What's Going On Inside Today's Storage Tanks?

Lorri Grainawi,
STI/SPFA

NISTM

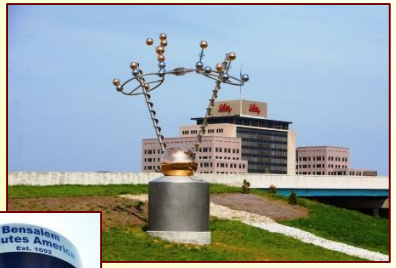
November 7, 2013

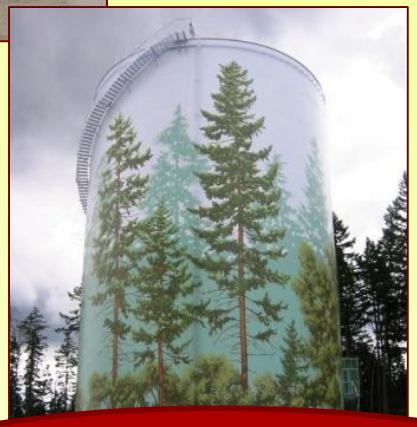
Columbus, OH

Who and What is STI/SPFA?

- Association of 180 fabricating and affiliate companies of steel construction products – shop-fab tanks, field erect tanks, pipe, pressure vessels and other special fabricated products
- STI members account for nearly all of the total shop fabricated underground steel storage tank production capacity in North America

2012 Annual Product Awards: Steel Fabricated Products





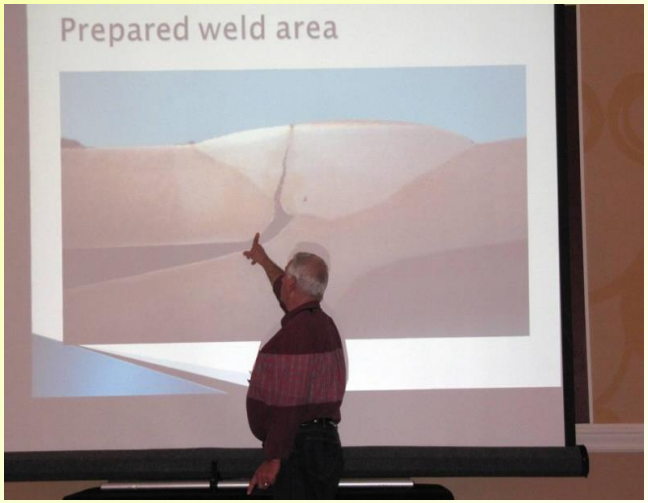
www.steeltank.com

What does the Steel Tank Institute do?

- UST and AST tank technologies
- Industry standards and recommended practices
- License manufacturers to build tanks to STI specifications
- Quality control
- Information resource
- Certification

