SAE AS8660	DEF STAN 68-069	-
MIL-L-8937D (Obsolete)	-	S-1738	OBSOLETE - superseded by MIL-L-46010B	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-T-9188C (Obsolete)	MIL-T-9188B	-	Tricresyl phosphate for use as an aviation gasoline additive	-	-
MIL-L-9236B (Obsolete)	-	-	OBSOLETE - superseded by MIL-L-27502	-	-
MIL-PRF-10924H	MIL-PRF-10924G	G-403	Multi-purpose grease	DEF STAN 91-027	-
MIL-L-11734C (Obsolete)	MIL-L-11734B	-	Synthetic lubricating oil (mechanical time fuses)	-	-
MIL-C-11796C	MIL-C-11796B MIL-C-15167 MIL-C-6708 in part		Corrosion preventive, petrolatum, hot application	-	
		C-633	Class 1 - hard film		-
		-	Class 1A - hard film, non-stick		-
		-	Class 2 - medium film (Obsolete)		-
		C-627 (Obsolete)	Class 3 - soft film		-
MIL-A-13881C (Obsolete)	MIL-A-13881B	-	Mica based anti-seize compound	-	-
MIL-H-13919B (Obsolete)	-	-	OBSOLETE - superseded by MIL-H-46170	-	-
MIL-PRF-14107D	-	O-157	Low temperature oil for aircraft weapons	DEF STAN 91-102	-
MIL-PRF-15074E	MIL-C-15074D	-	Corrosion preventive - fingerprint remover	-	-
MIL-L-15719A	MIL-L-15719	-	Lubricating grease (high temperature, electric motor, ball and roller bearings)	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-PRF-16173E	MIL-C-16173D MIL-C-972 MIL-C-19471	 C-632 C-620 - - -	Corrosion preventive, solvent cut back cold application Grade 1 - hard film Grade 2 - soft film Grade 3 - soft film, water displacing Grade 4 - transparent film, non-tacky Grade 5 – low pressure steam removable	-	 - - - - -
MIL-DTL-16884P	MIL-DTL-16884N	F-76	Alternative turbine/diesel engine fuel for use in certain Naval helicopters	DEF STAN 91-004	-
MIL-DTL-17111E	MIL-DTL-17111D	H-575	Power transmission fluid	-	-
MIL-PRF-17672E	MIL-PRF-17672D	H-573	Hydraulic fluid, petroleum, inhibited	-	-
MIL-G-18709A (Obsolete)	-	-	Ball and roller bearing grease. This specification cancelled - use DOD-G-24508 (see later in this section).	-	-
MIL-W-18723D (Obsolete)	-	-	Waterproof solvent type aircraft wax. Specification now cancelled.	-	-
MIL-H-19457D	MIL-H-19457C	H-580	Fire resistant phosphate ester hydraulic fluid	-	-
MIL-L-19701B (Obsolete)	MIL-L-19701A	-	Semi-fluid lubricant for aircraft ordnance. Specification now cancelled.	-	-
MIL-O-19838 (Inactive for new design)	-	-	Installation and test of aircraft oil system - INACTIVE	-	-
MIL-G-21164D	MIL-G-21164C MIL-G-7187	G-353	Molybdenum disulphide grease, for low and high temperature	DEF STAN 91-057	AeroShell Grease 64

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-PRF-21260E	MIL-L-21260D	-	Internal lubricating oil - combustion engine preservation. This specification covers a range of grades.	-	-
MIL-H-22072C	MIL-H-22072B	H-579	Catapult hydraulic fluid	-	-
MIL-L-22851D (Obsolete)	-	-	OBSOLETE - superseded by SAE J1899 (see later in this section)		
MIL-C-23112 (Obsolete)	-	-	Fire resistant corrosion preventive - superseded by MIL-H-19457	-	-
MIL-L-23398D	MIL-L-23398C	S-749	Lubricant, solid film air drying	(MIL-L-23398D)	-
MIL-C-23411A (Obsolete)	-	-	CANCELLED - superseded by MIL-C-81309	-	-
MIL-DTL-23549D	MIL-G-23549C	-	General purpose grease	-	-
MIL-PRF-23699G Grade STD Grade C/I Grade HTS	MIL-L-23699E	 O-156 O-152 O-154	Synthetic lubricating oil for aircraft gas turbines, 5 mm^2/s viscosity Grade STD (Standard) Grade C/I (Corrosion Inhibited grade) Grade HTS - (High Thermal Stability)	DEF STAN 91-101 Grade OX-27	 AeroShell Turbine Oil 500 - AeroShell Turbine Oil 560 AeroShell Ascender
MIL-PRF-23827C (Type I & Type II)	MIL-G-23827B MIL-G-7118A MIL-G-3278A MIL-G-7421B MIL-G-15793	G-354	Grease for aircraft instruments, gears and actuator screws Type I Type II	DEF STAN 91-053	 AeroShell Grease 33 AeroShell Grease 7

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-L-24131C	MIL-L-24131B	-	Colloidal graphite in isopropanol	-	-
MIL-PRF-24139A	MIL-G-24139A	G-450 (Obsolete)	Multi-purpose quiet service grease	DEF STAN 91-028 (Obsolete)	AeroShell Grease 6
MIL-H-24459 (Obsolete)	-	-	OBSOLETE - superseded by MIL-L-17672	-	-
MIL-L-24478C	MIL-L-24478B	-	Lubricant, molybdenum disulphide in isopropanol	-	-
MIL-G-25013E	MIL-G-25013D MIL-G-27343A	G-372	Extreme high temperature ball and roller bearing grease	DEF STAN 91-055 (Obsolete)	-
MIL-PRF-25017H	MIL-PRF-25017G	S-1747	Fuel soluble corrosion inhibitors for aviation turbine fuels	-	-
MIL-DTL-25524G	MIL-DTL-25524F	-	Thermally stable aviation turbine fuel	-	-
MIL-G-25537C	MIL-G-25537B	G-366	Helicopter oscillating bearing grease	DEF STAN 91-051	AeroShell Grease 14
MIL-F-25558C (Obsolete)	MIL-F-25558B	-	Fuel, ramjet - Grade RJ-1	-	-
MIL-DTL-25576E	MIL-DTL-25576D	-	Propellant - kerosine, Grade RP-1	-	-
MIL-DTL-25681E	DOD-L-25681D	S-1735	Molybdenum disulphide lubricating oil, silicone base	(MIL-DTL-25681E)	-
MIL-G-25760A (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-81322A	-	-
MIL-C-25769J (Obsolete)	-	-	Specification cancelled, use MIL-C-87936	-	-
MIL-C-27251A (Obsolete)	-	-	Low temperature aircraft surface cleaning compound. Specification now cancelled.	-	-
MIL-F-27351 (Obsolete)	-	-	Specification now cancelled. Use MIL-PRF-7024	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-L-25702 (Obsolete)	MIL-L-9236B	-	High temperature synthetic lubricating oil for aircraft gas turbines	-	-
MIL-G-27549 (Obsolete)	-	-	Heavy load-carrying aircraft grease	-	-
MIL-PRF-27601C (Obsolete)	MIL-H-27601B	-	High temperature, petroleum base, hydraulic fluid for flight vehicles. Specification now cancelled.	-	-
MIL-PRF-27617G	MIL-PRF-27617F	 G-397 G-398 G-399 G-1350	Grease, fuel and oxidiser resistant Type I Type II Type III Type IV	-	-
MIL-DTL-27686G (Obsolete)	MIL-I-27686F	S-748 (Obsolete)	Fuel system icing inhibitor (ethylene glycol monomethyl ether) – superseded by MIL-DTL-85470	DERD 2451 Grade AL-31 (Obsolete)	-
MIL-L-27694A (Obsolete)	MIL-L-27694	-	Lubricating oil, instrument	-	-
MIL-PRF-32033A	MIL-PRF-32033	 O-190 -	General purpose oil and preservative (water displacing, low temperature) Type I Type II	DEF STAN 91-079 (Obsolete)	-
MIL-DTL-38219D (Inactive for new design)	MIL-PRF-38219D	-	Low volatility turbine fuel Grade JP-7	-	-
MIL-G-38220 (Obsolete)	-	-	OBSOLETE - superseded by MIL-G-27617	-	-
MIL-G-38277 (Obsolete)	-	-	OBSOLETE	-	-
MIL-PRF-38299E	MIL-PRF-38299D	-	Purging fluid for preserving fuel tanks of jet aircraft	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-C-43616C (Obsolete)	MIL-C-43616B	-	Aircraft surface cleaning compound. Specification cancelled, superseded by A-A-59921	-	-
MIL-L-45983	-	-	Solid film heat cured lubricant	-	-
MIL-L-46000C	MIL-L-46000B	O-158 (Obsolete)	Semi-fluid lubricating oil for automatic weapons	-	-
MIL-PRF-46002D	MIL-PRF-46002C	-	Contact and volatile corrosion inhibited preservative oil	-	-
MIL-G-46003A (Obsolete)	MIL-G-46003	-	Grease, rifle	-	-
MIL-H-46004 (Obsolete)	-	H-535 (Obsolete)	Hydraulic fluid petroleum base for missiles. Superseded by MIL-PRF-5606	-	-
MIL-PRF-46010H	MIL-PRF-46010G	S-1738	Corrosion inhibiting heat cured solid film lubricant	-	-
MIL-PRF-46147D	MIL-PRF-46147C	-	Corrosion inhibiting air cured solid film lubricant	-	-
MIL-L-46150 (Inactive for new design)	-	-	Semi-fluid lubricant for weapons	-	-
MIL-L-46156A (Obsolete)	MIL-L-46156	-	Corrosion removing compound for sodium hydroxide base - superseded by A-A-59261	-	-
MIL-PRF-46167D	MIL-PRF-46167C	O-184 (Obsolete)	Lubricating oil, IC Engine, Arctic	-	-
MIL-PRF-46170E	MIL-PRF-46170D	 H-544 -	Fire resistant preservative synthetic hydrocarbon hydraulic fluid Type I - undyed Type II - dyed red for aerospace (Obsolete)	-	 AeroShell Fluid 61 -
MIL-G-46178 (Obsolete)	-	-	Helicopter drive shaft coupling grease. Specification now cancelled.	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-G-46886B (Obsolete)	MIL-G-46886A	-	Silicone grease - superseded by A-A-59173	-	-
MIL-F-47174A (Obsolete)	-	-	Hydraulic fluid, petro base, intermediate viscosity. Specification now cancelled.	-	-
MIL-G-47219A (Obsolete)	MIL-G-47219	-	Halofluorocarbon lubricating grease. Specification now cancelled.	-	-
MIL-C-47220B (Obsolete)	MIL-C-47220A	-	Dielectric coolant fluid - superseded by MIL-C-87252	-	-
MIL-L-60326 (Obsolete)	-	-	Lubricant, fluorocarbon telomer dispersion	-	-
MIL-PRF-63460F	MIL-PRF-63460E	S-758	Lubricant, cleaner and preservative for weapons and weapon systems	-	-
MIL-H-81019D	MIL-H-81019C	-	Hydraulic fluid, petroleum base (ultra low temperature)	-	-
MIL-S-81087C (Obsolete)	MIL-S-81087B	H-536 (Obsolete)	Hydraulic fluid, chlorinated silicone - INACTIVE Specification now cancelled.	(MIL-S-81087C) (Obsolete)	-
MIL-R-81261A (Obsolete)	MIL-R-81261	-	Rain repellent glass window shield for in-flight application. Specification now cancelled.	-	-
MIL-PRF-81309H	MIL-PRF-81309G	-	Ultra thin film water displacing corrosion preventive compound	-	-
MIL-PRF-81322G	MIL-PRF-81322F MIL-G-7711A MIL-G-3545C MIL-G-25760A	G-395	General purpose grease, wide temperature range	DEF STAN 91-052 (Obsolete)	AeroShell Grease 22
MIL-PRF-81329E	MIL-PRF-81329D	S-1737	Lubricant, solid film, extreme environment	-	-
MIL-B-81744A	-	-	Lubricant migration deterring barrier coating solution	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-G-81827A	MIL-G-81827	-	Molybdenum disulphide grease with high load capacity, wide temperature range	-	-
MIL-L-81846A (Obsolete)	-	-	OBSOLETE superseded by DOD-L-81846B (see entry later in this section)	-	-
MIL-F-81912 (Inactive for new design)	-	-	Fuel for expendable turbine engine - INACTIVE	-	-
MIL-G-81937A	MIL-G-81937	-	Ultra clean instrument grease	-	-
MIL-P-82522C (Obsolete)	MIL-P-82522B	-	Propellant, jet engine, T-H dimer Grade RJ-4. Specification now cancelled.	-	-
MIL-R-83055 (Obsolete)	-	-	General specification for aircraft windshield rain repellent dispensing systems. Specification now cancelled, use MIL-E-87145	-	-
MIL-R-83056 (Obsolete)	-	-	Rain repellent applied in flight, aircraft windshield. Specification now cancelled, use MIL-R-81261.	-	-
MIL-DTL-83133K	MIL-DTL-83133J	 F-34 F-37 F-35	Aviation turbine fuel kerosine type JP-8 (freeze point -47°C) JP-8 +100 Jet A-1	 DEF STAN 91-087 - DEF STAN 91-091	 Shell JP-8 Shell JP-8 +100 Shell Jet A-1 Shell AeroJet*
MIL-L-83176A (Obsolete)	MIL-L-83176	-	Instrument bearing lubricant. Specification now cancelled.	-	-
MIL-PRF-83261D	MIL-PRF-83261C	-	Grease, aircraft, EP/anti-wear	-	-
MIL-PRF-83282D	MIL-H-83282C	H-537	Fire resistant hydraulic fluid, synthetic hydrocarbon base	(MIL-PRF-83282D)	AeroShell Fluid 31
MIL-H-83306 (Obsolete)	-	-	Fire resistant hydraulic fluid, phosphate ester based. Specification now cancelled.	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-PRF-83363E	MIL-PRF-83363D	G-396	Helicopter transmission grease PTFE	(MIL-G-83363B)	-
MIL-D-83411A (Obsolete)	-	-	De-icer/anti-icer fluid for runways and taxiways. Specification now cancelled, use AMS 1432.	-	-
MIL-G-83414 (Obsolete)	-	-	Grease, aircraft gunmount. Specification now cancelled	-	-
MIL-PRF-83483E	MIL-PRF-83483D	-	Anti-seize thread compound, molybdenum disulphide and petrolatum	-	-
MIL-DTL-85054D	MIL-DTL-85054C	-	A clear water displacing corrosion preventive compound	-	-
MIL-PRF-85336B	DOD-L-85336A	-	Lubricant, all weather (automatic weapons)	-	-
MIL-DTL-85470B	MIL-I-85470A	S-1745	High flash type fuel system icing inhibitor (di-ethylene glycol monomethyl ether)	DEF STAN 68-252 Grade AL-41	-
MIL-PRF-85570E	MIL-PRF-85570D	-	Aircraft exterior cleaning compound	-	-
MIL-PRF-85704C	MIL-C-85704B	-	Turbine engine gas path cleaning compound	-	-
MIL-PRF-87100A (Obsolete)	MIL-L-87100	-	Aircraft turbine engine oil, polyphenyl ether base. Specification now cancelled.	-	-
MIL-DTL-87107E	MIL-DTL-87107D	-	Propellant, high density synthetic hydrocarbon type Grade JP-10	-	-
MIL-C-87159A (Obsolete)	-	-	Water dilutable cleaning compound. Specification now cancelled, use MIL-C-87936.	-	-
MIL-DTL-87173C (Inactive for new design)	MIL-DTL-87173B	-	Propellant, priming fuel ALCM engine Grade PF-1 - INACTIVE	-	-
MIL-DTL-87177B	MIL-L-87177A	-	Synthetic water displacing corrosion preventive compound	-	-
MIL-PRF-87252E	MIL-PRF-87252D	S-1748	Coolant fluid, hydrolytically stable, dielectric	-	AeroShell Fluid 602

