



Fuels

GASEOUS FUELS FOR GAS TURBINES

The recommended and optional test packages developed in this section are based on the international specification for Natural Gas and Gaseous Mixtures, ISO 6974. These required tests are further supplemented according to guidelines provided by the various turbine manufacturers. A list of other optional tests is also given. A combination of our recommended tests and the available optional tests should satisfy the requirements for gaseous fuels for most turbine manufacturers.

ISO 6974 Specification for Gas Fuel	
Test Code	Description
ASTM D 1945.a	Composition of Natural Gas by Gas Chromatography: Includes Hydrogen, Nitrogen, Oxygen, Carbon Monoxide, Carbon Dioxide, Argon, Helium, Methane, Ethane, Propane, iso-Butane, n-Butane, iso-Pentane, n-Pentane, and Hexane
Calculated	Hydrocarbon Dewpoint (client must provide measurement at sampling point)
ASTM D 3588.a	Calorific Value and Specific Gravity of Gaseous Fuels
ASTM D 3588.b	Higher Heating Value (HHV), as Btu/SCF and as Btu/lb.
ASTM D 3588.c	Lower Heating Value (LHV), as Btu/SCF and as Btu/lb.
Calculated	Molecular Weight
ASTM D 3588.d	Specific Gravity at 59°F and 1 atmosphere
Calculated	Density
ASTM D 3246	Total Sulfur in Petroleum Gas by Microcoulometry, (Condensables)
ASTM D 1142	Water Vapor Content (Moisture Content) of Gaseous Fuels by Measurements of Dew Point Temperature
Additional Tests	
ASTM D 1945.b	Extended Composition of Natural Gas by Gas Chromatography. Includes mole percent of the following components when their presence is suspected: Acetylene, Ethylene, Propylene, Butylene, Octane, Nonane, Decane, Undecane, Dodecane, and Tridecane
TOL SC 6028.a	Collection and Microscopical Sizing, Counting of Particulates in Gas, μm
TOL SC 6028.b	Maximum Size of Particulates in Gas, μm
ASTM D 3605.g	Trace Metals in Gas Turbine Fuels by Flame Atomic Absorption Spectroscopy. Includes: Sodium, Potassium, Vanadium, Lead, Calcium, Barium, Magnesium, and Phosphorous, LOD = 0.05 ppm
ASTM D 4629	Nitrogen, Organically Bound, by Chemiluminescence
ASTM D 5504	Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Chemiluminescence. Includes: Hydrogen Sulfide, Carbonyl Sulfide, Hydrogen Cyanide, Ammonia, and other contaminants above 0.001 vol. % (above 1 ppm)

GASEOUS FUELS FOR GAS TURBINES

Individual gas turbine manufacturers have specifications that may be more detailed than those identified in ISO 6974. This is often true with regard to higher carbon number contaminants, particulates, or trace metals. Texas OilTech Laboratories, Inc. is prepared to recommend specific test packages for individual turbine manufacturers based on our knowledge of their fuel specifications.

Some turbine manufacturers have fuel specifications with additional testing requirements and these include:

- Siemens Specification ZDX555-DC02-MPB-2500-01
 - a. Qualification Tests
 - b. Performance Tests
- General Electric Corporation Specification TMD-TD-00001
- Pratt & Whitney Specification FR-2
- Solar Turbines Specification ES-9-98

Siemens Specification ZDX555-DC01-MBP-2500-01, Qualification Tests for Gas Fuels

Note 1: This test is included for the following Gas Turbine Frames: SGT-1000F, SGT6-2000E(6), SGT5-2000(3),(6),(7), SGT5-3000E(2), SGT6-4000F(2),(4), SGT5-4000F(2),(4)

Note 2: Higher Heating Value, HHV, and Lower Heating Value, LHV, can also be provided in units of Btu/lb or Btu/scf

Note 3: In lieu of ASTM D 3605. This method is more accurate and has better detection limit.

Siemens Specification Package ZDX555-DC01-MBP-2500-01 Performance Tests for Gas Fuels

General Electric Corporation MID-TD-00001 Specification, Recommended Tests

PWPS Specification FR-2, Recommended Tests

Solar Turbines Specification ES 9-98-U, Recommended Tests

GASEOUS FUELS FOR GAS TURBINES

Liquid Petroleum Gas (LPG) specifications can be found in GPA 2140 from the Gas Producers Association or in ASTM D 1835, as shown below.