4 – 50,000 Gallon Permatanks Installed at Northwestern Univeristy

Education, Research, & Advocacy



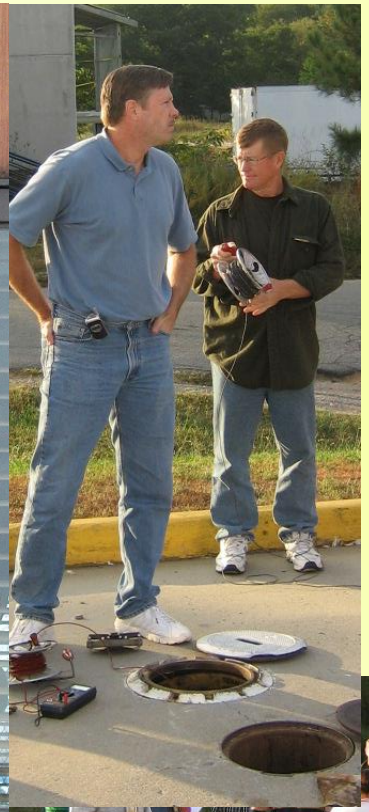
Steel Fact Sheets

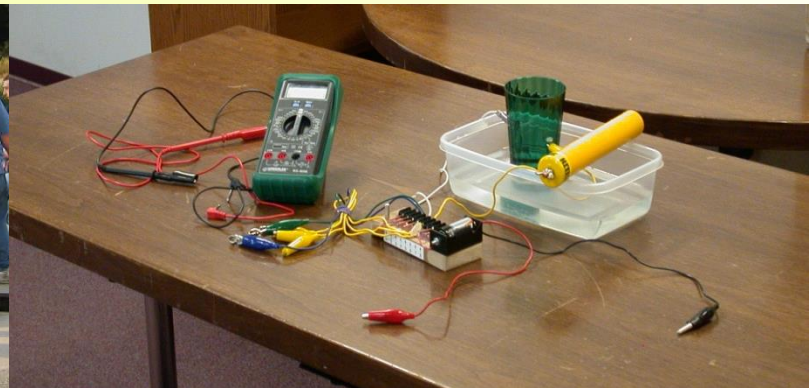
www.steeltank.com

STI Certification Programs

- 927 Certified SP001 Aboveground Storage Tank Inspectors
- 484 Certified Cathodic Protection Testers
- Over 130,000 sti-P3 tanks tested for cathodic protection through WatchDog program
- NEW: On Line Learning Program
  - T*I*M *Tank Integrity Management*

STI cp tester class!

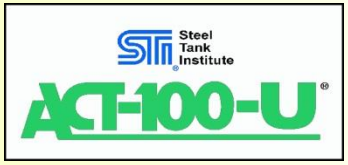


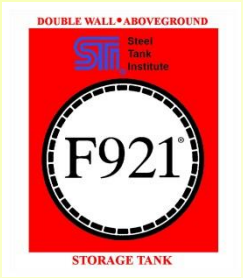


- Virginia Beach, VA
- Nov. 11 - 13, 2013
- 2 day certification class
- **NEW!** One day troubleshooting class

STI Shop-Fabricated Tank Program

- > 100 tank shops licensed and inspected
- 14 tank fabrication standards
- 19 recommended practices for testing, installation and inspection
  - *NEW:* R111 Storage Tank Maintenance
  - Under Development: SP131- UST Inspection, Repair, & Modification
- 6 UL files with hundreds of volumes & 4 SWRI technology programs





Tank Compatibility - Biofuels

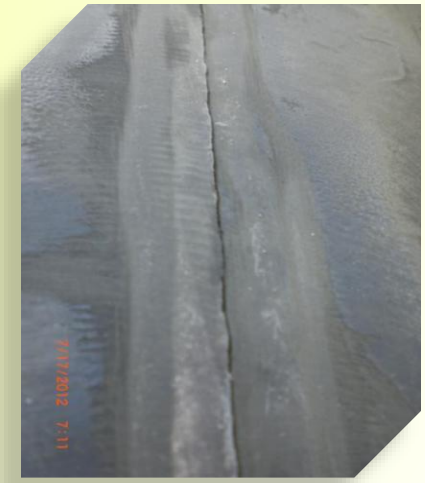
- E10, E15, E85, B2, B20, B100
- Steel Tank Manufacturer Certification Statements
- STI Web Site
- Performance
- Tanks are Cleaner – Sludge
- Biodiesel Shelf Life
- Water Concerns
- Phase Separation - Ethanol

