

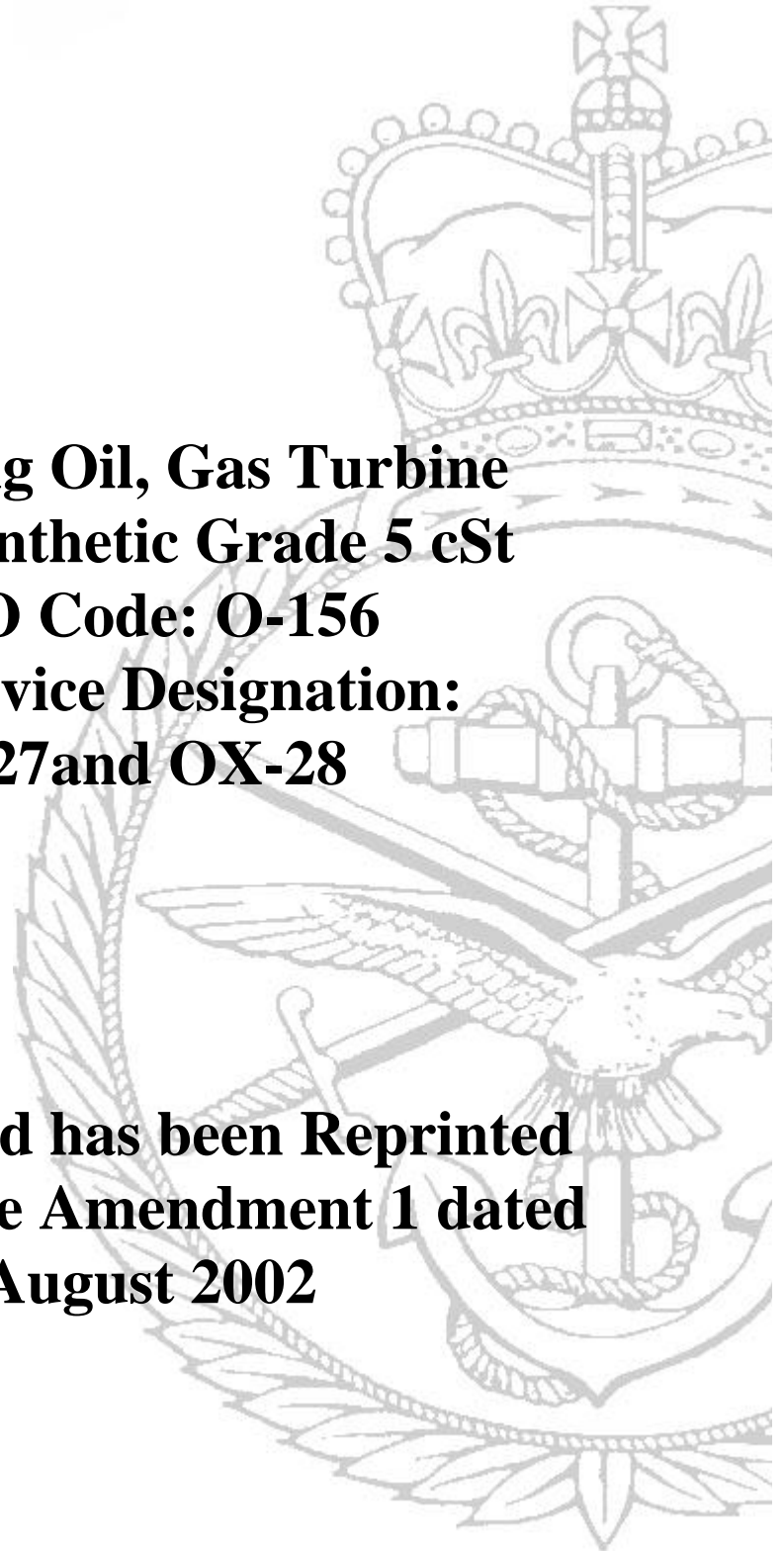


Ministry of Defence Defence Standard 91-101

Issue 3 Publication Date 31 August 2001

**Lubricating Oil, Gas Turbine
Engine, Synthetic Grade 5 cSt
NATO Code: O-156
Joint Service Designation:
OX-27and OX-28**

