NOT MEASUREMENT SENSITIVE

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SUPERSEDING
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MILITARY SPECIFICATION

FUEL, DIESEL, REFEREE GRADE

This specification is approved for use within the USA Belvoir Research, Development, and Engineering Center, Department of the Army, and is available 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 6.2) 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 VV-F-800 or MIL-T-83133 (see 6.1)

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 Government documents.

2.1.1 Specifications and standards. The following specifications and standards 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).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: SATBE-TSE, Fort Belvoir, VA, 22060-5606 b y using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9140

SPECIFICATIONS

FEDERAL

VV-F-800 - Fuel Oil, Diesel.

MILITARY

MIL-I-25017 - Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble (Metric).
MIL-S-53021 - Stabilizer Additive, Diesel Fuel.
MIL-I-85470 - Inhibitor, Icing, Fuel System, High Flash.
MIL-T-83133 - Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8) and NATO F-35.

STANDARDS

FEDERAL

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

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-290 - Packaging of Petroleum and Related Products.

QUALIFIED PRODUCTS LIST

QPL-25017 - Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble.
QPL-53021 - Stabilizer Additive, Diesel Fuel.

(Unless otherwise indicated, copies of federal and military specifications, standards, and QPLs are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 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).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 56 - Tester, Closed Flash Point by Tag.
D 86 - Distillation of Petroleum Products.
D 93 - Flash Point by Pensky-Martens Closed Tester.
D 97 - Pour Point of Petroleum Oils.
D 129 - Sulfur in Petroleum Products by the Bomb Method.

D 130 - Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test.
D 156 - Saybolt Color of Petroleum Products.
D 240 - Heat of Combustion of Liquid hydrocarbon Fuels by Bomb Method.
D 381 - Existent Gum In Fuels by Jet Evaporation.
D 445 - Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).
D 482 - Ash from Petroleum Products.
D 524 - Ramsbottom Carbon Residue of Petroleum Products.
D 613 - Ignition Quality of Diesel Fuels by the Cetane Method.
D 974 - Neutralization Number by Color-Indicator Titration.
D 976 - Calculated Cetane Index of Distillate Fuels.
D 1094 - Water Reaction of Aviation Fuels, Test Method for.
D 1266 - Standard Test Method For Sulfur in Petroleum Products, (Lamp Method).
D 1298 - Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Hydrocarbon Products by Hydrometer Method.
D 1319 - Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.
D 1322 - Smoke Point of Aviation Turbine Fuel.
D 1552 - Sulfur in Petroleum Products (High Temperature Method).
D 1840 - Fuel Aviation Turbine by Ultraviolet Spectrophotometry, Naphthalene Hydrocarbons In.
D 2274 - Oxidation Stability of Distillate Fuel Oil (Accelerated Method).
D 2382 - Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High Precision Method)
D 2386 - Freezing Point of Aviation Fuels, Test Method for.
D 2500 - Cloud Point of Petroleum Oils.
D 2550 - Water Separation Characteristics of Aviation Turbine Fuel.
D 2622 - Sulfur in Petroleum Products (X-Ray Spectrographic Method).
D 2624 - Electrical Conductivity of Aviation and Distillate Fuels Containing A Static Dissipator, Test Method for.
D 2887 - Boiling Range Distribution of Petroleum Fractions by Gas Chromatograph, Test Method for.
D 3120 - Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidation Microcoulometry.
D 3227 - Mercaptan Sulfur in Gasoline, Kerosene, Aviation Turbine and Distillate Fuels.
D 3241 - Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure), Standard Test Method for.
D 3242 - Acidity in Aviation Turbine Fuels, Test Method for.
D 3338 - Estimation of Heat of Combustion of Aviation Fuels, Method for.
D 3343 - Estimation of Hydrogen Content of Aviation Fuels.
D 3701 - Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry.
D 3828 - Flash Point by Setaflash Closed Tester, Test Method for.
D 3948 - Method For Determining Water-Separation Characteristics of Aviation Turbine Fuel by Portable Separometer.
D 4052 - Density and Relative Density of Liquids by Digital Density Meter.
D 4057 - Manual Sampling of Petroleum and Petroleum Products.
D 4176 - Free Water and Particulate Contamination in Distillate Fuels (Clear and Bright Pass/Fail Procedures).
D 4177 - Automatic Sampling of Petroleum Products.