LPG Quality Assurance Test Package per ASTM D 1835 and GPA 2140	
Test Code	Description
ASTM D 1267	Vapor Pressure of Liquefied Petroleum (LP) Gases
ASTM D 1837	Volatility of Liquefied Petroleum (LP) Gases
ASTM D 2158	Residual Matter in Liquefied Petroleum Gases
ASTM D 1838	Corrosion, Copper Strip, Liquefied Petroleum Gas
ASTM D 2784	Sulfur in Liquefied Petroleum Gases
ASTM D 2420	Hydrogen Sulfide in Liquefied Petroleum (LP) Gases
ASTM D 2163	Composition of Liquid Petroleum (LP) Gas and Propane by GC
ASTM D 1835.a	Free Water Content, Visual Method
ASTM D 1657	Relative Density at 60/60°F (15.6/15.6°C)
Additional Tests	
ASTM D 2713	Dryness of Propane, Valve Freeze Method (Performed on site only)
ASTM D 2598	Calculation of Certain Physical Properties of Liquefied Petroleum (LP) Gases from Compositional Analysis (price includes compositional analysis)
ASTM D 3605.c	Trace Metals in Gas Turbine Fuels by Flame Atomic Absorption Spectrometry. Includes: Sodium, Potassium, and Lithium, LOD = 0.05 ppm

When the focus is on contaminants in Pipeline Gas, a special group of tests is also identified below:

Gas Pipeline Contaminants Analysis	
Test Code	Description
ASTM D 4951.a	Additive Elements in Lubricating Oils by Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES)
ASTM D 482	Ash Content of Petroleum Products
ASTM F 1375	Energy Dispersive X-Ray Analysis (EDX)
TOL 5054	Scanning Electronic Microscope (SEM) Analysis
Optional Tests for Gas Fuel Analysis	
Test Codes	Description
ASTM D 6420	Aromatics, Paraffins, and Olefins Content by GC/MS
ASTM D 5504	Hydrogen Sulfide, Carbonyl Sulfide, Hydrogen Cyanide, Ammonia
ASTM D 3588.a	Calorific Value and Specific Gravity, Compressibility, and Molecular Weight of Gases
ASTM D 3246	Total Sulfur in Gas
ASTM D 5454	Water Vapor Content of Gaseous Fuels Using Electronic Moisture Analyzers
ASTM D 1142	Water Vapor Content of Gaseous Fuels by Dewpoint
ASTM D 4629	Nitrogen, Organically Bound, by Chemiluminescence
ASTM D 3605.g	Metals by Flame AA. Includes: Na, K, V, Pb, Ca, Ba, Mg, P, Cr, ppm.
TOL SC 6028.a	Collection and Microscopical Sizing, Counting of Particulates in Gas (Recommended for overseas gas samples)

GAS TURBINE LIQUID FUEL

The test packages for liquid fuels for stationary gas turbines in power plants are based on ASTM Specification D 2880. ISO 4261 is a parallel document to ASTM D 2880 with similar testing procedures and specifications for gas turbine liquid fuels. ASTM Specification D 6615 covers jet fuels for aircraft.

There are five grades of fuel covered by ASTM D 2880. Grades 1-GT and 2-GT are distillate fuels, which differ in viscosity range. Grade 1-GT (1 to 2 cP) is the most widely used in power plants. Grade 2-GT (2 to 4 cP) may be slightly less clean burning.

Grades 3-GT and 4-GT are typically residual fuel oils or blends with viscosity from 5 cP upward to semi-solid hydrocarbons that require fuel heating. The gas turbine manufacturers should be consulted for appropriate specification limits. Grade 0-GT includes naphtha, Jet B fuel, and other light hydrocarbon liquids with low flash point and low viscosity.

Individual gas turbine manufacturers have specifications that may be more detailed than those identified in ASTM D 2880. This is often true with regard to contaminants such as water, microbial slimes, particulates, and trace metals. We can recommend specific test packages to meet individual turbine manufacturers' specifications.

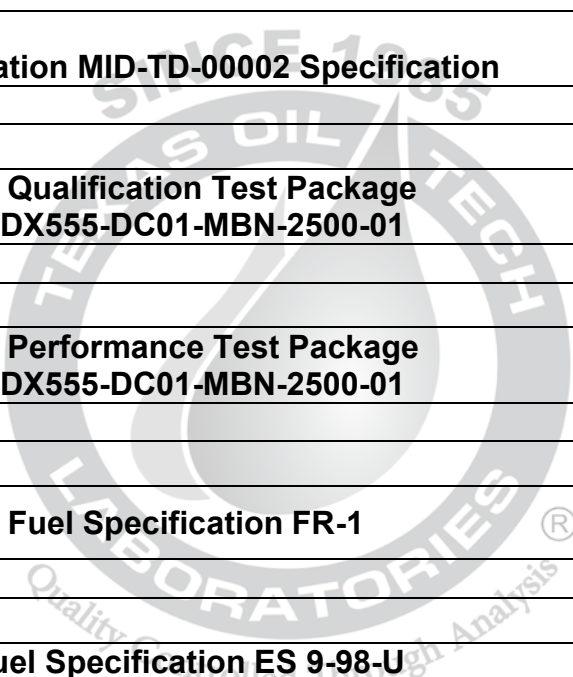
Gas Turbine Fuel Oil General Electric Corporation MID-TD-00002 Specification

Gas Turbine Liquid Fuel Qualification Test Package Siemens Specification ZDX555-DC01-MBN-2500-01

Gas Turbine Liquid Fuel Performance Test Package Siemens Specification ZDX555-DC01-MBN-2500-01

Test Package per PWPS Fuel Specification FR-1

Solar Turbines Liquid Fuel Specification ES 9-98-U Qualification Tests



GAS TURBINE LIQUID FUEL

ISO 4261 is a parallel document to ASTM D 2880 and offers similar testing procedures and specifications for gas turbine fuel oils. Individual gas turbine manufacturers have specifications that may be more detailed than those identified in ASTM D 2880. This is often true with regard to contaminants such as water, microbial slimes, particulates, and trace metals. Texas OilTech Laboratories, Inc. is prepared to recommend specific test packages for individual turbine manufacturers based on our knowledge of their fuel specifications.