**This Standard has been Reprinted
to Incorporate Amendment 1 dated
30 August 2002**



AMENDMENT RECORD

Amd No	Date	Text Affected	Signature and Date
1	30/08/02	Test 14, Limits	

REVISION NOTE

This Defence Standard has been revised to incorporate Amendment 1 dated 30 August 2002.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 91-101 Issue 3 dated 31 August 2001
Def Stan 91-101 Issue 2 dated 31 December 1997
Def Stan 91-101 Issue 1 dated 7 October 1994
DERD 2499 Issue 1 dated November 1982

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PREFACE

LUBRICATING OIL, GAS TURBINE ENGINE, SYNTHETIC GRADE 5 cSt

NATO CODE: O-156

JOINT SERVICE DESIGNATION (JSD): OX-27 AND OX-28

- a.** This standard provides requirements for Gas Turbine Engine Lubricating Oil.
- b.** This standard has been produced on behalf of the Standardization Advisory Group (SAG) by the Joint Petroleum Products Subcommittee (JPPSC) (E10).
- c.** The Technical Authority for this Defence Standard is the Defence Fuels Group, Defence Petroleum Centre, Ministry of Defence.
- d.** This standard has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc. and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization (DStan) shall be informed so that a remedy may be sought.
- e.** Any enquiries regarding this standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.
- f.** Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.
- g.** This standard has been devised solely for the use of the Ministry of Defence (MOD) and its contractors in the execution of contracts for the MOD. To the extent permitted by law, the MOD hereby excludes all liability whatsoever and howsoever arising (including, but without limitation, liability resulting from negligence) for any loss or damage however caused when the standard is used for any other purpose.

TEXT

LUBRICATING OIL, GAS TURBINE ENGINE, SYNTHETIC GRADE 5 cSt

NATO CODE: O-156

JOINT SERVICE DESIGNATION (JSD): OX-27 AND OX-28

SECTION 1 GENERAL REQUIREMENTS

1 SCOPE

1.1 This Defence Standard specifies the requirements for two grades of synthetic lubricating oils. Those oils which meet the requirements for OX-27 are intended primarily for use in aircraft gas turbine engines and relevant ancillary equipment. Only those oils which also meet the requirements for OX-28 may be used in RN marine gas turbine engines.

1.2 Lubricating oil provided to this specification shall possess satisfactory performance and properties when used in appropriate vehicles and/or gas turbines and ancillary equipment operated by the Crown.

2 WARNING

The Ministry of Defence (MOD), like its contractors, is subject to both United Kingdom and European laws regarding Health and Safety at Work, without exemption. All Defence Standards either directly or indirectly invoke the use of processes and procedures that could be injurious to health if adequate precautions are not taken. Defence Standards or their use in no way absolves users from complying with statutory and legal requirements relating to Health and Safety at Work.

3 RELATED DOCUMENTS

3.1 The publications shown in Annex C are referred to in the text of this standard. Publications are grouped and listed in alpha numeric order.

3.2 Reference in this standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

3.3 In consideration of **3.2** above, users shall be fully aware of the issue and amendment status of all related documents, particularly when forming part of an invitation to tender or contract. Responsibility for the correct application of standards rests with users.

SECTION 1 GENERAL REQUIREMENTS

3.4 DStan can advise regarding where related documents are obtained from. Requests for such information can be made to the DStan Helpdesk. How to contact the helpdesk is shown on the outside rear cover of Def Stans.

4 MATERIALS

4.1 The lubricating oil shall consist of a stable homogeneous blend of synthetic base oil and suitable additives.

4.2 The Ministry of Defence reserves the right to require that the oil and any components used are subjected to toxicological and physiological tests to ascertain their suitability for use.

5 PRODUCT CONFORMITY CERTIFICATION

5.1 Product Conformity Certification (PCC) procedure applies to product supplied for MoD use against this standard.

5.2 Before any product can be considered as complying with this standard, the manufacturer must demonstrate to the Technical Authority that the product meets all the requirements of this standard including those of Annex A. At this time a declaration, in confidence, of the formulation including source and identification of all components, and place of manufacture is required. The Technical Authority will then assign a unique identification reference to this product, which becomes a Technically Acceptable Product. The Authority will maintain a list of Technically Acceptable Products in a Technically Acceptable Products List (TAPL).

5.3 Once accepted as a Technically Acceptable Product, no change to the product so referenced shall be made without prior notification to the Technical Authority. Only those products that are listed on the TAPL may be stated as complying with the requirements of this specification.