D 4294 - Sulfur in Petroleum Products by Energy-Dispersive X-Ray Fluoresence Spectroscopy.
D 4737 - Calculated Cetane Index by Four Variable Equation.
D 4809 - Heat of Combustion of Liquid Hydrocarbons by Bomb Calorimeter (Intermediate Precision Method).
D 4955 - Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test).
D 5006 - Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels.
E 29 - Recommended Practices for Indicating Which Places of Figures are to be Considered Significant in Specified Limited Values.

(The test methods listed above are included in Volumes 05.01, 05.02, 05.03, and 05.04 of the Annual Book of ASTM Standards and are available individually. Applications for copies of all ASTM publications should be addressed to the American Society for Testing of Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 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 shall be refined petroleum distillates. Those fuels meeting the requirements shall contain catalytically or thermally processed blending fractions with additives as specified in 3.2.

3.2 Additives. Additive use shall be as specified.

3.2.1 Additives for type I fuel. Additives use shall be as specified in 3.2.1.1 through 3.2.1.3.

3.2.1.1 Stabilizer additive. The addition of stabilizer additives is mandatory. The finished fuel shall contain one of the following stabilizer additives at the concentration indicated:

a. Any product qualified under the provisions of MIL-S-53021 at the recommended effective concentration for that product.
b. FOA-15 [1/] at a concentration of 71 ±3 g/m^3 plus Biobor JF [2/] at a concentration of 227 ±10 g/m^3.

1/ FOA-15 is available from E. I. du Pont de Nemours and Company, Wilmington, DE 19898.

2/ Biobor JF is available from US Borax and Chemical Corporation, 3075 Wilshire Boulevard, Los Angeles, CA 90010.

3.2.1.2 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 any one 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.

3.2.1.3 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.

3.2.2 Additives for type II fuel. Additives use shall be as specified in 3.2.2.1 through 3.2.2.5. The type and amount of each additive shall be reported (see 6.3).

3.2.2.1 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 mg nor more than 24.0 mg of active ingredient per liter of fuel (6.0 to 8.4 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 24.0 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.

3.2.2.1.1 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 percent max tert-butylphenols and tri-tert-butylphenols
e. 72 percent min 6-tert-butyl-2,4-dimethylphenol
   28 percent max tert-butyl-methylphenols and tert-butyl-dimethylphenols

3.2.2.2 Metal deactivator. A metal deactivator, N,N'-disalicylidene-1, 2-propanediamine or N,N'-disalicylidene-1, 2-cyclohexanediamine may be blended into the fuel in an amount not to exceed two pounds active ingredient per 1,000 barrels of fuel (22 mg/gal (US), 26 mg/gal (UK), or 5.8 mg/liter).

3.2.2.3 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 (see 6.2). The approved electrical conductivity additive is Stadis 450 marketed by E. I. duPont de Nemours Company, Wilmington DE.

3.2.2.4 Corrosion inhibitor. A corrosion inhibitor conforming to MIL-I-25017 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 listed in the latest revision of QPL-25017. 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 to the qualification products listed in QPL-25017. The point of injection of the corrosion inhibitor shall be determined by agreement between the purchasing authority and the supplier.

3.2.2.5 Fuel systems icing inhibitor. The fuel system icing inhibitor is mandatory and shall conform to MIL-I-85470.

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

3.3.1 Type I referee fuel. The finished type I referee fuel which meets the minimum requirements of VV-F-800, shall conform to the requirements specified in table I.

TABLE I. Physical and chemical requirements and test methods for type I Referee.