Gas Turbine Fuel Oil, ASTM D 2880 Specification Distillate Grades No. 1-GT and No. 2-G T

Test Code	Description
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 2709	Water and Sediment in Distillate Fuels, BS&W
ASTM D 86.b	Distillation of Petroleum Products
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 524.b	Carbon Residue, Ramsbottom on 10% Residue
ASTM D 482	Ash Content of Petroleum Products
ASTM D 1298	API Gravity of Petroleum Products, Hydrometer Method (Density, Relative Density, Specific Gravity)
ASTM D 97	Pour Point of Petroleum Oils

Gas Turbine Fuel Oil, ASTM D 2880 Specification Additional Tests for Liquid Turbine Fuels

Test Code	Description
ASTM D 95	Water by Distillation, Petroleum Products
ASTM E 203	Water Content by Karl Fischer Method, Engine Coolants
ASTM D 512	Chloride, Inorganic, in Water and Wastewater
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems
ASTM D 5452	Particulate Contamination in Aviation Fuels by Laboratory Filtration
ASTM D 6217	Particulate Contamination in Middle Distillate Fuels by Filtration
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy LOD = 0.01 wt%
ASTM D 3605.b	Trace Metals by Flame Atomic Absorption Spectroscopy. Includes: Sodium and Potassium, LOD = 0.05 ppm
ASTM D 5673.b	Trace Metals by ICP-MS Includes: Vanadium, Sodium, Potassium, Lithium, Lead, and Calcium. LOD = 0.05 ppm
ASTM D 6728	Metals and Contaminants in Gas Turbine and Diesel Engine Fuel by Rotating Disc Electrode Atomic Emission Spectrometry

AVIATION TURBINE FUEL

Aviation turbine fuels are Middle Distillate products containing special additives to achieve the desired performance.

ASTM Specification D 6615 identifies a specific type of aviation turbine fuel for civil use which is a wide boiling range distillate fuel and has an advantage of operating in very low temperature environments. ASTM D 6155 is a related specification for Aviation Turbine Fuels that requires many of the same test procedures.

ASTM D 7223 is the current standard specification for Jet C-1 Aviation Certification Turbine Fuel.

Aviation Turbine Fuel, Jet B, Wide Boiling Range ASTM D 6615 Specification, Qualification Test Package

Test Code	Description
ASTM D 1319	Hydrocarbon Types in Liquid Petroleum by Fluorescent Indicator Absorption (FIA)
ASTM D 6379	Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates
ASTM D 3277	Mercaptan Sulfur in Gasoline, Kerosene and Distillate Fuels
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy LOD = 0.01 wt%
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 4052	Density and Relative Density of Liquids by Digital Density Meter
ASTM D 5191	Vapor Pressure of Petroleum Products, Automatic Method
ASTM D 2386	Freezing Point of Aviation Fuels
ASTM D 4809	Heat of Combustion of Liquid Hydrocarbon Fuel by Bomb Calorimeter
ASTM D 1322	Smoke Point of Kerosene and Aviation Turbine Fuels
ASTM D 1840	Naphthalene Content in Aviation Turbine Fuels
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 3241	Thermal Oxidation Stability of Aviation Turbine Fuels, JFTOT Procedure
ASTM D 381.b	Gum Content, Existent, in Fuels by Steam Jet Evaporation
ASTM D 2624	Electrical Conductivity, Aviation Fuels
ASTM D 3948	Separometer Index, Water Separation Characteristics, Micro (WISM or MSEA)

Additional Tests	
ASTM D 4952	Doctor Test, Sulfur Species in Fuels and Solvents
ASTM D 5901	Freezing Point of Aviation Fuels, Automatic Optical Method
ASTM D 5972	Freezing Point of Aviation Fuels, Automatic Phase Transition Method
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems

Additives: Any additives to be used as supplements to an approved Aviation Turbine fuel must be separately approved on an individual basis. These may include: Antioxidants, Metal Deactivators, Electrical Conductivity Additives, Leak Detecting Additives, and Fuel System Icing Inhibitors. Request separate quotation.

