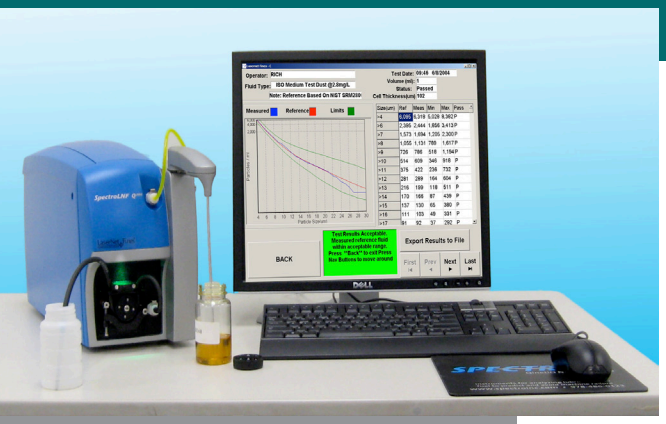
Application Note

Measuring Fuel Cleanliness with SpectroLNF Q200



Abstract

Contamination control is a critical part of fuel system maintenance. Fuel cleanliness is important to ensure that the fuel is of quality before it is used in a fuel system and to ensure emission controls are continuing to be met.

Introduction

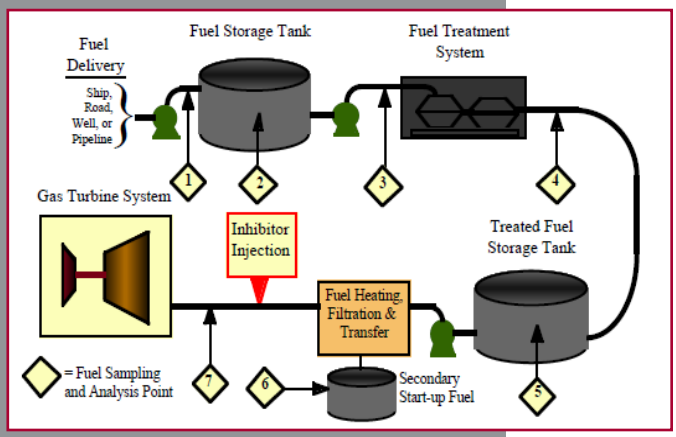
Contamination control is a critical part of fuel system maintenance. Contaminant particles cause:

- Fuel injector Wear
- Poor combustion
- Combustion chamber deposits
- Exceed emissions requirements

Contamination control standards have been most often specified for hydraulic and lubrication systems for many years, however comparable standards were only specified for fuels designated for aviation consumption. Recently fuel cleanliness has been receiving a lot of attention. There are two driving forces for this.

Rise of Alternative Fuels

New fuel sources, notably biodiesel and ethanol, is being blended into the fuel supply chain. These fuels may be delivered by a number of vessels, the transfer from each vessels (such as a railcar to truck) providing opportunity for sand and dirt ingression into the fuel.



Emissions Considerations

A very important reason for more scrutiny of fuel cleanliness is due to the much stricter emissions controls in place in many areas of the World. A fuel that has been filtered for particulate will increase the effectiveness of DLE (dry low emissions) technology on engine and turbine exhausts. Cleaner engines also tend to run at much higher fuel delivery pressures (30,000 psi is not uncommon), meaning less forgiveness for particulate laden fuel. As routine particle counting for fuels becomes widespread practice, the SpectroLNF Q200 may be used to determine fuel cleanliness in addition to its' comprehensive capabilities as a wear particle classifier.

Traditional Methods for Particulate Analysis in Fuels

Solid contamination for fuels has been traditionally measured by centrifuge, known as the bottom sediment and water test. A sample of the fuel is centrifuged at high speed, and the sediment and gross water is measured by reading a graduated conical centrifuge tube. A typical limit (ASTM D 1796) is 0.05% by volume.

