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MIL-DTL-46162E
8 November 2002
SUPERSEDING
MIL-F-46162D
23 November 1992

DETAIL SPECIFICATION

FUEL, DIESEL, REFEREE GRADE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers two types of referee fuel (see 1.2 and 6.1), for use in research, development and verification testing of all compression-ignition engines, diesel-powered auxiliary units, gas turbine engine driven ground vehicles, mobile electric power generators and other fuel handling supply items designed to operate with either fuel conforming to A-A-52557 or MIL-DTL-83133.

1.2 Classification. This specification applies to the following classification types of referee grade diesel fuel (see 6.3 and 6.7).

Type I	- Referee diesel fuel.
Type II	- Referee JP-8 fuel (i.e., intended primarily for ground - vehicle/equipment applications).

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirement documents cited in sections 3 and 4 of this specification, whether or not they are listed.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-D/210, 6501 E. 11 Mile Road, Warren, MI 48397-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9140

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2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

A-A-52557 - Fuel Oil, Diesel; For Posts, Camps and Stations.

DEPARTMENT OF DEFENSE

MIL-PRF-25017 - Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble.
MIL-S-53021 Stabilizer Additive, Diesel Fuel.
MIL-DTL-83133 - Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35 and JP-8 + 100.
MIL-DTL-85470 - Inhibitor, Icing, Fuel System, High Flash NATO Code Number S-1745.

STANDARDS

FEDERAL

FED-STD-313 - Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities.
FED-STD-791 - Lubricants, Liquid Fuels and Related Products; Methods of Testing.

DEPARTMENT OF DEFENSE

MIL-STD-290 - Packaging and Marking of Petroleum and Related Products.

(Unless otherwise indicated, copies of federal and military specifications and standards are available from Document Automation and Production Service, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 or website: www.astimage.daps.dla.mil)

2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

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ASTM INTERNATIONAL

D56	- Standard Test Method for Flash Point by Tag Closed Cup Tester (DoD Adopted).
D86	- Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure (DoD Adopted).
D93	- Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester (DoD Adopted).
D97	Standard Test Method for Pour Point of Petroleum Products (DoD Adopted).
D129	- Standard Test Method for Sulfur in Petroleum Products (General Bomb Method) (DoD Adopted).
D130	- Standard Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test (DoD Adopted).
D156	Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method) (DoD Adopted).
D240	- Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (DoD Adopted).
D381	- Standard Test Method for Gum Content In Fuels by Jet Evaporation (DoD Adopted).
D445	- Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity) (DoD Adopted).
D482	- Standard Test Method for Ash from Petroleum Products (DoD Adopted).
D524	- Standard Test Method for Ramsbottom Carbon Residue of Petroleum Products (DoD Adopted).
D613	- Standard Test Method for Cetane Number of Diesel Fuel Oil (DoD Adopted).
D974	- Standard Test Method for Acid and Base Number by Color-Indicator Titration (DoD Adopted).
D976	- Standard Test Method for Calculated Cetane Index of Distillate Fuels (DoD Adopted).
D1094	- Standard Test Method for Water Reaction of Aviation Fuels (DoD Adopted).
D1266	- Standard Test Method For Sulfur in Petroleum Products (Lamp Method) (DoD Adopted).
D1298	- Standard Test Method For Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method (DoD Adopted).
D1319	- Standard Test Method For Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption (DoD Adopted).

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D1322 - Standard Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel (DoD Adopted).
D1552 - Standard Test Method for Sulfur in Petroleum Products (High Temperature Method) (DoD Adopted).
D1840 - Standard Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry (DoD Adopted).
D2274 - Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method) (DoD Adopted).
D2386 - Standard Test Method for Freezing Point of Aviation Fuels (DoD Adopted).
D2500 - Standard Test Method for Cloud Point of Petroleum Products (DoD Adopted).
D2622 - Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrometry (DoD Adopted).
D2624 - Standard Test Method for Electrical Conductivity of Aviation and Distillate Fuels (DoD Adopted).
D2887 - Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography (DoD Adopted).
D3120 - Standard Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry (DoD Adopted).
D3227 - Standard Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method) (DoD Adopted).
D3241 - Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure) (DoD Adopted).
D3242 - Standard Test Method for Acidity in Aviation Turbine Fuels (DoD Adopted).
D3338 - Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels (DoD Adopted).
D3343 - Standard Test Method for Estimation of Hydrogen Content of Aviation Fuels (DoD Adopted).
D3701 - Standard Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry (DoD Adopted).
D3828 - Standard Test Method for Flash Point by Small Scale Closed Tester (DoD Adopted).
D3948 - Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer (DoD Adopted).
D4052 - Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter (DoD Adopted).

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D4057 - Standard Test Method for Manual Sampling of Petroleum and Petroleum Products (DoD Adopted).
D4176 - Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures) (DoD Adopted).
D4177 - Standard Test Method for Automatic Sampling of Petroleum and Petroleum Products (DoD Adopted).
D4294 - Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectrometry (DoD Adopted).
D4737 - Standard Test Method for Calculated Cetane Index by Four Variable Equation (DoD Adopted).
D4809 - Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method) (DoD Adopted).
D4952 - Standard Test Method For Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test) (DoD Adopted).
D5006 - Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels (DoD Adopted).
D5452 - Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration (DoD Adopted).
D6217 - Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration.
E29 - Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications (DoD Adopted).

(Application for copies should be addressed to ASTM International, 100 Barr Harbor Drive, PO Box C700,West Conshohocken, PA 19428-2959 or website: www.astm.org)

INSTITUE OF PETROLEUM (IP)

IP 170 - Determination of Flash Point – Abel Closed Cup Method.