AVIATION TURBINE FUEL

Aviation Turbine Fuel, Grades JP-4 (NATO F-40) and JP-5 (NATO F-44) MIL-DTL-5624U Specification, Qualification Test Package

Test Code	Description
ASTM D 156	Color, Saybolt Chromometer Method
ASTM D 3242	Acidity in Aviation Turbine Fuel, Acid Number
ASTM D 1319	Hydrocarbon Types in Liquid Petroleum by Fluorescent Indicator Absorption (FIA)
ASTM D 3277	Mercaptan Sulfur in Gasoline, Kerosene and Distillate Fuels
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy LOD = 0.01 wt%
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 1298	Specific Gravity at 60°F and 100°F
ASTM D 976	Cetane Index, Calculated from API Gravity and Distillation
ASTM D 323	Vapor Pressure of Petroleum Products, Reid Method
ASTM D 2386	Freezing Point of Aviation Fuels
ASTM D 445.c	Viscosity, Kinematic, at -20°C
ASTM D 4809	Heat of Combustion of Liquid Hydrocarbon Fuel by Bomb Calorimeter
ASTM D 3701	Hydrogen Content of Aviation Turbine Fuels by NMRS
ASTM D 1322	Smoke Point of Kerosene and Aviation Turbine Fuels
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours at 100°C
ASTM D 3241	Thermal Oxidation Stability of Aviation Turbine Fuels, JFTOT Procedure
ASTM D 381.b	Gum Content, Existent, in Fuels by Steam Jet Evaporation
ASTM D 5452	Particulate Contamination in Aviation Fuels by Laboratory Filtration
ASTM D 1094	Water Reaction of Aviation Fuels
ASTM D 4948	Separometer Index, Water Separation Characteristics, Micro (WISM or MSEA)
ASTM D 5006	Anti-Icing Inhibitors (Ether) in Aviation Fuel
ASTM D 2624	Electrical Conductivity, Aviation Fuels

Additional Tests

ASTM D 6045	Color of Petroleum Products by Tristimulus Method
ASTM D 4952	Doctor Test, Sulfur Species in Fuels and Solvents
ASTM D 2622	Sulfur, X-Ray Spectrometry, LOD = 0.001 wt%
ASTM D 5972	Freezing Point of Aviation Fuels, Automatic Phase Transition Method

Fuel System Icing Inhibitors Type III - DiEGME Diethylene Glycol Monomethyl Ether - ASTM D 4171.b

Test Code	Description
ASTM D 1613	Acidity in Volatile Solvents and Chemical Inhibitors
ASTM D1209	Color, APHA, Platinum Cobalt Scale
ASTM E 70	pH of Aqueous Solutions, with Glass Electrode
ASTM D 4052	Density and Relative Density of Liquids by Digital Density Meter
ASTM D 1364	Water Content by Karl Fischer Method, Volatile Solvents
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 6810	Antioxidant Concentration in HL Turbine Oils

Additional Tests

ASTM D 5006	Anti-Icing Inhibitors (Ether) in Aviation Fuels
ASTM E 1064	Water Content by Karl Fischer Method, Organic Liquids
ASTM E 203	Water Content by Volumetric Karl Fischer Method

DIESEL FUELS AND BIODIESEL

Diesel engines can burn a wide range of hydrocarbon fuels ranging from light distillate fuels such as No 1 Diesel to heavy residual fuels such as Bunker C or No. 5 Fuel Oil. New regulations for Diesel Motor Fuels dictate low sulfur levels.

ASTM D 975 covers seven grades of diesel fuel oils that are suitable for various types of diesel engines:

1. Grade No. 1-D S15 is a special purpose, light middle distillate fuel with a maximum of 15 ppm sulfur.
2. Grade No. 1-D S500 is a special purpose, light middle distillate fuel with a maximum of 500 ppm sulfur.
3. Grade No. 1-D S5000 is a special purpose, light middle distillate fuel with a maximum of 5000 ppm sulfur.
4. Grade No. 2-D S15 is a general purpose, middle distillate fuel with a maximum of 15 ppm sulfur.
5. Grade No. 2-D S500 is a special purpose, middle distillate fuel with a maximum of 500 ppm sulfur.
6. Grade No. 2-D S5000 is a special purpose, middle distillate fuel with a maximum of 5000 ppm sulfur.
7. Grade No. 4-D is a heavy distillate fuel, or blend of distillate and residual oil.

The S5000 grades correspond to the previous “regular” sulfur grades. The S500 grades correspond to the previous “low sulfur” grades. The S15 grades were previously called “ultra-low sulfur” grades or ULSD.

Diesel Fuel Oils, ASTM D 975 Specification Qualification Test Package, Grades No. 1-D S500 and 2-D S500

Test Code	Description
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 2709	Water and Sediment in Distillate Fuels, BS&W
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 482	Ash Content of Petroleum Products
ASTM D 2622	Sulfur, X-Ray Spectrometry. LOD = 0.001 wt%
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 613	Cetane Number, Ignition Quality of Diesel Fuels
ASTM D 287.a	API Gravity, Hydrometer Method
ASTM D 976	Cetane Index, Calculated from Distillation and API Gravity
ASTM D 2500	Cloud Point of Petroleum Products
ASTM D 4539	Filterability of Diesel Fuels by Low Temperature Flow Test (LTFT) Method
ASTM D 524.b	Carbon Residue, Ramsbottom on 10% Residue
ASTM D 6079	Lubricity of Diesel Fuels by the High Frequency Reciprocating Rig (HFRR)
ASTM D 4308	Electrical Conductivity of Liquid Hydrocarbons

