

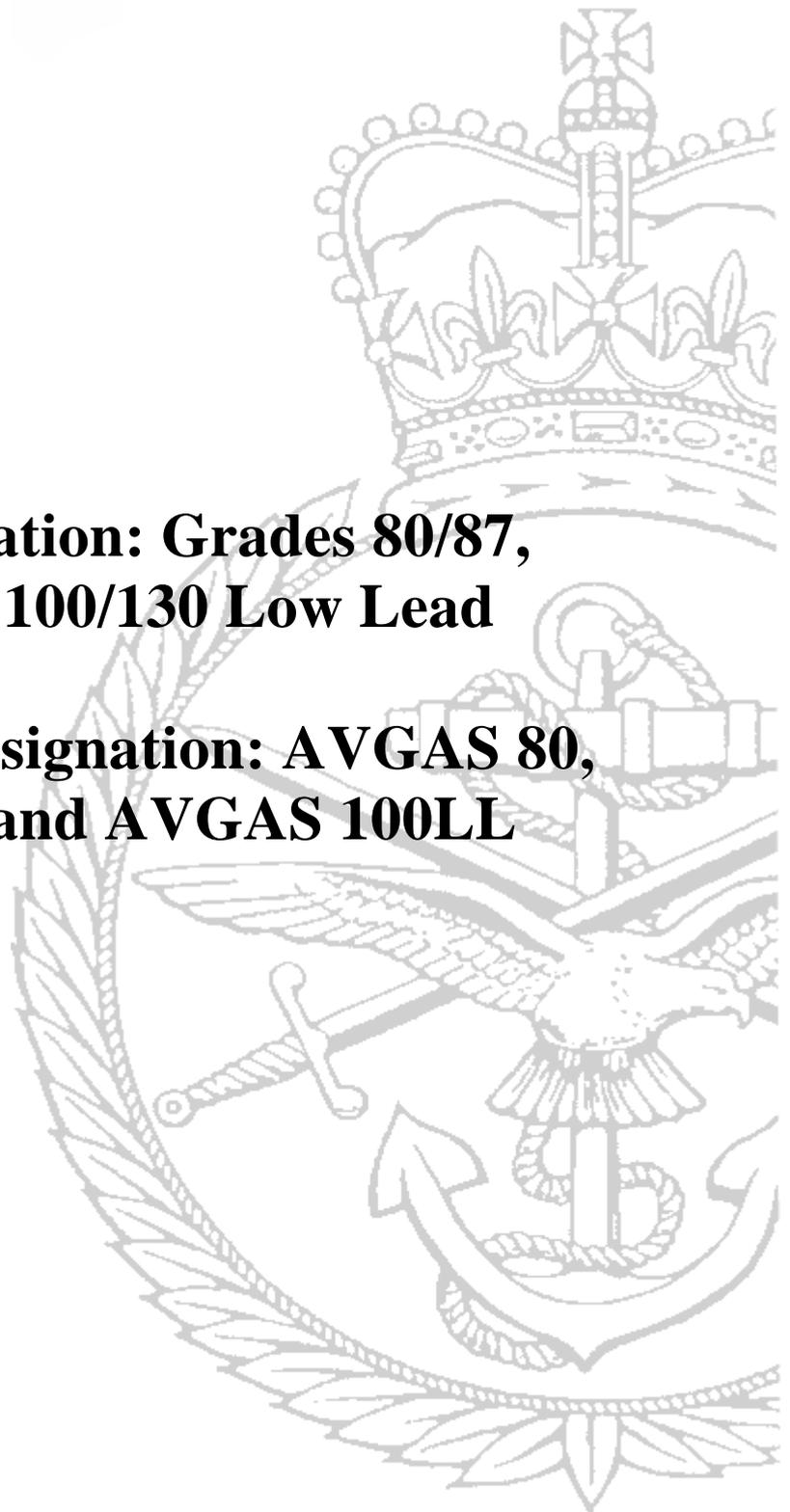


# Ministry of Defence Defence Standard 91-90

Issue 2 Publication Date 31 March 2006

**Gasoline, Aviation: Grades 80/87,  
100/130 and 100/130 Low Lead**

**Joint Service Designation: AVGAS 80,  
AVGAS 100 and AVGAS 100LL**



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## Foreword

### AMENDMENT RECORD

Amd No	Date	Text Affected	Signature and Date

### REVISION NOTE

This standard has been raised to Issue 2 to bring the test methods and tests into line with up to date requirements.