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
MIL-PRF-87257C	MIL-PRF-87257B	H-538	Low temperature synthetic hydrocarbon fire resistant hydraulic fluid	(MIL-PRF-87257C)	-
MIL-C-87936A (Obsolete)	-	-	Water dilutable aircraft exterior surface cleaning ompound - superseded by MIL-C- 87937	-	-
MIL-PRF-87937D	MIL-PRF-87937C	-	Cleaning compound, Aerospace equipment	-	-
DOD-G-24508A	DOD-G-24508	-	High performance ball and roller bearing grease	-	AeroShell Grease 22
DOD-PRF-24574	-	-	Lubricating fluid for low and high pressure oxidising gas mixtures	-	-
DOD-L-81846B (Inactive for new design)	MIL-L-81846A	-	High flash point lubricating oil for instrument ball bearing -INACTIVE	-	-
DOD-G-85733	-	-	High temperature grease for catapult systems	-	-
DOD-PRF-85734A	DOD-L-85734	-	Synthetic ester oil for helicopter transmissions	-	AeroShell Turbine Oil 555
O-E-760D (Obsolete)	O-E-760C	S-738	Eythl alcohol, denatured alcohol - superseded by A-A-59282, 51693, 53880	-	-
O-M-232N	O-M-232M	S-747	Methanol	BS 506-1:1987	-
P-D-680B (Obsolete) Type I Type II	P-D-680A	 S-752 S-753	White spirit - superseded by MIL-PRF-680 Type I - Flashpoint 38°C Type II - Flashpoint 65°C	BS 245:1976	 - -
SS-G-659A (Inactive for new design)	MIL-G-6711 SS-G-659	S-732	Graphite powder - lubricating grade	DEF STAN 96-001 (Obsolete)	-
TT-I-735A Grade B	TT-I-735 MIL-F-5566	S-737	Isopropyl alcohol (anti-icing fluid)	BS 1595-1:1986	-
TT-S-735A (Obsolete)	MIL-S-3136B	-	Standard hydrocarbon test fluid - superseded by ASTM D471	-	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
TT-T-656C (Inactive for new design)	TT-T-656B	-	Tricresyl phosphate - INACTIVE	-	-
VV-D-1078B	MIL-S-21568A VV-D-1078C	 S-1714 S-1716 S-1718 S-1720 S-1724 S-1726 S-1728 S-1732	Damping fluids silicone base Grade 10 Grade 20 Grade 50 Grade 100 Grade 7500 Grade 20000 Grade 100000 Grade 200000	DEF STAN 91-046 (Obsolete)	-
VV-G-671G	VV-G-671F	G-412	Graphite grease	-	-
VV-L-800C (Obsolete)	VV-L-800B	O-190	General purpose oil and preservative (water displacing low temperature) - superseded by MIL-PRF-32033	-	-
VV-L-820C (Obsolete)	VV-L-820B	O-196 (Obsolete)	General purpose light oil. Cancelled, superseded by VV-L-800	-	-
VV-P-216C (Obsolete)	VV-P-216B	-	Penetrating oil - superseded by A-A-50493	-	-
VV-P-236A (Inactive for new design)	VV-P-236	S-743	Technical petrolatum - INACTIVE	DEF STAN 91-038 Grade PX-7	-
ASTM D770	TT-I-735B Grade B	S-737	Isopropyl alcohol	BS 1595-1:1986	-
ASTM D910	-	F-12 (Obsolete) - F-18	Aviation gasoline, various grades	DEF STAN 91-090	- Shell Avgas 100 Shell Avgas 100LL

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
ASTM D1655	-	F-35	Aviation turbine fuel, kerosine type	DEF STAN 91-091	Shell Jet A-1 Shell AeroJet*
SAE AS1241D	SAE AS1241C	-	Fire resistant phosphate ester hydraulic fluid for aircraft	-	-
SAE AS5780D	SAE AS5780C	-	Aero and Aero-Derived Gas Turbine Engine Lubricants Grade SPC Grade SPC Grade HPC	-	 AeroShell Turbine Oil 500 AeroShell Turbine Oil 560 AeroShell Ascender
SAE AS6625A	MIL-S-6625A SAE AS6625	-	Anti-icing spray equipment for aircraft windshield	-	-
SAE AS8660	MIL-S-8660C	S-736	Silicone compound	DEF STAN 68-069	-
SAE AMS1424P	MIL-A-8243D SAE AMS1424N	-	De-icing/anti-icing fluid, SAE Type I	-	-
SAE AMS2518D	MIL-T-5544C SAE AMS2518C	S-720	Graphite-petrolatum anti-seize thread compound	DEF STAN 80-080	-
SAE AMS3052A	SAE AMS3052	-	General purpose low temperature range, Lithium thickened aircraft grease	-	AeroShell Grease 33
SAE AMS3057A	SAE AMS3057	-	Lubricant, semi-fluid for aircraft gearboxes	-	-
SAE AMS3058	-	-	Wide temperature range grease for aircraft wheel bearings	-	AeroShell Grease 58
SAE AMS3151C	SAE AMS3151B	-	Aircraft compass fluid	-	-
SAE AMSG4343A	MIL-G-4343C SAE AMSG4343	G-392	Grease for pneumatic systems	-	-
SAE AMSG6032A	MIL-G-6032D SAE AMSG6032	G-363	Gasoline and oil resistant grease	DEF STAN 91-006	-

Specification	Superseded Specification	NATO Code	Product and Application	Alternative British Specification	AeroShell Grade
SAE AMSM7866B	MIL-M-7866C SAE AMSM7866A	S-740	Molybdenum disulphide powder	DEF STAN 68-062	-
SAE J1899	MIL-L-22851D	 O-123 (Obsolete) O-125 (Obsolete) O-128 (Obsolete) XO-162	Ashless dispersant aircraft piston engine oil SAE Grade 40 SAE Grade 40 SAE Grade 50 SAE Grade 50 SAE Grade 60 SAE Grade Multigrade	SAE J1899	 AeroShell Oil W80 AeroShell Oil W80 Plus AeroShell Oil W100 AeroShell Oil W100 Plus AeroShell Oil W120 AeroShell Oil W 15W-50
SAE J1966	MIL-L-6082E	 O-113 (Obsolete) O-115 (Obsolete) O-117 (Obsolete) -	Aircraft piston engine lubricating oil SAE Grade 30 SAE Grade 40 SAE Grade 50 SAE Grade 60	SAE J1966	 AeroShell Oil 65 AeroShell Oil 80 AeroShell Oil 100 AeroShell Oil 120
FMS-1071	-	-	Grease for aircraft sweep wing pivot hinge	-	-
BMS 3-11	-	-	Boeing material specification for phosphate ester hydraulic fluid	-	-
BMS 3-24A (Obsolete)	BMS 3-24	-	Boeing material specification for general purpose grease	-	-
BMS 3-32C	BMS 3-32B	-	Boeing material specification for specially fortified hydraulic fluids for aircraft landing gear shock struts Type I - preservative version Type II - low temperature version	 - -	 - AeroShell LGF
BMS 3-33C	BMS 3-33B	-	Boeing material specification for general purpose airframe grease	-	AeroShell Grease 33
BMS 3-34	-	-	Boeing material specification for grease for sealed-for-life bearings	-	-

NOTES

BRITISH AVIATION SPECIFICATIONS

Scope of list

This list is comprised of British Specifications in the DTD, DTD.900, DED, DEF, DEF STAN, D.Eng.R.D., D.Eng.D., DERD, BS, CS and TS series which cover aviation fuels, lubricants and allied products.

It should be noted that the original title “Director General Engine Research and Development” was modified to exclude “Research” and this resulted in a general change from D.Eng.R.D. to D.Eng.D. Both D.Eng.R.D. and D.Eng.D. were then changed to DERD as the specifications were amended, or new specifications were issued by the department concerned.

In the 1980s, many British Ministry of Defence DTD specifications were rewritten as DEF STAN specifications. Subsequently, all DTD specifications were declared Obsolescent from 1st April 1999.

More recently, it was decided to standardise British Specifications as Defence Standards (commonly referred to as DEF STAN), and many of the DERD specifications have since been changed over. The changeover is virtually complete and all current DERD, DTD, CS and TS specifications have now been converted to DEF STAN specifications; in doing so the numeric part has also been changed. Obsolete or Cancelled British Specifications will not be changed.

The British Ministry of Defence has also adopted certain U.S. Military Specifications, these include MIL-DTL-5020, MIL-PRF-46010, MIL-S-81087, MIL-L-46000, MIL-PRF-83282, DOD-L-25681 and SAE J1899 and J1966. Details of these specifications are included in the section on U.S. Aviation Specifications.

British Defence Standards can be downloaded as Acrobat documents from the UK MoD website **www.defencegateway.mod.uk/home/**

Interpretation of list

In the column headed "Alternative U.S. Specification", only those specifications which are equivalent, or acceptable alternatives, to the British Specification are shown.

Where an asterisk * appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses of the official specifications, but is the nearest product marketed by Shell.

For easy reference, obsolete specifications are shown in both the current and superseded specification columns. In the former case, a suitable comment is made, namely, "OBSOLETE – superseded by ..."

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DTD.72A (Obsolete)	DTD.72	-	OF-300 (Obsolete)	Treated castor oil, specification now OBSOLETE	-	-
DTD.279C (Obsolete)	-	-	-	CANCELLED - superseded by DEF STAN 80-083	-	-
DTD.392B (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-080	-	-
DTD.406B (Obsolete)	DTD.406A	S-745	AL-5	De-icing fluid ethylene glycol/alcohol/water mixture - OBSOLETE	-	AeroShell Compound 07*
DTD.417B (Obsolete)	DTD.4127A DTD.201	O-140 (Obsolete)	OM-150	Low temperature oil for aircraft controls. OBSOLETE - superseded by DEF STAN 91-114	-	-
DTD.445A (Obsolete)	-	-	-	OBSOLETE	-	-
DTD.581C (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-112	-	-
DTD.585 (Obsolete)	-	-	-	Hydraulic oil - petroleum base	MIL-H-5606A (Obsolete)	AeroShell Fluid 4*
DTD.585B (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-048 Grade Superclean	-	-
DTD.791C (Obsolete)	-	C-613 (Obsolete)	PX-13 (Obsolete)	OBSOLETE - superseded by DEF STAN 81-205	-	-
DTD.804 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-034	-	-
DTD.806B (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-054	-	-
DTD.822B (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-049	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DTD.878A (Obsolete)	-	-	-	OBSOLETE - superseded by DTD.5601. AeroShell Grease 5 still available for civil market meeting DTD.878A	-	AeroShell Grease 5*
DTD.897B (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-056	-	-
DTD.900AA Series (Obsolete)	DTD.900Z	-	-	Approval procedure for proprietary materials and processes. See later in this section for details of selected individual approvals.	-	-
DTD.900/4042A (Obsolete)	-	S-718	ZX-24	Anti-seize compound, aircraft oxygen system	-	-
DTD.900/4081C (Obsolete)	-	-	-	OBSOLETE - superseded by DTD.900/6103A	-	-
DTD.900/4386A (Obsolete)	DTD.900/4386	-	OX-16	Dowty liquid fluid for aircraft	-	-
DTD.900/4630A (Obsolete)	-	-	-	Molybdenum disulphide grease for certain precision ball bearings and actuator gearboxes	-	-
DTD.900/4639 (Obsolete)	-	-	ZX-30	Lubricant, solid film, unbonded, graphite dispersion	-	-
DTD.900/4802B (Obsolete)	-	-	-	Lubrication of gearbox drive, shaft universal joints	-	-
DTD.900/4872A (Obsolete)	DTD.900/4309 DTD.900/4872	-	XG-344 (Obsolete)	Lubricant for certain turbine, engine starters. OBSOLETE	-	-
DTD.900/4877A (Obsolete)	-	-	ZX-36	Lubricant for fitting electrical cables in aircraft	-	-
DTD.900/4881D (Obsolete)	DTD.900/4881C	-	OX-20	Phosphate ester hydraulic fluid	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DTD.900/4907 (Obsolete)	-	S-1746	AL-34	Anti-icing protection fluid for parked aircraft. Not suitable for use in aircraft de-icing systems.	-	-
DTD.900/4910A (Obsolete)	DTD.900/4910	-	-	Grease for actuator screw jack and flap transmission system of certain aircraft	-	-
DTD.900/4913A (Obsolete)	-	-	-	OBSOLETE - superseded by MIL-C-6529C Type I	-	AeroShell Fluid 2XN*
DTD.900/4914A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-085	-	-
DTD.900/4939A (Obsolete)	DTD.900/4939	-	AL-36	Windscreen washing fluid for certain aircraft	-	-
DTD.900/4981A (Obsolete)	-	-	OEP-215	Helicopter gearbox oil	-	AeroShell Fluid S.8350*
DTD.900/4990 (Obsolete)	-	-	-	Molybdenum disulphide grease for special applications	-	-
DTD.900/6103A (Obsolete)	DTD.900/4081	-	OX-87	Hydraulic fluid for certain aircraft	-	-
DTD.5527A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-057	-	-
DTD.5530 (Obsolete)	-	-	-	OBSOLETE - superseded by DTD.5617	-	-
DTD.5540B (Obsolete)	-	C-635	PX-26	OBSOLETE - superseded by DEF STAN 80-142	-	-
DTD.5578 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-047	-	-
DTD.5579 (Obsolete)	-	-	-	OBSOLETE - superseded by DTD.5601	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DTD.5581 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-046	-	-
DTD.5585A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-055	-	-
DTD.5586 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-061	-	-
DTD.5598 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-053	-	-
DTD.5601A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-052	-	-
DTD.5609 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-051	-	-
DTD.5610 (Obsolete)	-	-	-	OBSOLETE - superseded by MIL-G-4343C	-	-
DTD.5617 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-081	-	-
DEF.2001A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-044	-	-
DEF.2004A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-042	-	-
DEF.2007A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-039	-	-
DEF.2181A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-040	-	-
DEF.2261A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-012	-	-
DEF.2304 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-062	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF.2331A (Obsolete)	DEF.2331 DTD.121D	C-614	PX-1 dyed PX-1 undyed	Temporary rust preventive - dyed Temporary rust preventive – undyed OBSOLETE – superseded by DEF STAN 80-217	MIL-C-16173E Grade 2 -	- -
DEF.2332A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-034	-	-
DEF.2333 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-038	-	-
DEF.2334 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-085 (formerly DEF STAN 91-50)	-	-
DEF STAN 01-005	-	-	-	Fuels, lubricants and associated products	-	-
DEF STAN 05-050	-	-	-	Series of test methods for testing fuels, lubricants and associated products	-	-
DEF STAN 59-010 (Obsolete)	-	-	-	Silicone compound for insulating and sealing electrical equipment. Specification now superseded by DEF STAN 68-069	-	-
DEF STAN 68-007 (Obsolete)	-	-	ZX-33 (Obsolete)	CANCELLED	-	-
DEF STAN 68-010	DTD.900/4916 CS.3122	C-634	PX-24	Water displacing and protective fluid	-	-
DEF STAN 68-011 (Obsolete)	-	-	PX-10 (Obsolete)	CANCELLED - superseded by DEF STAN 68-010	-	-
DEF STAN 68-061 (Obsolete)	DTD.5586	-	AL-26 (Obsolete)	Inhibited coolant fluid	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 68-062	DEF.2304	S-740	ZX-35	Molybdenum disulphide powder	SAE AMSM7866B	-
DEF STAN 68-069	DEF STAN 59-010	S-736	XG-250	Electrical insulating silicone compound	SAE AS8660	-
DEF STAN 68-108 (Obsolete)	-	-	AL-20	Technical ethanediol	-	-
DEF STAN 68-118 (Obsolete)	DEF STAN 68-217	-	-	De-icing/anti-icing fluid for runways. Specification superseded by Dual National Standard VG9700	-	-
DEF STAN 68-127	TS10177	S-757	AL-39	Inhibited ethanediol antifreeze	-	-
DEF STAN 68-128 (Obsolete)	TS10067E	-	-	OBSOLETE - superseded by DEF STAN 68-150	-	-
DEF STAN 68-129	TS10188	-	AL-40	Methanol/water mixture for hydrogen generation	-	-
DEF STAN 68-150	DEF STAN 68-128	-	AL-48	Mixture of AL-41 and AL-61	-	-
DEF STAN 68-217 (Obsolete)	-	-	-	CANCELLED - see DEF STAN 68-118	-	-
DEF STAN 68-251	DERD 2461	S-1747	AL-61	Fuel soluble pipeline corrosion inhibitor/lubricity improving additive for aviation turbine fuels	MIL-PRF-25017H	-
DEF STAN 68-252	DERD 2451	S-1745	AL-41	Fuel system icing inhibitor, high flash type	MIL-DTL-85470B	-
DEF STAN 68-253	DERD 2491	-	AL-24 (Obsolete)	Methanol/water mixtures	-	-
DEF STAN 68-253	DERD 2491	S-1744	AL-28	Methanol/water mixtures	-	-
DEF STAN 68-253	DERD 2491	S-1739	WTA	Demineralised water	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 80-034	DEF.2332A DTD.804	-	PX-4	Corrosion preventive compound	-	-
DEF STAN 80-080	DTD.392B	S-720	ZX-13	Anti-seize compound for aircraft, graphite and petroleum mixture	SAE AMS2518D	-
DEF STAN 80-081 (Obsolete)	DTD.5617	S-722	ZX-38	Anti-seize compound, molybdenum disulphide	-	-
DEF STAN 80-083	DTD.279A	-	PX-32	Corrosion preventive compound for aircraft structures	-	-
DEF STAN 80-085 (Obsolete)	DEF.2334 DEF STAN 91-050	C-628 (Obsolete)	PX-11	Corrosion preventive compound - WITHDRAWN	-	-
DEF STAN 80-142 (Obsolete)	DTD.5540B	C-635	PX-26	Preservative mineral hydraulic fluid of improved cleanliness	MIL-PRF-6083G	-
DEF STAN 80-143	TS.10131	-	PX-28	Preservative for internal airframe surfaces	-	-
DEF STAN 80-145 (Obsolete)	-	-	PX-15	Corrosion preventive. CANCELLED	-	-
DEF STAN 80-186 (Obsolete)	TS.10164	-	PX-31	Corrosion preventive	-	-
DEF STAN 80-217	DEF.2331A	C-614	PX-1	Corrosion preventive, Soft film, Cold application	-	-
DEF STAN 81-205	DTD.791C	C-613 (Obsolete)	PX-13 (Obsolete)	Aircraft piston engine corrosion preventive oil	-	-
DEF STAN 91-004	-	F-76	DIESO F-76	Alternative turbine/diesel engine fuel for use in certain Naval helicopters. This specification is primarily for F-76 (DIESO F-76, Fuel, Naval Distillate)	MIL-DTL-16884P	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-006	-	G-363	XG-235	Gasoline and oil resistant grease	SAE AMSG6032A	-
DEF STAN 91-012 (Obsolete)	DEF.2261A	G-382	XG-271 (Obsolete)	General purpose aircraft grease. CANCELLED	MIL-G-7711A (Obsolete)	AeroShell Grease 6*
DEF STAN 91-019 (Obsolete)	-	-	-	CANCELLED - superseded by U.S. Specification MIL-L-8937D which in turn has been superseded by MIL-PRF-46010 (NATO S-1738, Joint Service ZX-34)	-	-
DEF STAN 91-027	-	G-403	XG-279	Grease	MIL-PRF-10924H	-
DEF STAN 91-028 (Obsolete)	-	G-450 (Obsolete)	XG-274 (Obsolete)	Multipurpose quiet service grease superseded by DEF STAN 91-105	MIL-PRF-24139A	AeroShell Grease 6*
DEF STAN 91-030 (Obsolete)	-	-	-	CANCELLED	-	-
DEF STAN 91-035	-	-	OX-30	Emulsifying petroleum hydraulic fluid for use in certain types of radar equipment	-	-
DEF STAN 91-038	DEF.2333	 - S-743	 PX-6 PX-7	Technical petrolatum Stiff, tacky petrolatum Soft petrolatum	 - VV-P-236A	 - -
DEF STAN 91-039	DEF.2007A	H-576	OM-33	Hydraulic oil for certain radar equipment	-	-
DEF STAN 91-040 (Obsolete)	DEF.2181A	C-615	PX-27	Corrosion preventive oil for aircraft piston engines	-	-
DEF STAN 91-044 (Obsolete)	DEF.2001A DTD.44D	O-134	OM-13 (Obsolete)	General purpose lubricating oil	-	AeroShell Turbine Oil 3*