Three Fuels of Concern Today

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

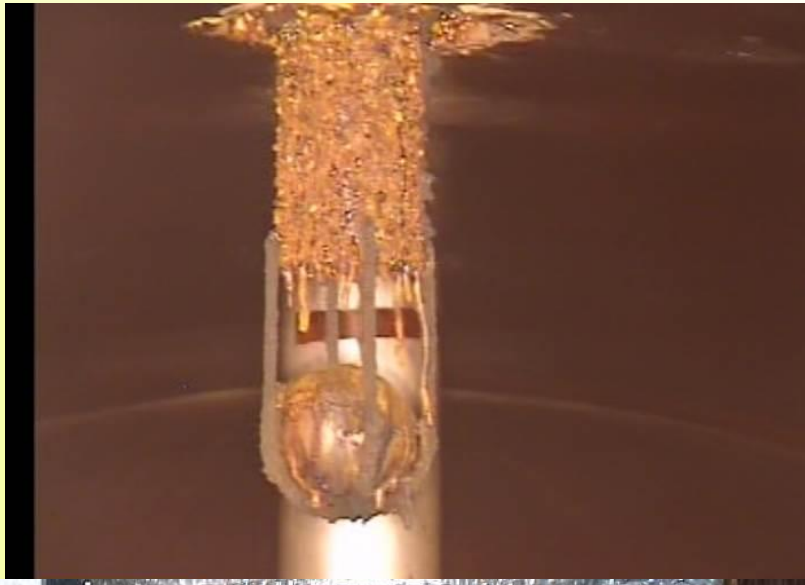
Recent Events Biofuels

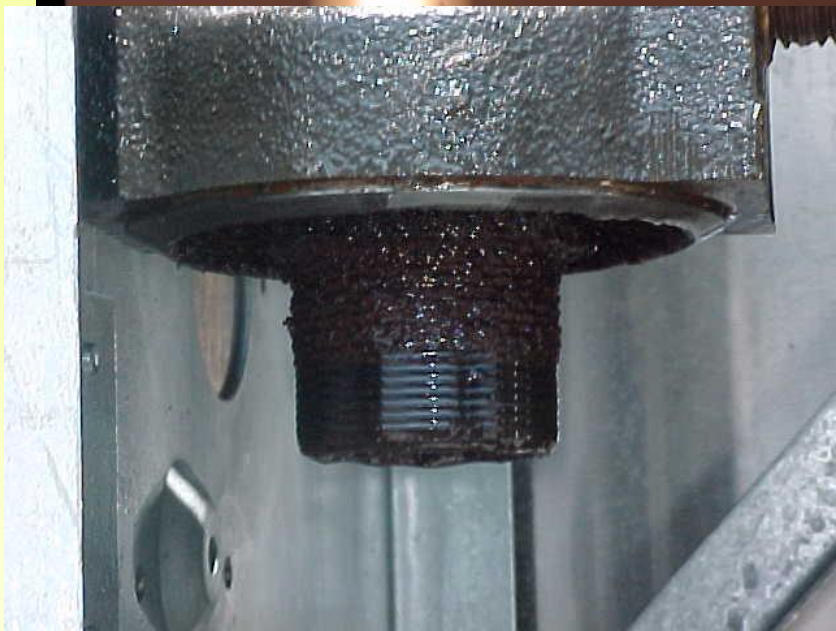
- **Sumps**
  - EPA ORD Research
  - NIST Research
- **Publications**
  - "Compatibility of UST Systems with Biofuels,"
  - Published by ASTSWMO
  - Case Studies
- **Research and Work Groups**
  - Underground tanks storing E85



Ultra Low Sulfur Diesel Issues

- **Corrosion of metal components within tanks storing ULSD**





How was the issue raised?

- **December 24, 2007 - A post on the PEI website identified a concern with rust and corrosion of STPs and pump castings**

How did I get involved in this?

- Education, BS Mechanical Engineer
- Chair, NACE Underground Storage Tank Committee
- Co-Chair, ASTM D02.14 Fuel Corrosivity Committee
- Folks started sending me photos of equipment with corrosion issues


07.11.2009 13:28


Oct 2013

History

- In June 2009 STI presented to ASTM Fuels committee. Members suggested collecting more details to determine if there are patterns
- Are problems associated with
  - One brand of eqpt?
  - One refinery?
  - Type of diesel?
  - Any other factors?
- Bottom line was pattern could not be found

Galvanic Corrosion?

Corrosion Occurring in all 3 Areas

ULSD Changes – Impact On Biological Problems

	Changes in ULSD		Impact on Microbial Growth
↓	**Sulfur reduction 500 to <15 ppm**	↑	**Sulfur antagonistic to microbial growth**
↓	**Aromatic and phenolic compounds**	↑	**Aromatic and phenolic compounds are good growth inhibitors**
↑	**Saturates**	↑	**Saturates preferred food source compared to aromatics**
↑	**Water (free, non-dissolved)**	↑	**Free water availability increases**

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More History

- **January 2010 PEI arranged meeting with interested parties (EPA OUST, ASTs, Clean Air, PMAA, ATA, NBB, Truck Stop, API, Fuel Additive Companies, others)**
- **Issue brought to attention of CDFA**