### HISTORICAL RECORD

This standard supersedes the following:

Def Stan 91-90 Issue 1 dated 8 May 1996

DERD 2485 Issue 9 dated June 1983

- a) This standard provides requirements for Aviation gasoline intended primarily for use in aircraft spark ignition reciprocating engines and supersedes Def Stan 91-90 Issue 1.
- b) This standard has been produced on behalf of the Defence Material Standardization Committee (DMSC) by the UK Aviation Fuels Committee (AFC).
- c) 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 UK Defence Standardization (DStan) shall be informed so that a remedy may be sought.
- d) 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.
- e) Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.
- f) 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.

## **Introduction**

Defence Standard 91-90 is the standard for aviation gasoline intended primarily for use in aircraft spark ignition reciprocating engines, which the United Kingdom Civil Aviation Authority (CAA) has agreed is under the technical authority of the Director Defence Fuels Group.

NOTE: the Technical/Specification Authority is the Director Defence Fuels Group, Defence Petroleum Centre, West Moors, Wimborne, Dorset, BH21 6QS, United Kingdom.

# Standards for Defence - Gasoline, Aviation, Grades 80/87, 100/130 and 100/130 Low Lead. JSD: AVGAS 80, AVGAS 100 and AVGAS 100LL

## 1 Scope

This Defence Standard specifies the requirements for three grades (AVGAS 80, AVGAS 100 and AVGAS 100LL) of gasoline type aviation fuel intended primarily for use in aircraft spark ignition reciprocating engines. Fuel provided to this specification shall possess satisfactory performance and properties when used in appropriate aircraft or engines operated by the Crown, or for which the CAA is the certificating agency.

## 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 Normative References

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

**3.2** Reference in this standard to any normative reference 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 normative references, particularly when forming part of an invitation to tender or contract. Responsibility for the correct application of standards rests with users.

**3.4** DStan can advise regarding where normative references are obtainable. Requests for such information can be made to the DStan Helpdesk. How to contact the helpdesk is shown on the outside rear cover of Defence Standards.

## 4 Materials

**4.1** The fuel shall consist wholly of hydrocarbon compounds and approved additives only as listed in **Annex A**. Only additives and non-petroleum fuel components approved by and on behalf of the UK AFC shall be permitted.

**4.2** Additives shall be identified by the appropriate RDE/A/XXX number or by name as shown in **Annex A**. The amount, including NIL additions, of all additive additions shall be reported to the purchaser on batch quality certificates or as otherwise directed by the purchaser and/or contract.

**4.3** The Ministry of Defence and/or its appointed agent(s) reserves the right to require that the material and any components used are subject to toxicological and physiological tests to ascertain their suitability for use.

## 5 Quality Assurance

**5.1** Representative samples of each batch of the finished product shall be tested to show batch homogeneity and compliance with the requirements of **clause 4** and **Table 1** of this standard. Results shall be reported on the appropriate batch certificate to show compliance with all requirements of the standard. A batch of fuel is defined as a distinct quantity of jet fuel that can be characterised by one set of test results including types of additives and quantities added. Documentation shall be available on request for the Technical Authority, purchaser or end user to show that the fuel meets the requirements of this standard and show traceability to point of manufacture.

**5.2** The Technical Authority, purchaser or end user reserves the right to require additional testing of the product at any time and to sample and test the product and/or ingredients at any time during or after manufacture.

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

**5.4** Materials used in refinery processing might be carried over in trace quantities into aviation fuels and have been known to cause operational problems in aircraft fuel systems. Appropriate management of change measures should be used at manufacturing locations to manage the risk of this type of contamination in aviation fuels. (see **A.7**).