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-046 (Obsolete)	DTD.5581	-	-	Damping fluid, dimethyl silicone, various grades. CANCELLED	W-D-1078B	-
Grade 3	-	S-1712	ZX-41 (Obsolete)			-
Grade 10	-	S-1714	ZX-42 (Obsolete)			-
Grade 20	-	S-1716	ZX-43			-
Grade 50	-	S-1718	ZX-44			-
Grade 100	-	S-1720	ZX-45			-
Grade 500	-	-	ZX-46			-
Grade 1000	-	-	ZX-47			-
Grade 7500	-	S-1724	ZX-48 (Obsolete)			-
Grade 12500	-	-	ZX-49 (Obsolete)			-
Grade 20000	-	S-1726	ZX-50 (Obsolete)			-
Grade 60000	-	-	ZX-51			-
Grade 100000	-	S-1728	ZX-52 (Obsolete)			-
Grade 200000	-	S-1732	ZX-53 (Obsolete)			-
DEF STAN 91-047 (Obsolete)	DTD.5578	O-142	OM-12	General purpose lubricating oil of low freezing point	MIL-PRF-7870E	AeroShell Fluid 3*
DEF STAN 91-048 Grade Superclean	DTD.585B	H-515	OM-15	Hydraulic fluid of improved cleanliness and performance	MIL-PRF-5606J	AeroShell Fluid 41 (European production approved, U.S. production is equivalent)
DEF STAN 91-048 Grade Normal	TS.10165	H-520 (Obsolete)	OM-18	Hydraulic fluid of improved performance	-	AeroShell Fluid 41*
DEF STAN 91-049	DTD.822B	O-147	OX-14	Low temperature synthetic lubricating oil	MIL-PRF-6085E	AeroShell Fluid 12*
DEF STAN 91-050 (Obsolete)	-	-	-	Replaced by DEF STAN 80-085	-	-
DEF STAN 91-051	DTD.5609	G-366	XG-284	Helicopter general purpose and anti-fretting grease	MIL-G-25537C	AeroShell Grease 14

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-052 (Obsolete)	DTD.5601A	G-395	XG-293	Multi-purpose aircraft grease	MIL-PRF-81322G	AeroShell Grease 22*
DEF STAN 91-053	DTD.5598	G-354	XG-287	Grease, multi-purpose, low temperature	MIL-PRF-23827C	AeroShell Grease 33*
DEF STAN 91-054 (Obsolete)	DTD.806B	G-355	XG-285	Graphited grease	MIL-G-7187 (Obsolete)	-
DEF STAN 91-055 (Obsolete)	DTD.5585A	G-372	XG-300	Extreme high temperature ball and roller bearing grease. UK MoD has adopted MIL-G-25013E	MIL-G-25013E	-
DEF STAN 91-056	DTD.897A	G-394	XG-315	Silicone grease for pneumatic systems	-	-
DEF STAN 91-057	DTD.5527A	G-353	XG-276	Molybdenum disulphide grease for use in heavily loaded applications at high and low temperatures	MIL-G-21164D	AeroShell Grease 64*
DEF STAN 91-064 (Obsolete)	-	-	XG-305	Molybdenum disulphide grease	-	-
DEF STAN 91-066	-	-	-	The segregation, handling and quality assurance of petroleum fuels, lubricants and associated products	-	-
DEF STAN 91-069 (Provisional)	-	-	OX-125	Helicopter transmission fluid 9 mm^2/s	-	-
DEF STAN 91-071 (Obsolete)	TS.10134	-	OX-165	Synthetic lubricating fluid for gears and transmissions	-	-
DEF STAN 91-078	-	-	PX-19 (Obsolete)	Soft film corrosion preventive. CANCELLED	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-079 (Obsolete)	-	O-190	OX-18 (Obsolete)	CANCELLED. Preservative general purpose lubricating oil. Requirements now contained in DEF STAN 91-102	MIL-PRF-32033A	-
DEF STAN 91-085	DTD.900/4914A	G-357 (Obsolete)	XG-273	Synthetic grease with graphite	-	-
DEF STAN 91-086	DERD 2452	F-44	AVCAT/FSII	Aviation turbine fuel, high flash type with FSII	MIL-DTL-5624W Grade JP-5	Shell JP-5 Special arrangements necessary
DEF STAN 91-087	DERD 2453	F-34	AVTUR/FSII	Aviation turbine fuel, kerosine type with FSII	MIL-DTL-83133K Grade JP-8	Shell JP-8 Special arrangements necessary
DEF STAN 91-088	DERD 2454	F-40	AVTAG/FSII	Aviation turbine fuel, wide cut type with FSII	MIL-DTL-5624W Grade JP-4	-
DEF STAN 91-089 (Obsolete)	DERD 2492	S-746 (Obsolete)	AVPIN (Obsolete)	Isopropyl nitrate for certain engine starters - WITHDRAWN	-	-
DEF STAN 91-090	DERD 2485	F-12 (Obsolete)	AVGAS 80 (Obsolete)	Aviation gasoline Grade 80/87	ASTM D910	-
DEF STAN 91-090	DERD 2485	-	AVGAS 100 (Obsolete)	Aviation gasoline Grade 100/130	ASTM D910	Shell Avgas 100
DEF STAN 91-090	DERD 2485	F-18	AVGAS 100LL	Aviation gasoline 100/130 Low Lead	ASTM D910	Shell Avgas 100LL
DEF STAN 91-091	DERD 2494	F-35	AVTUR	Aviation turbine fuel, kerosine type	MIL-DTL-83133K ASTM D1655	Shell Jet A-1 Shell AeroJet*
DEF STAN 91-092 (Obsolete)	-	-	-	Intended to replace DERD 2450 but will not now be issued	-	-
DEF STAN 91-093 (Obsolete)	DERD 2458	-	OX-22 (Obsolete)	Synthetic lubricating oil for marine gas turbines - WITHDRAWN	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-094	DERD 2468	-	OX-7	Synthetic lubricating oil for aircraft turbine engines 3 mm^2/s viscosity	-	AeroShell Turbine Oil 390
DEF STAN 91-096 (Obsolete)	-	-	-	Intended to replace DERD 2472 but will not now be issued	-	-
DEF STAN 91-097 (Obsolete)	DERD 2479/0	O-138	OM-71	Mineral lubricating oil 9 mm^2/s viscosity. CANCELLED	-	-
DEF STAN 91-097 (Obsolete)	DERD 2479/1	O-136	OEP-71	Mineral lubricating oil with EP additive 9 mm^2/s viscosity. CANCELLED	-	-
DEF STAN 91-098	DERD 2487	O-149	OX-38	Synthetic lubricating oil for aircraft gas turbine engines 7.5 mm^2/s viscosity	-	AeroShell Turbine Oil 750
DEF STAN 91-099	DERD 2490	O-135	OM-11	Mineral aviation turbine oil, 3 mm^2/s viscosity	-	AeroShell Turbine Oil 3
DEF STAN 91-100	DERD 2497	O-160	OX-26	Synthetic lubricating oil for aircraft gas turbines 5 mm^2/s viscosity	-	Equivalent to specification. AeroShell Turbine Oil 555
DEF STAN 91-101 Grade OX-27	DERD 2499 Grade OX-27	O-156	OX-27	Synthetic lubricating oil for aircraft gas turbines 5 mm^2/s viscosity	MIL-PRF-23699G Grade STD Grade HTS	AeroShell Turbine Oil 500 AeroShell Turbine Oil 560* AeroShell Ascender*
DEF STAN 91-101 Grade OX-28	DERD 2499 Grade OX-28	-	OX-28 (Obsolete)	Synthetic lubricating oil for certain gas turbines 5 mm^2/s viscosity (marine use)	-	-
DEF STAN 91-102	DEF STAN 91-079	O-157	OX-24	Low temperature lubricating oil for weapons	MIL-PRF-14107D	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DEF STAN 91-103	-	-	PX-36	Corrosion preventive, cleaner and lubricant for weapons	-	-
DEF STAN 91-105	DEF STAN 91-028	G-421	XG-291	Grease, multi-purpose, heavy duty	-	-
DEF STAN 91-106	-	-	XG-294	Grease, multi-purpose, elevated temperature range	-	-
DEF STAN 91-112	DTD.581C	O-153 O-153	OEP-30 OEP-70	Extreme pressure gear oil Grade Light Grade Medium	MIL-PRF-6086F Grade Light MIL-PRF-6086F Grade Medium	- AeroShell Fluid 5M-A
DEF STAN 91-114	DTD.417B	-	OM-150	Low temperature oil for aircraft controls	-	-
DEF STAN 96-001 (Obsolete)	DTD.77	S-732	ZX-20 (Obsolete)	Graphite powder - lubricating grade. Specification now obsolete	SS-G-659A	-
DED.2472 (Obsolete)	-	-	-	OBSOLETE - superseded by D.Eng.R.D. 2472	-	-
DED.2480 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2450 Grade D-65 (Obsolete)	-	O-123 (Obsolete)	OMD-160	Lubricating oil for aircraft piston engines - ashless dispersant type, SAE Grade 40	SAE J1899 Grade 40	AeroShell Oil W80*
DERD 2450 Grade D-80 (Obsolete)	-	O-125 (Obsolete)	OMD-250	Lubricating oil for aircraft piston engines - ashless dispersant type, SAE Grade 50	SAE J1899 Grade 50	AeroShell Oil W100*
DERD 2450 Grade D-100 (Obsolete)	-	O-128 (Obsolete)	OMD-370	Lubricating oil for aircraft piston engines - ashless dispersant type, SAE Grade 60	SAE J1899 Grade 60	AeroShell Oil W120*

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DERD 2451 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-252	-	-
DERD 2452 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-086	-	-
DERD 2453 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-087	-	-
DERD 2454 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-088	-	-
DERD 2458 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-093	-	-
DERD 2461 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-251	-	-
DERD 2468 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-094	-	-
DERD 2469 (Obsolete)	-	-	-	OBSOLETE	-	-
D.Eng.R.D. 2470 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2472 A/O (Obsolete)	DED 2472	O-115 (Obsolete)	OM-170	Lubricating oil for aircraft piston engines, SAE Grade 40	SAE J1966 Grade 40	AeroShell Oil 80*
DERD 2472 B/O (Obsolete)	DED 2472	O-117 (Obsolete)	OM-270	Lubricating oil for aircraft piston engines, SAE Grade 50	SAE J1966 Grade 50	AeroShell Oil 100*
DERD 2472 A/2 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2472 B/2 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2475 (Obsolete)	-	-	-	OBSOLETE - superseded by DERD 2485	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DERD 2479/0 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-097	-	-
DERD 2479/1 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-097	-	-
D.Eng.R.D. 2481 (Obsolete)	-	-	-	OBSOLETE - superseded by DERD 2491	-	-
D.Eng.R.D. 2482 (Obsolete)	-	-	-	OBSOLETE - superseded by DERD 2494	-	-
DERD 2485 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-090	-	-
DERD 2486 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2487 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-098	-	-
D.Eng.R.D. 2488 (Obsolete)	-	-	-	OBSOLETE - superseded by DERD 2498	-	-
DERD 2490 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-099	-	-
DERD 2491 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-253	-	-
DERD 2492 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-089	-	-
DERD 2493 (Obsolete)	-	-	-	OBSOLETE	-	-
DERD 2494 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-091	-	-
D.Eng.R.D. 2495 (Obsolete)	-	-	-	OBSOLETE	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
DERD 2497 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-100	-	-
DERD 2498 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-086	-	-
DERD 2499 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-101	-	-
BS 245:1976 Type 1	-	S-752	White Spirit	White Spirit	MIL-PRF-680C Type 1	-
BS.290	-	-	-	Turpentine (included in BS.244)	-	-
BS 506-1:1987	-	S-747	AL-14	Methanol for industrial use	O-M-232N Grade A	-
BS 1595-1:1986	-	S-737	AL-11	Isopropyl alcohol (anti-icing fluid)	TT-I-735A Grade B	-
BS 3591:1985	DEF.58 CS.606F	-	-	Denatured ethyl alcohol, for windscreens and carburettor de-icing	MIL-A-6091C (Obsolete)	-
CS.3118 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-079	-	-
CS.3120 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-078	-	-
TS.10035A (Obsolete)	-	-	-	OBSOLETE	-	-
TS.10067E (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-128	-	-
TS.10131 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-143	-	-
TS.10134A (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-071	-	-

Specification	Superseded Specification	NATO Code	Joint Service Designation	Product and Application	Alternative U.S. Specification	AeroShell Grade
TS.10164 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 80-186	-	-
TS.10165 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 91-048 Grade Normal	-	-
TS.10177 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-127	-	-
TS.10180 (Obsolete)	-	-	-	OBSOLETE	-	-
TS.10188 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-129	-	-
TS.10228	-	-	-	Ice control agent for aircraft runways	-	-
TS.10281	-	-	-	Cleaning compound for aircraft surfaces	-	-
TS.10151 (Obsolete)	-	-	-	OBSOLETE - superseded by DEF STAN 68-010	-	-

NOTES

NATO CODE NUMBERS

Scope of list

These symbols are used to denote the products in current use by the NATO countries. This is not intended to be a comprehensive list of all NATO products, but is a selection comprising all aviation fuels, engine oils, hydraulic fluids, greases and allied products.

Interpretation of list

In the columns headed “British Specification” and “U.S. Specification” the specifications listed are the official specifications for the NATO Code Number. Where both the British and U.S. Specifications are listed for the same NATO Code Number this means that these specifications are officially equivalent and completely interchangeable for NATO applications.

Where an asterisk* appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses of the official specifications, but is the nearest product marketed by Shell.

For easy reference, obsolete specifications are shown in both the current and superseded specification columns. In the former case, a suitable comment is made, namely, “OBSOLETE - superseded by...”

