

WHITE PAPER:

Diesel Fuel Sediment Characterisation

Modern diesel engine technology relies unconditionally on fuel quality. Fuel injection systems have become far more sensitive to particle size and amounts. This paper discusses the correlation between different tests to assess particulate size distribution in fuel systems.

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Background

Historically, sediment or particulate control by measurement of total mass or volume has been sufficient to determine fuel cleanliness. However, as fuel injection system pressures and event precision requirements (including timing of injection events and multiple injections per power stroke) have increased, the fuel injection systems have become far more sensitive to particle size and amounts.

Although various diesel fuel specifications around the world specify different cleanliness limits, and while typically they are based on the absolute or relative weight of sediments present in a defined fuel volume or weight, only ASTM has developed a particle size rating procedure that describes particle size and related count information (Test Method D7619).

As an example, the following specifications specifies the following cleanliness requirements:

- SANS 342: 24 mg/kg
- EN 590: 24 mg/kg
- ASTM D975: 0.05 % vol (50 ppm) water/sediments
    - Annex X8.3 Sediment using ISO Codes 4406
- CAN/CGSB-3.517: 0.02 % vol (20 ppm) water/sediments

Particle Size Distribution

As stated, most of these fuel specifications should adopt a testing methodology to recognize the relative amount of particle based on their physical sizes, i.e. particle size distribution per unit of volume which ultimately provides a better understanding of the amount of solid contaminant present in fuel or oil at any given times.

While fuel manufacturers define diesel fuel cleanliness using a gravimetric test (e.g. Methods IP 440, ASTM D1796, 2709 etc.) reporting a weight of particulate matter per fuel volume (mg/L or % vol.), equipment and engine OEMs are now specifying a fuel cleanliness using particle size distribution.

The ISO cleanliness code is used to quantify particulate contamination levels per millilitre of fluid at 3 sizes 4µ[c], 6µ[c], and 14µ[c]. The number of particles greater than 4µm, >6 µm, >14 µm are provided via an automated particle counter using a laser technology to deliver a particle count

Test instruments meeting IP 564/ASTM D8166, IP 565/ASTM D7619 or IP 577 are used to deliver such ISO 4406 cleanliness codes such as 18/16/13. Table 1 is used for the interpretation on the number of particles associated with such code.

Diesel engine OEMs typically mandates a maximum fuel cleanliness of 18/16/13 or less. Based on Table 1 this would represents the following:

18: 1300 to 2500 particles greater than or equal to 4 µm/mL

16: 320 to 640 particles greater than or equal to 6 µm /mL

13: 40 to 80 particles greater than or equal to 14 µm /mL

As stated in https://icermax.com/literature-2/, *"measuring particle fuel contamination purely on weight is outdated and blind to what the real contamination levels are. The inherent dangerous composition of particle size distribution in any given batch of diesel may vary drastically and therefore may alter the level of contamination present."*

So how can we correlate, as an example, the maximum gravimetric weight of 24 mg/kg specified in SANS 342 and the maximum ISO code of 18/16/13 prescribed by engine OEMs?

From several research using ISO12103-1 A2 fine test dust, laboratory correlation efforts followed by US Army sampling initiative, it was determined that 1 mg/L was equivalent to ISO Codes 19/17/14 with 92 % agreement. Additional laboratory analysis has delivered results of 4 mg/g being equivalent to ISO 21/19/16 so a gravimetric weight of 24 mg/kg would be at least 6 x more particles based on the ISO codes Table. Having said this, SANS 342 gravimetric requirements therefore exceed by many folds the OEM requirements of 18/16/13.

Table 1 - ISO 4406 Table

Number of particles per millilitre		Scale number
More than	**Up to and including**	
2 500 000		>28
1 300 000	2 500 000	28
640 000	1 300 000	27
320 000	640 000	26
160 000	320 000	25
80 000	160 000	24
40 000	80 000	23
20 000	40 000	22
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2,5	5	9
1,3	2,5	8
0,64	1,3	7
0,32	0,64	6
0,16	0,32	5
0,08	0,16	4
0,04	0,08	3
0,02	0,04	2
0,01	0,02	1
0,00	0,01	0

This situation can be compounded by the presence of contaminants found in the fuel supply chain equipment such as storage tanks, marine vessels, pipelines baulk haulers etc. Also, presence of low levels of free water can have a large impact on particle count readings. So, treatment to eliminate the interference of free water droplets should also be considered when focusing on the concentration of sediment only.