Additional Tests	
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems
ASTM D 6468	Oxidation Stability, Distillate Fuels
ASTM D 2274	Oxidation Stability, Light Fuel Oils, 16 hr
ASTM D 1319	Hydrocarbon Types in Liquid Petroleum by Fluorescent Indicator Absorption (FIA)
ASTM D 2624	Electrical Conductivity, Aviation Fuels
ASTM D 6217	Particulate Contamination in Middle Distillate Fuels by Filtration
ASTM D 97	Pour Point of Petroleum Oils
ASTM D 2887.c	Simulated Distillation, SimDis, Lower Temperature Range, 55 to 538°C, C ₅ to C ₄₄
ASTM D 3117	Wax Appearance Point of Distillate Fuels
ASTM D 6371	Cold Filter Plugging Point of Diesel and Heating Fuels, CFPP
ASTM D 6078.a	Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator, (SLBOCLE), Procedure A: Incremental Load
ASTM D 6078.b	Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator, (SLBOCLE). Procedure B: Single-Load Test

BIODIESEL FUEL, B 100 BLEND STOCK

Biodiesel Blend Stock is derived from vegetable oil and animal fat and may be blended with petroleum distillate fuels to achieve regulated levels of sulfur or aromatics. Presently, Biodiesel B 100 Blend Stock is available in two grades. S15 has a sulfur content of less than 15 ppm (0.0015 wt %), S500 has a sulfur content of less than 500 ppm (0.05 wt %).

Up to 5% Biodiesel that meets ASTM Specification D 6751-08 is permitted for use in No. 1 and No. 2 grades of Diesel Fuel. Test method EN 14078 for Fatty Acid Methyl Esters (FAME) is used to determine the percentage of Biodiesel in a diesel fuel.

Biodiesel Fuel (B 100) Blend Stock, ASTM D 6751 Specification Grade S15 and Grade S500, Qualification Test Package	
Test Code	Description
EN 14538.a	Calcium, Magnesium Content
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 2709	Water and Sediment in Distillate Fuels, BS&W
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 874	Ash, Sulfated Residue, Lube Oils and Additives
ASTM D 5453	Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by UV Fluorescence
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 613	Cetane Number, Ignition Quality of Diesel Fuels
ASTM D 2500	Cloud Point of Petroleum Products
ASTM D 4530	Carbon Residue (Micro Method)
ASTM D 664	Acid Number of Petroleum Products, Potentiometric Titration
ASTM D 6584	Glycerin, Free and Total, in Biodiesel Fuel B 100 (Methyl Esters) by Gas Chromatography
ASTM D 4951.b	Phosphorus Content in Biodiesel Fuels by ICP-AES
ASTM D 1160	Distillation of Petroleum Products at Reduced Pressures, 5 and 10 mm
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems
EN 14538.b	Potassium and Sodium Content
EN 14112	Oxidation Stability
Additional Tests	
ASTM D 3242	Acidity in Aviation Turbine Fuel, Acid Number
ASTM D 287.a	API Gravity, Hydrometer Method
ASTM D 189.b	Carbon Residue, Conradson on 10% Residue
ASTM D 524.b	Carbon Residue, Ramsbottom on 10% Residue
ASTM D 4737	Cetane Index, Calculated by Four Variable Equation (may be substituted for Cetane Number when ASTM D 613 is not available).
ASTM D 976	Cetane Index, Calculated from Distillation and API Gravity
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 6079	Lubricity of Diesel Fuels by the High Frequency Reciprocating Rig (HFRR)
ASTM D 6078.a	Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator, (SLBOCLE), Procedure A: Incremental Load
ASTM D 6078.b	Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator, (SLBOCLE). Procedure B: Single-Load Test
EN 14110	Methanol Content
ASTM D 2274	Oxidation Stability, Light Fuel Oils, 16 hr
ASTM D 6217	Particulate Contamination in Middle Distillate Fuels by Filtration
ASTM D 1266	Sulfur, Lamp Method. LOD = 0.01 wt%
ASTM D 2622	Sulfur, X-Ray Spectrometry. LOD = 0.001 wt%
ASTM D 3120	Sulfur, by Microcoulometry, Light Hydrocarbons
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%
ASTM D 1796	Water and Sediment in Fuel Oils, BS&W
ASTM D 3117	Wax Appearance Point of Distillate Fuels

FUEL OILS, RESIDUAL OILS, AND KEROSENE

Distilled petroleum products, and blends of distilled and residual products, are covered by several specifications. Fuel oils are middle distillate fuels and resemble diesel fuels in terms of distillate range. However, the products described in ASTM D 396 (Fuel Oils) and ASTM D 3699 (Kerosene) are primarily non-automotive grades and are used for heating in burners and furnaces.