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
C-608	Aircraft engine corrosion preventive oil - concentrate	MIL-C-6529C Type I	(MIL-C-6529C Type I)	ZX-21 (Obsolete)	AeroShell Fluid 2XN
C-609	Piston engine corrosion preventive oil	MIL-C-6529C Type II	-	OX-270 (Obsolete)	-
C-610	Turbine engine corrosion preventive oil	MIL-C-6529C Type III	-	ZX-17 (Obsolete)	-
C-612 (Obsolete)	OBSOLETE	-	-	-	-
C-613 (Obsolete)	Temporary protective for aircraft engine cylinders	-	DEF STAN 81-205	PX-13 (Obsolete)	-
C-614	Short term protective at medium ambient temperatures - mixture of lanolin/white spirit	-	DEF STAN 80-217	PX-1	-
C-615	Corrosion preventive oils for aircraft engines during storage	-	DEF STAN 91-040 (Obsolete)	PX-27	-
C-618 (Obsolete)	Long term protective at medium and high ambient temperatures, superseded by PX-32 or PX-28	-	-	PX-3 (Obsolete)	-
C-620	Corrosion preventive solvent cut-back, cold application - soft film	MIL-PRF-16173E Grade 2	-	-	-
C-627 (Obsolete)	Corrosion preventive, petrolatum, hot application - soft film	MIL-C-11796C Class 3	-	-	-
C-628 (Obsolete)	Corrosion preventive, petrolatum, hot application - soft film	-	DEF STAN 80-085 (Obsolete)	PX-11	-
C-629 (Obsolete)	Temporary protective for preservation of aircraft spare parts	-	-	-	-
C-630	Soluble corrosion preventive oil	MIL-DTL-4339E	-	-	-
C-632	Corrosion preventive, solvent cut-back, cold application - hard film	MIL-PRF-16173E Grade 1	-	-	-
C-633	Corrosion preventive, petrolatum, hot application - hard film	MIL-C-11796C Class 1	-	-	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
C-634	Water displacing corrosion preventive	-	DEF STAN 68-010	PX-24	-
C-635	Preservative oil of improved cleanliness for hydraulic equipment	MIL-PRF-6083G	DEF STAN 80-142 (Obsolete)	PX-26	-
C-638	High temperature synthetic corrosion protective oil for turbine engines	MIL-PRF-8188D	-	-	-
C-639 (Obsolete)	OBSOLETE	-	-	-	-
C-654 (Obsolete)	Corrosion preventive, soft film hot application	-	-	-	-
F-12 (Obsolete)	Aviation gasoline Grade 80/87	MIL-G-5572F (Obsolete) ASTM D910	DEF STAN 91-090	-	-
F-18	Aviation gasoline Grade 100/130 Low Lead	ASTM D910	DEF STAN 91-090	AVGAS 100LL	Shell Avgas 100LL
F-34	Aviation turbine fuel - kerosine type with fuel system icing inhibitor (-47°C freeze point)	MIL-DTL-83133K Grade JP-8	DEF STAN 91-087	AVTUR/FSII	Shell JP-8 Special arrangements necessary
F-35	Aviation turbine fuel - kerosine type (-47°C freeze point)	MIL-DTL-83133K ASTM D1655	DEF STAN 91-091	AVTUR	Shell Jet A-1 Shell AeroJet*
F-37	Aviation turbine fuel F-34 plus thermal stability additive S-1749	MIL-DTL-83133K	-	-	Shell JP-8 +100
F-40	Aviation turbine fuel - wide cut type with fuel system icing inhibitor	MIL-DTL-5624W Grade JP-4	DEF STAN 91-088	AVTAG/FSII	-
F-43 (Obsolete)	Aviation turbine fuel - high flash type (-46°C freeze point) replaced by F-44	-	DERD 2498 (Obsolete)	AVCAT (Obsolete)	-
F-44	Aviation turbine fuel - high flash type (-46°C freeze point) with fuel system icing inhibitor	MIL-DTL-5624W Grade JP-5	DEF STAN 91-086	AVCAT/FSII	Shell JP-5 Special arrangements necessary

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
F-76	Alternative turbine/diesel engine fuel for use in certain Naval helicopters	MIL-F-16884L	DEF STAN 91-004	DIESO F-76	-
G-350 (Obsolete)	OBSOLETE - superseded by G-354	-	-	-	-
G-352 (Obsolete)	OBSOLETE - superseded by G-354	-	-	-	-
G-353	Synthetic molybdenum disulphide aircraft grease	MIL-G-21164D	DEF STAN 91-057	XG-276	AeroShell Grease 64
G-354	Synthetic aircraft grease for aircraft and instruments	MIL-PRF-23827C	DEF STAN 91-053	XG-287	AeroShell Grease 33
G-355	Graphited aircraft grease	MIL-G-7187 (Obsolete)	DEF STAN 91-054 (Obsolete)	XG-285	-
G-357 (Obsolete)	Graphited synthetic grease for flexible cables	-	DEF STAN 91-085	XG-273	-
G-359	High temperature aircraft grease	MIL-G-3545C (Obsolete)	DTD.878A (Obsolete)	XG-277 (Obsolete)	AeroShell Grease 5
G-361	Wide temperature range synthetic aircraft grease	MIL-G-25760A (Obsolete)	DTD.5579 (Obsolete)	XG-292 (Obsolete)	-
G-363	Hydrocarbon resistant plug grease	SAE AMSG6032A	DEF STAN 91-006	XG-235	-
G-366	Helicopter oscillating bearing grease	MIL-G-25537C	DEF STAN 91-051	XG-284	AeroShell Grease 14
G-372	High temperature synthetic grease	MIL-G-25013E	DEF STAN 91-055 (Obsolete)	XG-300	-
G-382	Aircraft general purpose grease	MIL-G-7711A (Obsolete)	DEF STAN 91-012 (Obsolete)	XG-271 (Obsolete)	AeroShell Grease 6
G-392	Synthetic grease for pneumatic systems	SAE AMSG4343A	(SAE AMSG4343A)	XG-269	-
G-394	Silicone based grease for pneumatic systems	-	DEF STAN 91-056	XG-315	-
G-395	Multi-purpose aircraft grease	MIL-PRF-81322G	DEF STAN 91-052 (Obsolete)	XG-293	AeroShell Grease 22
G-396	Aircraft grease PTFE	MIL-PRF-83363E	-	-	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
G-397	Grease fuel and oil resistant, liquid oxygen compatible	MIL-PRF-27617G Type I	-	-	-
G-398	Grease liquid oxygen compatible	MIL-PRF-27617G Type II	-	-	-
G-399	Grease liquid oxygen compatible	MIL-PRF-27617G Type III	-	-	-
G-403	All purpose grease	MIL-PRF-10924H	DEF STAN 91-027	XG-279	-
G-408	Graphite grease	VV-G-671G Grade 1	-	-	-
G-421	Grease, general use	-	DEF STAN 91-105	XG-291	-
G-450 (Obsolete)	Multi-purpose quiet service grease	MIL-PRF-24139A	DEF STAN 91-028 (Obsolete)	XG-274 (Obsolete)	AeroShell Grease 6*
G-1350	Grease liquid oxygen compatible	MIL-PRF-27617G Type IV	-	-	-
H-515	Hydraulic fluid, petroleum base, improved cleanliness and performance	MIL-PRF-5606J	DEF STAN 91-048 Grade Superclean	OM-15	AeroShell Fluid 41
H-520 (Obsolete)	Hydraulic fluid, petroleum base, improved performance	-	DEF STAN 91-048 Grade Normal	OM-18	AeroShell Fluid 41*
H-535 (Obsolete)	OBSOLETE	-	-	-	-
H-536 (Obsolete)	Hydraulic fluid, chlorinated silicone	MIL-S-81087C Type 1 (Obsolete)	(MIL-S-81087C) (Obsolete)	OX-50 (Obsolete)	-
H-537	Hydraulic fluid, fire resistant synthetic hydrocarbon	MIL-PRF-83282D	(MIL-PRF-83282D)	OX-19	AeroShell Fluid 31
H-538	Low temperature synthetic hydrocarbon hydraulic fluid	MIL-PRF-87257C	(MIL-PRF-87257B)	OX-538	-
H-540	Petroleum hydraulic fluid	-	-	-	-
H-544	Preservative grade fire resistant synthetic hydrocarbon hydraulic fluid	MIL-PRF-46170E Type I	-	-	AeroShell Fluid 61
H-575	Inhibited petroleum hydraulic oil	MIL-DTL-17111E	-	-	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
H-576	General purpose hydraulic fluid	-	DEF STAN 91-039	OM-33	-
H-579	Fire resistant hydraulic fluid, water glycol	MIL-H-22072C	-	-	-
H-580	Hydraulic fluid, phosphate ester fire resistant	MIL-H-19457D	-	-	-
O-113 (Obsolete)	Lubricating oil for aircraft piston engines - SAE Grade 30	SAE J1966 Grade 30	-	OM-107 (Obsolete)	AeroShell Oil 65*
O-115 (Obsolete)	Lubricating oil for aircraft piston engines - SAE Grade 40	SAE J1966 Grade 40	SAE J1966 Grade 40	OM-170	AeroShell Oil 80*
O-117 (Obsolete)	Lubricating oil for aircraft piston engines - SAE Grade 50	SAE J1966 Grade 50	SAE J1966 Grade 50	OM-270	AeroShell Oil 100*
O-123 (Obsolete)	Lubricating oil for aircraft piston engines - dispersant SAE Grade 40	SAE J1899 Grade 40	SAE J1899 Grade 40	OMD-160	AeroShell Oil W80* AeroShell Oil W80 Plus*
O-125 (Obsolete)	Lubricating oil for aircraft piston engines - dispersant SAE Grade 50	SAE J1899 Grade 50	SAE J1899 Grade 50	OMD-250	AeroShell Oil W100* AeroShell Oil W100 Plus*
O-128 (Obsolete)	Lubricating oil of aircraft piston engines - dispersant SAE Grade 60	SAE J1899 Grade 60	SAE J1899 Grade 60	OMD-370	AeroShell Oil W120*
O-132 (Obsolete)	Mineral lubricating oil for aircraft turbine engines - petroleum Grade 1005	MIL-PRF-6081E Grade 1005	-	-	-
O-133	Mineral lubricating oil for aircraft turbine engines - petroleum Grade 1010	MIL-PRF-6081E Grade 1010	-	OM-10 (Obsolete)	AeroShell Turbine Oil 2
O-134	General purpose lubricating oil	-	DEF STAN 91-044 (Obsolete)	OM-13 (Obsolete)	AeroShell Turbine Oil 3*
O-135	Mineral lubricating oil for aircraft turbine engines - 3 mm²/s viscosity	-	DEF STAN 91-099	OM-11	AeroShell Turbine Oil 3

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
O-136	Mineral lubricating oil for aircraft turbine engines – EP – 9 mm²/s viscosity	-	DEF STAN 91-097 (Obsolete)	OEP-71	-
O-138	Mineral lubricating oil for aircraft turbine engines - 9 mm²/s viscosity	-	DEF STAN 91-097 (Obsolete)	OM-71	-
O-140 (Obsolete)	Low temperature oil for aircraft controls	-	DTD.417B (Obsolete)	OM-150	-
O-142	General purpose low temperature lubricating oil	MIL-PRF-7870E	DEF STAN 91-047 (Obsolete)	OM-12	AeroShell Fluid 3
O-147	Lubricating oil for aircraft instruments	MIL-PRF-6085E	DEF STAN 91-049	OX-14	AeroShell Fluid 12
O-148	Synthetic ester lubricating oil for aircraft turbine engines - 3 mm²/s viscosity	MIL-PRF-7808L Grade 3	(MIL-PRF-7808L Grade 3)	OX-9	AeroShell Turbine Oil 308
O-149	Synthetic ester lubricating oil for aircraft turbine engines - 7.5 mm²/s viscosity	-	DEF STAN 91-098	OX-38	AeroShell Turbine Oil 750
O-150	Synthetic ester lubricating oil for aircraft turbine engines - 3 mm²/s viscosity	-	-	-	-
O-152	Synthetic ester lubricating oil for aircraft turbine engines - corrosion inhibited 5 mm²/s	MIL-PRF-23699G Grade C/I	-	-	-
O-153	Extreme pressure gear oil - light grade	MIL-PRF-6086F Grade L	DEF STAN 91-112 Grade Light	OEP-30	-
O-154	Synthetic ester lubricating oil for aircraft turbine engines - high thermal stability 5 mm²/s	MIL-PRF-23699G Grade HTS	-	-	AeroShell Turbine Oil 560 AeroShell Ascender
O-155	Extreme pressure gear oil - medium grade	MIL-PRF-6086F Grade M	DEF STAN 91-112 Grade Medium	OEP-70	AeroShell Fluid 5M-A

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
O-156	Synthetic ester lubricating oil for aircraft turbine engines - 5 mm²/s viscosity standard grade	MIL-PRF-23699G Grade STD	DEF STAN 91-101 Grade OX-27	OX-27	AeroShell Turbine Oil 500
O-157	Low temperature oil for aircraft weapons	MIL-PRF-14107D	DEF STAN 91-102	OX-24	-
O-158 (Obsolete)	Low temperature lubrication of automatic weapons	MIL-L-46000C	(MIL-L-46000C)	XG-485 (Obsolete)	-
O-159	Synthetic ester lubricating oil for aircraft turbine engines - 7.5 mm²/s viscosity	-	-	-	AeroShell Turbine Oil 750*
O-160	Synthetic ester lubricating oil for aircraft turbine engines - 5 mm²/s viscosity	-	DEF STAN 91-100	OX-26	AeroShell Turbine Oil 555
O-162 (Obsolete)	Lubricating oil for aircraft piston engines, ashless dispersant SAE 15W-50	SAE J1899 Multigrade	-	OMD-162	AeroShell Oil W 15W-50*
O-163	Synthetic engine oil for military gas turbines	MIL-PRF-7808L Grade 4	-	-	-
O-184 (Obsolete)	OBSOLETE - superseded by O-266	-	-	-	-
O-190	General purpose oil and preservative, water displacing low temperature	MIL-PRF-32033A	DEF STAN 91-079 (Obsolete)	OX-18 (Obsolete)	-
O-192	Preservative lubricating oil - medium	MIL-PRF-3150E	-	-	-
O-196 (Obsolete)	General purpose light oil	VV-L-820C (Obsolete)	-	-	-
O-218 (Obsolete)	Lubricating oil, colloidal graphite	-	DEF STAN 91-030 (Obsolete)	OX-320 (Obsolete)	-
S-712 (Obsolete)	Aircraft compass liquid (mineral type)	MIL-L-5020E	-	OM-1 (Obsolete)	-
S-716	Anti-seize compound (lead free)	TT-S-1732 (Obsolete)	-	-	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
S-717	Anti-seize compound for aircraft oxygen	MIL-T-5542E (Obsolete)	-	ZX-32 (Obsolete)	-
S-718	Aqueous colloidal graphite for screw threads of low pressure oxygen cylinders	-	DTD.900/4042A (Obsolete)	ZX-24	-
S-720	Aircraft grease for sparking plugs and other threads	SAE AMS2518D	DEF STAN 80-080	ZX-13	-
S-722	Molybdenum disulphide anti-seize compound for heavily loaded surfaces	-	DEF STAN 80-081 (Obsolete)	ZX-38	-
S-725 (Obsolete)	OBSOLETE - superseded by S-716	-	-	-	-
S-732	Lubricating graphite	SS-G-659A	DEF STAN 91-006	ZX-20 (Obsolete)	-
S-736	Insulating compound for use in assembly of ignition harness	SAE AS8660	DEF STAN 68-069	XG-250	-
S-737	Isopropyl alcohol (anti-icing fluid)	TT-I-735A Grade B	BS 1595-1:1986	AL-11	-
S-738	Denatured ethyl alcohol (de-icing fluid) for aircraft windscreens and carburettors	O-E-760D Type III	-	-	-
S-740	Molybdenum disulphide powder	SAE AMSM7866B	DEF STAN 68-062	ZX-35	-
S-742	De-icing and defrosting fluid	MIL-A-8243D Type II (Obsolete)	-	-	-
S-743	Technical petroleum	VV-P-236A	DEF STAN 91-038 Grade PX-7	PX-7	-
S-745	De-icing/defrosting fluid	-	DTD.406B (Obsolete)	AL-5	AeroShell Compound 07
S-746 (Obsolete)	Isopropyl nitrate	-	DEF STAN 91-089 (Obsolete)	AVPIN (Obsolete)	-
S-747	Methanol for use in methanol water mixtures and anti-freeze solutions	O-M-232N Grade A	BS 506-1:1987	AL-14	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
S-748 (Obsolete)	Fuel system icing inhibitor (ethylene glycol monomethyl ether). Superseded by S-1745	MIL-DTL-27686G (Obsolete)	DERD 2451 Grade AL-31 (Obsolete)	AL-31 (Obsolete)	-
S-749	Lubricant, solid film, air drying	MIL-L-23398D	(MIL-L-23398D)	ZX-55	-
S-752	White spirit, flashpoint 38°C	MIL-PRF-680C Type I	BS 245:1976 Type I	White spirit	-
S-753	White spirit - high flash	MIL-PRF-680C Type II	-	-	-
S-756	Transformer oil	-	BS.148.84	OM-16	-
S-757	Inhibited ethanediol	-	DEF STAN 68-127	AL-39	-
S-758	Lubricant, cleaner and preservative for weapons	MIL-PRF-63460F	-	-	-
S-761	Multifunctional synthetic lubricant for weapons	-	-	-	-
S-1712	Damping fluid, dimethyl silicone Grade 3	-	DEF STAN 91-046 (Obsolete)	ZX-41 (Obsolete)	-
S-1714	Damping fluid, dimethyl silicone Grade 10	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-42 (Obsolete)	-
S-1716	Damping fluid, dimethyl silicone Grade 20	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-43	-
S-1718	Damping fluid, dimethyl silicone Grade 50	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-44	-
S-1720	Damping fluid, dimethyl silicone Grade 100	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-45	-
S-1722 (Obsolete)	OBSOLETE (Damping fluid, dimethyl silicone)	-	-	-	-
S-1724	Damping fluid, dimethyl silicone Grade 7500	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-48 (Obsolete)	-
S-1726	Damping fluid, dimethyl silicone Grade 20000	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-50 (Obsolete)	-

