Corrosion Technical Series

Octane Education Presents:

Corrosion Control for Backup Generators

New Filtration Standard: SAE J1488



- What is the new corrosion risk?
- How SAE J1488 filtration controls corrosion? J1488 is the only diesel filtration standard that specifically addresses biodiesel blended diesel
- What tests to use?
- What symptoms to look for in storage tanks?
- new greener backup generator model

Timelines

- Minimal corrosion with diesel (1900 2006)
- 2006 USA 4% Biodiesel introduced to ULSD
- 2007 USA "rapid and severe" corrosion found
- 2015 data, EPA corrosion report, 83% of tanks inspected have moderate to severe corrosion
- Corrosion never stops, now 100% severe ??

Timelines

2010 Quebec adds 4% biodiesel

2015 Ontario adds 4% biodiesel

2015 twenty tanks sampled in Ontario, biodiesel just introduced; < .05% vs target 4%

2020 twenty tanks sampled in Quebec, 4% since 2010

<u>Results</u>

Acids – Ontario tanks neutral pH, Quebec tanks TAN <u>.09 - .13</u>

Note: 2015 Ontario tested only for pH, TAN was not tested, and in the Quebec testing, only TAN tested, not pH.

Water – Ontario < 100 ppm, Quebec 2,800 ppm – 30,370 ppm

Particulate – Ontario at or below limits, Quebec all tanks above limits, highest 25/23/18

Limits: acids .05, water 200 ppm, particulate 21/18/16

Quebec's fuel today is the future for Ontario

KEY water has <u>migrated into the fuel column</u> from the tank bottom, forming <u>micelles</u>, microbes have followed

microbes produce acids and biosurfactants

microbial growth, volume, population, more acids

Main corrosion factors: **<u>new location</u>** of the <u>micelles</u> in fuel column with microbial growth

Water, biodiesel and surfactants are <u>polar</u> molecules, bond to each other, form <u>micelles</u>

Hydrogen bonds form between the oxygen atom in water and the hydrogen atom in biodiesel





Micelle

CRC Project DP-07-16-01, "Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Fuel Underground Storage Tanks":





Basics: What is a Micelle?



Reverse Micelle (W/O)

Normal Micelle (O/W)



Latest CRC Research, July 2021, Micelles



Figure 62. Surfactants – a) schematic of surfactant molecule showing polar head and nonpolar tail; b) schematic of invert-emulsion micelle encapsulating water droplet and nonpolar tails extending into the medium (i.e., fuel); c) schematic of invert emulsion micelles dispersed in fuel; d) photo of 10 mL each fuel and water – left: before shaking; right: 24h after shaking (<u>note</u> <u>stability of invert emulsion</u>).

CRC Project DP-07-16-01, "Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Fuel Underground Storage Tanks": "The results from this 12week study confirmed that the presence of free-water was essential to corrosion."

Difficulty Filtering Water From Micelles

In 3D, the micelle tails surround the water molecule in 360 degrees. The fatty acid tail forms a barrier, isolating the water from filter material.



A 3D example of a similar reverse micelle, a phospholipid molecule. The water droplet would be in the middle, not shown The water molecule does not often come in contact with traditional filter material. Filtration efficiency is low.

Microbial Growth Volume

LSD Before 2006

Microbial growth volume thickness sheet of paper 💊

Free Standing Water

Tank

Tank

ULSD/Biodiesel

Microbial growth volume thickness approx. <u>6 inches</u> Micelles + Free Standing Water

More microbes, more acids, more corrosion

The **only** diesel industry filtration test for biodiesel blends

"To determine the ability of a fuel/water separator to separate emulsified or finely dispersed water from fuels. This test method is <u>applicable for biodiesel fuel</u>" https://www.sae.org/standards/content/j1488_201010/

<u>Updated</u> in <u>2010</u> to address difficulty in filtering micelles from ULSD biodiesel blends

KEY Filtering of Micelles - 200 ppm Water Controls Microbial Growth and Corrosion

200 ppm is also the <u>warranty limit</u> for generator manufacturers, OEM's want fuel sample with warranty claims, now denying claims

J1488 two phase test, 1st pure diesel, 2nd B20 equivalent

1st tests free water filtration, 2nd micelle filtration

2500 ppm water added to each sample

Pure diesel – all filters 100% efficient

B20 – traditional filters inefficient at filtering micelles

Need a 92% filtration efficiency to keep water below 200 ppm

2500 * (1 - .92) = 200



Single point of failure, **acidified** fuel

35,000 + psi, designs for 60,000 + psi

Acidified fuel corrodes injectors tips, holes

Micelle water pits injector tips, +steam explosion

Reduced lubricity, friction damage

Failure of one injector disables generator Generator hunts for consistent power from each damaged injector, can shut down if not found