Property	Value	ASTM
Density, Kg/L @ 15°C	Report	D 1298
Flash point, °C, min.	52	D 93
Cloud point, °C, max.	-13	D 2500
Pour point, °C, max.	-18	D 97
Kinematic viscosity, cSt at 40 °C	1.9 to 4.1	D 445
Distillation, °C		D 86
Initial boiling point	Report	
10% recovered, min.	220	
50% recovered	255 to 305	
90% recovered	310 to 360	
95% recovered	315 to 365	
End point, max.	385	
Residue volume %, max.	3	
Carbon residue on 10% bottoms, % wt, max.	0.20	D 524
Sulfur, % wt 1/	0.95 to 1.05	D 1552, D 129, or D 2622
Copper strip corrosion, 3 hours @ 50°C, max.	1	D 130
Ash, % wt, max.	0.02	D 482
Accelerated stability, total insolubles, mg/100 mL, max.	1.5	D 2274
Neutralization No., TAN, max.	0.2	D 974
Aromatics, volume %	Report	D 1319
Net heat of combustion, MJ/kg	Report	D 240
Particulate contamination, mg/L, max.	10	Appendix B
Cetane number 2/	37 to 43	D 613 3/, D 976, or D 4737
Free water & particulate contamination	Pass	D 4176

1/ Naturally-occurring sulfur is preferred. If additional sulfur is required, non-naturally-occurring sulfur compounds may be blended into the fuel. However, not less than half of the total sulfur in the finished fuel shall be naturally-occurring.
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 D 613 is the referee method for determining cetane quality. ASTM D 976 and D 4737 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 D 613 shall be permitted.

3.3.2 Type II referee fuel. The finished type II referee fuel which meets the minimum requirements of MIL-T-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/	D 156
Total acid number, mg KOH/gm		0.015	D 3242
Aromatics, vol percent		25.0	D 1319
Olefins, vol percent		5.0	D 1319
Sulfur, total, wt. percent		0.30	D 1266, D 2622 D 3120, D 4294
Sulfur mercaptan, wt % or		0.002	D 3227
Doctor test		negative	D 4952
Distillation temperature, °C 2/ (D 2887 limits given in parentheses)			D 86, D 2887
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)	D 93 3/,D 3828
Density or gravity			
Density, kg/L at 15 °C or	0.775	0.840	D 1298 or D 4052
Gravity, API at 60 °F	37.0	43.0	D 1298
Freezing point, °C (°F)		-47 (-53°)	D 2386
Viscosity, @-20°C, cSt		8.0	D 445
Viscosity @ 40°C, cSt	1.0	1.35	D 445
Net heat of combustion, MJ/kg	42.8		D 3338 4/,
or BTU/lb	(18,400)		D 4809, D 240
Hydrogen content, wt percent	13.4		D 3701, D 3343
Smoke point, mm, or	25.0		D 1322
Smoke point, mm and	19.0		D 1322
Naphthalenes, vol percent		3.0	D 1840
Cetane number	37	43	D 613
Copper corrosion, 2 hr @ 100 °C (210 °F)		No. 1	D 130
Thermal stability			D 3241 5/
change in pressure drop, mm Hg		25	
heater tube deposit, visual rating		<3	
Existent gum, mg/100 mL		7.0	D 381
Particulate matter, mg/L		1.0	Appendix B
Filtration time, minutes		15	Appendix B
Water reaction interface rating		1b	D 1094
Water separation index	6/		D 2550, D 3948
Fuel system icing inhibitor, vol%	0.10	0.15	D 5006
Fuel electrical conductivity, pS/m	7/	7/	D 2624

1/ To be reported - not limited.
2/ A condenser temperature of 0 to 4 °C (32 to 40 °F) shall be used for the distillation by ASTM D 86. Distillation shall be corrected to 760 mm pressure.
3/ ASTM D 93 is the referee method. Method IP170 is also permitted. The minimum flash point shall be 40 °C by ASTM D 56, as it can be 1 to 2 °C lower than those obtained by other methods.
4/ When the fuel distillation test is performed using ASTM D 2887, the average distillation temperature, for use in ASTM D 3338 shall be calculated as follows:

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

5/ See 4.6.2.1 for ASTM D 3241 test conditions and test limits.
6/ The minimum 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 pS/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 6.5).

3.5 Workmanship. 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 D 4176, method A or B.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5, as appropriate to the referee fuel type. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Lot.