NATO Code	Product and Application	U.S. Specification	British Specification	Joint Service Designation	AeroShell Grade
S-1728	Damping fluid, dimethyl silicone Grade 100000	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-52 (Obsolete)	-
S-1730 (Obsolete)	OBSOLETE (Damping fluid, dimethyl silicone)	-	-	-	-
S-1732	Damping fluid, dimethyl silicone Grade 200000	VV-D-1078B	DEF STAN 91-046 (Obsolete)	ZX-53 (Obsolete)	-
S-1734 (Obsolete)	OBSOLETE (Damping fluid, dimethyl silicone)	-	-	-	-
S-1735	Molybdenum disulphide lubricant, silicone base	DOD-L-25681D	(DOD-L-25681D)	OX-70	-
S-1737	Lubricant solid film, extreme environment	MIL-PRF-81329E	-	-	-
S-1738	Heat cured solid film lubricant	MIL-PRF-46010H Type 1	SAE AS5272 Type 1	ZX-34	-
S-1739	Demineralised water	-	DEF STAN 68-253	WTA	-
S-1740 (Obsolete)	OBSOLETE	-	-	AL-24 (Obsolete)	-
S-1744	Thrust augmentation fluid for aircraft turbine engines (Methanol/Water 44/56 grade)	-	DEF STAN 68-253	AL-28	-
S-1745	High flash type fuel system icing inhibitor for aviation turbine fuel (di-ethylene glycol monomethyl ether)	MIL-DTL-85470B	DEF STAN 68-252 Grade AL-41	AL-41	-
S-1746	De-icing/Defrosting fluid	-	DTD.900/4907 (Obsolete)	AL-34	-
S-1747	Corrosion inhibitor/lubricity additive for jet fuel	MIL-PRF-25017H	DEF STAN 68-251	AL-61	-
S-1748	Coolant fluid, hydrolytically stable, dielectric	MIL-PRF-87252E	-	-	AeroShell Fluid 602
S-1749	Jet fuel thermal stability improver additive	MIL-DTL-83133K	-	-	-

NOTES

BRITISH JOINT SERVICE DESIGNATIONS

Scope of list

This list comprises the British Joint Service Designations which cover aviation fuels, engine oils, hydraulic fluids, greases and allied products.

Interpretation of list

The Joint Service Designations are allocated to grades which meet British Specifications (or those U.S. Specifications which have been adopted by the U.K.) and are supplied to the British Services. Hence only British Specifications are shown. However, in some cases the British Ministry of Defence uses U.S. Specifications and these are included for completeness.

Where an asterisk* appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses of the official specification, but is the nearest product marketed by Shell.

For easy reference, obsolete specifications are shown in both the current and superseded specification columns. In the former case, a suitable comment is made, namely, "OBSOLETE - superseded by..."

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
DIESO F-76	DEF STAN 91-004	F-76	Alternative turbine/diesel engine fuel for use in certain Naval helicopters	-
73 AVGAS (Obsolete)	-	-	OBSOLETE	-
80 NL AVGAS (Obsolete)	-	-	OBSOLETE	-
91/96 AVGAS	-	-	OBSOLETE	-
AVGAS 80 (Obsolete)	DEF STAN 91-090	F-12 (Obsolete)	Aviation gasoline, Grade 80	-
AVGAS 100 (Obsolete)	DEF STAN 91-090	-	Aviation gasoline, Grade 100/130	Shell Avgas 100
AVGAS 100LL	DEF STAN 91-090	F-18	Aviation gasoline, Grade 100/130 (low lead)	Shell Avgas 100LL
AVTAG/FSII	DEF STAN 91-088	F-40	Wide cut gasoline type fuel, with fuel system icing inhibitor	-
AVTUR/FSII	DEF STAN 91-087	F-34	Kerosine type fuel (-47°C freeze point) with fuel system icing inhibitor	Shell JP-8 Special arrangements necessary
AVCAT (Obsolete)	DERD 2498 (Obsolete)	F-43 (Obsolete)	High flash kerosine type fuel (-46°C freeze point). Replaced by AVCAT/FSII	-
AVCAT/FSII	DEF STAN 91-086	F-44	High flash kerosine type fuel (-46°C freeze point) with fuel system icing inhibitor	Shell JP-5 Special arrangements necessary
AVPIN (Obsolete)	DEF STAN 91-089 (Obsolete)	S-746 (Obsolete)	Turbine engine starter fuel (isopropyl nitrate)	-
AVTUR	DEF STAN 91-091	F-35	Aviation turbine fuel - kerosine type (-47°C freeze point)	Shell Jet A-1 Shell AeroJet*
WTA	DEF STAN 62-253	S-1739	Pure water for thrust augmentation	-
White Spirit	BS 245:1976 Type 1	S-752	White spirit	-
AL-3 (Obsolete)	-	-	Inhibited aircraft engine coolant and general purpose anti-freeze fluid	-
AL-5	DTD.406B (Obsolete)	S-745	De-icing fluid	AeroShell Compound 07
AL-7 (Obsolete)	-	-	OBSOLETE	-
AL-8 (Obsolete)	-	-	OBSOLETE - superseded by AL-11	-
AL-9 (Obsolete)	-	-	OBSOLETE - superseded by AL-14	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
AL-11	BS 1595-1:1986	S-737	Isopropyl alcohol anti-icing fluid	-
AL-14	BS 506-1:1987	S-747	Methanol	-
AL-20	DEF STAN 68-108 (Obsolete)	-	Ethanediol (used in DTD.406B)	-
AL-24 (Obsolete)	DEF STAN 68-253	-	Methanol/water mixture of certain aircraft piston engines	-
AL-26 (Obsolete)	DEF STAN 68-061 (Obsolete)	-	Coolant fluid - inhibited	-
AL-28	DEF STAN 68-253	S-1744	43.8% vol. Methanol/56.2% vol.	-
AL-29 (Obsolete)	-	-	OBSOLETE	-
AL-31 (Obsolete)	DERD 2451 (Obsolete)	S-748 (Obsolete)	Fuel system icing inhibitor (ethylene gylcol monomethyl ether). Superseded by AL-41	-
AL-32 (Obsolete)	-	-	OBSOLETE	-
AL-33 (Obsolete)	-	-	OBSOLETE	-
AL-34	DTD.900/4907 (Obsolete)	S-1746	Fluid for anti-icing and de-icing parked aircraft	-
AL-36	DTD.900/4939A (Obsolete)	-	Windscreen washing fluid for certain aircraft	-
AL-38 (Obsolete)	-	-	OBSOLETE - superseded by AL-48	-
AL-39	DEF STAN 68-127	S-757	Anti-freeze, inhibited ethanediol	-
AL-40	DEF STAN 68-129	-	Methanol/water mixture for hydrogen generation	-
AL-41	DEF STAN 68-252	S-1745	High flash fuel system icing inhibitor (di-ethylene gylcol monomethyl ether)	-
AL-48	DEF STAN 68-150	-	Mixture of AL-41 and AL-61	-
AL-61	DEF STAN 68-251	S-1747	Corrosion inhibitor/lubricity additive for jet fuel	-
OEP-30	DEF STAN 91-112 Grade L	O-153	EP gear lubricant of light viscosity	-
OEP-38	DEF STAN 91-059	O-186	Gear lubricant for very cold ambient temperatures	-
OEP-70	DEF STAN 91-112 Grade M	O-155	EP gear lubricant of medium viscosity	AeroShell Fluid 5M-A

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
OEP-71	DEF STAN 91-097 (Obsolete)	O-136	Mineral lubrication oil for aircraft, 9 mm^2/s viscosity	-
OEP-215	DTD.900/4981A (Obsolete)	-	Helicopter gearbox oil for certain Westland helicopters	AeroShell Fluid S.8350
OF-4 (Obsolete)	DTD.900/4081A (Obsolete)	-	Proprietary aircraft hydraulic fluid (castor oil base). Specification now cancelled; replaced by OX-87).	-
OM-1 (Obsolete)	(MIL-L-5020C)	S-712 (Obsolete)	Aircraft compass fluid, U.K. has adopted U.S. specification	-
OM-3 (Obsolete)	-	-	OBSOLETE	-
OM-10 (Obsolete)	-	O-133	Mineral lubricating oil for turbine engines, 2 mm^2/s viscosity	AeroShell Turbine Oil 2*
OM-11	DEF STAN 91-099	O-135	Mineral aviation turbine oil, 3 mm^2/s viscosity	AeroShell Turbine Oil 3
OM-12	DEF STAN 91-047 (Obsolete)	O-142	General purpose low temperature lubricating oil	AeroShell Fluid 3
OM-13 (Obsolete)	DEF STAN 91-044 (Obsolete)	O-134	Light lubricating oil. Replaced by OM-11	AeroShell Turbine Oil 3*
OM-15	DEF STAN 91-048 Grade Superclean	H-515	Extreme low temperature mineral hydraulic fluid of improved cleanliness and performance	AeroShell Fluid 41 (European production only, U.S. production is equivalent)
OM-16	BS.148:84 (Obsolete)	S-756	Oil for electrical purposes	-
OM-18	DEF STAN 91-048 Grade Normal	H-520 (Obsolete)	Hydraulic fluid - petroleum base of improved performance	AeroShell Fluid 41* AeroShell Fluid 4*
OM-21 (Obsolete)	BS.4475:75	-	Flushing oil. Specification now obsolete.	-
OM-22	BS.148:84 (Obsolete)	-	Transformer oil for aircraft electrical equipment (pourpoint -45°C max)	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
OM-33	DEF STAN 91-039	H-576	General purpose hydraulic oil	-
OM-71	DEF STAN 91-097 (Obsolete)	O-138	Mineral lubricating oil for miscellaneous applications	-
OM-107 (Obsolete)	-	O-113 (Obsolete)	Lubricating oil for aircraft piston engines. SAE Grade 30	AeroShell Oil 65*
OM-150	DEF STAN 91-114	O-140 (Obsolete)	Lubricating oil for aircraft controls	-
OM-170	SAE J1966 Grade 40	O-115 (Obsolete)	Lubricating oil for aircraft piston engines. SAE Grade 40	AeroShell Oil 80 AeroShell Oil W80 Plus
OM-270	SAE J1966 Grade 50	O-117 (Obsolete)	Lubricating oil for aircraft piston engines. SAE Grade 50	AeroShell Oil 100
OM-370 (Obsolete)	SAE J1966 Grade 60	-	Lubricating oil for aircraft piston engines. SAE 60 Grade.	AeroShell Oil 120*
OMD-160	SAE J1899 Grade 40	O-123 (Obsolete)	Lubricating oil for aircraft piston engines - ashless dispersant type. SAE Grade 40	AeroShell Oil W80
OMD-162	SAE J1899 Grade Multigrade	O-162 (Obsolete)	Lubricating oil for aircraft piston engines - ashless dispersant type SAE 15W-50	AeroShell Oil W 15W-50
OMD-250	SAE J1899 Grade 50	O-125 (Obsolete)	Lubricating oil for aircraft piston engines - ashless dispersant type. SAE Grade 50	AeroShell Oil W100 AeroShell Oil W100 Plus
OMD-270 (Obsolete)	DERD 2472B/2 (Obsolete)	O-127 (Obsolete)	OBSOLETE - Lubricating oil for aircraft piston engines	-
OMD-370	SAE J1899 Grade 60	O-128 (Obsolete)	Lubricating oil for aircraft piston engines - ashless dispersant type SAE Grade 60	AeroShell Oil W120
OX-7	DEF STAN 91-094	-	Synthetic turbine oil 3 mm²/s viscosity	AeroShell Turbine Oil 390
OX-9	(MIL-PRF-7808L Grade 3)	O-148	Synthetic turbine oil 3 mm²/s viscosity	AeroShell Turbine Oil 308
OX-14	DEF STAN 91-049	O-147	Synthetic oil with additives - low volatility aircraft instrument oil	AeroShell Fluid 12*
OX-15 (Obsolete)	-	-	OBSOLETE - superseded by PX-26	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
OX-16	DTD.900/4386A (Obsolete)	-	Silicone damping fluid	-
OX-18 (Obsolete)	DEF STAN 91-079 (Obsolete)	O-190	General purpose oil and preservative, water displacing low temperature	-
OX-19	(MIL-H-83282D)	H-537	Fire resistant synthetic hydrocarbon hydraulic fluid. U.K. has adopted U.S. Specification MIL-PRF-83282D.	AeroShell Fluid 31
OX-20	DTD.900/4881D (Obsolete)	-	Phosphate ester hydraulic fluid	-
OX-22 (Obsolete)	DEF STAN 91-093 (Obsolete)	O-291	Synthetic turbine oil for marine gas turbine engines. Replaced by OX-152.	-
OX-23 (Obsolete)	-	-	OBSOLETE - superseded by OX-27	-
OX-24	DEF STAN 91-102	O-157	Low temperature oil for aircraft weapons	-
OX-26	DEF STAN 91-100	O-160	Synthetic turbine oil 5 mm²/s viscosity	AeroShell Turbine Oil 555
OX-27	DEF STAN 91-101 Grade OX-27	O-156	Synthetic turbine oil 5 mm²/s viscosity	AeroShell Turbine Oil 500 AeroShell Turbine Oil 560* AeroShell Ascender*
OX-28 (Obsolete)	DEF STAN 91-101 Grade OX-28	-	Synthetic turbine oil 5 mm²/s viscosity for certain turbines. Replaced by OX-152.	-
OX-30	DEF STAN 91-035	H-584	Emulsifying petroleum hydraulic fluid for use in certain types of radar equipment	-
OX-38	DEF STAN 91-098	O-149	Synthetic turbine oil 7.5 mm²/s viscosity	AeroShell Turbine Oil 750
OX-50 (Obsolete)	(MIL-S-81087C) (Obsolete)	H-536 (Obsolete)	OBSOLETE – U.K. has adopted U.S. Specification MIL-S-81087C	-
OX-70	(DOD-L-25681D)	S-1735	Molybdenum disulphide lubricating oil, silicone base, U.K. has adopted U.S. Specification DOD-L-25681D.	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
OX-87	DTD.900/6103A (Obsolete)	-	Hydraulic fluid for certain aircraft	-
OX-125	DEF STAN 91-069 (Provisional)	-	Helicopter Transmission Lubricant (9 mm^2/s)	-
OX-165	DEF STAN 91-071 (Obsolete)	-	Synthetic gear lubricating oil	-
OX-270 (Obsolete)	-	C-609	Corrosion preventive oil. Meets U.S. Specification MIL-C-6529C Type II.	-
OX-275 (Obsolete)	-	-	OBSOLETE - superseded by PX-27	-
OX-320 (Obsolete)	DEF STAN 91-030 (Obsolete)	O-218 (Obsolete)	CANCELLED - lubricating oil, colloidal graphite	-
OX-538	(MIL-PRF-87257C)	H-538	Low temperature synthetic hydrocarbon hydraulic fluid	-
PX-1	DEF STAN 80-217	C-614	Lanolin/white spirit corrosion protective	-
PX-2 (Obsolete)	-	-	OBSOLETE - superseded by PX-31	-
PX-3 (Obsolete)	-	-	OBSOLETE - superseded by PX-32 or PX-28	-
PX-4	DEF STAN 80-034	C-642	Corrosion preventive compound	-
PX-6	DEF STAN 91-038 Grade PX-6	-	Stiff tacky petrolatum. Used mainly as an ingredient of PX-11	-
PX-7	DEF STAN 91-038 Grade PX-7	S-743	Mineral petrolatum	-
PX-9 (Obsolete)	-	-	OBSOLETE - superseded by PX-28	-
PX-10 (Obsolete)	-	-	OBSOLETE - superseded by PX-24	-
PX-11	DEF STAN 80-085 (Obsolete)	C-628 (Obsolete)	Long term mineral jelly/beeswax protective	-
PX-12 (Obsolete)	-	-	OBSOLETE - superseded by XG-250 for certain special applications	-
PX-13 (Obsolete)	DEF STAN 81-205	C-613 (Obsolete)	Wax thickened engine protective	-
PX-14 (Obsolete)	-	-	OBSOLETE - superseded by PX-4	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
PX-15	DEF STAN 80-145 (Obsolete)	-	Corrosion preventive	-
PX-19 (Obsolete)	DEF STAN 91-078	-	Soft film temporary protective. OBSOLETE – superseded by XG-380	-
PX-24	DEF STAN 68-010	C-634	Water displacing and protective fluid. Also replaces PX-10 and PX-29	-
PX-25 (Obsolete)	-	-	OBSOLETE	-
PX-26	DEF STAN 80-142 (Obsolete)	C-635	Preservative mineral hydraulic fluid	-
PX-27	DEF STAN 91-040 (Obsolete)	C-615	Storage oil for piston engine preservation	-
PX-28	DEF STAN 80-143	-	Preservative for internal airframe surfaces	-
PX-29 (Obsolete)	-	-	OBSOLETE - superseded by PX-24	-
PX-30 (Obsolete)	-	-	OBSOLETE	-
PX-31	DEF STAN 80-186 (Obsolete)	-	Corrosion preventive compound	-
PX-32	DEF STAN 80-083	-	Corrosion preventive compound for aircraft structures	-
PX-36	DEF STAN 91-103	-	Corrosion preventive, weapon cleaner, lubricant	-
XG-235	DEF STAN 91-006	G-363	Fuel and oil resistant grease	-
XG-250	DEF STAN 68-069	S-736	Compound for use in assembly of ignition harness	-
XG-261	-	-	Silicone grease	-
XG-265 (Obsolete)	-	-	OBSOLETE - superseded by XG-293	-
XG-269	SAE AMSG4343A	G-392	Synthetic grease for pneumatic systems. U.K. has adopted SAE AMSG4343.	-
XG-271 (Obsolete)	DEF STAN 91-012 (Obsolete)	G-382	Aircraft general purpose grease. OBSOLETE – superseded by XG-291	AeroShell Grease 6*
XG-273	DEF STAN 91-085	G-357 (Obsolete)	Graphite grease for lubrication of Bowden cables	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
XG-274 (Obsolete)	DEF STAN 91-028 (Obsolete)	G-450 (Obsolete)	Multi-purpose quiet service grease. OBSOLETE – superseded by XG-291	AeroShell Grease 6*
XG-275 (Obsolete)	-	-	OBSOLETE - superseded by XG-287	-
XG-276	DEF STAN 91-057	G-353	Synthetic grease containing molybdenum disulphide	AeroShell Grease 64
XG-277 (Obsolete)	DTD.878A (Obsolete)	G-359	OBSOLETE - superseded by XG-293. AeroShell Grease 5 is still available meeting the obsolete British Specification.	AeroShell Grease 5*
XG-278 (Obsolete)	-	-	OBSOLETE - superseded by XG-287	-
XG-279	DEF STAN 91-027	G-403	All purpose grease	-
XG-284	DEF STAN 91-051	G-366	Aircraft anti-fret grease and helicopter general purpose grease	AeroShell Grease 14
XG-285	DEF STAN 91-054 (Obsolete)	G-355	Graphited grease for aircraft general use	-
XG-287	DEF STAN 91-053	G-354	Load carrying synthetic grease for aircraft gears	-
XG-291	DEF STAN 91-105	G-421	Grease, general use	-
XG-292 (Obsolete)	DTD.5579 (Obsolete)	G-361	OBSOLETE - superseded by XG-293	-
XG-293	DEF STAN 91-052 (Obsolete)	G-395	Synthetic general purpose grease, wide temperature range	AeroShell Grease 22
XG-294	DEF STAN 91-106	G-1352	Grease, multi-purpose, elevated temperature range	-
XG-295 (Obsolete)	-	-	OBSOLETE - superseded by XG-287	-
XG-300	DEF STAN 91-055 (Obsolete)	G-372	Extreme high temperature ball and roller bearing grease. UK has adopted MIL-G-25013E	-
XG-305	DEF STAN 91-064 (Obsolete)	-	Molybdenum disulphide grease	-
XG-315	DEF STAN 91-056	G-394	Silicone grease for metal to metal rubber lubrication	-
XG-329 (Obsolete)	-	-	OBSOLETE - superseded by XG-293	-
XG-344 (Obsolete)	DTD.900/4872A (Obsolete)	-	Grease for certain turbine engine starters - OBSOLETE	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
XG-350 (Obsolete)	-	-	OBSOLETE - superseded by XG-271	-
XG-410 (Obsolete)	-	-	OBSOLETE - superseded by XG-235	-
XG-480 (Obsolete)	-	-	OBSOLETE	-
XG-485 (Obsolete)	(MIL-L-46000C)	O-158 (Obsolete)	Low temperature lubrication of automatic weapons. U.K. has adopted U.S. Specification MIL-L-46000C.	-
ZX-13	DEF STAN 80-080	S-720	Graphited anti-seize compound	-
ZX-14 (Obsolete)	-	-	OBSOLETE - superseded by XG-235	-
ZX-17 (Obsolete)	-	C-610	Corrosion preventive oil for aircraft gas turbines	-
ZX-20 (Obsolete)	DEF STAN 96-001 (Obsolete)	S-732	Graphite powder - lubricating grade	-
ZX-21 (Obsolete)	(MIL-C-6529C Type I)	C-608	Inhibited lubricating oil concentrate for engine protection. U.K. has adopted U.S. Specification.	AeroShell Fluid 2XN*
ZX-24	DTD.900/4042A (Obsolete)	S-718	Proprietary brand of aqueous colloidal graphite	-
ZX-28 G & P (Obsolete)	-	-	OBSOLETE	-
ZX-29 (Obsolete)	-	-	OBSOLETE - superseded by PX-24	-
ZX-30	DTD.900/4639 (Obsolete)	-	Dry lubricating coating for certain metal parts	-
ZX-31 (Obsolete)	-	-	OBSOLETE	-
ZX-32 (Obsolete)	-	S-717	Anti-seize and sealing thread compound for oxygen systems. Meets U.S. Specification MIL-T-5542E.	-
ZX-33 (Obsolete)	DEF STAN 68-007 (Obsolete)	-	CANCELLED. Cleaning and lubricating compound	-
ZX-34	SAE AS5272 Type 1	S-1738	Bonded dry film lubricant	-
ZX-35	DEF STAN 68-062	S-740	Molybdenum disulphide powder	-
ZX-36	DTD.900/4877A (Obsolete)	-	Lubrication for fitting electrical cables in aircraft	-
ZX-38	DEF STAN 80-081 (Obsolete)	S-722	Anti-seize compound, molybdenum disulphide type	-