## 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** when tested by the methods referred to therein or **Annex B**.

NOTE: The IP 367 procedure, which covers the use of precision data, may be used for the interpretation of test results in cases of dispute between purchaser and supplier.

**6.2** Methods quoted in **Table 1** are referee methods. In cases of dispute the referee methods shall be used. Approved alternative methods are listed in **Annex B**.

## 7 Containers and Marking of Containers

**7.1** 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.

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

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

**Table 1 - Test Requirements**

Test	Property	Units	Limits			Method
			Grade 80	Grade 100	Grade 100LL	
1	Appearance		Clear, bright and visually free from solid matter and undissolved water at ambient temperature			Visual Examination
2	Colour, visual (see NOTE 1)		Red	Green	Blue	
3	Corrosion Copper Strip		Max 1			IP 154/ ASTM D 130
4	Density at 15°C	kg/m <sup>3</sup>	Report			IP 365/ ASTM D4052
5	Total Sulfur	% m/m	Max 0.05			IP 107/ ASTM D1266
6	Existent Gum	mg/100 ml	Max 3.0			IP 131/ ASTM D381
7	Freezing Point	°C	Max minus 58.0			IP 16/ ASTM D2386 (see NOTE 2)
8	Specific Energy	MJ/kg	Min 43.50			IP 12
9	Reid Vapour Pressure at 37.8°C	kPa	Min 38.0 Max 49.0			IP 69/ ATSM D323
10	Knock Rating:					
10.1	Lean Mixture Motor Method Octane Number		Min 80.0	Min 99.5	Min 99.5	IP 236/ ASTM D2700 (see NOTE 3)
10.2	Rich Mixture Octane Number		Min 87.0	-	-	IP 119/ ASTM D 909 (see NOTE 3)
10.3	Performance Number		-	Min 130	Min 130	IP 119/ ASTM D 909 (see NOTE 3)

Continued on page 4

**Table 1: Test Requirements (continued)**

Test	Property	Units	Limits			Method
			Grade 80	Grade 100	Grade 100LL	
11	Distillation:					IP 123/ ASTM D 86 Group 2
11.1	Initial Boiling Point	°C	Report			
11.2	Temperature at % fuel evaporated					
11.2.1	10 vol %	°C	Max 75.0			
11.2.2	40 vol %	°C	Min 75.0			
11.2.3	50 vol %	°C	Max 105.0			
11.2.4	90 vol %	°C	Max 135.0			
11.3	Final Boiling Point	°C	Max 170.0			
11.4	Sum of 10% and 50% Evaporated Temperatures	°C	Min 135.0			
11.5	Residue	% v/v	Max 1.5			
11.6	Loss	% v/v	Max 1.5			
12	Oxidation Stability, 16 hours:					IP 138/ ASTM D 873
12.1	Potential Gum	mg/100ml	Max 6			
12.2	Precipitate	mg/100ml	Max 2			
13	Tetraethyl Lead Content	gPb/l	Max 0.14	Max 0.85	Max 0.56	IP 270
14	Water Reaction					IP 289/ ASTM D 1094
14.1	Volume Change	ml	Max 2			

Continued on page 5

**Table 1: Test Requirements (concluded)**

Test	Property	Units	Limits			Method
			Grade 80	Grade 100	Grade 100LL	
15	Electrical Conductivity	pS/m	See NOTE 4			IP 274/ ASTM D 2624
16	Colour, Lovibond					IP 17 (see NOTE 5)
16.1	Blue		- -	Min 1.7 Max 3.5	Min 1.7 Max 3.5	
16.2	Yellow		- -	Min 1.5 Max 2.7	- -	
16.3	Red		Min 6.7 Max 9.1	- -	- -	
NOTE 1: The visual colour must also comply with test 16 of this table.						
NOTE 2: If no crystals appear when the thermometer indicates a temperature of -58°C, the freezing point shall be recorded as below -58°C.						
NOTE 3: Knock rating shall be reported to the nearest 0.1 for Octane Number and nearest whole number for Performance Number.						
NOTE 4: When a Static Dissipator Additive has been added to the fuel the conductivity at the point, time and temperature of delivery to the purchaser shall be in the range 50 to 600 pS/m.						
NOTE 5: Use test method IP 17 (Method A) using a 50.8 mm cell.						

