



TEXAS OILTECH LABORATORIES PORTFOLIO OF FLUID ANALYSES FOR GAS TURBINE UNITS AND THEIR SYSTEMS, ACCORDING TO OEM SPECIFICATIONS

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This document describes the set of analyses currently performed by Texas OilTech Laboratories on Gas Turbine Power Unit fluid samples and foreign materials collected onboard FPSOs located at the coast of Brazil, and from turbines installed in power plants onshore. The lists of analyses for diesel and gas fuels, lubricant oils, water and steam, and coolant fluids are comprehended into requirements and specifications from Gas Turbines manufacturers for operations quality assurance and asset integrity maintenance and preservation.

About Texas OilTech Laboratories, Inc.:

Texas OilTech laboratories, Inc. is an independent, investigative analytical services laboratory founded in 1985, in Houston/TX. Since then, it has been providing analytical services according to methods approved by the American society for Testing and Materials (ASTM), the International Standards Organization (ISO), the U. S. Environmental Protection Agency (EPA), and the Association of Official Analytical Chemists (AOAC). We are an ISO certified laboratory and operate according to ISO 9001-2008 & ISO 17025:2005.

All Analyses are performed using standard Quality Assurance/Quality Control (QA/QC) protocols that include blanks, standards, controls, replicates, and spikes that are appropriate for each test according to ASTM, ISO or EPA methodology. Typically, samples are analyzed in duplicate, and on multiple instruments, whenever possible. We welcome additional QA/QC testing as required by our clients. A copy of our Quality Assurance/Quality Control Manual can be provided upon request for your review.

Our laboratory and/or our staff are affiliates or certified members of the following organizations:

- ASTM - American Society for Testing and Materials
- STLE - Society for Testing Laboratory Engineers
- NAPE - National Association of Professional Engineers
- TAPE - Texas Association of Professional Engineers
- ASQC - American Society for Quality Control

As an ISO certified testing laboratory, we are capable of performing over 700 different procedures on liquid and gaseous fuels, new and in-service lubricants, crude oils, solvents, petrochemicals, waste oils, process water, and wastewater. We have been the primary testing laboratory for leading companies in the fields of power plant design and construction, oil and gas exploration, refining and distribution, chemical and petrochemical production, and industrial turbine manufacturing and maintenance.

Our clients also include many U.S. and international companies and U.S. government agencies, and we have vast experience in performing laboratory and field analysis on GT fluids according to OEM, such as: Alstom Power, Siemens, A. G., Siemens Westinghouse Power Corporation, GE Power Systems, GE Packaged Power, Pratt & Whitney Power Systems, Wartsila North America, Caterpillar, and Detroit Allison

Laboratory Operations in Brazil:

Texas OilTech Laboratories do Brasil, TOLBR, is operative into the Brazilian market, incorporated under the Brazilian laws. Since then, TOLBR has been equipping its laboratory with cutting-edge instruments and training its team to match the same quality standards of our headquarters (TOL), in Houston, working as an extension of Texas OilTech Laboratories, Inc. operations in Brazil. TOLBR incorporation is a result of a very





successful project between TOL Houston and an important multinational client operating FPSOs in Brazil and around the world, experiencing our Brazilian laboratory services and results for the last three years. TOL is an American company founded 30 years ago, in Houston/TX, by scientists that provide state-of-the-art oil and gas services for all types of industry, including without limiting to the U.S. Government. In Brazil, its local laboratory team is composed of Brazilian PhD., MSc. and BSc. chemists working together with the entire team in the U.S. through an integrated computerized system, making TOLBR an extension of TOL activities in Brazil.

We are pleased to share the below lists of analytical capabilities our laboratories can offer regarding analyses of fluids involved in the operations of Gas Turbine Power Generation Units.

Table 1: Analyses performed at *Texas OilTech Laboratories do Brasil* on Gas Turbine fuel samples.