Joint Service Designation	British Specification	NATO Code	Product and Application	AeroShell Grade
ZX-41(Obsolete)	DEF STAN 91-046 (Obsolete)	S-1712	Damping fluid dimethyl silicone Grade 3	-
ZX-42 (Obsolete)	DEF STAN 91-046 (Obsolete)	S-1714	Damping fluid dimethyl silicone Grade 10	-
ZX-43	DEF STAN 91-046 (Obsolete)	S-1716	Damping fluid dimethyl silicone Grade 20	-
ZX-44	DEF STAN 91-046 (Obsolete)	S-1718	Damping fluid dimethyl silicone Grade 50	-
ZX-45	DEF STAN 91-046 (Obsolete)	S-1720	Damping fluid dimethyl silicone Grade 100	-
ZX-46	DEF STAN 91-046 (Obsolete)	-	Damping fluid dimethyl silicone Grade 500	-
ZX-47	DEF STAN 91-046 (Obsolete)	-	Damping fluid dimethyl silicone Grade 1000	-
ZX-48 (Obsolete)	DEF STAN 91-046 (Obsolete)	S-1724	Damping fluid dimethyl silicone Grade 7500	-
ZX-49 (Obsolete)	DEF STAN 91-046 (Obsolete)	-	Damping fluid dimethyl silicone Grade 12500	-
ZX-50 (Obsolete)	DEF STAN 91-046 (Obsolete)	S-1726	Damping fluid dimethyl silicone Grade 20000	-
ZX-51	DEF STAN 91-046 (Obsolete)	-	Damping fluid dimethyl silicone Grade 60000	-
ZX-52 (Obsolete)	DEF STAN 91-046 (Obsolete)	S-1728	Damping fluid dimethyl silicone Grade 100000	-
ZX-53 (Obsolete)	DEF STAN 91-046 (Obsolete)	S-1732	Damping fluid dimethyl silicone Grade 200000	-
ZX-55	(MIL-L-23398D)	S-749	Lubricant, solid film air drying corrosion inhibiting. U.K. has adopted the U.S. Specification.	-

NOTES

FRENCH AVIATION SPECIFICATIONS

Scope of list

This list covers French aviation specifications for aviation fuels, lubricants and allied products. The equivalent British and American specifications can be found elsewhere in this guide.

French specifications are being converted from Normes AIR (issued formerly by Delegation Generale pour l'Armement) to DCSEA (issued by Service des Essences des Armées). Since 1997, SEA has been responsible for writing these specifications.

Norme AIR have all been downgraded as non-suitable for new design. Nevertheless, they can still be used if there is no replacement specification.

According to SEA policy, it is no longer essential for a product to be manufactured in France to be approved to the French specification, either Norme AIR or DCSEA.

Interpretation of list

Where an asterisk* appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses of the official specification, but is the nearest product marketed by Shell.

For easy reference, obsolete specifications are shown in both the current and superseded specification columns. In the former case, a suitable comment is made, namely, "OBSOLETE - superseded by..."

French Specification	NATO Code	Product and Application	AeroShell Grade
AIR 1501 (Inactive)	C-614	Corrosion protective	-
AIR 1502 (Obsolete)	C-629 (Obsolete)	Corrosion protective	-
AIR 1503/B Type A	C-615	Piston engine storage oil	-
AIR 1503/B Type B Concentrate (Inactive)	C-608	Piston engine storage oil	AeroShell Fluid 2XN*
AIR 1503/B Type B (Inactive)	C-609	Piston engine storage oil	-
AIR 1504/B (Obsolete)	C-610	Turbine engine corrosion preventive – superseded by DCSEA 510/A	-
AIR 1506/B (Obsolete)	C-635	Preservative mineral hydraulic fluid of improved cleanliness - superseded by DCSEA 535/A	-
AIR 3401/1 Grade 80/87 (Obsolete)	F-12 (Obsolete)	Aviation gasoline - Grade 80/87 (Obsolete)	-
AIR 3401/1 Grade 100/130 (Obsolete)	F-18	Aviation gasoline - Grade 100/130 Low Lead - superseded by DCSEA 118/B	Shell Avgas 100LL
AIR 3401/1 Grade 115/145 (Obsolete)	F-22 (Obsolete)	Aviation gasoline - Grade 115/145 (Obsolete)	-
AIR 3404/C Grade F-43 (Obsolete)	F-43 (Obsolete)	Aviation turbine fuel - high flash type - superseded by DCSEA 144/A	-
AIR 3404/C Grade F-44 (Obsolete)	F-44	Aviation turbine fuel - high flash type with fuel system icing inhibitor - superseded by DCSEA 144/C	Shell JP-5
AIR 3405/D Grade F-34 (Obsolete)	F-34	Aviation turbine fuel - kerosine type with fuel system icing inhibitor - superseded by DCSEA 134/C	Shell JP-8
AIR 3405/D Grade F-35 (Obsolete)	F-35	Aviation turbine fuel - kerosine type - superseded by DCSEA 134/C	Shell Jet A-1 Shell AeroJet*
AIR 3407/B (Obsolete)	F-40	Aviation turbine fuel - wide cut type with fuel system icing inhibitor	-
AIR 3511/A	O-147	Low volatility aircraft instrument and general purpose oil	AeroShell Fluid 12
AIR 3512/A	O-138	Mineral turbine engine oil	-

French Specification	NATO Code	Product and Application	AeroShell Grade
AIR 3513 (Inactive) AIR 3514	- O-150	Both AIR 3513 and AIR 3514 are very specialised. French Specifications required for a limited number of domestic applications. AIR 3513 specified a 3 mm^2/s synthetic oil and was originally covered by NATO Code O-148. By 1970 AIR 3513 was superseded by AIR 3514. Various AeroShell synthetic turbine oils are approved by brand name for the majority of engines for which AIR 3514 is specified.	- -
AIR 3515/B	O-135	3 mm^2/s mineral turbine engine oil	AeroShell Turbine Oil 3*
AIR 3516/A	O-133	2 mm^2/s mineral turbine engine oil	AeroShell Turbine Oil 2*
AIR 3517/A	O-159	7.5 mm^2/s synthetic turbine engine oil	AeroShell Turbine Oil 750*
AIR 3520/B Grade H-515 (Obsolete)	H-515	Mineral hydraulic fluid of improved cleanliness - superseded by DCSEA 415/A	AeroShell Fluid 41*
AIR 3520/B Grade H-520 (Obsolete)	H-520 (Obsolete)	Mineral hydraulic fluid - superseded by DCSEA 415/A	AeroShell Fluid 41* AeroShell Fluid 4*
AIR 3525/B (Obsolete)	O-155	Extreme pressure oil for gearboxes - superseded by DCSEA 255/A	AeroShell Fluid 5M-A*
AIR 3560/D SAE Grade 30 (Obsolete)	O-113 (Obsolete)	Piston engine oil	AeroShell Oil 65*
AIR 3560/D SAE Grade 40 (Obsolete)	O-115 (Obsolete)	Piston engine oil	AeroShell Oil 80*
AIR 3560/D SAE Grade 50 (Obsolete)	O-117 (Obsolete)	Piston engine oil	AeroShell Oil 100*
AIR 3565/A	S-743	Soft film protective	-
AIR 3570 SAE Grade 40 (Obsolete)	O-123 (Obsolete)	Ashless dispersant piston engine oil	AeroShell Oil W80* AeroShell Oil W80 Plus*
AIR 3570 SAE Grade 50 (Obsolete)	O-125 (Obsolete)	Ashless dispersant piston engine oil	AeroShell Oil W100* AeroShell Oil W100 Plus*
AIR 3570 SAE Grade 60 (Obsolete)	O-128 (Obsolete)	Ashless dispersant piston engine oil	AeroShell Oil W120*
AIR 3634 (Obsolete)	C-634	Corrosion preventive compound, water displacing – superseded by DCSEA 534/A	-

French Specification	NATO Code	Product and Application	AeroShell Grade
AIR 3651/A (Methanol) (Inactive)	S-747	Methanol for use in methanol/water mixtures	-
AIR 3651/A (Water) (Inactive)	S-1739	Demineralised water	-
AIR 3651/A (60/40) (Inactive)	S-1741 (Obsolete)	Methanol/water mixture	-
AIR 3651/A (50/50) (Inactive)	S-1742 (Obsolete)	Methanol/water mixture	-
AIR 3651/A (44/56)	S-1744	Methanol/water mixture	-
AIR 3652/B Grade S-748 (Obsolete)	S-748 (Obsolete)	Fuel system icing inhibitor	-
AIR 3652/B Grade S-1745 (Obsolete)	S-1745	High flash fuel system icing inhibitor for aviation turbine fuel (di-ethylene glycol monomethyl ether) - superseded by DCSEA 745/A	-
AIR 3655 (Obsolete)	S-738	De-icing fluid – superseded by DCSEA 638/A	-
AIR 3660/A (Obsolete)	S-737	De-icing fluid – superseded by DCSEA 637/A	-
AIR 4205/B (Obsolete)	G-359	High temperature aircraft grease - superseded by DCSEA 359/A	AeroShell Grease 5*
AIR 4206/B (Obsolete)	G-355	Graphite grease - superseded by DCSEA 355/A	-
AIR 4207/A (Obsolete)	G-361	Synthetic wide temperature range grease - superseded by DCSEA 361/B	-
AIR 4210/B (Obsolete)	G-354	Synthetic grease - superseded by DCSEA 354/A	AeroShell Grease 7*
AIR 4214/B (Obsolete)	G-363	Gasoline and oil resistant grease - superseded by DCSEA 363/B	-
AIR 4215/B (Obsolete)	G-382	Aircraft general purpose grease - superseded by DCSEA 382/A	AeroShell Grease 6*
AIR 4217/A (Obsolete)	G-353	Molybdenum disulphide grease - superseded by DCSEA 353/A	-
AIR 4222 (Obsolete)	G-395	Synthetic general purpose grease - superseded by DCSEA 395/A	AeroShell Grease 22*
AIR 4223 (Obsolete)	S-740	Molybdenum disulphide powder – superseded by DCSEA 640/B	-