## Annex A

### List of Qualified Additives

#### A.1 Antioxidants

**A.1.1** Antioxidants or mixtures of antioxidants, of a type detailed in **A.1.2** and at a concentration detailed in **A.1.3**, may be added to the fuel.

**A.1.2** The following antioxidant formulations are qualified:

<u>Formulation</u>	<u>Qualification Reference</u>
(a) 2,6-ditertiary-butyl-phenol	RDE/A/606
(b) 2,6 ditertiary-butyl-4-methyl-phenol	RDE/A/607
(c) 2,4-dimethyl-6-tertiary-butyl-phenol	RDE/A/608
(d) 75 percent minimum, 2,6-ditertiary-butyl-phenol 25 percent maximum, tertiary and tritertiary-butyl-phenols	RDE/A/609
(e) 55 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 15 percent minimum, 4 methyl-2,6-ditertiary-butyl-phenol Remainder, 30 percent maximum, as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols	RDE/A/610
(f) 72 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 28 percent maximum, mixture of tertiary-butyl-methyl-phenols and tertiary-butyl dimethyl phenols	RDE/A/611

**A.1.3** The total concentration of active material(s) shall not exceed 24.0 mg/l.

#### A.2 Antiknock Additive

**A.2.1** Tetraethyl lead shall be present and added in the form of an antiknock mixture containing not less than 61% mass of tetraethyl lead and sufficient ethylene dibromide to provide two atoms of bromine per atom of lead. The balance shall contain no added ingredient other than kerosene, an approved oxidation inhibitor and blue dye as specified in clause **A.3**. The maximum lead concentration limit for each grade is specified in **Table 1**.

#### A.3 Dye (Grade Identification)

**A.3.1** The following dye shall be used, within the concentration limits prescribed in **Table 2**, to give the finished fuel the appropriate grade identification colour:

- (a) Blue      essentially 1,4 dialkylamino-anthraquinone
- (b) Yellow    essentially diethylaminoazobenzene or 1,3-benzenediol 2,4-bis [alkyl (phenol) azo-]
- (c) Red        essentially alkyl derivatives of azobenzene-4-azo-2-naphthol.

**Table 2 - Dye Requirements**

Dye	Maximum Concentration (mg/l)		
	Grade 80	Grade 100	Grade 100LL
Blue	0.2	2.7	2.7
Yellow	None	2.8	None
Red	2.3	None	None

**A.4 Static Dissipator Additive (SDA)**

**A.4.1** An SDA of a type detailed in **A.4.2** and at a concentration detailed in **A.4.3** may be added to the fuel to impart electrical conductivity in accordance with test 15 of **Table 1**.

**A.4.2** The following material is qualified:

<u>Product</u>	<u>Manufacturer</u>	<u>Qualification Reference</u>
Stadis® 450	Octel Starreon (USA)/ The Associated Octel Company Ltd (UK)	RDE/A/621

**A.4.3** The concentration of SDA shall not exceed 3.0 mg/l.

**A.5 Fuel System Icing Inhibitor (FSII)**

**A.5.1** An FSII, of a type detailed in **A.5.2** and at concentrations detailed at **A.5.3** and **A.5.4**, may be added to the fuel by agreement between purchaser and supplier.

**A.5.2** The following materials are qualified and must comply:

<u>Product</u>	<u>Qualification Standard</u>
Diethylene Glycol Monomethyl Ether (DiEGME)	Def Stan 68-252
Or	
Propan-2-ol (Isopropyl Alcohol)	ASTM D 4171 (Type II)

**A.5.3** The concentration of DiEGME shall not be less than 0.10% and not more than 0.15% by volume at the time of the delivery to the purchaser. A suitable method for determining DiEGME concentration is ASTM D 5006.