5.4 Before any changes are made to the product, the supplier shall notify the Technical Authority of the proposed changes. The supplier shall also certify that the performance of the product as defined by Table 1 has not been impaired by the changes. Evidence supporting this certification shall be provided to the Technical Authority and shall include the necessary OEM approvals (see Annex A). Once such certification and evidence has been received, the changed product will be assigned a new discrete identification reference number, and will be added to the TAPL.

5.5 When supplying products to the MoD, the supplier shall certify that:

5.5.1 The product delivered complies with the formulation declared under clause **5.2** or **5.4** of this specification.

5.5.2 Representative samples of the finished product comply with the requirements of tests 1 to 9 of Table 1. The Technical Authority reserves the right to require additional evidence that the product is compliant.

SECTION 1 GENERAL REQUIREMENTS

5.6 If any sample taken from the consignment is found not to comply with any of the requirements of this standard, the whole consignment may be rejected.

SECTION 2 TEST REQUIREMENTS

6 TESTING

6.1 Properties of the product shall not exceed the maximum nor be less than the minimum values set out in Table 1.

6.2 Methods quoted in the table are referee methods and shall be used in cases of dispute. Alternative technically equivalent methods may be used with the agreement of the responsible Technical Authority. Alternative methods that are jointed with the referee methods are identified in Annex C. Jointed methods may be used in lieu of the referee methods without restriction provided that their jointed status is in existence at the time of use.

6.3 IP 367, which covers the use of precision data, shall be used for the interpretation of test results.

SECTION 2 TEST REQUIREMENTS

Table 1 Test Requirements				
Test	Property	Units	Limits	Method
1	Appearance		Clear, bright and free from undissolved water, sediments and other impurities.	Visual examination
2	Density at 15°C	kg m ⁻³	Report	IP 365
3	Flash Point	°C	Min 246	IP 36
4	Pour Point	°C	Max Minus 54	IP 15
5	Total Acid Number (TAN)			SAE ARP 5088
5.1	Base Stock	mg KOH g ⁻¹	Max 0.1	
5.2	Fully Formulated Oil	mg KOH g ⁻¹	Report	
6	Viscosity, Kinematic			IP 71
6.1	at 100°C	mm ² s ⁻¹	Min 4.90 Max 5.40	
6.2	at 40°C	mm ² s ⁻¹	Max 30.00	
6.3	at Minus 40°C	mm ² s ⁻¹	Max 13000	
7	Foaming Characteristics Sequence I, II and III			IP 146
7.1	Tendency	ml	Max 25	
7.2	Stability	ml	Nil	

Table 1 Test Requirements				
Test	Property	Units	Limits	Method
8	Solid Particle contamination			FED-STD-791 Method 3010
8.1	Sediment	mg l ⁻¹	Max 10	
8.2	Total Ash of Sediment (See NOTE 1)	mg l ⁻¹	Max 1	
9	Trace Element Content			Atomic Emission Spectrometry (See NOTE 2)
	Aluminium	mg kg ⁻¹	Max 2	
	Iron	mg kg ⁻¹	Max 2	
	Chromium	mg kg ⁻¹	Max 2	
	Silver	mg kg ⁻¹	Max 1	
	Copper	mg kg ⁻¹	Max 1	
	Tin	mg kg ⁻¹	Max 4 (See NOTE 3)	
	Magnesium	mg kg ⁻¹	Max 2	
	Nickel	mg kg ⁻¹	Max 2	
	Titanium	mg kg ⁻¹	Max 2	
	Silicon	mg kg ⁻¹	Max 10	
	Lead	mg kg ⁻¹	Max 2	
	Molybdenum	mg kg ⁻¹	Max 3	
	Zinc	mg kg ⁻¹	Max 2	
10	Confined Heat Stability:			Def Stan 05-50 (Part 61) Method 1
10.1	S Temperature after 192 Hours (S ₃ ¹⁹²)	°C	Report	
10.2	Viscosity Stability at 100°C: viscosity decrease	%	Max 5.0	
11	Evaporation Ambient: Sea Level 6.5 hours at 204°C	% m/m	Max 10.0	ASTM D972