U.S. Regulations 40CFR, Part 80 requires that a sufficient amount of Red Dye 164 be added to non-taxable middle distillates for off-road use

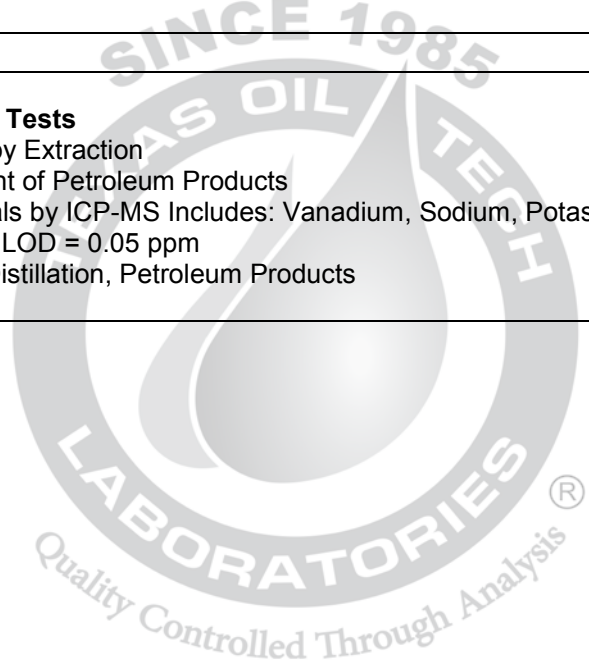
Fuel Oil, ASTM D 396 Specification	
Grades No 1S 500, No 1S 5000, No 2S 5000, and No 4 (Light)	
Test Code	Description
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 2709	Water and Sediment in Distillate Fuels, BS&W
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 524.b	Carbon Residue, Ramsbottom on 10% Residue
ASTM D 482	Ash Content of Petroleum Products
ASTM D 2622	Sulfur, X-Ray Spectrometry. LOD = 0.001 wt%
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 1298	API Gravity of Petroleum Products, Hydrometer Method (Density, Relative Density, Specific Gravity)
ASTM D 97	Pour Point of Petroleum Oils
Additional Tests	
ASTM D 5291.a	Carbon, Hydrogen, and Nitrogen in Petroleum Products, Instrumental
ASTM D 2500	Cloud Point of Petroleum Products
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems
ASTM D 3245	Pumpability of Industrial Fuel Oils
ASTM D 95	Water by Distillation, Petroleum Products
ASTM D 5673.b	Trace Metals by ICP-MS Includes: Vanadium, Sodium, Potassium, Lithium, Lead, and Calcium. LOD = 0.05 ppm
ASTM D 473	Sediment by Extraction
ASTM D 2887.c	Simulated Distillation, SimDis, Lower Temperature Range, 55 to 538°C, C5 to C44
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%

Kerosene, ASTM D 3699 Specification	
Qualification Test Package for Grades 1K (Low Sulfur) and 2K	
Test Code	Description
ASTM D 56	Flash Point, Tag Closed Tester
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 1266	Sulfur, Lamp Method LOD = 0.01 wt%, Referee Method
ASTM D 3277	Mercaptan Sulfur in Gasoline, Kerosene and Distillate Fuels
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 2386	Freezing Point of Aviation Fuels
ASTM D 187	Burning Quality of Kerosene, 16 hr and 48 hr
ASTM D 156	Color, Saybolt Chromometer Method

FUEL OILS, RESIDUAL OILS, AND KEROSENE

The Basic 6 Test Package represents the traditional test for quality control of distillate fuels. The Basic 8 Test Package also includes Water by Distillation and Sediment by Extraction for heavier distillates or blends distillate with residual fuel, or when BS&W is greater than 0.5 vol%. The Basic 10 Test Package, in keeping with current best practice for fuel oil quality control, further adds Ash and Trace Metals analysis by ICP/MS.

Fuel Oil Quality Control, ASTM D 396 Specification Basic 6, Basic 8, and Basic 10 Test Packages	
Test Code	Description
ASTM D 287.a	API Gravity of Petroleum Products, Hydrometer Method (Density, Relative Density, Specific Gravity).
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 97	Pour Point of Petroleum Oils
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%
ASTM D 1796	Water and Sediment in Fuel Oils, BS&W
Additional Tests	
ASTM D 473	Sediment by Extraction
ASTM D 482	Ash Content of Petroleum Products
ASTM D 5673.b	Trace Metals by ICP-MS Includes: Vanadium, Sodium, Potassium, Lithium, Lead, and Calcium. LOD = 0.05 ppm
ASTM D 95	Water by Distillation, Petroleum Products



MARINE FUELS

Marine diesel engines are designed to burn a wide range of hydrocarbon fuels ranging from light distillate fuels to residual fuels such as Bunker C or No. 5 Fuel Oil.

Test packages for marine diesel fuels are based on the International Standards Specification ISO 8217. The corresponding ASTM D 2069 Specification was withdrawn in the year 2003. There is a direct correspondence between the two specifications and for each required test.

The specification ISO 8217 covers a total of nineteen grades of Marine Fuel (Class F), which include four grades of Marine Distillate Fuel and fifteen grades of Marine Residual Fuel. This classification reflects the wide range of petroleum fuels that are used in marine diesel engines and boilers.

Our test packages show the recommended tests for qualifying a given fuel grade. Other optional tests are also shown to give a more detailed description of stored fuels when oxidation or contamination may be of special concern.