NOTE: Concentrations of less than 0.02% by volume can be considered negligible and do not require agreement/notification. The assent to allow these small quantities of FSII without agreement/notification is to facilitate the changeover from fuels containing FSII to those not containing FSII where the additive may remain in the fuel system for a limited time. This does not allow the continuous addition of FSII at these low concentrations.

**A.5.4** The concentration of Isopropyl Alcohol shall be recommended by the aircraft manufacturer at the time of delivery to the purchaser and typically not exceeding 1% v/v. Suitable methods for determining Isopropyl Alcohol concentration are IP 526 and ASTM D 4815.

## A.6 Corrosion Inhibitor Additives

**A.6.1** The following corrosion inhibitors may be added to the gasoline in concentrations not to exceed the maximum allowable concentration (MAC) listed for each additive:

**Table 3: List of Corrosion Inhibitor Additives**

Product	MAC (g/m <sup>3</sup> )	Manufacturer
DCI-4a	22.5	Octel Starreon (USA)/ The Associated Octel Company Ltd (UK)
DCI-6a	9.0	Octel Starreon (USA)/ The Associated Octel Company Ltd (UK)
HITEC 580	22.5	Ethyl Petroleum Additives Ltd
NALCO/EXXON 5403	22.5	Nalco Chemical Co.
NALCO/EXXON 5405	11.0	Nalco Chemical Co.
PRI-19	22.5	Apollo Technologies International Corp.
UNICOR J	22.5	UOP LLC
SPEC-AID 8Q22	24.0	Betz Dearborn
TOLAD 351	24.0	Baker Petrolite
TOLAD 4410	22.5	Baker Petrolite

## A.7 Contamination by Processing Additives

**A.7.1** Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels which may not be detected by the standard specification testing detailed in **Table 1**. Whilst the standard (4.1) states that non-approved additives are not permitted, defining a zero level is not straightforward; particularly given that:

- (a) modern analytical techniques are capable of detecting extremely low levels of chemical species,
- (b) there could be a wide range of materials involved and
- (c) in most cases there are no data on their effects in aircraft systems to use to define a no-harm level.

**A.7.2** It is therefore not practical for this standard to require detailed chemical analysis of each production batch of aviation fuel beyond the requirements listed in this standard. Instead, it is recommended that manufacturing locations ensure that they have adequate quality assurance and management of change procedures in place to ensure that refinery processing additive use is well defined and controlled. Any changes in additive composition/manufacturing source or refinery processing conditions should be subject to a formal risk assessment to ensure maintenance of finished product quality.

**A.7.3** Due to known problems arising from the carry over of the refinery processing additive (corrosion inhibitor) 1,2-diaminoethane (ethylene diamine), its use is specifically not recommended in the manufacture of aviation gasoline.

**Annex B****Alternative Test Methods for use with Table 1 Test Requirements****Table 4: Alternative Test Methods**

<b>Table 1 Test Number</b>	<b>Property</b>	<b>Alternative</b>
1	Appearance	ASTM D 4176 Procedure 1
4	Density at 15°C	IP 160 / ASTM D 1298
5	Total Sulfur	IP 243 ASTM D 2622 ASTM D 5453
8	Specific Energy	ASTM D 3338 ASTM D 4809
9	Vapour Pressure	See NOTE IP 394 ASTM D 5191 ASTM D 5190
13	Tetraethyl Lead Content	IP 228 / ASTM D 5059 IP 428 / ASTM D 3341

NOTE: Results shall be reported as dry vapour pressure equivalent (DVPE), as defined in the approved alternative method used.