Table 1 Test Requirements				
Test	Property	Units	Limits	Method
12	Corrosiveness and Oxidation Stability			Annex B
12.1	175°C, 72 Hours: Viscosity Change TAN Change Sludge Content	% mg KOH g ⁻¹ mg/100 ml	Minus 5 to Plus 15 Max 2.0 Max 50	
	Metal Wt. Change			
	Steel	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Silver	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Aluminium	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Magnesium	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Copper	mg cm ⁻²	Minus 0.4 to Plus 0.4	
12.2	204°C, 72 Hours: Viscosity Change TAN Change Sludge Content	% mg KOH g ⁻¹ mg/100 ml	Minus 5 to Plus 25 Max 3.0 Max 50	
	Metal Wt. Change			
	Steel	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Silver	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Aluminium	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Magnesium	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Copper	mg cm ⁻²	Minus 0.4 to Plus 0.4	
12.3	218°C, 72 Hours: Viscosity Change TAN Change Sludge Content	% mg KOH g ⁻¹ mg/100 ml	Report Report Max 50	
	Metal Wt Change			
	Steel	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Silver	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Aluminium	mg cm ⁻²	Minus 0.2 to Plus 0.2	
	Titanium	mg cm ⁻²	Minus 0.2 to Plus 0.2	

Table 1 Test Requirements					
Test	Property	Units	Limits		Method
13	Coking Propensity Maximum tube temperature of 375°C and test duration of 20 hours.	mg	Report		SAE ARP 5996
14	Elastomer Compatibility		OX-27	OX-28	Def Stan 05-50 (Part 61) Method 22
14.1	Weight change (after 24 hours)				
	Nitrile	% mass	Report	9.0 to 16.0	
	Fluorocarbon	% mass	Report	3.5 to 7.5	
	LCS Fluorocarbon	% mass	Report	3.0 to 6.5	
	Silicone	% mass	Report	9.0 to 16.0	
14.2	Weight change (after 120 hours)				
	Nitrile	% mass	Report	9.0 to 17.0	
	Fluorocarbon	% mass	Report	4.5 to 9.0	
	LCS Fluorocarbon	% mass	Report	4.0 to 8.0	
	Silicone	% mass	Report	9.0 to 17.0	
14.3	Weight change (after 240 hours, See NOTE 4)				
	Fluorocarbon	% mass	Report	5.5 to 9.5	
	LCS Fluorocarbon	% mass	Report	5.0 to 9.0	
14.4	Embrittlement Procedure	Days	Report	Min 10	

Table 1 Test Requirements				
Test	Property	Units	Limits	Method
15	Miscibility and Compatibility (See NOTES 5 and 6)			Def Stan 05-50 (Part 61) Method 8
15.1	Miscibility at 205°C		There shall be no visible signs of separation, gelation or formation of insoluble matter	Procedure A
15.2	Miscibility at Minus 40°C		There shall be no visible signs of separation, gelation or formation of insoluble matter.	Procedure B
15.3	Compatibility, Increase in Toluene Insolubles (See NOTE 6)	% m/m	Max 0.05	Procedure C
16	Hydrolitic Stability $D^{90}_{1.5}$	Hours	Min 24	Def Stan 05-50 (Part 61) Method 6
17	Load Carrying Ability		Report	See NOTE 7
18	Viscosity Kinematic High Temperature 200°C	mm^2s^{-1}	Min 1.25	IP 71 See NOTE 8
19	Viscosity Stability. Change after 72 hours at Minus 40°C	%	Max 6	ASTM D2532
20	OEM Certification	N/A	OEM approval shall be obtained for unrestricted use in all relevant systems	See Annex A
<p>NOTE 1 If the total sediment does not exceed 1 mg/1, the ash content requirement shall be waived.</p> <p>NOTE 2 The trace metal content of the lubricant shall be determined with an atomic emission spectrometer. Appropriate spectrometric calibration standards, covering the concentration ranges of interest, shall be used.</p>				

NOTE 3 When testing is performed by a facility in the US Department of Defence Joint Oil Analysis Program, Pensacola, FL, USA, the limit for Tin is 11 mg/kg. For other spectrometers and test methods, the limit for tin is 4 mg/kg.

NOTE 4 When testing lubricants for compliance with the requirements of OX-28, the weight gain determination procedure described in Def Stan 05-50(Part 61) method 22, shall be extended for a further 120 hours to a total of 240 hours, for the fluorocarbon and LCS fluorocarbon O-rings only. Weight determinations shall therefore be made at 24, 120 and 240 hours. This extension does not affect the embrittlement procedure which shall be conducted on one of the O-rings of each type of elastomer as described in Def Stan 05-50(Part 61) method 22, throughout this extended period.

NOTE 5 Miscibility and compatibility is to be shown for all oils complying with the requirements of this standard, Def Stan 91-100 and 91-98. Additionally, for oils which are assigned the joint service designation (JSD)OX-28, miscibility and compatibility is also to be shown with all oils complying with the requirements of Def Stan 91-93.