4.2.1 Bulk lot. An indefinite quantity of a homogeneous mixture of one type of referee fuel offered for acceptance in a single, isolated container; or manufactured in a single plant run (not exceeding 24 hours), through the same processing equipment, with no change in the ingredient materials.

4.2.2 Packaged lot. An indefinite number of 55-gallon drums or smaller unit containers of identical size and type, offered for acceptance, and filled with a occurring mixture of one type of referee fuel from a single, isolated container; or filled with a homogeneous mixture of one type of referee fuel, manufactured in a single plant run (not exceeding 24 hours), through equipment, with no change in the ingredient materials.

4.3 Sampling.

4.3.1 Sampling for examination of filled containers. Take a random sample of filled containers from each packaged lot in accordance with MIL-STD-105 at inspection level II.

4.3.2 Sampling for tests. Take samples for tests in accordance with ASTM D 4057 or D 4177, except where individual test procedures contain specific sampling instructions.

4.4 Inspection. Perform inspection in accordance with FED-STD-791, method 9601. Samples taken in accordance with 4.3 shall be visually examined for compliance with 3.5.

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

4.4.2 Examination of filled containers. Examine samples taken in accordance with 4.3.1 for compliance with 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. If the number of defective or underfilled containers exceeds the acceptance number for the appropriate plan of MIL-STD-105, reject the lots represented by the sample.

4.5 Classification of tests. All tests are quality conformance tests.

4.6 Test methods. Perform tests in accordance with the applicable methods listed as specified.

4.6.1 Test methods for type I. Perform tests listed in table I and appendices A and B.

4.6.2 Test methods for type II. Perform tests in accordance with the applicable methods listed in table II for referee fuel type II, and those specified herein. For rounding off of significant figures, ASTM E 29 shall apply to all tests required by this specification.

4.6.2.1 Thermal stability. The thermal stability test shall be conducted using ASTM D 3241 (JFTOT). The heater tube shall be rated visually (see appendix C).

4.6.2.2 ASTM D 3241 test conditions.

a.	Heater tube temperature at maximum point:	260 °C (500 °F).
b.	Fuel system pressure:	3.45 MPa (500 psig).
c.	Fuel flow rate:	3.0 mL/min.
d.	Test duration:	150 minutes.

4.6.2.3 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 millimeters 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) (appendix C, 10.6.3.1 and 10.6.3.2).

4.6.2.4 ASTM D 3241 reported data. The following data shall be reported:

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

4.6.3 Test report. Unless otherwise specified (see 6.2), test data required by 4.6 shall be reported in the same order as listed in table I or table II, as appropriate.

4.7 Report of analysis. The contractor shall provide copies of analysis reports, giving the results of these tests and a statement of the types and concentrations of the additives used in the referee fuel.

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

5. PACKAGING

5.1 Packing and marking. Referee fuel contained in the size and type container specified (see 6.2), shall be packed and marked in accordance with MIL-STD-290. Packing shall be level B, C, or commercial as specified (see 6.2).

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 for use in research, development and verification testing of all compression-ignition engines, diesel-powered auxiliary units, turbine engine driven ground vehicle, 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 VV-F-800 or MIL-T-83133 (ground systems only) fuels without approval of the engine manufacturer or from the US Army Belvoir Research, Development, and Engineering Center, ATTN: SATBE-FL, Fort Belvoir, VA 22060-5606. The referee fuel Type I meets the requirements of the 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, VV-F-800, and JP-8 under MIL-T-83133, respectively. Type I referee fuel has the same cloud point (-13 °C) and pour point (-18 °C) as DF-2 procured for Europe and South Korea. The actual low temperature 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 a 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 1.1).
c. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
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 3.2.2.3 and table II).
e. When test data will be reported in an order other than as specified (see 4.6.3).
f. Size and type of container required (see 5.1)
g. Level of packing required (see 5.1)
h. Quantity of referee fuel required. The unit of purchase is the U.S. gallon (231 cubic inches at 60 °F [15.6 °C]).