Clean Diesel Fuel Alliance

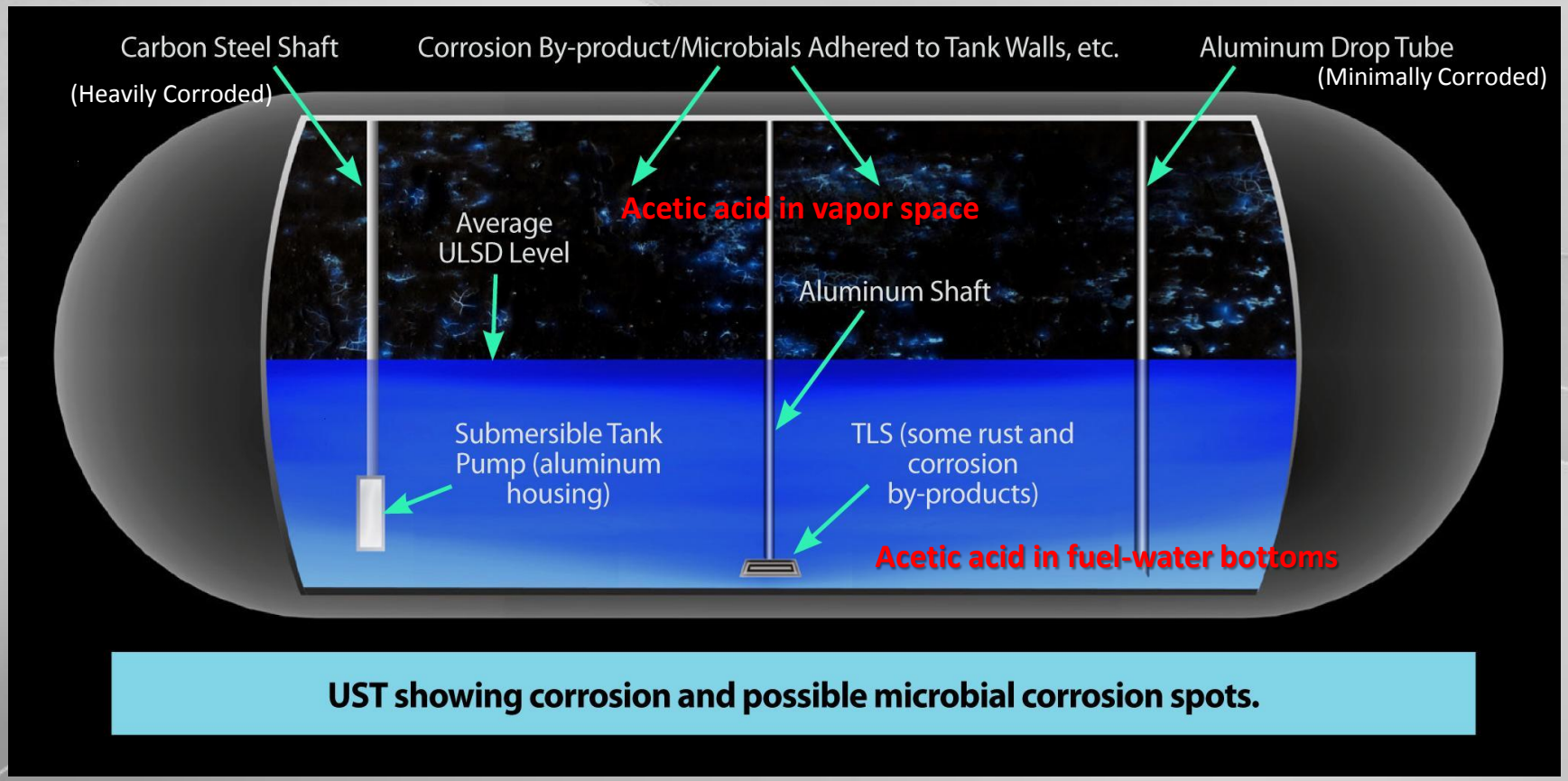
- AAA, www.aaa.com
- Alliance of Automobile Manufacturers, www.autoalliance.org
- American Petroleum Institute, www.api.org
- American Trucking Associations, www.truckline.com
- Association of International Automobile Manufacturers, Clean
- Association of Oil Pipe Lines, www.aopl.org
- Diesel Technology Forum, http://www.dieselforum.org/meet-clean-diesel
- Engine Manufacturers Association, www.enginemanufacturers.org
- Independent Liquid Terminals Association, www.ilta.org
- Manufacturers of Emission Controls Association, www.meca.org
- National Automobile Dealers Association, www.nada.org
- National Association of Convenience Stores, www.nacsonline.com
- National Association of Fleet Administrators, www.nafa.org

NATSO, Inc., representing Truck Stops & Travel Plazas, www.natso.com
National Petrochemical & Refiners Association, www.npra.org
National Tank Truck Carriers, Inc., www.tanktruck.org
Petroleum Equipment Institute, www.pei.org
Petroleum Marketers Association of America, www.pmaa.org
Society of Independent Gasoline Marketers of America, www.sigma.org
Steel Tank Institute, www.steeltank.com
Truck Renting and Leasing Association, www.trala.org
U.S. Environmental Protection Agency, www.epa.gov
U.S. Department of Energy, www.doe.gov
U.S. Energy Information Administration, www.eia.doe.gov
Western States Petroleum Association, www.wspa.org

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

ULSD Corrosion – UST Detail



UST showing corrosion and possible microbial corrosion spots.

