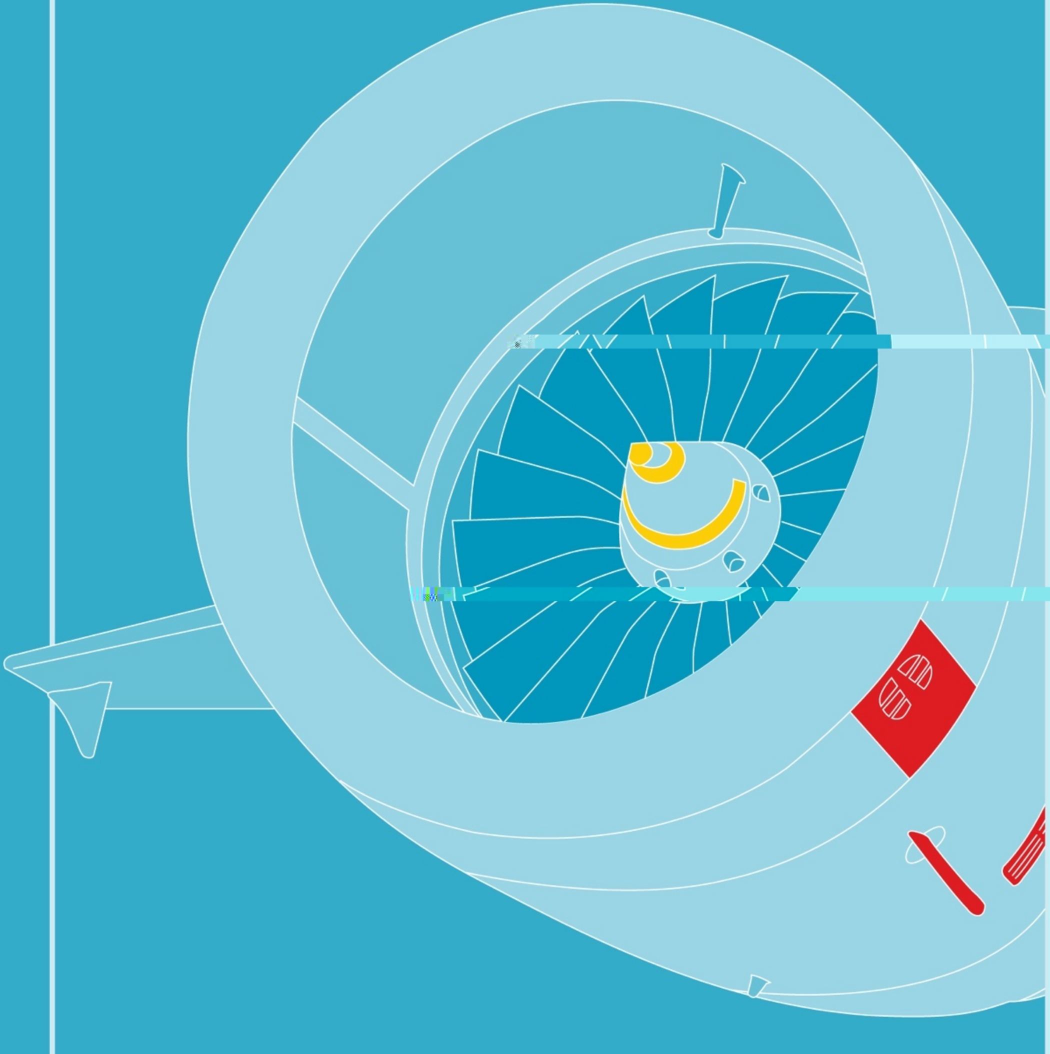
AEROSHELL TURBINE ENGINE OILS



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 @ 100°C (212°F) @ 40°C (104°F) @ –40°C (–40°F) @ –51°C (–60°F)	mm^2/s	 3.0 min 11.5 min – 17000 max	 3.1 12.0 2400 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 - bronze	 gm/m^2 gm/m^2	 + 4.5 max + 4.5 max	 0.01 0.05
Deposit test - deposit rating - neutralisation number change - viscosity change @ 40°C (104°F)	 % %	 1.5 max 20 max 100 max	 0.8 2.0 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

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 necessa lRD 2nm911laoac13.6 (a)-711ltocvnd (e)8 (r)ie(e)-5.4 (m)-2 4 (s)9.3 (e)-5.3 (of)4.3 ( )UT

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

PROPERTIES		DOD-PRF-85734A	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F) @ –40°C (–40°F)	mm^2/s	 4.90 to 5.40 23.0 min 13000 max	 5.2 26.5 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) SAE AMS3217/4 72 hrs @ 204°C (399°F)	 swell % swell %	 5 to 25 5 to 25	 14 14
Thermal stability/corrosivity (96 hrs) - metal weight change @ 274°C (525°F) - viscosity change - Total acid number change	 mg/cm^2 % mgKOH/g	 4.0 max 5.0 max 6.0 max	 Passes 1.4 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

