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 manufactures 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