French Specification	NATO Code	Product and Application	AeroShell Grade
AIR 4224 (Obsolete)	S-732	Graphite powder, lubricating – superseded by DCSEA 632/B	-
AIR 4225/B (Obsolete)	G-350 (Obsolete)	Extreme pressure grease	-
AIR 4226 (Obsolete)	G-352 (Obsolete)	Aircraft grease. Specification obsolete, replaced by AIR 4210/B	-
AIR 4246 (Obsolete)	O-158 (Obsolete)	Lubricating oil, semi-fluid (-54°C to +130°C)	-
AIR 4247/A	S-720	Graphited anti-seize compound	-
AIR 8130 (Obsolete)	C-630	Corrosion preventive soluble oil	-
AIR 8132 (Obsolete)	C-620	Corrosion preventive	-
AIR 8136 (Obsolete)	C-627	Petroleum jelly/beeswax mixture for general preservation	-
DCSEA 118/C	F-18	Aviation gasoline, grade 100/130	Shell Avgas 100LL
DCSEA 134/E	F-34	Aviation turbine fuel with fuel system icing inhibitor	Shell JP-8
DCSEA 134/E	F-35	Aviation turbine fuel - kerosine type	Shell Jet A-1 Shell AeroJet*
DCSEA 144/D	F-44	Aviation turbine fuel, high flash point type, with fuel system icing inhibitor	Shell JP-5 (special arrangements necessary)
DCSEA 202/B (Obsolete)	-	White spirit	-
DCSEA 255/A	O-155	Extreme pressure oil for transmissions	AeroShell Fluid 5M-A*
DCSEA 262/A	XO-162 (SEA code)	Ashless dispersant piston engine oil 15W-50	AeroShell Oil W 15W-50
DCSEA 299/A	O-156	5mm²/s synthetic turbine engine oil	AeroShell Turbine Oil 500* AeroShell Turbine Oil 560* AeroShell Ascender*
DCSEA 300 (Obsolete)	G-403	All purpose grease	-
DCSEA 353/A (Obsolete)	G-353	Synthetic molybdenum disulphide grease	AeroShell Grease 64*
DCSEA 354/B	G-354	Synthetic grease for airframe and instruments	AeroShell Grease 33*
DCSEA 355/A	G-355	Graphited aircraft grease	-
DCSEA 359/A	G-359	Mineral Grease	AeroShell Grease 5*
DCSEA 361/B	G-361	Wide temperature range synthetic aircraft grease	-
DCSEA 363/B	G-363	Gasoline and oil resistant grease	-

French Specification	NATO Code	Product and Application	AeroShell Grade
DCSEA 382/A	G-382	Aircraft general purpose mineral grease	AeroShell Grease 6*
DCSEA 392/A (Obsolete)	G-392	Synthetic grease for pneumatic systems – superseded by SAE AMSG4343	-
DCSEA 395/C	G-395	Multipurpose synthetic aircraft grease	AeroShell Grease 22*
DCSEA 415/A	H-520 (Obsolete)	Mineral hydraulic fluid	AeroShell Fluid 4
DCSEA 415/A	H-515	Mineral hydraulic fluid	AeroShell Fluid 41
DCSEA 437/B	H-537	Synthetic hydrocarbon hydraulic fluid	AeroShell Fluid 31*
DCSEA 501/A	S-758	Lubricant, cleaner and preservative	-
DCSEA 502/A (Obsolete)	S-761	Multifunctional synthetic lubricant for weapons	-
DCSEA 510/B	C-610	Turbine engine corrosion preventive	-
DCSEA 534/B	C-634	Corrosion preventive compound, water displacing	-
DCSEA 535/A	C-635	Preservative mineral hydraulic fluid	-
DCSEA 632/B	S-732	Graphite powder, lubricating	-
DCSEA 637/A	S-737	De-icing fluid	-
DCSEA 638/A	S-738	De-icing fluid	-
DCSEA 640/B	S-740	Molybdenum disulphide powder	-
DCSEA 745/B	S-1745	Fuel system icing inhibitor, high flash point type	-
DCSEA 745/B	XS-1745 (SEA code)	Mixture of S-1745 with anti-corrosion additive	-

RUSSIAN AVIATION SPECIFICATIONS

Scope of list

This list is comprised of Russian Aviation Specifications which cover aviation engine oils,hydraulic fluids, greases and allied products. The list is composed of two parts, firstly a listing of specifications and then secondly a listing of grade names.

In Russia lubricants are governed by State Standards and are designated under a series of specifications including:

GOST: Gozudarstuyeny Standart
VTU-(BTY): Temporary Technical Conditions
TU-(TY): Technical Conditions
MRTU: Inter Republic Technical Conditions

Interpretation of list

In this list where a grade is shown in brackets it indicates that the grade is an industrial grade. Where an asterisk* appears in the list, the AeroShell grade recommended does not necessarily meet all the clauses/requirements of the Russian Specifications, but is the nearest product marketed by Shell.

Any grade marked with brackets or an asterisk has not necessarily been tested for suitability as a replacement. Shell Companies have not been able to test samples of Russian aviation lubricants using U.S. or British test methods nor have Shell Companies been able to test AeroShell grades in full scale hardware tests prescribed by the Russian Authorities.

For this reason Shell Companies make no representation as to the fitness or suitability of any AeroShell lubricant listed in this List. Responsibility for evaluation of an AeroShell Grade as a suitable alternative is that of the customer or operator. Although the information set forth herein is presented in good faith and believed to be correct at time publication Shell Companies make no representation as to the completeness or accuracy thereof.

This information is included in this publication upon the condition that the customer/operator using this information will make their own determination as to suitability for their purpose prior to use. In no event will Shell Companies be responsible for damages of any nature whatsoever resulting from the use or reliance upon the information. Nothing contained in this section is to be construed as a recommendation to use any product.

Specification GOST	Grade Name	AeroShell Grade	Remarks
782-59	Grease UN	-	Technical vaseline for protection of metal surfaces against corrosion
982-68	TK TKP	AeroShell Turbine Oil 3* AeroShell Turbine Oil 3*	Transformer oil Transformer oil with anti-oxidant additive
1012-72	Avgas 95/130	Shell Avgas 100 Shell Avgas 100LL	-
1013-49 (Superseded by 21743-76)	MS-14 MS-20 MK-22	AeroShell Oil 80 AeroShell Oil W80 AeroShell Oil 100 AeroShell Oil W100 -	Aircraft piston engine oils
1033-73	US-1 US-2	-	Medium melting point multi-purpose grease
1631-61 (Obsolete)	43843	-	High temperature grease for roller bearings
1642-50	Spindle Oil AV	-	Highly refined spindle oil
1805-76	MVP	-	Instrument oil
1957-72	UT (Constalin-1)	-	Calcium based multi-purpose grease
20734-75	7-50S-3	-	-
2712-75	AMS-1 AMS-3	-	Lubrication of mechanisms
2967-52	Grease AF-70	-	Instrument grease
3005-51	Gun grease	-	Corrosion protection of mechanisms
3276-74 (Obsolete)	GOI-54p	AeroShell Grease 6*	Lubricant and protective
3333-80	USsA	-	Graphite grease
4003-53	Hypoid Gear oil	-	Hypoid gear oil

Specification GOST	Grade Name	AeroShell Grade	Remarks
4216-55 (Obsolete, superseded by 18375-73)	OKB-122-3 OKB-122-4 OKB-122-5 OKB-122-14 OKB-122-16	- - - - -	A series of instrument oils
4366-76	Press Solidol S Solidol S	-	Multi-purpose, high melting point
5020-75	Steol-M	-	Synthetic hydraulic fluid
5546-66	HF-12-18	-	Refrigerator oil for Fron system in Mi-8 helicopter
5573-67 (Obsolete)	NK 50 (HK-50)	AeroShell Grease 5* AeroShell Grease 22	High temperature wheel bearing grease
6267-74	CIATIM 201	AeroShell Grease 22 AeroShell Grease 6*	Multi-purpose grease
6457-66	MK-8 MK-8P	AeroShell Turbine Oil 3 AeroShell Turbine Oil 2*	3 mm^2/s mineral turbine
6794-78	AMG-10	AeroShell Fluid 41	Mineral hydraulic fluid
7171-78	BU	-	Gasoline and oil resistant grease
7903-74	BM-4 (VM-4)	-	-
8313-88	-	-	Fuel anti-icing additive
8551-74	CIATIM 205	-	Anti-seize grease/compound
8773-73	CIATIM 203	AeroShell Grease 22 AeroShell Grease 6*	Grease for high load mechanisms
9320-60 (Superseded by 21743-76)	MS-20S	AeroShell Oil 100 AeroShell Oil W100	Aircraft piston engine oils
9433-80	CIATIM 221	AeroShell Grease 22	Multi-purpose engine grease
9762-61	Grease MS-70	-	-
10227-86	TS-1	Shell TS-1	Jet fuel
10328-63	MK-6	AeroShell Turbine Oil 2*	Mineral turbine oil

Specification GOST	Grade Name	AeroShell Grade	Remarks
10568-63	PVK Grease	-	Grease lubrication and corrosion protection
10817-64	VNII NP-44-2 VNII NP-44-2C	- -	Petroleum oils for turbo-prop applications
10877-64	K-17	-	Preservative grease
10957-64	Lubricant No. 6	-	-
11110-75	CIATIM 202	AeroShell Grease 22 AeroShell Grease 6*	Instrument and roller bearing grease
11122-66	VNII NP-25	-	Bearing and pivot lubricant
11552-65	MS-6	AeroShell Turbine Oil 2*	Mineral turbine oil
12030-66	VNII NP-223	-	Lubrication of roller bearings
12031-66	VNII NP-262	-	Lubrication of bearings of electric spindles
12245-66	VNII NP-7	AeroShell Turbine Oil 750*	Synthetic turbine oil
12308	T-8V, T-6	-	Military jet fuels
13076-86	VNII NP 50-1-4F	AeroShell Turbine Oil 390* AeroShell Turbine Oil 560*	Synthetic turbine oil
14068-79	VNII NP-232	-	Anti-seize compound
15171-70	AKOR-1	AeroShell Fluid 2XN*	Preservative additive
15866-70	PFMS-4	-	Organosilicone fluid
16422-70	CIATIM 208	-	Transmission grease
16564-71	RT	Shell Jet A-1	Jet aircraft fuel
16728-71	VNII NP-403	-	Hydraulic oil
18179-72	OKB-122-7	AeroShell Grease 33 AeroShell Grease 6*	General purpose grease
18375-74 (Replaces 4216-55)	OKB-122-3 (132-19) OKB-122-5 (132-08) OKB-122-14 (132-20) OKB-122-16 (132-21) OKB-122-4 (132-07)	- - - - -	Series of oils

Specification GOST	Grade Name	AeroShell Grade	Remarks
18852-73	VNII NP-246	-	High temperature grease
19537-74	PVK	-	Soft film protective
19774-74	VNII NP-207	AeroShell Grease 22	Multi-purpose grease
19782-74	VNII NP-225	-	Molybdenum disulphide grease
20734-75	7-50C-3	-	Silicone hydraulic fluid
21743-96	MS-14 MS-20 MS-20S MK-22 MS-20P	AeroShell Oil 80 AeroShell Oil W80 AeroShell Oil 100 AeroShell Oil W100 AeroShell Oil W 15W-50 AeroShell Oil 100 AeroShell Oil W100 - -	Aircraft piston engine oils
21791-76	MAS-8N MAS-14N MAS-30NK	- - -	Synthetic oils
23907-79	-	-	De-icing fluids
24300-80	LZ-31	-	Grease
24926-81	VNII NP-282	-	Grease

Specification TU	Grade Name	AeroShell Grade	Remarks
6-020-531-69	PFMS-4S	-	Specialised grease
6-02-917-79	PFMS-4S	-	Specialised grease
11-100-69	MD-BF	-	-
38-00180-75	IPM-10	AeroShell Turbine Oil 390*	Synthetic turbine oil. See also TU 38.1011299-90
38-001116-73	Grease No. 9	-	-
38-1-158-68	VNII NP-225	-	-
38-1-230-66 (Obsolete)	Grease OKB-122-7 Grease OKB-122-7-5 Grease OKB-122-8	AeroShell Grease 6* AeroShell Grease 22 AeroShell Grease 6*	Believed to be superseded by GOST 18179-72
38-101-295-75 (Obsolete) Supersedes 38-1-164-65 and 38-1-157-65)	36/1 36/1K B3-V	AeroShell Turbine Oil 390 AeroShell Turbine Oil 390 AeroShell Turbine Oil 500*	Synthetic turbine oils (see also TU 38.101384-78)
38-101-295-85	B3-V	AeroShell Turbine Oil 560 AeroShell Turbine Oil 500*	Synthetic turbine oils
38-101-297-78	VNII NP 235	AeroShell Grease 15*	High temperature grease
38-101-384-78	36/1Ku-A	AeroShell Turbine Oil 390 AeroShell Turbine Oil 560* AeroShell Turbine Oil 500*	Synthetic turbine oils
38-101-419-79 (Obsolete)	CIATIM 221S	-	Grease
38-101-722-85	MN-7.5U	AeroShell Turbine Oil 750	Synthetic turbine oil
38-101-740-80	NGJ-4	-	Phosphate ester hydraulic fluid
38-101-741-78	-	-	Fuel static dissipater additive
38-101-950-00	ERA (VNII NP 286M)	AeroShell Grease 33 AeroShell Grease 22* AeroShell Grease 6*	Multi-purpose grease

Specification TU	Grade Name	AeroShell Grade	Remarks
38-101-1181-88	MS-8RK	-	Mineral preservation oil for engines
38-101-1219-89	ST (NK-50)	AeroShell Grease 22	Grease
38-101-1243-89	CIATIM 221S	AeroShell Grease 22*	Grease
38-101-1299-06	IPM-10	AeroShell Turbine Oil 390*	Synthetic turbine engine oil
38-101-1332-90	TSgip	-	Heavily loaded gear oil
38-401-58-12-91	VNII NP 50-1-4U	AeroShell Turbine Oil 390 AeroShell Turbine Oil 560	Synthetic turbine engine oil
38-401-58-57-93	NGJ-5u	-	Phosphate ester hydraulic fluid
38-401-121-75 (Obsolete)	VNII NP 286M	AeroShell Grease 22 AeroShell Grease 6*	Grease
38-401-286-82	VNII-NP 50-1-4U	AeroShell Turbine Oil 390 AeroShell Turbine Oil 560	Synthetic turbine engine oil
38-401-337	PTS-225	-	Synthetic turbine engine oil
301-04-010-92	LZ-240	AeroShell Turbine Oil 560	Synthetic turbine engine oil

Specification OCT/CTY/VT	Grade Name	AeroShell Grade	Remarks
OCT 6-08-431-75	Grade C-1	-	Graphite powder
OCT 38-01145-80	I-13	-	Obsolete
OCT 38-01163-78	MS-8P	-	Mineral turbine engine oil
OCT 38-01180-80	CIATIM 221S CIATIM 221C	AeroShell Grease 22	Grease
OCT 38-01294-83	IPM-10	AeroShell Turbine Oil 390*	Synthetic turbine engine oil
OCT 38-1355-84	CT (HK-50) ST	AeroShell Grease 5* AeroShell Grease 22	Wheel bearing grease
OCT 95-510-77	Grease No.8	-	Anti-seize grease
CTY 36-13-719-61	PFMS-4S	-	-
VT UNP-18-58	CIATIM 221S	AeroShell Grease 22	Grease

Grade Name	Specification	AeroShell Grade
AF-70	Refer to "Grease AF-70"	-
AKOR-1	GOST 15171-70	AeroShell Fluid 2XN*
AMG-10	GOST 6794-78	AeroShell Fluid 41
AMS-1	GOST 2712-75	-
AMS-3	GOST 2712-75	-
AV	Refer to "Spindle Oil AV"	-
B3-V	TU 38-101-295-75 TU 38-101-295-85	AeroShell Turbine Oil 500* AeroShell Turbine Oil 560
BM-4 (VM-4)	GOST 7903-74	-
BU	Refer to 'Gasoline Proof Grease'	-
C-1	OCT 6-08-431-75	-
CIATIM 201	GOST 6267-74	AeroShell Grease 22 AeroShell Grease 6*
CIATIM 202	GOST 11110-75	AeroShell Grease 22* AeroShell Grease 6*
CIATIM 203	GOST 8773-73	AeroShell Grease 22 AeroShell Grease 6*
CIATIM 205	GOST 8551-74	-
CIATIM 208	GOST 16422-70	-
CIATIM 221	GOST 9433-80	AeroShell Grease 22
CIATIM 221S (221C)	TU 38-101-419-79 VT UNP-18-58 OCT 38-01180-80	-
CT (HK-50) or ST	OCT 38-1355-84	AeroShell Grease 5* AeroShell Grease 22
ERA (VNII NP 286M)	TU 38-101-950-83	AeroShell Grease 22 AeroShell Grease 6*
Gasoline Proof Grease	GOST 7171-78	-