PROPERTIES		MIL-PRF-23699G Grade HTS SAE AS5780D Grade SPC	TYPICAL
Oil type		Synthetic ester	Synthetic ester
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F) @ −40°C (−40°F)	mm^2/s	 4.90 to 5.40 23.0 min 13000 max	 5.21 26.7 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) LCS Fluorocarbon @ 200°C (392°F) Nitrile @ 130°C (266°F) Silicone @ 175°C (347°F) Perfluoroelastomer @ 200°C (392°F)		 10/15 max 10/20 max 19.5/22 max 16.5/16.0 max N/A	 Passes Passes Passes Passes Passes
Thermal stability/corrosivity 96 hrs @ 274°C (525°F) - metal weight change - viscosity change @ 37.8°C (100°F) - Total acid number change	 mg/cm^2 % mgKOH/g	 ± 4.0 max 5.0 max 6.0 max	 Passes 0.3 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 @ 100°C (212°F) @ 40°C (104°F) @ –40°C (–40°F)	mm^2/s	 4.90 to 5.40 23.0 min 13000 max	 5.02 25.77 < 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

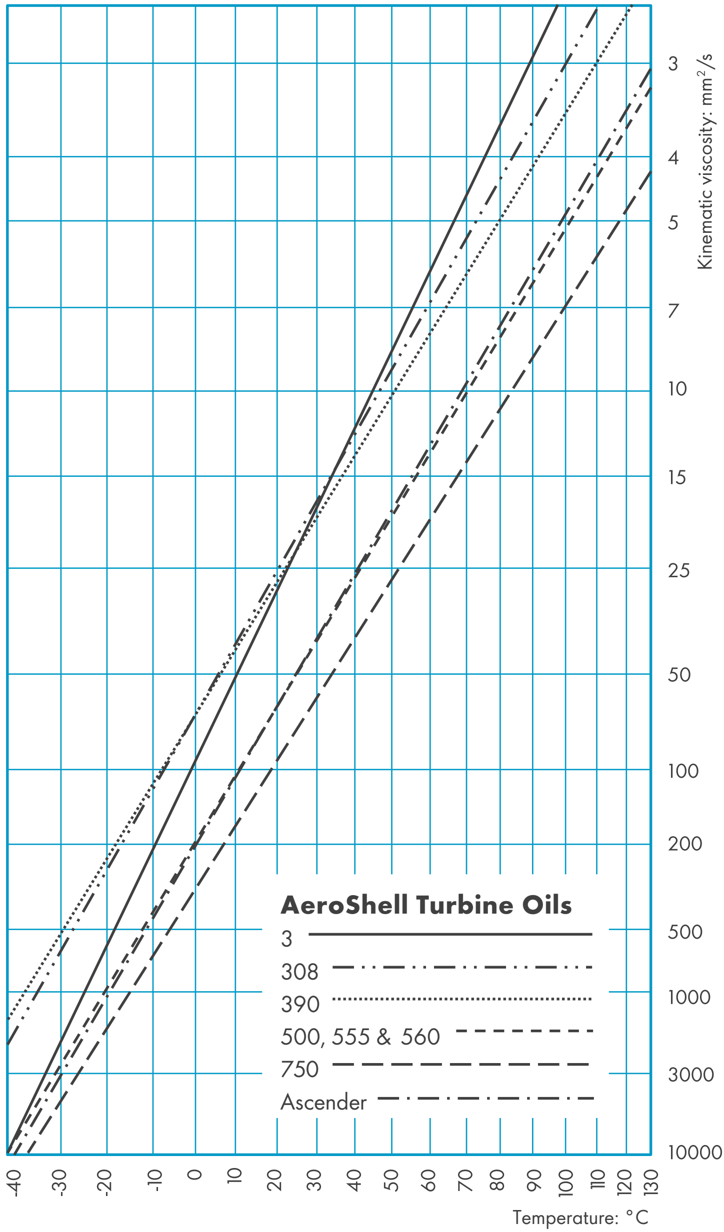
ENGINE MANUFACTURER	ENGINE MODEL	AEROSHELL TURBINE OIL 390	500	555	560	750	Ascender
General Electric	LM100, 150, 250 and 350		✓	✓	✓		
	LM2500		✓	✓	✓		
	LM5000		✓		✓		
	LM6000		✓		✓		
	LMS100		✓		✓		
Honeywell	TF-25, -35, -40		*		*		
Mitsubishi Power (formerly Turbo Power & Marine (P&W))	GG3 / FT3		✓		✓		
	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	✓				✓	

TYPICAL TEMPERATURE/VISCOSITY CURVES OF AEROSHELL TURBINE OILS



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