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Clean Diesel Fuel Alliance Information Center - Government - Industry - Consumers - Windows Internet Explorer provided by API

http://www.clean-diesel.org/

File Edit View Favorites Tools Help

Google MECA diesel Search Share Bookmarks Check AutoFill MECA

IP3 NetAccess | Crowne Plaza Hotel ST. PAUL... | Clean Diesel Fuel Alliance ...

> Highway ULSD Fuel
> Non-Road ULSD Fuel
> Vehicle Performance
> Environment & Health
> Frequently Asked Questions
> Quicklinks to Member Web Sites

Ultra Low Sulfur Diesel (ULSD) fuel and new engines and vehicles with advanced emissions control systems offer significant air quality improvement.

Highway ULSD Fuel

EPA standards have led to a major reduction in the sulf content of diesel fuel
Highway Diesel

New Diesel Technology

Ultra Low Sulfur Diesel (ULSD) is a cleaner-burning diesel fuel containing a maximum 15 parts-per-million (ppm) sulfur.
Vehicle Performance

Non-Road ULSD Fuel

New EPA fuel standards for diesel fuel also apply to locomotive, marine and non-road engines and equipment, such as farm or constr equipment.
Non-Road Diesel

Environmental Benefits

ULSD fuel along with new engine and emission control system technologies have an important role in improving air quality and providing human health benefits by significantly reducing current emissions.
Environment and Health

Para leer en español el folleto sobre diesel ultra bajo en azufre

Energy Tomorrow Radio Podcast on ULSD

Battelle Study Questions

- Need a clean tank site.
- Is this problem unique to FRP tanks?
- Is ethanol really responsible for the corrosion?
- What effect is upstream fuel systems having on downstream fuel, i.e., service stations?

CDFA – Phase 2

- About a year ago, CDFA committee decided to conduct a second phase to the study
- Asked committee members for their input on what to do next
- Options included:
  - Additional service station site testing
  - Terminal, refinery, pipeline, testing
  - Simulated laboratory testing

CDFA – Phase 2

- Proposal was developed,
- Quotes received
- BUT….committee could not reach consensus

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

Ultra Low Sulfur Diesel Issues

- **STI Research**
  - Fuel samples extracted and tested
  - Example – Las Vegas service station tanks under same owner
  - FRP tank vapor control fitting – top right photo
  - Steel tank vapor control fitting – bottom right photo

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 study results

- 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

CDFA Interested Parties

Contract No. CON00008697
Study No 10001550
Final Report

Corrosion in Systems Storing and Dispensing Ultra Low Sulfur Diesel (ULSD), Hypotheses Investigation

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

To
Clean Diesel Fuel Alliance
C/O Mr. Prentiss Searles
American Petroleum Institute
1220 L Street, NW
Washington, DC 20005-4070

September 5, 2012

- First study report of published Sept 2012
- CDFA interested parties meet in Chicago Oct 3, 2013
- Agreed to several goals and projects

Program Goals

1. Prove or disprove the Battelle report's hypothesis that acetic acid is the likely cause of the corrosion.

2. Determine if the cause of the accelerated corrosion is introduced at the retail site or some upstream modality or facility (i.e., tank truck, bulk plant, terminal, pipeline and/or refinery).

3. Determine if the accelerated corrosion of metal appurtenances is occurring exclusive to fiberglass underground storage tanks (UST) systems or if it equally affects steel systems.

4. Determine if accelerated corrosion is occurring in metal components at facilities upstream of retail (i.e., tank truck, bulk plant, terminal, pipeline and/or refinery) or is the corrosion restricted to UST systems at retail sites.

Prioritized Projects

Top three projects:

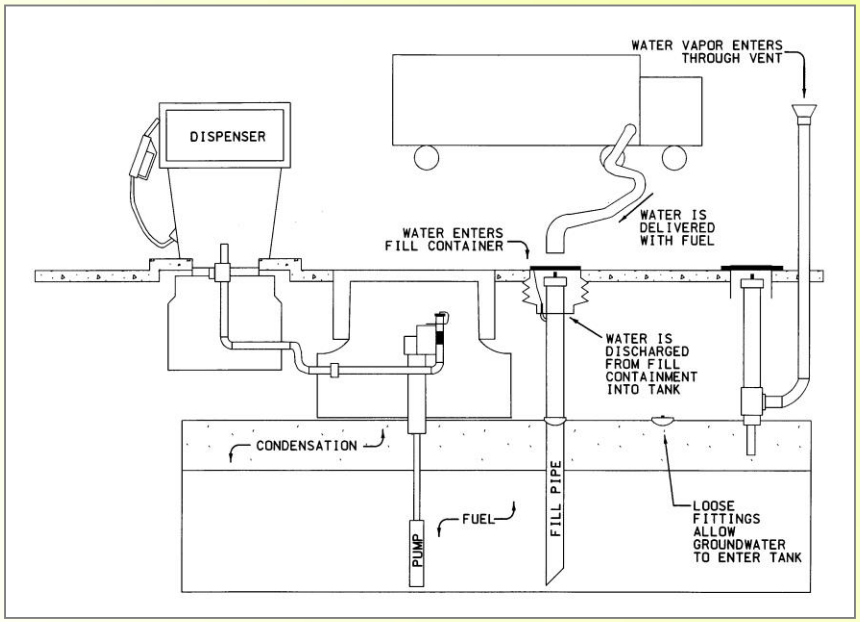
1. Conduct a laboratory bench test that replicates the corrosion being seen at retail stations and determine which contaminants and characteristics make a big difference
   - Is there a path to doing controlled studies in the lab (coupons, etc.)? One area that could be of interest is a NIST / Colorado School of Mines approach of inoculating the metal coupon with bacteria as an “extreme” scenario.
   - Vary the conditions to examine what is causing the corrosion (water, diesel, temperature, bacteria, etc.)
2. Define a clean site and corroded site: Develop a process and tools to define what is a clean site and a corroded site. (Boundaries, limits of corrosion, etc.).
3. Fill in the gaps that are in the Battelle Research study by looking at clean sites and comparing them to the sites presented in the original study. This would be a method to validate the results of the Battelle research.

Oct 14th, CRC meeting Coordinated Research Council

- CDFA participants would like to continue the work and asked to bring in the work under the umbrella of the CRC Diesel Performance Group to take advantage of its wider membership and the expertise and peer review structure.
- The topic is within the scope of the Cleanliness Panel, currently led by Rick Chapman.
- CRC agreed, provided the project:
  - Comes with its own funding ,and
  - Be led by a volunteer such as Prentiss Searles of API

Inspection and Maintenance

STI R111
Storage Tank Maintenance



Check Your Fuel - ASTM

Inspection and Maintenance of the Tank System

STI Webinar
December 18, 2013
www.steeeltank.com

Perpetual Tank System Life

1986 Sti-P3 E85 Tank
Removed in 2013 – No Leaks

- Manufacturer's Warranty
  - 10 Year, 30 Year
- Steel Capabilities as a Material
- Desirable Operations
  - Routine Maintenance
  - Tank Inspection
  - Fuel Usage
- Corrosion Protection
- Component Life

