“What’s going on Inside Today’s Fuel Storage Tank?”

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Three Fuels of Concern Today

- Ultra Low Sulfur Diesel (ULSD)
- Ethanol Blends
- Biodiesel

2012 Battelle study

- Clean Diesel Fuel Alliance hired Battelle to study ULSD corrosion related issues
- 6 sites studied across US
- Service stations with underground tanks
- Hypothesis formed that corrosion is due to ethanol and acetic acid found in the fuel

STI part of Clean Diesel Fuel Alliance (CDFA)

- CDFA members have expressed a sense of urgency to resolve unanswered questions from 2012 study
  - Impossible to form conclusion without clean tank site.
  - Why are glycolic acid and formic acid in the fuel?
  - Is this problem unique to FRP tanks?
  - Need to test sites with steel tanks

CDFA – Phase 2

- In June, project manager Prentiss Searles presented at the ASTM fuels meeting
- Asked committee members for their input on what to do next
- Teleconference meeting will likely be held next to discuss options
- Options include:
  - Additional service station site testing
  - Terminal, refinery, pipeline, testing
  - Simulated laboratory testing

STI conducted own study

- Study included both fiberglass and steel tanks
- USTs from five regions of the countries tested
- One fiberglass and one steel tank in each region
- Tanks were chosen randomly with no previous investigation of any corrosion issues
- Both fuel and water bottom sample obtained

Testing

- Testing was based on Battelle study
- Analysis based on what appeared to be causing corrosion in tanks
  - Ethanol
  - Acetate
  - Other acids
  - pH level of fuel

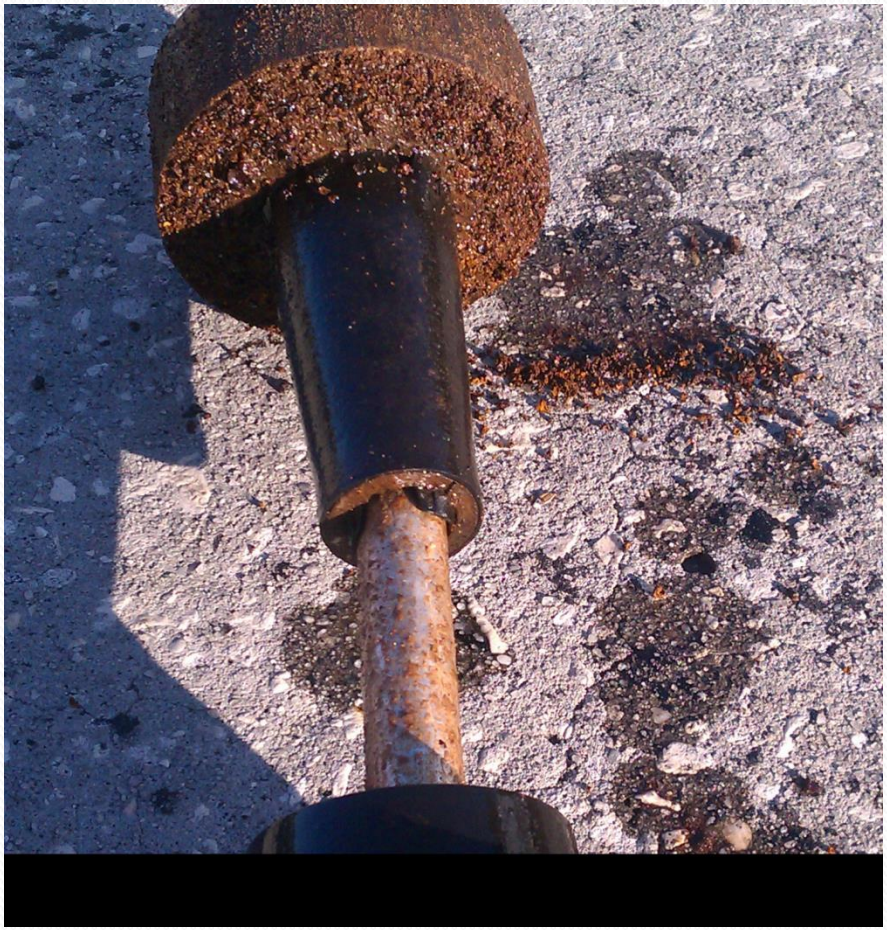
STI conducted own study

- Acetic acid and ethanol found in 5 regions
- Highest levels of acetic acid found in fiberglass tanks
- However data inconclusive to answer big questions
  - Is same type of corrosion happening in steel tanks?
  - Is acetic acid/ethanol responsible for corrosion?