(Application for copies should be addressed to Institute of Petroleum, 61 New Cavendish Street, London, W1G 7AR, United Kingdom, or website: www.petroleum.co.uk)

NORTH ATLANTIC TREATY ORGANIZATION (NATO)

STANAG 4195, AEP-5 - NATO Standard Engine Laboratory Test for Diesel and Gasoline Engines and Gas Turbine Engines.

(Application for copies should be addressed to the North Atlantic Treaty Organization (NATO), Military Agency for Standardization (MAS), Blvd Leopold III, 1110 Brussels, Belgium or website: www.nato.int)

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2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Material. The referee fuels supplied under this specification shall be refined hydrocarbon distillate fuel oils with catalytically or thermally processed blending fractions containing additives in accordance with 3.2.1. The feed stock from which the fuel is refined shall be crude oils derived from petroleum, tar sands, oil shale, or mixtures thereof.

3.1.1 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.2 Chemical and physical requirements. The chemical and physical requirements of the finished fuel shall conform to the requirements listed in section 3 and tables I and II, as applicable, when tested in accordance with the applicable test methods.

3.2.1 Additives. Additive use shall be as specified.

3.2.1.1 Additives for type I fuel. Additive use shall be as specified in 3.2.1.1.1 through 3.2.1.1.3.

3.2.1.1.1 Stabilizer additive. The addition of stabilizer additives is mandatory. The finished fuel shall contain one of the following stabilizer additives at the concentration indicated (see 6.6):

a. Any product qualified under the provisions of MIL-S-53021 at the recommended effective concentration for that product (see 6.6.4).
b. FOA-35A at a concentration of 71 ± 3 grams per cubic meter (g/m^3) (see 6.6.1) and Biobor JF at a concentration of 227 ± 10 g/m^3 (see 6.6.2).

3.2.1.1.2 Cetane improver. Cetane improvers are allowed if necessary to meet requirements of this specification. The cetane number requirements specified in table I may be obtained by use of anyone or any combination of the approved cetane improvers (isopropyl nitrate, amyl nitrate, hexyl nitrate, cyclohexyl nitrate, and octyl nitrate), including the structural isomers of amyl, hexyl, and octyl nitrates. The total concentration of cetane improvers in the finished fuel shall not exceed 0.50 percent by weight.

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3.2.1.1.3 Pour-point depressant or flow improver. Pour-point depressants are allowed if necessary to meet requirements of this specification. A pour-point depressant or flow-improver additive may be used to meet the pour point requirement specified in table I.

3.2.1.2 Additives for type II fuel. Additive use shall be as specified in 3.2.1.2.1 through 3.2.1.2.5.

PRECAUTION

When mixing additives; to prevent possible reaction among the concentrated forms of different additives for type II referee fuel, the fuel supplier is cautioned about the indiscriminate co-mingling of the additives prior to their addition to the fuel.

3.2.1.2.1 Antioxidants. Immediately after processing and before the fuel is exposed to the atmosphere (i.e., during rundown into feed/batch tankage), add an approved antioxidant in order to prevent the formation of gums and peroxides after manufacture. The concentration of antioxidant to be added shall be:

a. Not less than 17.2 milligrams (mg) nor more than 24 mg of active ingredient per liter (L) of fuel (6 to 8.4 pounds (lb)/1000 barrels) to all JP-8 fuel that contains blending stocks that have been hydrogen treated.
b. At the option of the supplier, not more than 24 mg of active ingredient per liter of fuel (8.4 lb/1000 barrels) may be added to JP-8 fuels that do not contain hydrogen treated blending stocks.

3.2.1.2.1.1 Antioxidant formulations. The following antioxidant formulations are approved:

a. 2,6-di-tert-butyl-4-methylphenol
b. 6-tert-butyl-2,4-dimethylphenol
c. 2,6-di-tert-butylphenol
d. 75 percent (%) min 2,6-di-tert-butylphenol
   25 % max tert -butylphenols and tri- tert -butylphenols
e. 72 % min 6- tert -butyl-2,4-dimethylphenol
   28 % max tert -butyl-methylphenols and tert -butyl-dimethylphenols
f. 55 % min 2,4-dimethyl-6-tert-butylphenol and
   15 % min 2,6-di-tert-butyl-4-methylphenol and
   30% max mixed methyl and dimethyl tert-butylphenols

3.2.1.2.2 Metal deactivator. A metal deactivator, N,N'-disalicylidene-1, 2-propanedlamlne or N,N'-disalicylidene-1, 2-cyclohexanediamine may be blended into the fuel in an amount not to exceed two pounds active ingredient per 1000 barrels of fuel (22 mg/gallon (gal) (US), 26 mg/gal (UK), or 5.8 mg/L).

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3.2.1.2.3 Static dissipator additive. An additive shall be added to the fuels in sufficient concentration to increase the conductivity of the fuel to within the range specified in table II at the point of injection. The point of injection of the additive shall be determined by agreement between the purchasing authority and the supplier. The following electrical conductivity additive Stadis 450 is an approved additive (see 6.6.3).

3.2.1.2.4 Corrosion inhibitor. A corrosion inhibitor conforming to MIL-PRF-25017 (see 6.6.5) shall be blended into the fuel by the contractor. The amount added shall be equal to or greater than the minimum effective concentration and shall not exceed the maximum allowable concentration approved by manufacturer. The contractor or transporting agency, or both, shall maintain and upon request shall make available to the Government evidence that the corrosion inhibitors used are equal in every respect conforming to MIL PRF-25017. The point of injection of the corrosion inhibitor shall be determined by agreement between the purchasing authority and the supplier.

