

Marathon BioDiesel, Inc. Presents: Motor Fuels- Water Tendency and Corrosion in Diesel and Bio-Diesel Fuels

Jeff Lillie

This document was prepared to educate the interested reader on the water tendencies and corrosion effects on ALL Motor Fuels and contains actual test analysis, pictures and comments from fuel testing laboratories on the Marathon BioDiesel B-100 Bio-fuel product. Summary and comments are by Gary Smith, Fuel Specialist.

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Diesel Fuel Water and Corrosion Information

Crude-Oil Diesel Fuel Water/Corrosion Tendencies based on Fuel's Location and Temperature Changes:

Location of Diesel Fuel	Fuel Temperature	Free Water, PPM	Entrained Water, PPM
Refinery	100	0	1.3
Pipeline	60	.5	.8
Terminal Tank	35	.9	.4
Transporter	15	1	.03
Bulk Tank Below Ground	50	.6	.7
Tank Truck	-10	1.3	0

Water in any Carbon Diesel fuel or BIO-Fuel is expected (Measured and managed by pipeline spec), and naturally occurs based on several organic chemical reactions (The formation of peroxides and acids) and the interaction with metals, combined with outside environmental factors.

Oxygen, water and temperature changes are the 3 primary contributors to the start of oxidation and corrosion reactions in any fuel or oil product.

How fast these reactions start, and how drastic the fuel failure is, depends completely on the combination and severity of all of the above listed factors.

We (The Industry) **manage and control these factors** using additives and chemical control of these natural reactions/contaminations in the fuel or oil while in storage, and in-vehicle during use.

All Motor Fuels Contain Water... Eventually!

The natural reactions of oxygen, water and temperature changes causes acids to form in the Diesel fuel causing corrosion, which is why corrosion specs are tested in the ASTM Diesel Fuel specification and managed by additives during the time between terminal storage and end use in the engine. (NOT added at refinery)

Any rapid temperature increase or drop causes entrained water to “fall out” of the fuel resulting in harmful free water. The free water can cause severe acid reactions, peroxides, corrosion, waxy gums and microbial growth problems.

Understanding Fuel Corrosion:

All Motor Fuels, whether crude-oil middle/light distillate fractions (#2 Diesel Fuels and Gasoline), or Cellulosic Bio-Diesel (B-100 BIO Fuel) will naturally either contain water, or have the propensity to produce water based on production method, storage, chemical composition, temperature change and exposure to oxygen.

In order for corrosion of any kind to occur, 4 primary elements are required to start (Initiate), maintain (Continue by itself) and propagate (Grow) corrosion, or RUST.

These 4 Elements Are:

1. **Anode:** The site where positively charged metal ions and electrons form on the metal. (In this case, any uneven, protruding or deposited surface on the metal)
2. **Cathode:** The site where the reduction of oxygen and hydrogen in water consumes electrons. (In this case the water/oxygen/acid reactions occur at the fuel oil, water and oxygen interface in the tank)
3. **Electrolyte:** A wet path connecting the anode and cathode (In this case, the Fuel or lubricating oil)
4. **Conductor:** A metal bridge that connects the anode and cathode to complete the circuit. (In this case, any and all metal surfaces around the anode site, anywhere there is METAL in the engine.)

It is important to understand that the job of any fuel or oil corrosion inhibitor is to remove or modify one of the four elements needed to start, maintain and grow corrosion (Rust).

Once a corrosion cell has been established, the formation of the rust can be maintained without the addition of more water. Only oxygen is now required to propagate (Grow) the rust.

The fuel additive blended in the Marathon BioDiesel Water-Free B-100 product uses surfactants to prevent the bridging (Conductor), and to control anode formation and cathode reactions on metal surfaces. The additive also controls oxidative changes (Stabilizers) in the fuel during motion - oxygen mixing in the fuel, and temperature changes.

This is the corrosion typical untreated diesel fuel (Pipeline) produces:



This is a regular diesel fuel treated with our corrosion inhibitor:



This is a typical untreated Bio-Diesel:



Below is Marathon BioDiesel's 100% ASTM Water-Free B-100 treated with our corrosion inhibitor. This was the actual test picture from Marathon's analysis.



Notice the Marathon BioDiesel product has LESS corrosion than the regular untreated #2 Diesel Fuel sample pin tested (Top, above).

When we tested this treated fuel blend, we were very impressed with the low corrosion tendency of Marathon's B-100 bio fuel, and were even more impressed with the ZERO water content rating, (See attached fuel analysis).

Our testing shows that this blended bio-fuel should perform very well in engines, and should produce a very low level of the expected bio-fuel corrosion levels, as pictured above.

Gary Smith,

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Fuel and Lubrication Specialists



BG Products, Inc.

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Lab No: 12-523
Date: 10/8/2012

Attn: Robert Thomas
Customer: Marathon Biodiesel
Sample Source:
Fuel Grade: B100 Biodiesel

Gary and Melinda Smith
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Sample Additive and Additive Treatment Ratio			B100	B100 BG 240 (1:1000)	
Oxidative/ Thermal Stability	Method	Specifications			
X Dupont Stability Test, % Reflectance	ASTM D6468	80% min.	97.0	98.3	
X RSSOT, minutes	ASTM D7545		14.2	15.6	
Cold Temperature Properties					
X Cold Filter Plugging Point (CFPP), °F	ASTM D6371	< ambient	-28	-30	
Pour Point, °F	ASTM D97	< ambient			
Cloud Point, °F	ASTM D2500	+10 max.**			
Instrumental Analysis					
X Gas Chromatography	In House	Match Reference	see attached.		
FTIR Scan*/ % Biodiesel	In House	Match Reference	100%		
ICP Metals, ppm	D4951	no metals			
Sulfur by X-ray, ppm	D7039	15/ 500 max.			
Physical Properties					
Distillation, °F	ASTM D86				
Initial Boiling Point		320 - 370			
10%		NA			
50%		NA			
90%		540 - 640			
95%		671 max.			
Final Boiling Point		689 max.			
% Residue, volume %		2% max.			
Flash Point, °F	ASTM D93	>125			
Cetane Index	ASTM D4737	45 min.			
API Gravity	ASTM D287	32 - 42			
X Water and Sediment, vol %	ASTM D1796	0.05% max	0.00%		
Particulate Contamination, mg/ L	ASTM D6217	10			
X Nace Rust Test	ASTM D665	No Rust	Heavy Rust	Light Rust	
HFRR, µm wear diameter	D6079	450			
Calculated BTU Content	Reference Table	136,000 min.			
X Haze Test	ASTM D4176	2 max.	1		
Microbial Analysis	Bug Check BF				
Bacteria		negative			
Fungus		negative			

Comments

- * Specifications based on EMA, ACEA, Alliance and JAMA recommendations.
- * The sample was clear and clean as received. The color was light amber.
- * Gas chromatography indicates what appears to be a predominate C18, oleic acid fraction, reacted with methanol,

Ken Skriser
Laboratory Manager

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