Results

- Ethanol found in all but one region of the country
  - How is ethanol getting in diesel fuel
  - Transporting trucks is one possibility
  - Also possible for ethanol to be formed inside the tank
- Acetic acid found in all but one region of the country

Equipment from Southeast Region in fiberglass tank



FRP tank riser NW area Acetate 462 ppm

Steel Tank riser, NW area Acetate 108 ppm

FRP riser, MA area
Acetate 25,600 ppm

Mixed Results

- Hypothesis that high acetate would indicate high corrosion
- Photos of risers don't indicate this
- Next step is to place cameras inside tanks at 3 locations
- Analysis to be done by end of July

E85 tanks

- Minnesota has a high percentage of underground tanks at gas stations storing 85% ethanol
- Last year, STI discovered 2 steel tanks failed
- Investigation concluded weld failure in both cases
- Failures were not related to the fuel stored

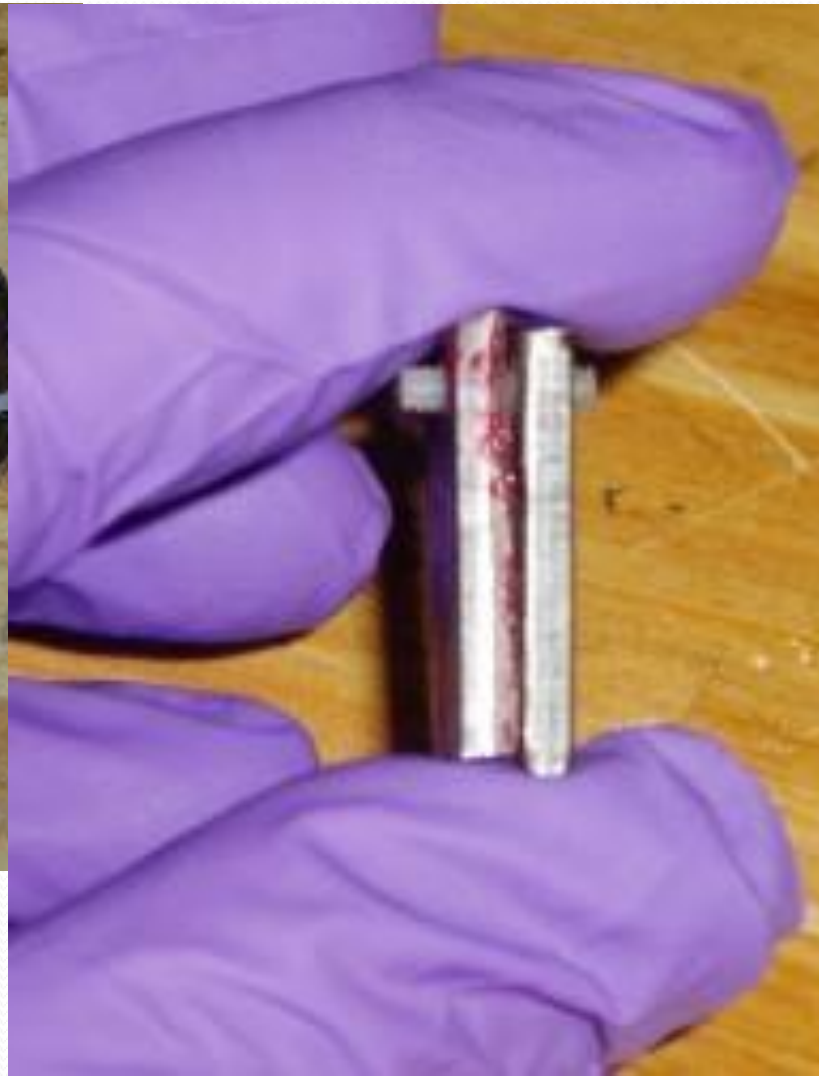
April 2013

- MN reported another steel tank failure
- This case may be internal corrosion
- Both the state and US EPA are investigating
- Because of this, STI is working with state to further investigate other steel tanks
- Investigation will include in-tank cameras
- Reports of corrosion stalactites on tank top
- Study is under development
- Input is welcome!