3.2.1.2.5 Fuel systems icing inhibitor. An icing inhibitor conforming to MIL-DTL-85470 is mandatory and shall be blended into the fuel system.

3.3 Physical and chemical requirements. The finished referee fuels shall conform to the requirements specified.

a. Types I and II fuels are not intended for use where ambient temperatures lower then -30°C (-22°F) generally occur.
b. When authorized NATO F-34 (JP-8) may be used in ground based turbine and diesel engines.

3.3.1 Type I referee fuel. The finished type I referee fuel which meets the minimum requirements of A-A-52557 shall conform to the requirements specified in table I.

TABLE I. Physical and chemical requirements and test methods for type I referee fuel.

Property	Value	ASTM
Density, Kg/L @ 15°C	Record	D1298
Flash point, °C, min.	52	D93
Cloud point, °C, max.	-13	D2500
Pour point, °C, max.	-18	D97
Kinematic viscosity, cSt at 40°C	1.9 to 4.1	D445
Distillation, °C		D86
Initial boiling point	Record	
10% recovered, min.	220	
50% recovered	255 to 305	
90% recovered	310 to 360	
95% recovered	315 to 365	

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TABLE I. Physical and chemical requirements and test methods for type I referee fuel – Continued.

Property	Value	ASTM
End point, max.	385	
Residue volume %, max.	3	
Carbon residue on 10% bottoms, % wt, max.	0.20	D524
Sulfur, % wt 1/	0.95 to 1.05	D1552, D129, or D2622
Copper strip corrosion, 3 hours @ 50°C, max.	1	D130
Ash, % wt, max.	0.02	D482
Accelerated stability, total insolubles, mg/100 mL, max.	1.5	D2274
Neutralization No., TAN, max.	0.2	D974
Aromatics, volume %	Record	D1319
Net heat of combustion, MJ/kg	Record	D240
Particulate contamination, mg/L, max.	10	D6217
Cetane number 2/	37 to 43	D613 3/, D976, or D4737
Free water & particulate contamination	Pass	D4176

1/ Naturally-occurring sulfur is preferred. If additional sulfur is required, supplementation shall only be achieved by blending sufficient amounts of ditertiary butyl disulfide to the finished fuel.

2/ See appendix A. If the fuel contains cetane improver additives, this limit shall apply only to the base fuel prior to addition of cetane improver.

3/ ASTM D613 is the referee method for determining cetane quality. ASTM D976 and ASTM D4737 are permitted as alternates. If cetane improvers (as determined by the method in appendix A) or non-naturally-occurring sulfur compounds have been utilized, only ASTM D613 shall be permitted.

3.3.2 Type II referee fuel. The finished type II referee fuel which meets the min requirements of MIL-DTL-83133, shall conform to the requirements specified in table II.

TABLE II. Physical and chemical requirements and test methods for type II referee fuel.

Property	Requirements		ASTM Test Methods
	Min	Max	
Color, saybolt		1/	D156
Total acid number, mg KOH/gm		0.015	D3242
Aromatics, vol percent		25.0	D1319
Olefins, vol percent		5.0	D1319
Sulfur, total, wt. percent		0.30	D1266, D2622 D3120, D4294

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TABLE II. Physical and chemical requirements and test methods for type II referee fuel - Continued.

Property	Requirements		ASTM Test Methods
	Min	Max	
Sulfur mercaptan, wt. % or		0.002	D3227
Doctor test		negative	D4952
Distillation temperature, °C 2/			D86, D2887
(D2887 limits given in parentheses)			
Initial boiling point		1/	
10 percent recovered		205 (186)	
20 percent recovered		1/	
50 percent recovered		1/	
90 percent recovered		1/	
End point		300 (330)	
Residue, vol percent		1.5	
Loss, vol percent		1.5	
Flash point, °C (°F)	38 (100)	44 (111)	D93 3/, D3828
Density or gravity			
Density, kg/L at 15 °C or	0.775	0.840	D1298 or D4052
Gravity, API at 60 °F	37.0	43.0	D1298
Freezing point, °C (°F)		-47 (-53°)	D2386
Viscosity, @-20°C, cSt		8.0	D445
Viscosity @ 40°C, cSt	1.0	1.35	D445
Net heat of combustion, MJ/kg	42.8		D3338 4/,
or (Btu/lb)	(18,400)		D4809, D240
Hydrogen content, wt percent	13.4		D3701, D3343
Smoke point, mm, or	25.0		D1322
Smoke point, mm and	19.0		D1322
Naphthalenes, vol percent		3.0	D1840
Cetane number	37	43	D613
Copper corrosion, 2 hr			
@ 100 °C (210 °F)		No.1	D130
Thermal stability			D3241 5/
change in pressure drop, mm Hg		25	
heater tube deposit, visual rating		<3	
Existent gum, mg/100 mL		7.0	D381
Particulate matter, mg/L		1.0	D5452
Filtration time, minutes		15	Appendix B
Water reaction interface rating		lb	D1094
Water separation index	6/		D3948
Fuel system icing inhibitor, vol %	0.10	0.15	D5006
Fuel electrical conductivity, pS/m	7/	7/	D 2624

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TABLE II. Physical and chemical requirements and test methods for type II referee fuel - Continued.