Marine Distillate Fuels, Class F, ISO 8217 Specification Qualification Test Package for Grades DMX and DMA	
Test Code	Description
ASTM D 4176.b	Visual Inspection, Procedure B
ASTM D 1298	API Gravity of Petroleum Products, Hydrometer Method (Density, Relative Density, Specific Gravity)
ASTM D 445.a	Viscosity, Kinematic, at 40°C, cSt
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 97	Pour Point of Petroleum Oils
ASTM D 2500	Cloud Point of Petroleum Products
ASTM D 524.b	Carbon Residue, Ramsbottom on 10% Residue
ASTM D 482	Ash Content of Petroleum Products
ASTM D 95	Water by Distillation, Petroleum Products
ASTM D 473	Sediment by Extraction
ASTM D 613	Cetane Number, Ignition Quality of Diesel Fuels
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%
Additional Tests	
ASTM D 976	Cetane Index, Calculated from Distillation and API Gravity
ASTM D 130	Corrosion from Petroleum Products, Copper Strip Tarnish Test, 2 hours @ 100°C
ASTM D 4052	Density and Relative Density of Liquids by Digital Density Meter
ASTM D 86.b	Distillation of Petroleum Products at Atmospheric Pressure
ASTM D 6079	Lubricity of Diesel Fuels by the High Frequency Reciprocating Rig (HFRR)
ASTM D 6078.b	Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator, (SLBOCLE). Procedure B: Single-Load Test
ASTM D 2709	Water and Sediment in Distillate Fuels, BS&W
ASTM D 381.b	Gum Content, Existent, in Fuels by Steam Jet Evaporation
ASTM D 3605.g	Trace Metals by Flame Atomic Absorption Spectroscopy. Includes: Sodium, Potassium, Vanadium, Lead, Calcium, Barium, Magnesium, and Phosphorous, LOD = 0.05 ppm

The test codes used to identify a test method are for identification and are generally related to the ASTM or other protocol. We use suffix letters with the test codes to identify different practices that may be defined within the same ASTM procedure, e.g., different test temperatures, or different test times.

FUELS FROM USED LUBRICATING OILS

There are two ASTM Specifications related to the use of used or reprocessed lubricating oils (lube oils), hydraulic fluids, or other hydrocarbon-based oils. Federal, state, and local regulations may dictate more restrictive requirements than are outlined in the ASTM documents.

ASTM D 6448 covers four grades of fuel oil that are made partly or entirely from used oils and are intended for use in industrial equipment (not residential heaters, combustion engines, or marine applications). The four grades, known as Reprocessed Fuel Oils (RFO) include RFO-4, RFO-5L, RFO-5H, and RFO-6, which differ in viscosity range.

Industrial Burner Fuels from Used Lubricating Oils ASTM D 6448 Specification Grades RFO-4, RFO-5L, RFO-5H, and RFO-6	
Test Code	Description
ASTM D 445.b	Viscosity, Kinematic, at 100°C, cSt
ASTM D 93	Flash Point, Pensky-Martens Closed Cup
ASTM D 95	Water by Distillation, Petroleum Products
ASTM D 473	Sediment by Extraction
ASTM D 97	Pour Point of Petroleum Oils Only required for Grade RFO4
ASTM D 1298	API Gravity of Petroleum Products, Hydrometer Method (Density, Relative Density, Specific Gravity)
ASTM D 482	Ash Content of Petroleum Products
ASTM D 4294	Sulfur by X-Ray Fluorescence Spectroscopy. LOD = 0.01 wt%
ASTM D 4980	pH of Waste by Screening Test
ASTM D 240	Heat of Combustion, by Bomb Calorimeter
Additional Tests	
ASTM D 4052	Density and Relative Density of Liquids by Digital Density Meter
ASTM D 129	Sulfur, Bomb Method. LOD = 0.1 wt%, Referee Method
ASTM D 5673.b	Trace Metals by ICP-MS Includes: Vanadium, Sodium, Potassium, Lithium, Lead, and Calcium. LOD = 0.05 ppm
ASTM D 6304	Water Content by Karl Fischer Method, Lubricating Oils and Additives
ASTM D 6469	Microbial Contamination in Fuels and Fuel Systems

ASTM D 6823 covers Recycled Fuel for Commercial Boilers (RFC) and identifies four grades; RFC-4, RFC-5L, RFC-5H, and RFC-6. The specification requires a minimum of 25% used lubricating oil and is intended for use in commercial boilers. Because Gross Heating Value, Trace Metals, and PCBs are defined, the RFO fuels often can qualify as Marine Fuels. Request a Quotation.

*The parameters listed above may also be used as an indicator of when more extensive testing is required.
In the United States, fuel must also meet the Federal Environmental Protection Agency (EPA)
parameters for recycled used oils as defined in Federal Code 40 CFR 279.11.
Some state and local jurisdictions may have more stringent requirements than the EPA.*

For a test package to meet your specific requirements, please request a quotation.

COAL, COKE AND SOLID FUELS

The grade of a sample of coal or coke does not precisely define its composition. The usefulness of coal or coke as a fuel requires a proximate and an ultimate (elemental) analysis.