Injector holes/needle tips micron size

Common Injector Failure Points https://youtu.be/NUvWnOd5IFw



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Lab tests for water in micelles and fuel acidification:

ASTM D664 (TAN) – Total Acid Number – .05 limit recently lowered from .08

<u>ASTM D6304</u> Karl Fisher (KF): 200 ppm generator warranty limit Traditional water tests cannot detect water in micelles

ISO 4406 Particulate: also indicates microbial growth

Visual, look for hazy fuel, visible water, particulate, corrosion

Summary: Acidification and Micelles in Diesel





Micelles increase from air moisture and water bottoms

Great increase in microbial population / acids / corrosion

Reduces life cycle of gensets, tanks, metal fittings, piping

Risk of generator failure: injectors corroded, pitted by acidified diesel/water, reduced lubricity

Emissions increase

Generator warranty, 200 ppm water limit often <u>broken</u> first load of fuel

Shortens storage life of fuel

Thick Biofilms

Quote from technician: "WOW. Never saw anything like this, check out the last picture. This was the consistency of boiled pig skin. It was lining the bottom of the tank."

Biofilm can cause generator failures by:

- 1 corrosion of injectors and tanks components
- 2 biofilm separates when is fuel added, plugs fuel pipes

3 – biofilm disintegrates, plugs filters



J1488 filtration with a 92% efficiency removes micelles, microbes, particulates, sludge, water < 200 ppm

Keeps fuel clean and dry

Keeps emergency generators operating, reduces emissions Recommended in Uptime Institute: "Reconsider Your Diesel Fuel Supply" https://journal.uptimeinstitute.com/reconsider-your-diesel-supply/





J1488 Field Results

J1488 Filtration effective at controlling corrosion

All installed J1488 filtration systems in Quebec and Ontario keep water below 100 ppm, TAN below .05, and particulates below 21/18/16

- Exergy provides and maintains a natural gas backup generator, while removing Capex acquisition and staffing costs
- removes the corrosion risk and the pollution of diesel systems
- bill client on a monthly basis
- Markets: provincial/municipal/city government and smaller commercial enterprises

What is the new corrosion risk?

Micelles concentrating on bottom six inches, greatly increases growth volume for microbes, microbes create acids

How SAE J1488 filtration controls corrosion?

J1488 is the only diesel filtration standard that tests removal of micelles



What tests to use?

<u>ASTM D664</u> TAN (acids), <u>ASTM D6304</u> Karl Fisher (KF water), <u>ISO 4406</u> (particulate)

What visual symptoms to look for in storage tanks?

Haze, water on the bottom, particulates, corrosion

New Greener Model of Backup Generator Use

Natural Gas Generator supplied, owned and maintained by 3rd Party, no Capex or personnel costs, billed on a monthly basis

CRC Project DP-07-16-01

"Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Fuel Underground Storage Tanks"

USAF, U of Oklahoma 2020

"In situ Linkage of Fungal and Bacterial Proliferation to Microbiologically Influenced Corrosion"

Mission Critical Magazine October 2019

"Keep Generators and Storage Tanks Alive in the Wake of the Corrosion Crisis"

Steel Tank Institute TankTalk June 30 2019

"Diesel Tank Corrosion Mechanism, and Corrosion Control"

Uptime Article 2017 "Reconsider Your Diesel Fuel Supply"

EPA 2016 "Investigation Of Corrosion-Influencing Factors In Underground Storage Tanks With Diesel Service"

Moisture Absorption In Biodiesel And Its PetroDiesel Blends

15 – 25 X pure diesel, 1,000 – 1,700 ppm https://pdfs.semanticscholar.org/cc73/05d9e6a775412f59e517565c5b739616596f.pdf

BioFuels Digest 2016

"SAE J1488_201010 needed for Diesel Infrastructure Corrosion Prevention"

Uptime Institute 2017

"Reconsider Your Diesel Fuel Supply"

Steel Tank Institute (STI) June 2019

"Diesel Tank Corrosion Mechanism, and Corrosion Control"

Mission Critical Magazine October 2019

"Keep Generators and Storage Tanks Alive in the Wake of the Corrosion Crisis"

Electrical Generating Systems Association November 2019

EGSA largest organization dedicated to On-Site Power Generation, and includes emergency generator manufacturers

Lecturer in BioFuelNet Canada's Advanced Biofuels Course, hosted on McGill University's myCourses platform. http://biofuelnet.ca/advanced-biofuels-course/

Speaker:

Sept 2018 National Tanks Conference Louisville Ky

November 2018 EPA/National Association Corrosion Engineers Washington DC November 2018

Presented EPA Washington DC, Office of Underground Storage Tanks, Sept 2016

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THANK YOU !!

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