1/ To be reported if requested by contract or work order- not limited.
2/ A condenser temperature of 0 to 4°C (32 to 40°F) shall be used for the distillation by ASTM D86. Distillation shall be corrected to 760 mm pressure.
3/ ASTM D93 is the referee method. Method IP 170 is also permitted. The min flash point shall be 40°C by ASTM D56, as it can be 1 to 2°C (1.8 to 3.6°F) lower than those obtained by other methods.
4/ When the fuel distillation test is performed using ASTM D2887, the average distillation temperature, for use in ASTM D3338 shall be calculated as follows:

$$V = (10\ \% + 50\ \% + 95\ \%) / 3$$

5/ See 4.3.2.1 through 4.3.2.4 for ASTM D3241 test conditions and test limits.
6/ The min water separation index rating for referee JP-8 shall be 85 with all additives except the corrosion inhibitor/lubricity improver additive and the static dissipator additive or 70 with all additives except the static dissipator additive.
7/ Unless otherwise specified (see 6.2), the conductivity must be between 150 and 600 pico Siemens (pS)/meter (m)) for F-34 and between 50 and 450 pS/m for F-35.

3.4 Material safety. The contractor shall comply with the material safety requirements of FED-STD-313 (see 6.4.1).

3.5 Workmanship. At the time of Government acceptance, the finished referee fuel shall be visually free from undissolved water, sediment, and suspended matter; and shall be clear and bright when tested in accordance with ASTM D4176, procedure 1, methods A and B (see 4.1.2).

4. VERIFICATION

4.1 Classification of inspection. The inspection requirements specified herein are classified as quality conformance tests.

4.1.1 Conformance inspection. Conformance inspection shall include those examinations and tests for all requirements specified in section 3, table I, table II and as defined in the contract. Quality conformance inspection shall include the test requirements herein.

4.1.2 Container inspection. Perform container inspection in accordance with FED-STD-791, method 9601 and shall be visually examined for compliance with 3.5.

4.1.2.1 Examination of empty container. Prior to filling, each empty unit container shall be visually inspected for cleanliness and suitability.

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4.1.2.2 Examination of filled containers. Examine fuels for compliance to MIL-STD-290 with regard to fill, closure, sealing, leakage, packaging, packing, and marking requirements. Reject any container having one or more defects or under the required fill.

4.2 Verification alternatives. The manufacturer may propose alternative test methods to those listed in tables I and II, such as techniques or equipment, including cost-effective sampling procedures, to verify performance. See the contract for alternatives that replace verifications required by this specification.

4.3 Test methods. Tests shall be performed in accordance with the applicable methods listed as specified for referee fuel types I and II (see 4.3.1 and 4.3.2). For rounding off of significant figures, ASTM E29 shall apply to all tests required by this specification.

4.3.1 Test methods for type I. Tests shall be performed in accordance with the applicable methods listed in 3.3.1 (table I) and appendix A.

4.3.2 Test methods for type II. Tests shall be performed in accordance with the applicable methods listed in 3.3.2 (table II), appendix B and C and those specified herein.

4.3.2.1 Thermal stability. The thermal stability test shall be conducted using ASTM D3241 Jet Fuel Thermal Oxidation Tester (JFTOT). The heater tube shall be rated visually (see appendix C).

4.3.2.2 ASTM D3241 test conditions.

a. Heater tube temperature at maximum point:	260 degrees Celsius (°C) (500 degrees Fahrenheit (°F)).
b. Fuel system pressure:	3.45 MPa (500 pounds per square inch gage (psig))
c. Fuel flow rate:	3.0 mL/min (0.1 ounce/min)
d. Test duration:	150 minutes.

4.3.2.3 Acceptability criteria. The fuel sample is acceptable if all the following criteria are met:

a. The maximum differential pressure across the test filter does not exceed 25 mm (1 in.) of mercury.
b. The maximum visual rating of the heater tube deposits is less than a code 3, and visual rating of the heater tube shows neither peacock type deposits (code P) nor abnormal type deposits (code A) (see appendix C.5.3.1 and C 5.3.2).

4.3.2.4 ASTM D3241 recorded data. The following data shall be recorded.

a. Differential pressure in millimeter of mercury at 150 minutes, or time to differential pressure of 25 mm of mercury, whichever comes first.

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b. Heater tube deposit visual code rating at the end of the test.
c. If a Mark 8A tube deposit rater (TDR) is available, the maximum SPUN TDR rating shall be recorded.

4.4 Inspection of packaging. The packaging shall be examined and tested to determine conformance with the quality assurance provisions of MIL-STD-290.

5. PACKAGING

5.1 Packing and marking. For acquisition purposes, the packaging shall be level B, C, or commercial as specified in the contract or order (see 6.2). When actual packaging of material is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files CD-ROM products, or by contacting the responsible packaging activity. Referee fuel contained in the size and type of container specified (see 6.2) shall be marked in accordance with MIL-STD-290.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. These referee fuels are intended strictly for engine testing IAW AR70-12 and not intended for field use. It's for use in research, development and verification testing of all compression-ignition engines, diesel-powered auxiliary units, turbine engine driven ground vehicles, mobile electric power generators, and other fuel handling supply items. The use of referee fuel in conjunction with Development Testing (DTI through DTIII) is considered necessary to uncover potential operational problems with respect to performance and to enable data correlation of all testing sites regardless of geographical location. Referee fuels are not intended for use in engines or other equipment in the field as a substitute for A-A-52557 or MIL-DTL-83133 (ground systems only) fuels without approval of the engine manufacturer or from the U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-D/210, 6501 E. 11 Mile Road, Warren, MI 48397-5000. The referee fuel Type I meets the requirements of fuel required for use in engine qualification testing programs as specified in the NATO engine qualification procedure STANAG 4195, AEP-5.