6.3 Precaution for mixing additives. To prevent possible reaction among the concentrated forms of different additives (see 3.2.2) 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.

6.4 Definition. Referee grade fuel is defined as fuel representing the minimal or marginal quality level which can be procured under specification VV-F-800 or MIL-T-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 VV-F-800 or MIL-T-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-T-5624.

6.5 Material safety. The contracting officer will ensure that the contractor prepares Material Safety Data Sheets in accordance with FED-STD-313 and that copies are provided to the pertinent Government mailing address that are listed in FED-STD-313, appendix B (see 3.4).

6.6 Subject term (key word) listing.

Compression ignition
DF-2
Engine certification
Engine qualification
JP-8
Research
Testing
Turbine

Custodian:
Army - ME

Review activities:
Army - AT, GL
DLA - PS

User activity:
Army - CE, TE

Preparing activity:
Army - ME

Project 9140-A127

DETECTION OF NITRATE-TYPE IGNITION IMPROVERS IN DIESEL FUEL

10. SCOPE

10.1 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 D 524, ASTM D 976, and ASTM D 4737.

20. SUMMARY

20.1 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.

30. APPARATUS

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

30.2 Glass fiber filter paper. Glass fiber filter paper, 37-mm diameter, Grade 934 AH (Whatman, Ltd., or equivalent).

30.3 Pipette. Pipette, 10-mL 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.

30.4 Graduated cylinder. Graduated cylinder, 10-mL and 25-mL capacity.

30.5 Suction flask. Suction flask with a suitable holder to accommodate a 60-mL glass-fitted crucible.

30.6 Crucible. Crucible, 60-mL capacity, glass-fitted, medium porosity.

30.7 Oven. Oven suitable for drying filter discs at 110 °C.

40. REAGENTS

40.1 Saponification mixture (1N). Prepare by mixing 6.5 g of potassium hydroxide (ADS reagent grade) with 100 mL 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.

40.2 Diphenylamine (1 percent solution). Prepare by dissolving 0.250 g of diphenylamine (ACS indicator grade in 25 mL of sulfuric acid (sp gr 1.834).

40.3 Toluene (ACS reagent grade).

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

50. PROCEDURE

50.1 Pipette 10 mL of the sample into the reaction bottle and add 5 mL of toluene followed by 10 mL of the saponification mixture.

-----NOTE-----
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 30.3 should be used.

50.2 Affix cap to the reaction bottle tightly and, after mixing the contents, place it in an oven maintained at 110 °C for four hours.

50.3 Remove the reaction bottle from the oven and allow it to cool to 25 ±3 °C.

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

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

50.6 Carefully remove the glass fiber filter disc and dry it in oven at 110 °C for 15 minutes.

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

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

60. REPORT

60.1 The presence of organic nitrate ester-type cetane improvers will be reported if the formation of a blue color occurs. Reference samples of diesel fuels containing 0.5 percent by volume of any one of the approved cetane improvers (see 3.2.2) give an intense blue to blue-black color throughout the reagent spot whereas those samples containing only 0.1 percent 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 D 524) must be performed on a neat or base-fuel blend.

METHODS FOR DETERMINATION OF FILTRATION TIME AND TOTAL SOLIDS (PARTICULATE)

10. 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.

20 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).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 2276 - Particulate Contaminant in Aviation Turbine Fuels.

(Applications for copies should be addressed to the American Society for Testing of Materials, 1916 Race Street, Philadelphia, PA 19103.)

30. Summary of methods. 3.79 liters (one gallon) 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.

40. Apparatus.

a. Membrane filter: White, plain 47 mm diameter, nominal pore size 0.8 micron. The membrane must be approved by ASTM for use with ASTM D 2276.
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 diameter paper flow reducer ring with dimensions to give filtering area of 4.8cm^2. (Millipore Corporation Part No. XX10 0447 10.)
d. Vacuum flask: A minimum of 4 liters.
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).
g. Forceps: Flat-bladed with unserrated nonpoint tips.
h. Solvent filtering dispenser: Containing a 1.2 micron maximum port size filter in the delivery line.
i. Glass petri dish: Approximately 125 mm in diameter with removable cover.
j. Analytical balance: Single or double pan, the precision standard deviation of which must be 0.07 mg or better.