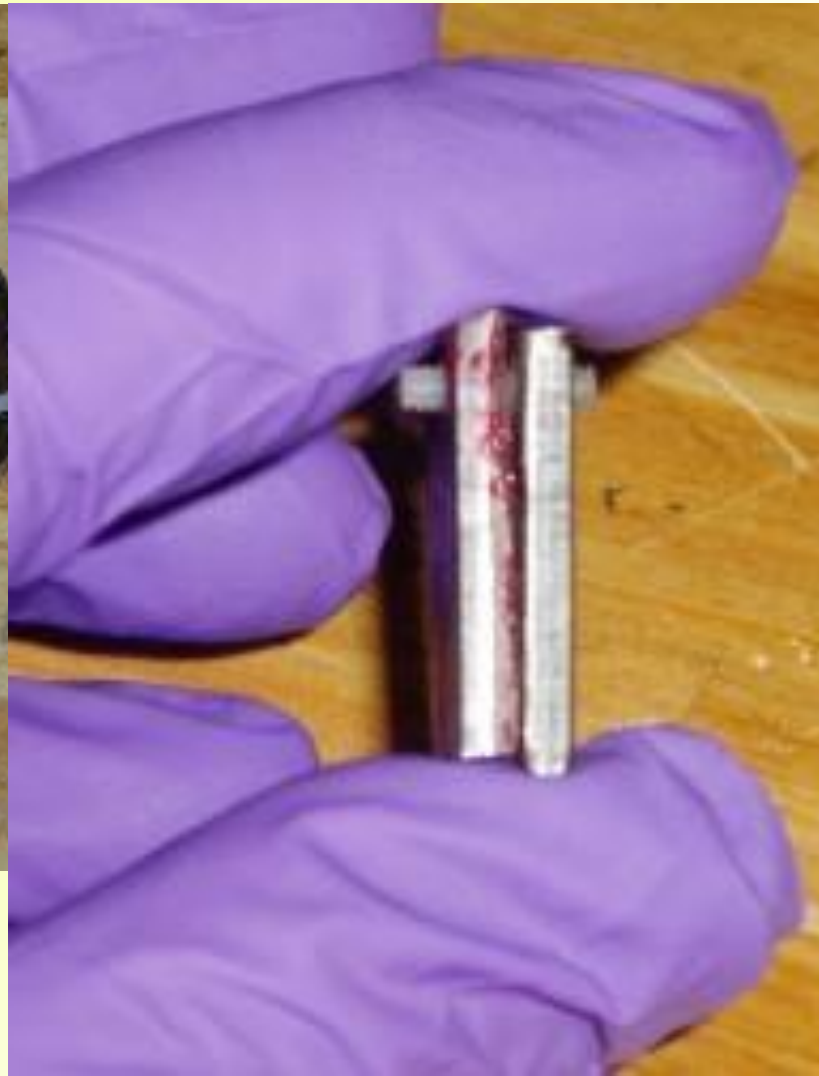
STI/SPFA Water Industry Century Club

- Dothan, Alabama
- Dixie Tank
- Built in 1897
- City landmark
- Civic pride
- 116 years old
- Remains in operation

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

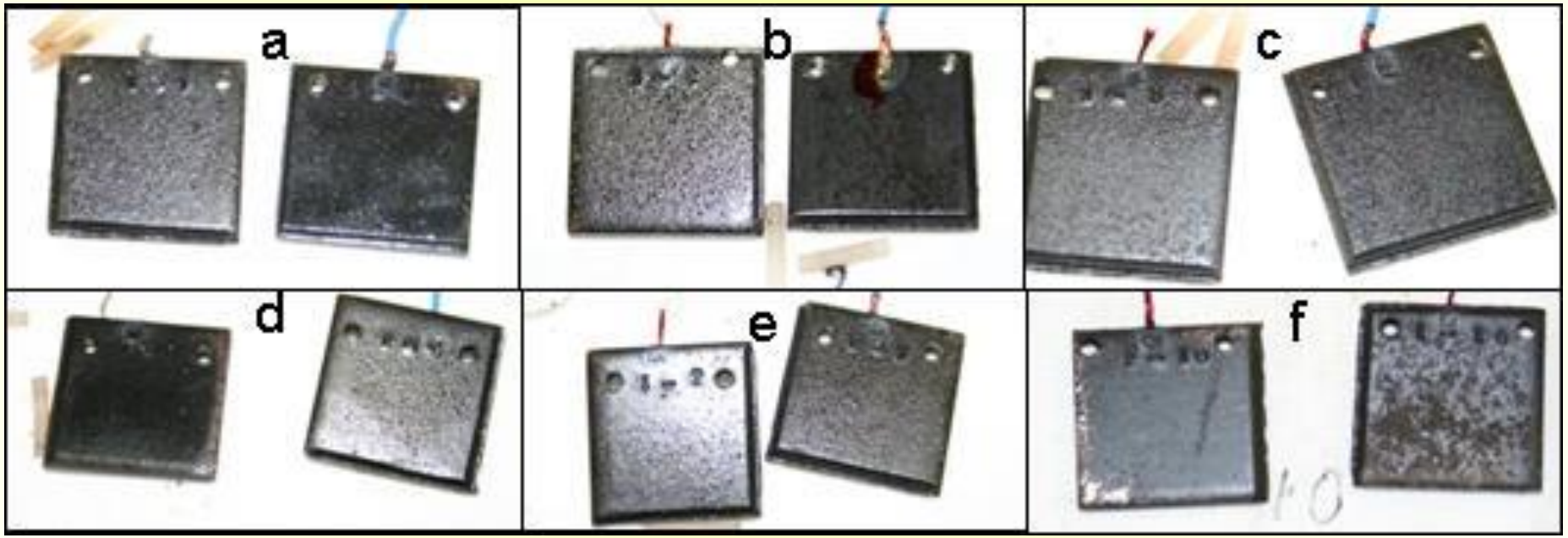


Figure 4. Photographs of carbon steel specimens exposed to ULSD and soy-based biodiesel blends with and without the presence of water: (a) 100 % biodiesel, no w added; (b) 50 % biodiesel + 50 %ULSD, no water added; (c) 100 % petrodiesel, no water added; (d) 100 % biodiesel, 1 vol% water added; (e) 50%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