6.1.1 Temperature range. Type I and type II referee grade fuels are intended for use in the same temperature range as OCONUS DF-2, A-A-52557, and JP-8 under MIL-DTL-83133, respectively. Type I referee fuel has the same cloud point of -13°C (8.6°F) and pour point of -18°C (-0.4°F) as DF-2 procured for Europe and South Korea. The actual low temperature

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operability limit depends on the vehicle fuel systems design (filter and pump locations, filter size and porosity, proximity to engine heat, etc.) as well as other fuel properties. Most vehicles will operate satisfactorily down to approximately the cloud point of the fuel, but some vehicles may be equipped with fuel heaters which enable them to operate well below the cloud point. If fuel waxing causes operability problems at or near the cloud point, type II referee fuel should be used.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this specification.
b. Type of referee fuel (see 1.2).
c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2.1 and 2.3).
d. Location and injection method for addition of electrical conductivity additive, fuel system icing inhibitor and corrosion inhibitor, as required (type II referee fuel only) (see 3.2.1.2 and table II).
e. Level of packing required (see 5.1).
f. Size and type of container required (see 5.1).
g. Quantity required and size containers desired.

6.3 Definitions.

6.3.1 Referee grade fuel. It is fuel representing the minimal or marginal quality level which can be procured under specification A-A-52557 or MIL-DTL-83133 while meeting all of its requirements. The referee grade diesel fuel (type I) is designed to be equivalent to the quality of OCONUS distillate production or that production available in times of national emergency. It is used for research ground turbine engines development and verification testing to assure that all diesel-consuming equipment will perform adequately with all fuels procured under A-A-52557 or MIL-DTL-83133. The referee grade turbine fuel (type II) is designed to maximize the efforts of lower viscosity, lower flash point, and lower cetane quality when used as intended. It is not intended to be a substitute for the referee JP-5/JP-8 ST fuel under MIL-DTL-5624.

6.4 Safety.

6.4.1 Material Safety Data Sheets (MSDS). Contracting officers should identify those activities requiring copies of completed MSDSs prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313; and 29 CFR 1910.1200 requires that the MSDS for each hazardous chemical used in an operation must be readily available to personnel using the material. Contracting officers will identify the activities requiring copies of the MSDS (see 3.4).

6.5 Reports. Reports are not requirements of this specification but may be requested in the contract or work order.

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6.5.1 Additives report. The type and amount of each additive if required (see 3.2.1.2).

6.5.2 Test report. Test data if required, is to be reported in the same order as listed in table I or table II, as appropriate (see 6.5).

6.5.3 Analysis report. The contractor is to provide copies of analysis reports if required, giving the results of these tests and a statement of the types and concentrations of the additives used in the referee fuel (see 6.5 and 6.5.2).

6.6 Approved products.

6.6.1 FOA-15. This additive is available from Octel Starreon, 200 Executive Drive, Newark, DE 19702, or website: www.octel-starreon.com (see 3.2.1.1.1).

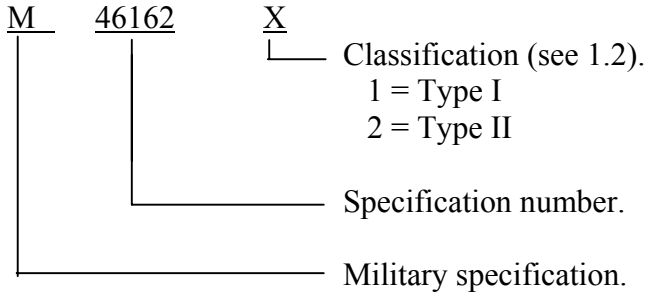
6.6.2 Biobor JF. This additive is available from Hammonds Fuel Additives, 15760 West Hardy Road, Suite 400, Houston, TX 77060-3147, or website: www.hammonds.com (see 3.2.1.1.1).

6.6.3 Stadis 450. This approved electrical conductivity additive is available from Octel Starreon, 200 Executive Drive, Newark DE 19702, or website: www.octel-starreon.com (see 3.2.1.2.3).

6.6.4 QPL-53021. This Qualified Products List (QPL) is active for MIL-S-53021 (see 3.2.1.1.1).

6.6.5 QPL-25017. This QPL is active for MIL-PRF-25017 (see 3.3.1.2.4).

6.7 Part or Identifying Number (PIN). The PINs to be used for the fuels acquired to this specification are created as shown below:



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6.8 Subject term (key word) listing.

Compression ignition engines
DF-2
Engine qualification testing
JP-8
Special test fuel
Turbine engines

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APPENDIX A

DETECTION OF NITRATE-TYPE IGNITION IMPROVERS IN DIESEL FUEL

A.1 SCOPE

A.1.1 Scope. This method of test covers the determination of organic nitrate ester-type cetane improver additives used in diesel fuel. It is intended as a screening test for those diesel fuel inspection test procedures that are affected by the presence of cetane improvers; namely, ASTM D524, ASTM D976, and ASTM D4737. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance only.

A.2 APPLICABLE DOCUMENTS.

No applicable documents are cited in this appendix.

A.3 SUMMARY

A.3.1 Summary. A diesel fuel sample is saponified in a potassium hydroxide-1-butanol mixture and then filtered through a glass fiber filter. The material remaining on the disc is treated with diphenylamine reagent after drying. The presence of a nitrate ester cetane improver is revealed by the formation of a blue ring or blue-black spot due to oxidation of diphenylamine to intense blue quinoidal compounds by the nitrate salt. No color change confirms the absence of a cetane improver.