## Annex C

### Normative References

Designation	Title
Def Stan 05-52 (Part 1)	Markings for the Identification of Fuels, Lubricants and Associated Products: Containers Holding 216.5 Litres or Less
Def Stan 68-252	Fuel System Icing Inhibitor JSD: AL-41
IP 12	Determination of Specific Energy
IP 16	Petroleum Products – Determination of the Freezing Point of Aviation Fuels
IP 17	Determination of Colour – Lovibond Tintometer Method
IP 69	Determination of Vapour Pressure – Reid Method
IP 107	Determination of Sulfur – Lamp Combustion Method
IP 119	Knock Characteristics of Aviation Gasoline by the Supercharged Method
IP 123	Petroleum Products – Determination of Distillation Characteristics at Atmospheric Pressure
IP 131	Petroleum Products – Gum Content of Light and Middle Distillate Fuels – Jet Evaporation Method
IP 154	Petroleum Products – Corrosiveness to Copper – Copper Strip Test
IP 160	Crude Petroleum and Liquid Petroleum Products – Laboratory Determination of Density – Hydrometer Method
IP 228	Determination of Lead Content of Gasoline – X-Ray Spectrometric Method
IP 236	Knock Characteristics of Motor and Aviation Fuels by the Motor Method
IP 243	Petroleum Products and Hydrocarbons – Determination of Sulfur Content – Wickbold Combustion Method
IP 270	Petroleum Products – Determination of Lead Content of Gasoline – Iodine Monochloride Method
IP 274	Petroleum Products – Aviation and Distillate Fuels - Determination of Electrical Conductivity
IP 289	Determination of Water Reaction of Aviation Fuels
IP 365	Crude Petroleum and Petroleum Products – Determination of Density – Oscillating U-tube Method
IP 367	Petroleum Products – Determination and Application of Precision Data in Relation to Methods of Test
IP 381	Calculation of Net Specific Energy of Aviation Fuels, Using Aniline Point Data

IP 394	Determination of Air Saturated Vapour Pressure (ASVP)
IP 424	Determination of Fuel System Icing Inhibitor Content of Aviation Turbine Kerosines by High Performance Liquid Chromatography
IP 526	Liquid Petroleum Products – Determination of Hydrocarbon Types and Oxygenates in Petrol – Multidimensional Gas Chromatography Method
ASTM D 56	Standard Test Method for Flash Point by Tag Closed Tester
ASTM D 86	Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 130	Standard Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test
ASTM D 323	Standard Test Method for Vapour Pressure of Petroleum Products (Reid Method)
ASTM D 381	Standard Test Method for Gum Content in Fuels by Jet Evaporation
ASTM D 873	Standard Test Method for Oxidation Stability of Aviation Fuels (Potential Residue Method)
ASTM D 909	Standard Test Method for Knock Characteristics by the Supercharged Method
ASTM D 1094	Test Method for Water Reaction of Aviation Fuels
ASTM D 1266	Standard Test Method for Sulfur in Petroleum Products (Lamp Method)
ASTM D 1298	Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
ASTM D 2386	Test Method for Freezing Point of Aviation Fuels
ASTM D 2622	Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrophotometry
ASTM D 2624	Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
ASTM D 2700	Standard Test Method for Knock Characteristics of Motor and Aviation Fuels by the Motor Method
ASTM D 3338	Standard Test Method for Estimation of the Net Heat of Combustion of Aviation Fuels
ASTM D 3341	Standard Test Methods for Lead in Gasoline – Iodine Monochloride Method
ASTM D 4052	Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter
ASTM D 4176	Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
ASTM D 4529	Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
ASTM D 4809	Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

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ASTM D 4815	Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C <sub>1</sub> to C <sub>4</sub> Alcohols in Gasoline by Gas Chromatography.
ASTM D 5006	Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
ASTM D 5059	Standard Test Method for Lead in Gasoline by X-ray Spectroscopy
ASTM D 5190	Standard Test Method for Vapour Pressure of Petroleum Products (Automatic Method)
ASTM D 5191	Standard Test Method for Vapour Pressure of Petroleum Products (Mini Method)
ASTM D 5453	Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel and Engine Oil by Ultraviolet Fluorescence

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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 an 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 on order that the matter may be investigated and appropriate action taken.