Aquafighter® and FUELSTAT®

So ultimately, to exceed the SANS 342 requirements for particulate matter and to meet OEM ISO codes, fuel should be free as much as possible of dissolved and free water. This can be accomplished by the use Aquafighter® product technology. Aquafighter® helps in desorbing fuel held in storage tanks from both dissolved and free water by bringing the total fuel water content well below fuel specification at approximately 100 ppm. Experienced by fuel maintainers have proven that the use of Aquafighter® helps also in reducing the concentration of particulate matter by at least 1 class number. This is achieved when water is entrapped by the Aquafighter® super absorbent polymer entraining fine sediments.

Considering the greater use of biodiesel in the diesel fuel industry, fuel has become more hygroscopic based on this change of fuel chemistry and provides a mean to suspend fine sediment. By managing closely water content, one can also reduce the overall concentration of sediments.

Minimal free water in diesel fuel tank will also help in preventing bacterial growth which should be monitored periodically to ensure fuel quality. FUELSTAT® test kit is designed to be used in the field, at tank-side to confirm the absence of microbial contamination.

To meet these new OEMs requirement, finer filtration should be considered at point of use to meet and exceed the cleanliness requirements of diesel engine OEMs. The use of filter water separator meeting the EI 1581 specification or water barrier filter elements meeting EI 1588 specification or equivalent filtration system should ensure that the needed fuel cleanliness is met.

Removal of water to prevent contamination



Aquafighter® filters actively remove bound, suspended and emulsified water out of diesel fuel directly in the tank and keeps it water-free at all times. This is accomplished through 3 indispensable actions that are necessary to achieve the desired fuel purity and consequently provide tank protection:

- Demulsifies water by physico-chemical adsorption of water molecules to less than 65ppm total fuel water content with maximum efficiency. (Aquafighter® causes water to release naturally from fuel and it achieves this without adding to or altering the fuel, unlike certain fuel additives would do. After market additives can cause corrosion themselves)
- Attracts & Captures water immediately upon release from the fuel molecules
- Isolates water in its protective gel to permanently segregate it from the fuel & tank environment so your fuel & tank is protected at all times. (Aquafighter® will encapsulate the water preventing corrosion, microbial growth & re-emulsification until it is removed from the tank)

AQUAFIGHTER

For more information visit:
http://www.conidia.com/Aquafighter®

Testing for microbial contamination with results in minutes

Traditionally, marine fuel testing methods have depended on fuel samples being sent onshore for analysis. Sending the fuel samples onshore isn't simple. ASTM D6469 highlights that if a sample is to be tested for microbial contamination and cannot be tested on-site, it should be transported on ice and tested within 24hrs, or the sample may no longer be a true representation of the environment from which it came. Delays cause varying results which may cause an increased risk to your asset.



Now with the innovative test at the tank technology that **FUELSTAT®** offers you can get results at sea as well as in port within 15 minutes. FUELSTAT® is an immunoassay fuel test kit for microbe detection, developed only to find micro-organisms that do damage to fuel. The kit is self-contained, requiring no additional equipment. It's so easy to use that an individual can carry out the tests with only minimal training.

FUELSTAT®

For more information visit:
www.conidia.com/FUELSTAT®

Who we are

Conidia Bioscience research, design, develop, manufacture and globally distribute innovative solutions for maintenance of fuel systems. Our products are designed to offer practical and easy to use, industry leading solutions to both maintain and monitor the stored fuel in your system, whether that be a fixed ground installed diesel fuel tank, or in an aircraft wing. Through simple steps of ensuring water doesn't develop within stored fuel, and instant testing at the tank, we keep fuel contamination free and ready to use, avoiding costly remedial action and fuel system failures.

FUELSTAT® fuel tests are developed, manufactured and marketed by Conidia Bioscience Limited. Based in UK, Conidia Bioscience Limited was founded in early 2000's by experts in immunoassay techniques and holds the internationally patented intellectual property for FUELSTAT®.

Conidia Bioscience manages the global distribution of Aquafighter® water removal filters for Diesel and middle distillate fuels.

Where to find us

FUELSTAT® and Aquafighter® are distributed globally by a network of specialist distributors covering the major sectors. Contact info@conidia.com who will arrange for a distributor to support you.

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