A.4 APPARATUS

A.4.1 Reaction bottle. Screw-cap bottle, 29.6 milliliter (mL) (1 fluid ounce (fl. oz.)) capacity, wide mouth, flint glass, with screw-cap lined with tin or tetrafluorethylene (TFE) resin.

A.4.2 Glass fiber filter paper. Glass fiber filter paper, 47 millimeters (mm) (1.9 in.) diameter, Grade 934 AH (Whatman, Ltd., or equivalent).

A.4.3 Pipette. Pipette, 10 mL (0.34 fl.oz) capacity, fitted with a pipetting bulb. Several types and makes of pipetting bulbs and assemblies are available. One of the following is suggested: Fisher Cat No. 13-681-50, Pipet Filler, or equal.

A.4.4 Graduated cylinder. Graduated cylinder, 10 mL and 25 mL (0.84 fl. oz) capacity.

A.4.5 Suction flask. Suction flask with a suitable holder to accommodate a 60 mL (2.03 fl. oz) glass-fitted crucible.

A.4.6 Crucible. Crucible, 60 mL capacity, glass-fitted, medium porosity.

A.4.7 Oven. Oven suitable for drying filter discs at 110°C (230°F).

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A.5. REAGENTS

A.5.1 Saponification mixture (1N). Prepare by mixing 6.5 grams (g) (0.23 oz) of potassium hydroxide (KOH), (ACS reagent grade) with 100 mL (3.34 oz) of absolute 1-butanol (ACS reagent grade) and heat to dissolve the KOH. After the solution cools, filter the mixture through the glass-fiber filter paper.

A.5.2 Diphenylamine (l percent solution). Prepare by dissolving 0.250 g (8.8 oz) of diphenylamine (ACS indicator grade in 25 mL of sulfuric acid (specific gravity (gr) 1.834)).

A.5.3 Toluene (ACS reagent grade).

WARNING

Toluene is flammable and toxic. Avoid breathing vapors or contact with skin.

A.6 PROCEDURE

A.6.1 Pipette 10 mL of the sample into the reaction bottle and add 5 mL (0.2 oz) of toluene followed by 10 mL of the saponification mixture.

WARNING

Oral pipetting techniques should not be used because of the toxicity of the substance involved. A pipetting bulb or assembly similar to one of those described in A.3.3 should be used.

A.6.2 Affix cap to the reaction bottle tightly and, after mixing the contents, place it in an oven maintained at 110°C (230°F) for four hours.

A.6.3 Remove the reaction bottle from the oven and allow it to cool to 25 ± 3°C (77 ± 5.4°F).

A.6.4 Filter the contents of the reaction bottle through the 60 mL glass-fitted crucible fitted with the glass filter disc.

A.6.5 Wash the reaction bottle with 25 mL of toluene and transfer it to the glass-fitted crucible.

A.6.6 Carefully remove the glass fiber filter disc and dry it in oven at 110°C (230°F) for 15 minutes.

A.6.7 Remove the filter disc and cool it to 25 ± 3°C.

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A.6.8 Add three drops of diphenylamine solution to the center of the disc and observe whether a blue or blue-black color forms.

A.7. REPORTS (Reports if required will be specified in the contract or work order).

A.7.1 The presence of organic nitrate ester-type cetane improvers will be recorded if the formation of a blue color occurs. Reference samples of diesel fuels containing 0.5 percent (%) by volume of anyone of the approved cetane improvers (see 3.2.1.1.2) give an intense blue to blue-black color throughout the reagent spot whereas those samples containing only 0.1 % by volume produce a blue ring at the outer boundary of the reagent. If a positive reaction occurs (i.e., a blue or blue-black coloration), the carbon residue determination (ASTM D524) must be performed on a neat or base-fuel blend.

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METHOD FOR DETERMINATION OF FILTRATION TIME

B.1 SCOPE

B.1.1 Scope. This method describes a procedure for determining singularly or simultaneously the filterability characteristics and solids contamination of jet fuel. The purpose is to detect and prevent contaminants in jet fuel that can plug and cause rupture of ground filtration equipment, thereby affecting flight reliability of aircraft. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance only.

B.2 APPLICABLE DOCUMENTS.

No applicable documents are cited in this appendix.

B.3 SUMMARY

B.3.1 Summary of methods. 3.79 liters (L) (1.0 gallon (gal)) of jet fuel is filtered through a membrane filter in the laboratory. The time required to filter this volume is measured in minutes and solids content is determined gravimetrically.

B.4 Apparatus.

a. Membrane filter: White, plain 47 mm (1.3 in.) diameter, nominal pore size 0.8 micrometer (3.1 in.). The membrane must be approved by ASTM for use with ASTM D5452.

b. Filtration apparatus: Of the types shown in figure 1. It consists of a funnel and funnel base with a filter support such that a membrane filter can be securely locked or clamped between the sealing surfaces of the funnel and its base. The funnel and funnel base shall be of stainless steel or glass construction.

c. Insert ring: A 47 mm (1.9 in.) diameter paper flow reducer ring with dimensions to give filtering area of 4.8 centimeters square (cm^2) (0.74 $in.^2$)). (Millipore Corporation Part No. XX 20 047 08).

d. Vacuum flask: A minimum of 4 liters (5.3 quarts (qts)).

e. Vacuum system: That develops in excess of 67.5 kPa (20 inches of mercury) vacuum.

f. Oven: Of the static type (without fan assisted circulation) controlling to 90 ± 5°C (194 ± 9°F).