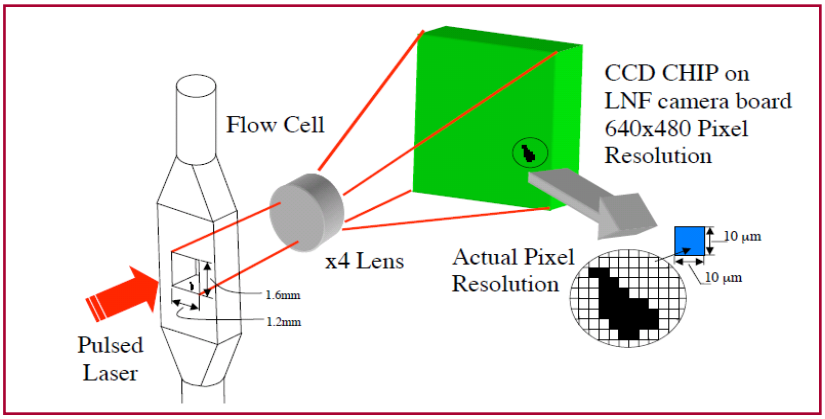
Fuel cleanliness for aviation fuels has also traditionally been tested by using a membrane filter patch test, (IP 423), (ASTM D 5452)

In both cases, the solid contamination is reported combined with free water in wt%, or vol %, (ASTM D975). These methods are time consuming and require a specialized laboratory to perform the tests. In many cases, the fuel was already consumed before the test results were received back to the requestor. This issue, combined with the concern that the tests are not accurate enough to detect potential fuel contamination problems has led many fuel customers to specify ISO cleanliness codes for contamination specifications. The SpectroLNF Q^{200} is an ideal solution for determining cleanliness, and the source of the particle contamination through particle shape classification.

Direct Imaging Technique

The SpectroLNF Q^{200} has as its principle of measurement the direct imaging technique, in which a fuel sample passes through a specially designed flow cell. As the fuel passes through, the contaminant particles are magnified and the images are captured on a sensitive CCD chip and then identified using artificial intelligence software. This measurement principle could be described as an automated digital micro imaging system. This approach to particle analysis provides distinct advantages for fuel and lubricant cleanliness.

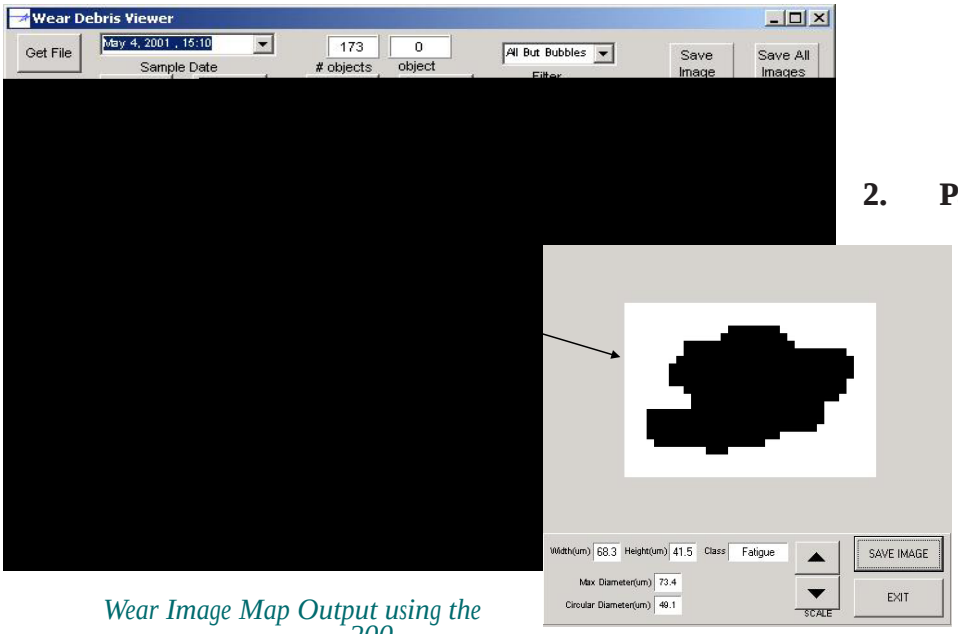
Basic Operation of the SpectroLNF Q^{200}