NOTE 6 The test temperature shall be 205°C for demonstrating compatibility with oils to this standard and Def Stan 91-93; 210°C for Def Stan 91-100 and 170°C for Def Stan 91-98.

NOTE 7 This Test Method is under review. Until further notice the test to be applied will be IP 166 Condition A and C with the procedures modified as follows:

1. Test oil temperature of 110°C for both conditions.
2. All four tests shall first be run on Reference oil RDE/O/623 and the reverse faces of the four gears used to determine the failure modes. Neither oil shall be changed for the other during the sequence of four tests with different gears.
3. All eight gears used (Condition A and C) shall be from the same batch of gears.
4. The test report shall identify each pair of results comprising the means of the initial and complete failure loads obtained for the reference oil and test oil on opposite faces of the same gear.
5. Calculate individual relative failure loads by expressing, for each paired result, the test oil results as a percentage of the reference oil results.

Alternatively, with the agreement of the Technical Sponsor, the Aviation Lubricant Tribology Evaluator (ALTE), SAE AIR 4978, may be used.

NOTE 8 As an alternative to determining the viscosity at 200°C by IP 71, the value may be estimated by extrapolation from viscosity determinations at 40°C and 100°C.

7 KEEPING QUALITIES

The product, when suitably stored in its original sealed containers shall retain the properties described in this Standard for a period of not less than 12 months in temperate climates and not less than six months in tropical climates, from the date defined in the contract.

8 CONTAINERS AND MARKING OF CONTAINERS

8.1 The product shall be supplied in sound, clean and dry containers, suitable for the product and in accordance with the requirements of the contract or order.

8.2 Coatings and paint finishes shall comply with the requirements for the contract or order. Markings shall be in accordance with the requirements of Def Stan 05-52 (Part 1). The product identification shall be as specified in the contract or order.

8.3 It shall be the responsibility of the contractor to comply with any legal requirements for the marking of containers.

ANNEX A

**ORIGINAL EQUIPMENT MANUFACTURER (OEM) APPROVAL OF THE
PRODUCT**

A.1 PRODUCTS ASSIGNED JSD OX-27

A.1.1 The products defined by this specification shall be approved by the appropriate OEMs for use in certain aircraft systems operated by the MoD. Details of the OEMs and the systems for which approval must be sought may be obtained from the address below.

AFTM
Defence Fuels Group
Defence Petroleum Centre
West Moors
Wimborne
Dorset
BH21 6QS

A.2 PRODUCTS ASSIGNED JSD OX-28

A.2.1 In addition to the requirements of clause **A.1**, for a product to be technically acceptable as an OX-28 the product shall also be approved by the appropriate OEMs for use in certain marine engines operated by the MoD. Details of the OEMs and the systems for which approval must be sought may be obtained from the address below.

Warship Support Agency
MPS 216
Foxhill
Bath
BA1 5AB

ANNEX B

CORROSIVENESS AND OXIDATION STABILITY

B.1 The corrosion and oxidation stability test shall be performed in accordance with FED-STD-791, method 5308, "Corrosiveness and Oxidation Stability of Light Oils (Metal Squares)," with the following modifications:

B.1.1 Three separate tests, each conducted for 72 hours, shall be conducted with bath temperatures of $(175 \pm 2.5) ^\circ\text{C}$, $(204 \pm 2.5) ^\circ\text{C}$ and $(218 \pm 2.5) ^\circ\text{C}$.

B.1.2 A liquid-medium or fluidised sand bath heating apparatus may be used in place of an aluminium block heater.

B.1.3 An electrolytic-grade, silver test square shall be substituted for the cadmium plated steel test square in the 218°C test. In place of copper and magnesium substitute titanium conforming to MIL-T-9046, type 1, composition C. Stainless steel or nickel-chrome wire may be used to tie the metal coupons together at all test conditions. The weight loss for titanium shall be reported as the average of the two squares. The condenser water temperature shall be maintained at $(18 \pm 2.5) ^\circ\text{C}$.

B.1.4 The total acid number shall be determined in accordance with SAE ARP 5088.

B.2 The post-test sludge content shall be determined as follows:

B.2.1 Decant oil from the test tube through a pre-weighed 10.0 micron polytetrafluoroethylene (Teflon) filter (Militec LCWP 047-00 or equivalent) and measure filtrate volume.