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g. Forceps: Flat-bladed with unserrated nonpoint tips.

h. Solvent filtering dispenser: Containing a 1.2 micrometers (0.0002 in.) maximum port size filter in the delivery line.

i. Glass petri dish: Approximately 125 mm (4.9 in.) in diameter with removable cover.

j. Analytical balance: Single or double pan, the precision standard deviation of which must be 0.07 milligrams (mg) (2.5 oz)) or better.

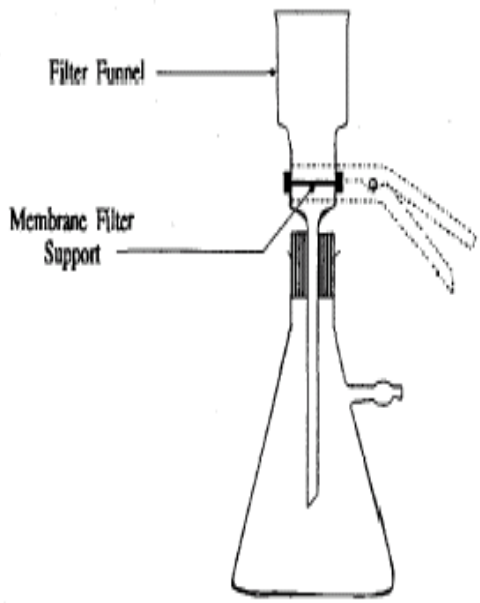

FIGURE 1. Filtration apparatus.

B.5 Preparation of apparatus and sample containers. All components of the filtration apparatus (except the vacuum flask), sample containers and their caps must be cleaned as described in section 10 of ASTM D5452. All metal parts of the filtration apparatus are to be electrical bonded including the fuel sample container and the metal insert ring, if used. See ASTM D5452 for other Precautionary Statements.

B.6 Sampling. Obtain a representative one gallon sample as directed in ASTM D5452 section 8, Sampling. When sampling from a flowing stream is not possible, an all level sample or an average sample, in accordance with ASTM D4057 or ASTM D4177 shall be permitted. The one-gallon sample container shall be an interior epoxy coated metal can, a brown glass bottle, or one-gallon sample container shall be an interior epoxy coated metal can, a brown glass bottle, or a clear glass bottle protected by suitable means from exposure to light.

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B.7 Test procedure.

a. Membrane filters shall be removed from the package and placed in an oven for a minimum of 15 minutes at 90°C (194°F). After preheating, but prior to weighing, the membrane filters shall be stored in a desiccator.

b. Each membrane filter shall be weighed. A filter weighing in excess of 90 mg (0.0003 oz) shall not be used in this test.

c. The membrane filter shall be placed directly over the insert ring. The top funnel shall be locked into place.

d. Immediately prior to filtering the fuel, shake the sample to obtain a homogenous mix and assure that fuel temperature does not exceed 30°C (86°F). Clean the exterior or top portion of the sample container to insure that no contaminants are introduced. Any free water present in the fuel sample will invalidate the filtration time results by giving an excessive filtration time rating.

e. With the vacuum off, pour approximately 200 mL (6.8 oz) of fuel into the funnel.

f. Turn vacuum on and record starting time. Continue filtration of the 3.79 liters (one gallon) sample, periodically shaking the sample container to maintain a homogenous mix. Determine the vacuum in kPa (inches of mercury) one minute after start again immediately prior to completion of filtration. Throughout filtration, maintain a sufficient quantity of fuel in the funnel so that the membrane filter is always covered.

g. Determine the filtration time in minutes expressed to the nearest whole number. If filtration of the 3.79 liters (one gallon) is not completed within 30 minutes, the test will be stopped and the volume of the fuel filtered will be measured. In these cases, results will be reported as 30+ minutes/volume of fuel filtered.

h. Determine the vacuum in kPa from the average of the two readings taken in B.7f.

i. After determining the filtration time, shut off the vacuum, rinse the sample container with approximately 100 mL of filtered petroleum ether and dispense into the filtration funnel. Turn the vacuum on and filter the 100 mL rinse. Turn vacuum off and wash the inside of the funnel with approximately 50 mL (1.7 oz) of filtered petroleum ether. Turn vacuum on and filter. Repeat the funnel rinse with another 50 mL of petroleum ether but allow the rinse to soak the filter for approximately 30 seconds before turning the vacuum on to filter the rinse. With vacuum on, carefully remove

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the top funnel and rinse the periphery of the membrane filter by directing a gentle stream of petroleum ether from the solvent dispenser from the edge of the membrane toward the center, taking care not to wash contaminations off the filter. Maintain vacuum after final rinse for a few seconds to remove the excess petroleum ether from the filter.

j. Using forceps, carefully remove the membrane filter from the filter base and place in a clean Petri dish. Dry in the oven at 90°C (194°F) for 15 minutes with the cover on the Petri dish slightly ajar. Place dish in a desiccator and allow to cool for a minimum of 15 minutes. If more than one sample is processed, cooling time will have to be increased. Reweigh the filter.

k. Determine the total solids content in mg/liter by using the following formula:

Weigh gain of filter in mgs/3.785 = mg/liter

l. Should the sample exceed the 30-minutes filtration time and a portion of the fuel is not filtered, the solids content in mg/liter will be figured as follows: Determine the volume of fuel filtered by subtracting the mL of fuel remaining from 3.785.