Using LNF Q^{200} to Monitor Fuel Cleanliness

Employing the SpectroLNF Q^{200} to measure fuels has distinct advantages over traditional patch methods and basic optical counters such as:

1. **Measuring dark or deeply dyed fuels:** The SpectroLNF Q^{200} uses a pulsed laser to illuminate the sample. A standard feature is AGC (automatic gain control), where the laser increases in intensity depending on the opacity of the fluid being measured. The advantage to the end user is greater time savings in analyzing fuel samples without the need to dilute (cut) the dark fuels.



Wear Image Map Output using the SpectroLNF Q^{200}

2. **Particle identification**: Non metallic particulate (sand, organic material) and fibers (from filters etc.) are common in fuels, picked up during storage, transport pipelines, and various handling procedures. The SpectroLNF Q^{200} is able to distinguish these particles, quantify and trend them for contamination control purposes and to assist in discovering the root cause of the contamination. Sand and dirt particles are often crystalline and translucent, making them hard to measure with traditional optical counting methods employing equivalent circular diameter measurement estimations. Direct imaging eliminates the uncertainty and accurately measures these common particles.

3. **Heavily contaminated samples:** Some fuel storage tanks may contain very high quantities of contamination, with levels than can easily saturate traditional optical counters, and require extra sample preparation steps that are not easy to perform in a field laboratory. The SpectroLNF Q^{200} has the highest particle concentration limit in the industry, at 5,000,000 particles per ml, thus reducing the need to cut the sample beforehand. Moreover, the unique design of the flow cell and image processing technology counts each particle individually, rather than as a clump. This leads to more accurate contamination analysis. Particles above 100 microns are screened out before they enter the instrument to prevent plugging.

Magni ed Dirt Particle as Shown on a Ferrogram Slide

4. **Low flashpoint/low vapor pressure considerations:** Another distinct advantage for fuels monitoring is the sample introduction approach. The sample is not pressurized or pulled through the counter by vacuum, rather a peristaltic pump gently (but quickly) introduces the sample to the flow cell. Volumes are low, yet enough to develop a representative analysis of the fuel sample. The low pressure, solid state flow cell and imaging technique reduces risk when working with highly flammable fluids.

Summary

The SpectroLNF Q200 particle counter and particle counter may be employed as a very effective particulate measurement tool in the field for fuel analysis, in addition to its outstanding suitability to monitor lubricating and hydraulic fluids.

Fuels that may be tested include:

- K-1 kerosene
- Aviation fuel
- Ultra low Sulfur Diesel(ULSD), Low Sulfur Diesel, (No. 1 thru 4),
- Marine distillate fuels (ISO 8217) DMA. DMB, DMC,
- Biodiesel (FAME) l B 2 to B100.

Applications for Fuel cleanliness testing by SpectroLNF Q200:

- Airport Fuel Farm
- Airplane Refueling
- Oil Refineries
- Distribution Terminals
- Hubs Pipeline & Storage
- Sea Ports Fuel Storage
- Fuel Testing Laboratories
- API/IP Full Scale Test Laboratories
- Engine Test Stands
- Private Light Aircraft Operators
- Helicopter Refueling

Benefits of Fuel Cleanliness Analysis:

- System Cleanliness
- Fuel Cleanliness/Quality
- Pipeline Commissioning
- Free water detection
- Go – Non Go Alarm detection
- Remote Monitoring
- Cost reduction in Laboratory expense
- Trend Analysis

Ref:

1: Caterpillar (GregoryPoole.com)
2 DEF STAN 91-91 Annex F