50. 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 D 2276. All metal parts of the filtration apparatus are to be electrical bonded and grounded, including the fuel sample container and the metal insert ring, if used. See ASTM D 2276 for other Precautionary Statements.

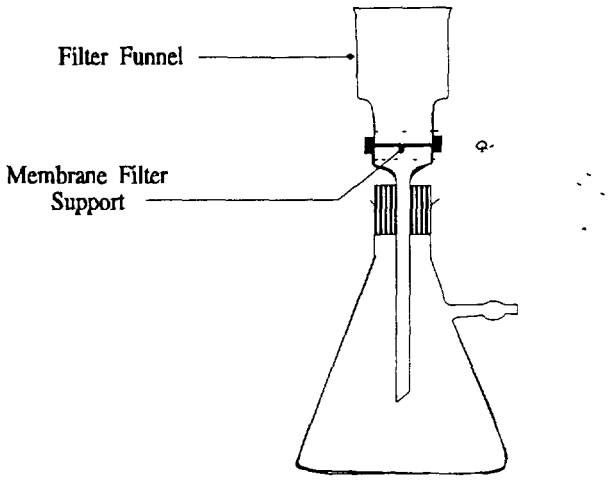

Figure 1

60. Sampling. Obtain a representative one gallon sample as directed in section 9. Sampling of ASTM D 2276. When sampling from a flowing stream is not possible, an all level sample or an average sample, in accordance with ASTM D 4057 or ASTM D 4177 shall be permitted. The 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.

70. 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. 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 will 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 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. Record the vacuum in kPa (inches of mercury) one minutes 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. Report 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. Report the vacuum in kPa (inches of mercury) as determined from the average of the two readings taken in 70.f.

i. After recording 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 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 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. Report the total solids content in mg/liter by using the following formula:

$$\frac{\text{Weigh gain of filter in mgs}}{3.785} = \text{mg/liter}$$

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 3785.

$$\frac{\text{Weigh gain of filter in mgs}}{\text{mL of fuel filtered X } 0.001} = \text{mg/liter}$$

80. 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 (20 inches of mercury).
(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.

90. NOTES.

90.1 If it is desired to determine the filtration time and not the total solids content, perform the test by omitting steps 70.i, 70.j, 70.k, 70.l.

90.2 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 8 of ASTM D 2276 apply.

HEATER TUBE DEPOSIT RATING

10. Visual method.

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

10.2 Push the heater tube against the stop of the adapter.

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

10.4 Insert the ASTM color standard into the tuberator.

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

10.6 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 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 (that is lower number) color standards. (NOTE: It is important that all light bulbs in the tuberator are functional as a change in light intensity can shift the rating significantly.) (NOTE: The person rating the tube should have normal ability to distinguish between colors: i.e., the rater should not be color blind.)

10.6.1 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.

10.6.2 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 sq cm (0.004 sq inch); i.e., approximately 1.5 mm x 1.5 mm (1/16 inch x 1/16 inch) square or an equivalent area. However, a streak deposit shall be ignored if less than 0.8 mm (1/32 inch) wide, regardless of the length. Note that the tube section is about 3 mm (1/8 inch) in diameter, thus a 1.5 mm (1/16 inch) wide spot is half the diameter of the tube test section and 0.8 mm (1/31 inch) wide streak is one fourth the diameter of the tube test section.

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

10.6.3.1 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.

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

10.6.3.3 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 to be reported 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 to be reported is 1A.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-F-46162D(ME)	2. DOCUMENT DATE (YYMMDD) 921123

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 (if applicable) (2) AUTOVON	7. DATE SUBMITTED

8. PREPARING ACTIVITY

a. NAME Betty Taylor	b. TELEPHONE (Include Area Code) (1) Commercial (703) 704-3466 (2) AUTOVON 654-3466
c ADDRESS (Include Zip Code US Army Belvoir RDE Center ATTN SATBE-TSE Fort Belvoir, VA 22060-5606	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340