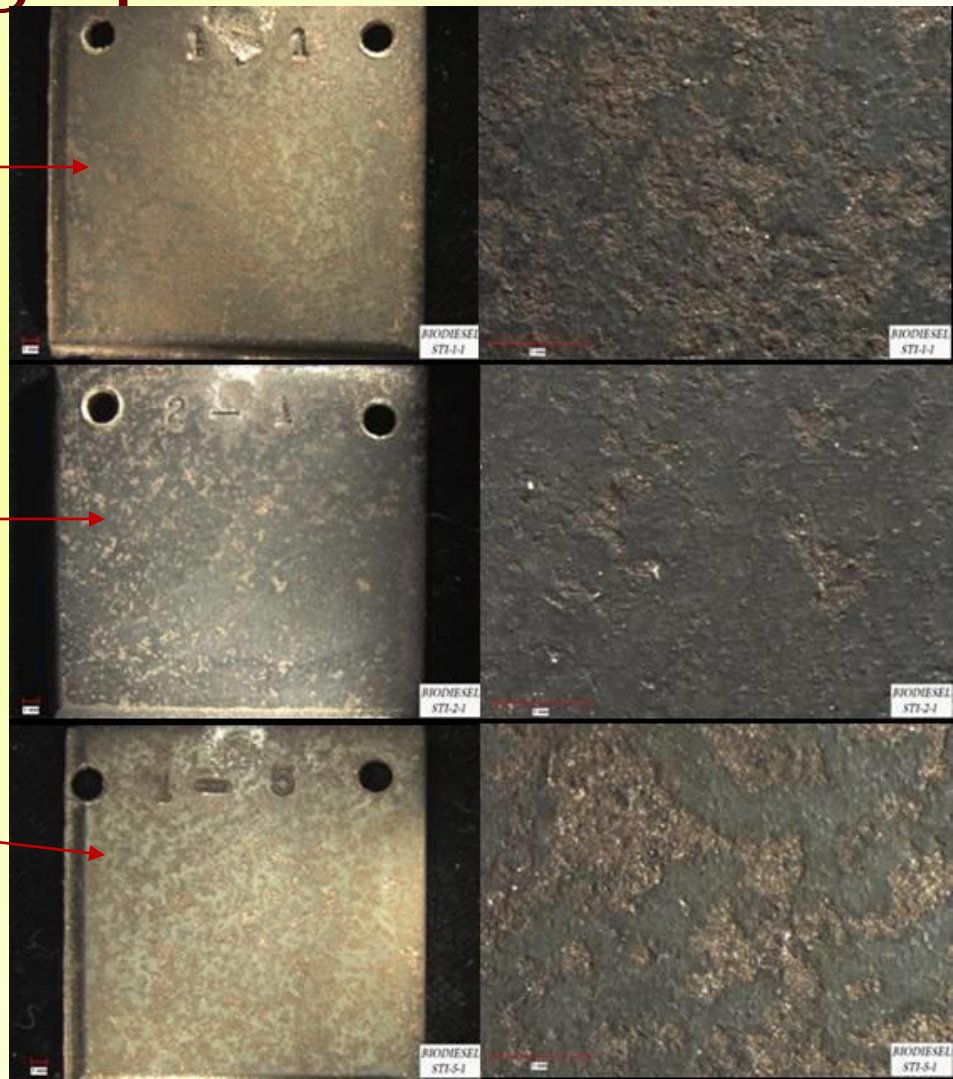
Low magnification optical micrographs

100%
Biodiesel

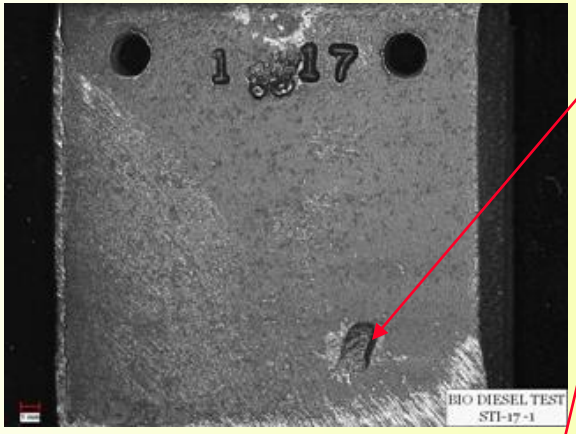
50% ULSD/
50%
Biodiesel

100% ULSD

No water
added to
any fuel



Typical Microscope Images



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1 mm

100 % animal-based biodiesel, no water

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


Steel
Steel Tank Institute
ACT-100-U


PERMATANK
DOUBLE-WALL
Steel Tank Institute
QUALITY ASSURANCE


Steel
TANK INSTITUTE
P3


Steel
Steel Tank Institute
ACT-100

50,000 Gallon
Double Wall
ACT-100 Tanks
Installed at
O'Hare Airport

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