Weigh gain of filter in mgs/ mL of fuel filtered X 0.001 = mg/liter

B.8 Test limits.

a. Filtration time:

(1) The maximum allowable filtration time shall be 15 minutes for Grade JP-8.
(2) The vacuum should exceed 67.5 kPa (20 inches of mercury) throughout the test (i.e., the differential pressure across the filter should exceed 67.5 kPa).
(3) The fuel temperature shall be between 18 and 30°C (64 and 86°F). If artificial heat (i.e.. a hot water bath) is used to heat the sample, erroneously high filtration times may occur, but this approach is allowed.

b. Total solids: Maximum allowable particulate matter is 1.0 mg/liter (3.5 oz/qt).

B.9 NOTES.

B.9.1 If it is desired to determine the filtration time and not the total solids content, perform the test by omitting steps B.7i through B.7l.

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B.9.2 If it is desired to determine the total solids contents and not the filtration time, use of the insert ring may be omitted. It is also permissible, but not required, to use a control filter for a specified analysis or a series of analyses. When this is accomplished, the procedures specified in section 10 of ASTM D5452 apply.

B.10 Reports. Reports if required will be specified in the contract or work order.

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HEATER TUBE DEPOSIT RATING

C.1 SCOPE

C.1.1 Scope. Visual method. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance only.

C.2 APPLICABLE DOCUMENTS. No applicable documents are cited in this appendix.

C.3 SUMMARY

C.3.1 Summary of method. Comparison rating method, using the heater tube residue deposit area and pattern coloring to where it corresponds with an identifiable ASTM Color Standard code number.

C.4 TEST PROCEDURE.

C.4.1 Step the upper end of the heater tube into the clamp of the adapter for the heater tube.

C.4.2 Push the heater tube against the stop of the adapter.

C.4.3 Slide the adapter with the heater tube over the guide rod into the tuberator equipped with a magnifying glass assembly.

C.4.4 Insert the ASTM Color Standard into the tuberator.

C.4.5 Rotate the adapter and position the heater tube so that the side with the maximum deposit is visible.

C.4.6 Within 30 minutes after completion of the test, visually examine the heater tube in a tuberator. The entire portion of the section between the bottom shoulder and the top shoulder of the heater tube test section shall be carefully examined using a magnifying glass in conjunction with the tuberator for any signs of discoloration, scratches, or other visually identified defects. When an area of the tube corresponds visually to an ASTM Color Standard, the color standard code number shall be recorded. If the area being rated has a color between two adjacent color standards, it shall be rated as the lighter (the lower number) color standard.

NOTE 1: It is important that all light bulbs in the tuberator are functional, as a change in light intensity can shift the rating significantly.

NOTE 2: The person rating the tube should have normal ability to distinguish between colors: i.e., the rater should not be color blind.

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C.5 RATINGS.

C.5.1 In rating the heater tube, the darker deposits govern and the code number representative of the deposit section, rather than the average deposit, shall be reported.

C.5.2 If a spot or streak is found on the heater tube, it shall be carefully examined under various lighting conditions using a magnifying glass to determine if it is a deposit, a scratch, or tube defect (note that the tube defects should have been found during the pretest inspection of the tube). If the spot or streak is determined to be a scratch or tube defect, it shall be disregarded. If the spot or streak is a deposit, it shall be rated against the ASTM Color Standards, if larger in area than about 0.025 cm^2. (0.004 $in.^2$); i.e., approximately 1.5 mm x 1.5 mm (1/16 in. x 1/16 in.) square or an equivalent area. However, a streak deposit shall be ignored if less than 0.8 mm (1/32 in.) wide, regardless of the length. Note that the tube section is about 3 mm (1/8 in.) in diameter, thus a 1.5 mm (1/16 in.) wide spot is half the diameter of the tube test section and 0.8 mm (1/31 in.) wide streak is one fourth the diameter of the tube test section.

C.5.3 If the heater tube has deposits which do not match the Color Standards, the following criteria shall be used.

C.5.3.1 If the deposit has peacock (rainbow) colors, rate this as code P (P for peacock). If some portion of the deposit does match the Color Standards, it shall be rated.

C.5.3.2 Deposits having abnormal colors (for example, blue or gray) shall have a rating of code A (A for abnormal color) assigned.

C.5.3.3 When reporting the overall tube rating, record the rating of the maximum deposit which matches the Color Standards plus P or A if the tube contains deposits which do not match the Color Standards. If the tube contains only P or A deposits, just report the appropriate letter (a); do not try to assign a numerical rating to a P or A deposit. Examples of how the rating procedure is to be used are given below:

Example 1: The darkest deposits on the heater tube match Color Standard 3. Also present are peacock colors. Thus, the overall tube rating is 3P.

Example 2: The heater tube has maximum deposits falling between Color Standards 2 and 3 and has no peacock or abnormal colors. The total tube is 2.

Example 3: The heater tube matches Color Standard 1 except for on abnormal deposit which does not match the ASTM Color Standard. The overall tube rating is 1A.

C.6 Reports. Reports if required will be specified in the contract or work order.

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Army - AT
Navy - SA
Air Force – 99

Review Activities:
Army - CE, GL, TE
DLA - PS
CIV - 6FEE

Preparing Activity:
Army – AT

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INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-DTL-46162E	2. DOCUMENT DATE *(YYYYMMDD)* 20021108

3. DOCUMENT TITLE FUEL, DIESEL, REFEREE GRADE

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN *(If applicable)*	7. DATE SUBMITTED *(YYYYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)* (1) Commercial (586) 753-2548 (2) DSN 786-2548
c. ADDRESS *(Include Zip Code)* Commander U.S. Army Tank-automotive and Armaments Command ATTN: AMSTA-TR-E/ESA 6501 E. 11 MILE ROAD Warren, MI 48397-5000	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888