Diesel Fuel Analyses	1	Particulate Contamination in Liquid Fuel
	2	Free Water and Sediment (BS&W)
	3	Total Sulfur - X-Ray
	4	Hydrogen, Carbon, Nitrogen via CHNO/S
	5	Trace Metals by ICP-OES
	6	Demulsification (Water Separation)
	7	Kinematic Viscosity at 40°C and 100°C
	8	Density at 60°F
	9	Asphaltenes in Petroleum Products
	10	Cloud Point
	11	Pour Point
	12	Flash Point - Closed Cup and Open Cup
	13	Manual or Automatic Distillation
	14	Ramsbottom Carbon Residue at 100% and 10%
	15	Specific Heat (BTU) - Bomb Calorimeter
	16	Ash Test for Liquids
	17	Copper Strip Corrosion
	18	Water content via Karl Fischer Coulometric
	19	Ions by Ion Chromatography
	20	Reid Vapor Pressure
	21	HFRR - Lubricity
Gas Fuel Analyses	22	Water Moisture in Gas
	23	Water Dew Point of Gas
	24	Gas Composition via Micro-GC
	25	Hydrocarbon Dew Point Gas
	26	H ₂ S in Fuel Gas
	27	Particulate Contamination in Gas Fuel



Table 2: Analyses performed at *Texas OilTech Laboratories do Brasil* on other Gas Turbine fluid samples.

Lube Oil Analyses	28	Water content via distillation
	29	Viscosity Index, Calculated at 40°C & 100 °C
	30	Pentane Insoluble Memb. Filtration
	31	Precipitation Number in Lube Oil
	32	Saponification Number
	33	Total Acid Number (TAN)
	34	Total Basic Number (TBN)
	35	Optical Particle Count - Particle Size Distribution
	36	Morphology of Particulates
	37	Color measurements and Appearance of liquids
	38	Oxidation Stability (16 hr)
Water and Steam Purity	39	pH measurements of Process Water
	40	Conductivity measurements of Process Water and Fuels
	41	Trace Metals in Water via ICP-OES
	42	Total Dissolved Solids in Process Water
	43	Total Suspended Solids in Process Water
	44	Anions Composition in Process Water via IC
Coolant Fluid Analyses	45	pH of Engine Coolants, Antifreezes and Anti-Rusts
	46	Reserve Alkalinity of Engine Coolants and Anti-rusts
	47	Freezing Point of Aqueous Engine Coolants, Refractometer Method
	48	Boiling Point of Engine Coolant
	49	Freezing Point of Aqueous Engine Coolant
Grease Analyses	50	NLGI Consistency Number of grease
	51	Grease Bleeding Test
	52	Contamination in grease
	53	Metal Content in Grease via ICP-OES
Elastomer	54	Elastomer Compatibility, Hardness, Volume, Weight Variations



Table 3: Analyses performed at *Texas OilTech Laboratories, Inc. (USA facilities)* on foreign materials collected from different locations (chip detectors, gas header, manifolds, filters, etc.) along Gas Turbine systems.

M50 Analyses	1	Scanning Electronic Microscope (SEM) Analysis
	2	Energy Dispersive X-Ray Analysis (EDX)
	3	Elemental Compositional Analysis by XRF
Bacteria & Oxidation Analysis	4	Mirco-Organism Culture Study, bacteria count/mL - Easi-Cult
	5	Oxidation Stability by Rotating Pressure Vessel Method, RPVOT
General Investigative Analyses on Foreign Material	6	Organic Composition Breakdown by GC-MS
	7	Trace Metals by ICP/MS Scan 27 metals
	8	Energy Dispersive X-Ray Analysis (EDX)
	9	Scanning Electronic Microscope (SEM) Analysis
Filter Investigative Analyses	10	Infrared Spectrochemistry; Full Spectrum FT-IR with Interpretation
	11	Organic Composition Breakdown by GC-MS
	12	Carbon, Hydrogen and Nitrogen in Petroleum Products, Instrumental
	13	SARA, Saturates, Aromatics, Resins and Asphaltenes Analysis
	14	Trace Metals by ICP/MS Scan 27 metals
	15	Ash Content of Petroleum Products
	16	Trace Metals by ICP/MS Scan 27 metals (on Ash material)
	17	Water Content by Karl Fischer Method, Organic Liquids
	18	Sulfur, X-Ray Spectrometry. LOD = 0.001 wt%
	19	Anions in Water by Chemically Suppressed Ion Chromatography
Gas Line Debris Investigative Analyses	20	Scanning Electronic Microscope (SEM) Analysis
	21	Energy Dispersive X-Ray Analysis (EDX)
	22	Trace Elements by ICP-AES
	23	Elemental Sulfur by GC-ECD
	24	Elemental Compositional Analysis by XRF
	25	Organic Composition Breakdown by GC-MS
	26	Ash Content to determine % organic