Biodiesel

- STI conducted one study with NBB in 2007
- Steel found to be compatible with various types of biodiesel
  - Soy
  - Animal fat
  - B5 thru B100
- Both ULSD and 3500 ppm diesel fuel used
- Study did not include microbiologically influenced corrosion

Steel Samples



Visual Inspection

- Upon visual inspection of the test coupons, a small amount of surface rusting was observed

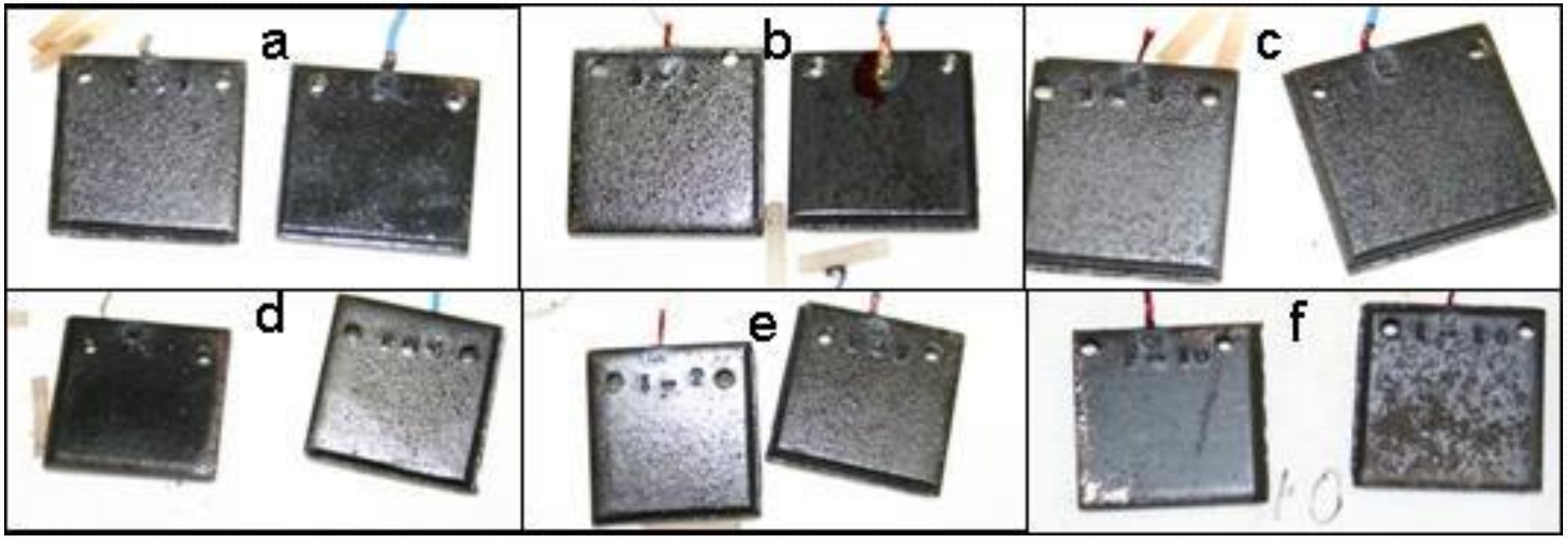


Figure 4. Photographs of carbon steel specimens exposed to ULSD and soy-based biodiesel blends with and without the presence of water: (a) 100 % biodiesel, no w added; (b) 50 % biodiesel + 50 %ULSD, no water added; (c) 100 % petrodiesel, no water added; (d) 100 % biodiesel, 1 vol% water added; (e) 50% biodiesel + 50 % ULSD, 1 vol% water added and (f) 100 % ULSD, 1 vol% water added. Exposure time: 2 months.

Surface Rust

- In most cases, the amount of surface rusting was slightly higher in 100 % ULSD than in biodiesel or biodiesel + ULSD blends.
- This surface rusting was caused by a reaction between the surface oxide layer of the metal and the fuel blend.