Grade Name	Specification	AeroShell Grade
GOI-54p	GOST 3276-74	AeroShell Grease 6*
Grease No. 8	OCT 95-510-77	-
Grease No. 9	TU 38-001116-73	-
Grease AF-70	GOST 2967-52	-
Grease MS-70	GOST 9762-61	-
Grease UN	GOST 782-59	-
Gun Grease	GOST 3005-51	-
HF-12-18	GOST 5546-66	-
HK-50 (NK-50)	GOST 5573-67	AeroShell Grease 5* AeroShell Grease 22
Hypoid Gear Oil	GOST 4003-53	-
I-13	GOST 1631-61 OCT 38-01145-80	-
IPM-10	TU 38-00180-75 OCT-38-01294-83 TU 38-101-1299-90	AeroShell Turbine Oil 390* AeroShell Turbine Oil 390* AeroShell Turbine Oil 390*
K-17	GOST 10877-64	-
Lubricant No. 6	GOST 10957-64	-
LZ-31	GOST 24300-80	-
LZ-240	TU 38-401-579-86 301-04-010-92 301-04-015-91	AeroShell Turbine Oil 500* AeroShell Turbine Oil 560 AeroShell Turbine Oil 560
CT (HK-50)	OCT 38-1355-84	AeroShell Grease 5* AeroShell Grease 22
MD-BD	TU 11-100-69	-
MAS-8N	GOST 21791-76	-
MAS-14N	GOST 21791-76	-
MAS-30NK	GOST 21791-76	-

Grade Name	Specification	AeroShell Grade
MN 7.5U-(or MH 7.5u)	TU 38-101-722-85	AeroShell Turbine Oil 750
MK-6	GOST 10328-63	AeroShell Turbine Oil 2*
MK-8	GOST 6457-66	AeroShell Turbine Oil 3 AeroShell Turbine Oil 2*
MK-8P	GOST 6457-66	-
MK-22	GOST 1013-49 GOST 21743-76	-
MS-6	GOST 11552-65	AeroShell Turbine Oil 2*
MS-8	-	AeroShell Turbine Oil 3
MS-8P	OCT 38-01163-78	-
MS-8RK	TU 38-101-1181-88	-
MS-14	GOST 1013-49 GOST 21743-76	AeroShell Oil 80 AeroShell Oil W80 AeroShell Oil 80 AeroShell Oil W80
MS-20	GOST 1013-49 GOST 21743-76	AeroShell Oil 100 AeroShell Oil W100 AeroShell Oil 100 AeroShell Oil W100 AeroShell Oil W 15W-50
MS-20P	-	-
MS-20S	GOST 9320-60 GOST 21743-76	AeroShell Oil 100 AeroShell Oil W100 AeroShell Oil 100 AeroShell Oil W100
MS-70	Refer to 'Grease MS-70'	-

Grade Name	Specification	AeroShell Grade
MVP	GOST 1805-76	-
NGJ-4	TU 38-101-740-80	-
NGJ-5U	TU-38-401-811-90	-
OKB-122-3	GOST 4216-55 GOST 18375-73	-
OKB-122-4	GOST 4216-55 GOST 18375-73	-
OKB-122-5	GOST 4216-55 GOST 18375-73	-
OKB-122-7	GOST 18179-72 TU 38-1-230-66	AeroShell Grease 6*
OKB-122-7-5	TU 38-1-230-66	AeroShell Grease 22
OKB-122-8	TU 38-1-230-66	AeroShell Grease 6*
OKB-122-14	GOST 4216-55 GOST 18375-73	-
OKB-122-16	GOST 4216-55 GOST 18375-73	-
PFMS-4	GOST 15866-70	-
PFMS-4S	TU 6-020-531-69 TU 6-02-917-79 CTY 36-13-719-61	-
Press Solidol S	GOST 4366-76	-
PTS-225	TU 38-401337	-
PVK	GOST 10586-63 GOST 19537-74	-
RT	GOST 16564-71	Shell Jet A-1*
Solidol S	GOST 4366-76	-

Grade Name	Specification	AeroShell Grade
Spindle Oil AV	GOST 1642-50	-
T-6	GOST 12308	-
T-8V	GOST 12308	-
TK	GOST 982-68	AeroShell Turbine Oil 3*
TKP	GOST 982-68	AeroShell Turbine Oil 3*
TS-1	GOST 10277-86	Shell TS-1
UN	Refer to 'Grease UN'	-
US-1	GOST 1033-73	-
US-2	GOST 1033-73	-
USsA	GOST 3333-80	-
UT	GOST 1957-72	-
VM-4	Refer to 'BM-4'	-
VNII NP 7	GOST 12246-66	-
VNII NP 25	GOST 11122-65	-
VNII NP 44-2	GOST 10817-64	-
VNII NP 44-2-C	GOST 10817-64	-
VNII NP 50-1-4F	GOST 13076-67	AeroShell Turbine Oil 390 AeroShell Turbine Oil 560
VNII NP 50-1-4U	TU 38-401-286-82	AeroShell Turbine Oil 390 AeroShell Turbine Oil 560
VNII NP 207	GOST 19774-74	AeroShell Grease 22
VNII NP 223	GOST 12030-66	-
VNII NP 225	GOST 19782-74 TU 38-1-158-68	-
VNII NP 232	GOST 14068-79	-
VNII NP 235	TU 38-101-297-78	-
VNII NP 246	GOST 18852-73	-
VNII NP 262	GOST 12031-66	-

Grade Name	Specification	AeroShell Grade
VNII NP 282	GOST 24926-81	-
VNII NP 286M (ERA)	TU 38-401-121-75	AeroShell Grease 22 AeroShell Grease 6*
	TU 38-101-950-83	AeroShell Grease 22 AeroShell Grease 6*
VNII NP 403	GOST 16728-71	-
7-50C-3	GOST 20734-75	-
36/1	TU 38-101-295-75	AeroShell Turbine Oil 390
36/1K	TU 38-101-295-75	AeroShell Turbine Oil 390
36/1 KUA	TU-38-101-384-78	AeroShell Turbine Oil 390 AeroShell Turbine Oil 500* AeroShell Turbine Oil 560
132-07	GOST 18375-73	-
132-08	GOST 18375-73	-
132-19	GOST 18375-73	-
132-20	GOST 18375-73	-
132-21	GOST 18375-73	-

NOTES

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AEROSHELL PRODUCT SPECIFICATIONS

Scope of list

This list is comprised of all current AeroShell Grades, namely: aviation oils, fluids, greases and other Shell products used in aircraft, i.e. aviation fuels and specialised products.

Interpretation of list

For each AeroShell Grade listed the relevant U.S. and U.K. Specifications, NATO Code Number and Joint Service Designation are listed. Details of the product and application are also given and where appropriate comments are included.

Where an asterisk* appears in the list, it means that the AeroShell Grade is not necessarily fully approved to that specification but is the nearest product marketed by Shell.

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
AVIATION FUEL						
Shell Avgas 100	ASTM D910	DEF STAN 91-090	-	AVGAS 100	Fuel for aircraft piston engines Grade 100/130	-
Shell Avgas 100LL	ASTM D910	DEF STAN 91-090	F-18	AVGAS 100LL	Fuel for aircraft piston engines Grade 100/130 Low Lead	-
Shell JP-8	MIL-DTL-83133K Grade JP-8	DEF STAN 91-087	F-34	AVTUR/FSII	Aviation turbine fuel, kerosine type with FSII	Special arrangements necessary
Shell JP-8 +100	MIL-DTL-83133K Grade JP-8 +100	-	F-37	-	Aviation turbine fuel. JP-8 + thermal stability additive S-1749	Special arrangements necessary
Shell Jet A-1	MIL-DTL-83133K ASTM D1655	DEF STAN 91-091	F-35	AVTUR	Aviation turbine fuel kerosine type	-
Shell JP-5	MIL-DTL-5624W Grade JP-5	DEF STAN 91-086	F-44	AVCAT/FSII	Aviation turbine fuel, high flash kerosine type with FSII	Special arrangements necessary
Shell Jet A	ASTM D1655	-	-	-	Aviation turbine fuel, freeze point -40°C	Normally only available in the U.S.A.
Shell Jet B	ASTM D6615	-	-	-	Aviation turbine fuel, wide cut	Normally only available in Canada meeting CAN/CGSB 3.23
Shell AeroJet	ASTM D1655*	DEF STAN 91-091*	F-35*	-	Aviation turbine fuel, kerosene type with FSII	Special arrangements necessary

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
OTHER PRODUCTS						
Shell Water Detector	-	-	-	-	Method for detecting water in jet fuel	-

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
PISTON ENGINE OILS						
AeroShell Oil 65	SAE J1966 Grade 30	-	O-113 (Obsolete)	OM-107 (Obsolete)	Aircraft piston engine oil	Discontinued AeroShell Grade
AeroShell Oil 80	SAE J1966 Grade 40	SAE J1966 Grade 40	O-115 (Obsolete)	OM-170	Aircraft piston engine oil	-
AeroShell Oil 100	SAE J1966 Grade 50	SAE J1966 Grade 50	O-117 (Obsolete)	OM-270	Aircraft piston engine oil	-
AeroShell Oil 120	SAE J1966 Grade 60	-	-	OM-370 (Obsolete)	Aircraft piston engine oil	-
AeroShell Oil W80	SAE J1899 Grade 40	SAE J1899 Grade 40	O-123 (Obsolete)	OMD-160	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil W80 Plus	SAE J1899 Grade 40	-	-	-	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil W100	SAE J1899 Grade 50	SAE J1899 Grade 50	O-125 (Obsolete)	OMD-250	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil W100 Plus	SAE J1899 Grade 50	-	-	-	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil W120	SAE J1899 Grade 60	SAE J1899 Grade 60	O-128 (Obsolete)	OMD-370	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil W 15W-50	SAE J1899 Grade Multigrade	SAE J1899 Grade Multigrade	O-162 (Obsolete)	OMD-162	Ashless dispersant aircraft piston engine oil	-
AeroShell Oil Sport Plus 4	API SL*	-	-	-	Specific oil for light sport and microlight 4-stroke aircraft engines	Approved to ROTAX RON 424
AeroShell Oil Diesel Ultra	ACEA A3/B4* API SM/CF*	-	-	-	Specific oil for aircraft diesel engines	Approved to Mercedes Benz MB229.5

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
TURBINE ENGINE OILS						
AeroShell Turbine Oil 2	MIL-PRF-6081E Grade 1010 Grade 1010N	- -	O-133 -	OM-10 (Obsolete) -	Mineral aviation turbine oil 2 mm²/s viscosity	-
AeroShell Turbine Oil 3	-	DEF STAN 91-099	O-135	OM-11	Mineral aviation turbine oil 3 mm²/s viscosity	Acceptable substitute for AeroShell Fluid 1
AeroShell Turbine Oil 308	MIL-PRF-7808L Grade 3	-	O-148	OX-9	Synthetic ester aviation turbine oil 3 mm²/s viscosity	-
AeroShell Turbine Oil 390	-	DEF STAN 91-094	-	OX-7	Synthetic ester aviation turbine oil 3 mm²/s viscosity	-
AeroShell Turbine Oil 500	MIL-PRF-23699G Grade STD SAE AS5780D Grade SPC	DEF STAN 91-101 Grade OX-27	O-156	OX-27	Standard Grade, synthetic ester aviation turbine oil 5 mm²/s viscosity	-
AeroShell Turbine Oil 555	DOD-PRF-85734A	DEF STAN 91-100*	O-160	OX-26	Synthetic ester oil for helicopter transmissions. High load synthetic ester aviation turbine oil 5 mm²/s viscosity	-
AeroShell Turbine Oil 560	MIL-PRF-23699G Grade HTS SAE AS5780D Grade SPC	DEF STAN 91-101 Grade OX-27*	O-154	OX-27	High thermal stability synthetic ester aviation turbine oil 5 mm²/s viscosity	-
AeroShell Ascender	MIL-PRF-23699G Grade HTS SAE AS5780D Grade HPC	DEF STAN 91-101 Grade OX-27*	O-154	OX-27	High performance capability synthetic ester aviation turbine oil 5 mm²/s viscosity	-

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
TURBINE ENGINE OILS *(continued)*						
AeroShell Turbine Oil 750	-	DEF STAN 91-098	O-149	OX-38	Synthetic ester aviation turbine oil 7.5 mm²/s viscosity	-
GREASES						
AeroShell Grease 5	MIL-G-3545C* (Obsolete)	DTD.878A* (Obsolete)	G-359	XG-277 (Obsolete)	High temperature aircraft grease	Still available for civil market meeting obsolete U.S. and U.K. Specifications
AeroShell Grease 6	MIL-G-7711A* (Obsolete)	DEF STAN 91-012* (Obsolete)	G-382	XG-271 (Obsolete)	Aircraft general purpose grease	Still available for civil market meeting obsolete U.S. and U.K. Specifications
	MIL-PRF-24139A	DEF STAN 91-028* (Obsolete)	G-450 (Obsolete)	XG-274 (Obsolete)	Multi-purpose quiet service grease	Approved to U.S. Specification. Equivalent to U.K. Specification
AeroShell Grease 7	MIL-PRF-23827C (Type II)	-	-	-	Synthetic grease for aircraft	-
AeroShell Grease 14	MIL-G-25537C	DEF STAN 91-051	G-366	XG-284	Helicopter general purpose grease	-
AeroShell Grease 22	MIL-PRF-81322G DOD-G-24508A	DEF STAN 91-052* (Obsolete)	G-395	XG-293	Synthetic general purpose aircraft grease	-
AeroShell Grease 33	MIL-PRF-23827C (Type I) SAE AMS3052A	DEF STAN 91-053*	G-354	XG-287	General purpose airframe grease	Approved to Boeing Specification BMS 3-33C

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
GREASES *(continued)*						
AeroShell Grease 58	SAE AMS3058	-	-	-	Wide temperature range grease for aircraft wheel bearings	Approved to Airbus AIMS 09-06-003
AeroShell Grease 64	MIL-G-21164D	DEF STAN 91-057	G-353	-	Synthetic ester aircraft grease with molybdenum disulphide	Formerly branded as AeroShell Grease 33MS
HYDRAULIC FLUIDS						
AeroShell Fluid 4	MIL-H-5606A* (Obsolete)	DTD.585* (Obsolete)	-	-	Mineral hydraulic fluid	Discontinued AeroShell Grade
AeroShell Fluid 31	MIL-PRF-83282D	(MIL-PRF-83282D)	H-537	OX-19	Synthetic hydrocarbon fire resistant hydraulic fluid	-
AeroShell Fluid 41	MIL-PRF-5606J	DEF STAN 91-048 Grade Superclean	H-515	OM-15	Mineral hydraulic fluid of improved cleanliness	-
AeroShell Fluid 61	MIL-PRF-46170E Type I	-	H-544	-	Preservative synthetic hydrocarbon fire resistant hydraulic fluid	-
AeroShell LGF	-	-	-	-	Fluid based on MIL-PRF-5606 for use in landing gear shock struts	Approved to Boeing Specification BMS 3-32C Type II
OTHER FLUIDS						
AeroShell Fluid 3	MIL-PRF-7870E	DEF STAN 91-047 *(Obsolete)	O-142	OM-12 (Obsolete)	General purpose lubricating oil	-
AeroShell Fluid 5M-A	MIL-PRF-6086F Grade Medium	DEF STAN 91-112 Grade Medium	O-155	OEP-70	Extreme pressure gear oil of medium viscosity	Discontinued AeroShell Grade

AeroShell Grade	U.S Specification	British Specification	NATO Code	Joint Service Designation	Product and Application	Remarks
OTHER FLUIDS *(continued)*						
AeroShell Fluid 12	MIL-PRF-6085E	DEF STAN 91-049*	O-147	OX-14*	Low volatility aircraft instrument oil	Approved to U.S. Specification Equivalent to U.K. Specification
AeroShell Fluid 602	MIL-PRF-87252E	-	S-1748	-	Avionic cooling fluid	Discontinued AeroShell Grade
AeroShell Fluid S.8350	-	DTD.900/4981A* (Obsolete)	-	OEP-215	Helicopter gearbox oil	-
AeroShell Calibrating Fluid 2	MIL-PRF-7024F Type II	-	-	-	Special run Stoddard Solvent	-
AeroShell Compound 07	-	DTD.406B* (Obsolete)	S-745	AL-5	Glycol/alcohol mixture	-

PRESERVATIVES						
AeroShell Fluid 2XN	MIL-C-6529C Type I	(MIL-C-6529C Type I)	C-608	ZX-21 (Obsolete)	Concentrate for AeroShell Fluid 2F	Discontinued AeroShell Grade

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