B.2.2 Set filtrate aside for viscosity and acid number tests.

B.2.3 Remove all sludge from the test equipment with a rubber policeman, wash the equipment and filtered sludge with petroleum ether, oven dry the sludge sample, weigh and calculate the sludge weight per 100 ml of oil.

B.2.4 Do not add the petroleum ether washings to the oil filtrate used for viscosity and acid number. Petroleum ether with a boiling range of 30 to 60°C , n-heptane shall be used in place of 1,1,1-trichloroethane (O-T-620).

ANNEX C

RELATED DOCUMENTS

Designation	Title
IP 15 (ASTM D97, ISO 3016, BS2000:Part 15)	Determination of Pour Point
IP 36 Method (ASTM D92)	Determination of Open Flash and Fire Point – Cleveland
IP 71 (ASTM D445, ISO 3104 BS2000:Part 71)	Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
IP 146 (ASTM D892, BS2000: Part 146)	Determination of Foaming Characteristics of Lubricating Oils
IP 166	Determination of Load-Carrying Capacity of Lubricants – IAE Gear Machine Method.
IP 365 (ISO 12185, BS2000: Part 365)	Determination of Density – Oscillating U-Tube Method.
IP 367 (BS2000:Part 367 BS EN ISO 4259)	Method for Determination and Application of Precision Data in Relation to Methods of Test for Petroleum products.
ASTM D972	Evaporation Loss of Lubricating Greases and Oils.
Def Stan 05-50 (Part 61)	Methods for Testing Fuels, Lubricants, and Associated Products.
Method 1:	Methods for Testing Gas Turbine Engine Synthetic Lubricants.
Method 6:	Confined Heating Stability.
Method 8	Hydrolytic Stability.
Method 22	Miscibility and Compatibility.
	Assessment of the Compatibility of Gas Turbine Lubricants with Elastomers
Def Stan 05-52 (Part 1)	Markings for the Identification of Fuels, Lubricants and Associated Products: Containers Holding 210 Litres or Less.
Def Stan 91-93	Lubricating Oil, Gas Turbine Engine, Synthetic Grade 4.5 cSt, Corrosion Inhibited, Maritime Ambient, Joint Service Designation:OX-22
Def Stan 91-98	Lubricating Oil, Gas Turbine Engine, Synthetic Grade 7.5 cSt NATO Code O-149. Joint Service Designation OX-38.
Def Stan 91-100	Lubricating Oil, Gas Turbine Engine, Synthetic Grade 5 cSt. NATO Code O-160. Joint Service Designation: OX-26.
ASTM D2532	Standard Test Method for Viscosity and Viscosity Change after Standing at Low Temperature of Aircraft Turbine Lubricants
FED-STD-791 No 3010	Solid Particle Contamination in Aircraft Turbine Engine

DEF STAN 91-101/3

	Lubricants (Gravimetric Procedure)
FED-STD-791-No 5308	Corrosiveness and Oxidation Stability of Light Oils (Metal Squares)
SAE AIR 4978	Temporary Methods for Assessing the Load Carrying Capacity of Aircraft Propulsion Systems.
SAE ARP 5088	Test Method for the Determination of Total Acidity in Polyol Ester and Diester Gas Turbine Lubricants by Automatic Potentiometric Titration
SAE ARP 5996	Evaluation of Coking Propensity of Aviation Lubricants by the Hot Liquid Process Simulator (HLPS) Single Phase Flow Technique.

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GLASGOW G2 8EX

DStan Helpdesk

Tel 0141 224 2531/2
Fax 0141 224 2503
Internet e-mail enquiries@dstan.mod.uk

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Contract Requirements

When Defence Standards are incorporated into contracts users are responsible for their correct application and for complying with contractual and statutory requirements. Compliance with a Defence Standard does not in itself confer immunity from legal obligations.

Revision of Defence Standards

Defence Standards are revised as necessary by up issue or amendment. It is important that users of Defence Standards should ascertain that they are in possession of the latest issue or amendment. Information on all Defence Standards is contained in Def Stan 00-00 Standards for Defence Part 3 , Index of Standards for Defence Procurement Section 4 'Index of Defence Standards and Defence Specifications' published annually and supplemented regularly by Standards in Defence News (SID News). Any person who, when making use of a Defence Standard encounters an inaccuracy or ambiguity is requested to notify the Directorate of Standardization (DStan) without delay in order that the matter may be investigated and appropriate action taken.