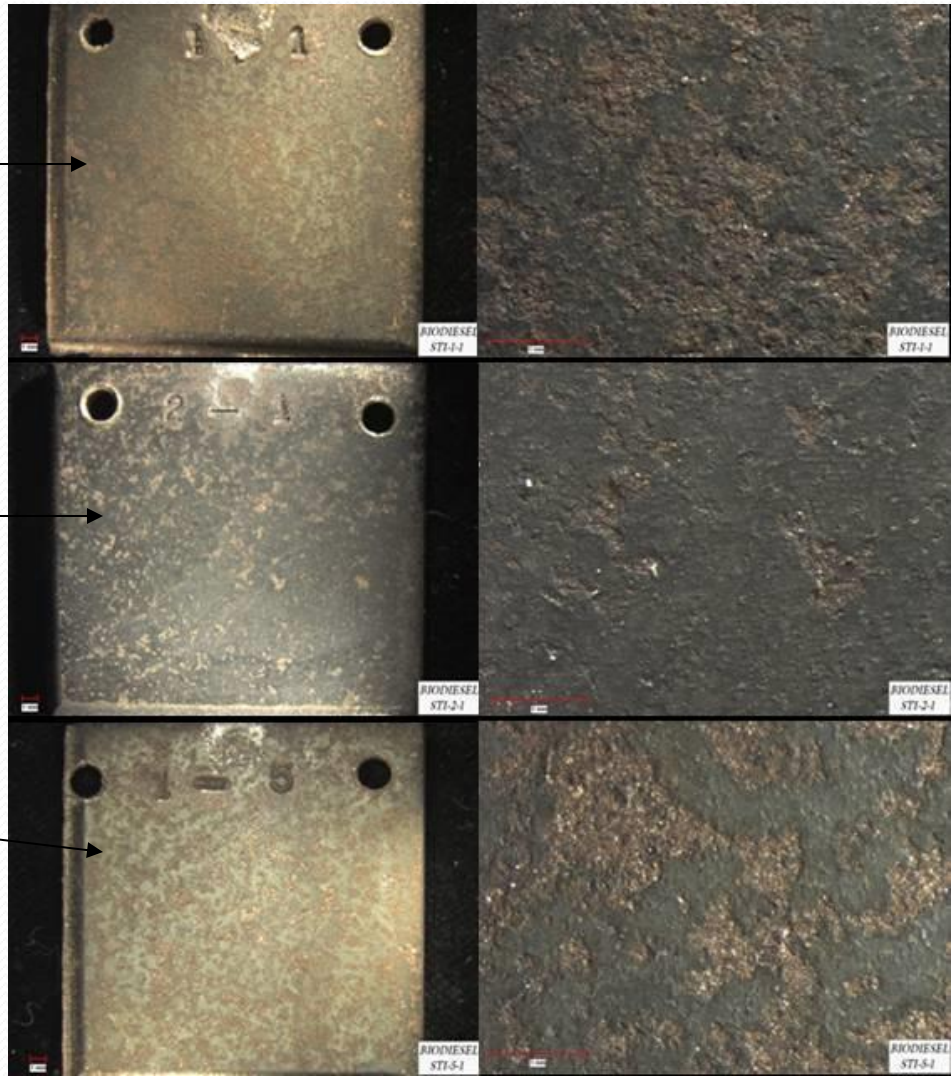
Low magnification optical micrographs

100%
Biodiesel

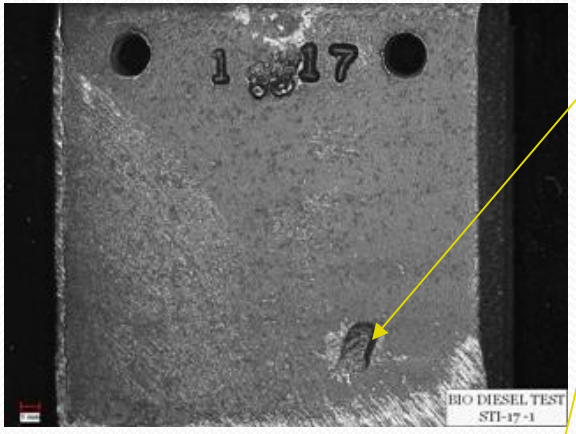
50% ULSD/
50%
Biodiesel

100% ULSD

No water added
to any fuel



Typical Microscope Images



toolmark

1 mm

100 % animal-based biodiesel, no water added

Sample 25

- Greatest weight loss occurred with 5% animal based biodiesel/ ULSD/ 1% water
- Optical examination indicated no measurable pits on this sample
- Corrosion rate calculated at 0.09 mm/yr

  (.00354 in/yr)
- Equates to Excellent Corrosion Resistance rating