Proximate analysis permits cursory valuation of coals and coke as fuel and requires moisture, volatile matter, ash, and fixed carbon. ASTM D 5142 is an instrumental method for these parameters while ASTM D 3172 is considered the referee method.

Proximate Analysis of Coal and Coke, ASTM D 5142 Instrumental Method	
Test Code	Description
ASTM D 5142.a	Proximate Analysis of Coal and Coke, Instrumental - Package

Proximate Analysis of Coal and Coke, ASTM D 3172 Referee Method	
Test Code	Description
ASTM D 3173	Moisture in the Analysis Sample of Coal and Coke
ASTM D 3175	Volatile Matter in the Analysis Sample of Coal and Coke
ASTM D 3174.a	Ash in the Analysis Sample of Coal and Coke, wt%
ASTM D 3174.b	Fixed Carbon

The elemental or ultimate analysis of coal or coke provides a uniform system for comparing coals and coke and requires the determination of Carbon, Hydrogen, Nitrogen, Sulfur, Oxygen, and Ash. Other tests for Heating Value or Trace Metals may also be required.

Ultimate (Elemental) Analysis of Coal and Coke, ASTM D 3176	
Test Code	Description
ASTM D 5373	Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Sample of Coal and Coke
ASTM D 3173	Moisture (as-received basis)
ASTM D 3177	Sulfur, Total, in the Analysis Sample of Coal and Coke
ASTM D 3174.a	Ash in the Analysis Sample of Coal and Coke, wt%
Calculated.1	Oxygen, calculated. (No direct method in ASTM tests for oxygen in coal)
Additional Tests	
ASTM D 3178	Carbon and Hydrogen in the Analysis Sample of Coal and Coke
ASTM D 3179	Nitrogen in the Analysis Sample of Coal and Coke
ASTM D 4239	Sulfur Analysis in Coal and Coke Using High Temperature Tube Furnace Combustion
ASTM D 3683.b	Trace Elements in Coal and Coke Ash by Atomic Absorption
ASTM D 6357	Trace Elements in Coal, Coke, and Combustion Residues by ICP-AES, ICP-MS, and GFAA.

ALTERNATIVE FUELS AND BIOFUELS

Bioenergy is energy contained in living, or recently living, biological organisms, a definition, which specifically excludes fossil fuels. In order to be considered a Biofuel, a fuel must contain over 80% renewable material. Biofuels are considered Alternative Fuels and may be used alone or as supplemental fuels to provide electricity and heat.

Liquid Biofuels are primarily Ethanol, Biodiesel, Vegetable Oil, Algae Oil, and Pyrolysis Oil. Biogas is usually methane gas recovered from manure, sludge, solid waste, or other biomass. Solid Biofuels include wood, dried manure, charcoal, and biomass pellets.

Many analytical procedures for Coal and Coke are also suitable for Solid Biofuels and Alternative Fuels, such as Tire Chips and Refuse Derived Fuel (RFD), share many analytical procedures as Coal and Coke.

TIRE DERIVED FUEL (TDF)

ASTM Standard Practice D 6270 gives guidance for the evaluation of chips from scrap tires, commonly called Tire-Derived Fuel or TDF, when used as a boiler fuel either alone, or co-fired with, coal, sludge, or wood.

TDF is defined as a tire that has been shredded and processed into a rubber chip ranging from 1 to 4 inches in size. These rubber-oil-carbon black chips are a high quality fuel with an energy content of about 30 MBtu/ton which ranks it below fuel oil but above sub-bituminous coal.

TDF provides a competitively priced fuel for use in co-fired boilers (10 to 30%) with wood or coal, or to supplement an existing fuel that is in limited supply.

Many of the test procedures parallel those for coal and those listed below serve as a guideline. As in all fuels, the emphasis is in the hydrocarbon content, the heating value of the fuel, the moisture and volatility, and the potential contaminants in the fuel and in the ash.

Scrap Tire-Derived Fuel (TDF), ASTM D 6270

Test Code	Description
ASTM D 2361	Chloride
ASTM D 3172.a	Proximate Analysis - Referee Method
ASTM D 3176	Ultimate Analysis (C, H, N, S, O)
ASTM D 3173	Moisture in the Analysis Sample
ASTM D 3174.a	Ash in the Analysis Sample, wt%
ASTM D 3175	Volatile Matter
ASTM D 3177	Sulfur, Total, in the Analysis Sample
ASTM D 3178	Carbon and Hydrogen in the Analysis Sample
ASTM D 3179	Nitrogen in the Analysis Sample
ASTM D 3682	Elemental Analysis in Ash by AA
ASTM D 4239	Sulfur Analysis Using High Temp Tube Furnace Combustion
ASTM D 5865	Calorific Value, Gross
ASTM D 4749	Sieve Analysis, per Sieve

These test procedures, or something related, can also be applied to many of the other Alternative Fuels and Biofuel products that are being developed as supplemental fuels. When no formal specifications are available, Biofuels must be evaluated in terms of their carbon, hydrogen, and nitrogen content, moisture and volatiles, potential Btu content, and for chlorine, fluorine, and any regulated metals in the combustion residue including zinc, calcium, iron, chromium, cadmium and lead.