

# Emerging Solutions for Biofuel-Induced Corrosion for ASTs & USTs



**Real world problems caused by the use of Ethanol, Bio-diesel, and Ultra-Low Sulfur Diesel, and a look at possible solutions**



**Marshall T. Mott-Smith, President**

**Mott-Smith Consulting Group, LLC**

1933 Commonwealth Lane, Tallahassee, FL 32303

marshall@mott-smithconsulting.com

mmott-smith@aetllc.com

www.mott-smithconsulting.com

850-391-9835 850-766-1562 cell 850-591-1434 cell



# Alternative Fuels



- E-10 Ethanol
- E-15 Ethanol
- E-85 Ethanol
- B-20 Bio-diesel
- ULSD – Ultra-Low Sulfur Diesel







ETHANOL TK 17



# Why are we using Ethanol?

## (from government sources)

- Air pollution – as an oxygenate to make fuel burn cleaner and reduce air pollution
- Augment the nations fuel supply and reduce reliance on foreign fuels
- Stimulate the economy
- It's a “Green” Fuel





# Problems with Ethanol...

1. Ethanol does not burn that much cleaner than regular gasoline
2. Using Ethanol leads to an energy drop-off
3. Using Ethanol competes with food crops and increases food costs
4. Chemically-speaking, Ethanol wants to become water
5. Phase Separation
6. Some older fiberglass systems are not compatible
7. Ethanol loves to eat soft metals, rubber, and plastics
8. More frequent dispenser filter changes
9. Ethanol has a scouring effect on tank systems
10. Ethanol is destroying our petroleum pumping infrastructure



# Alternative fuels (ULSD, Ethanol and Bio-diesel)



- Have only been in widespread use nationally for about five to six years
- Growing number of problems with the integrity of storage tank system equipment



Evidence of problems discovered from facility monthly visual inspections and State UST regulatory and fuel quality inspections

**Black “Gunk” in tank**



**Corrosion**



# Ethanol – E-10 & E-85





# Problems



Diesel sump, same facility, Georgetown,  
South Carolina, November 2011



Regular Unleaded gasoline sump, same facility,  
Georgetown, South Carolina, November 2011





Mississippi (e10)

Photo 12-09





South Carolina (e85)





Kentucky (e10)





Ohio





Idaho





Delaware (e85)

Installed 3-07 – Photo 3-08





Minnesota (e85)





Washington





California









Florida (e10)





Florida (e10)





Florida (e10)



How Long Does It Take For This Severe Corrosion To Occur?

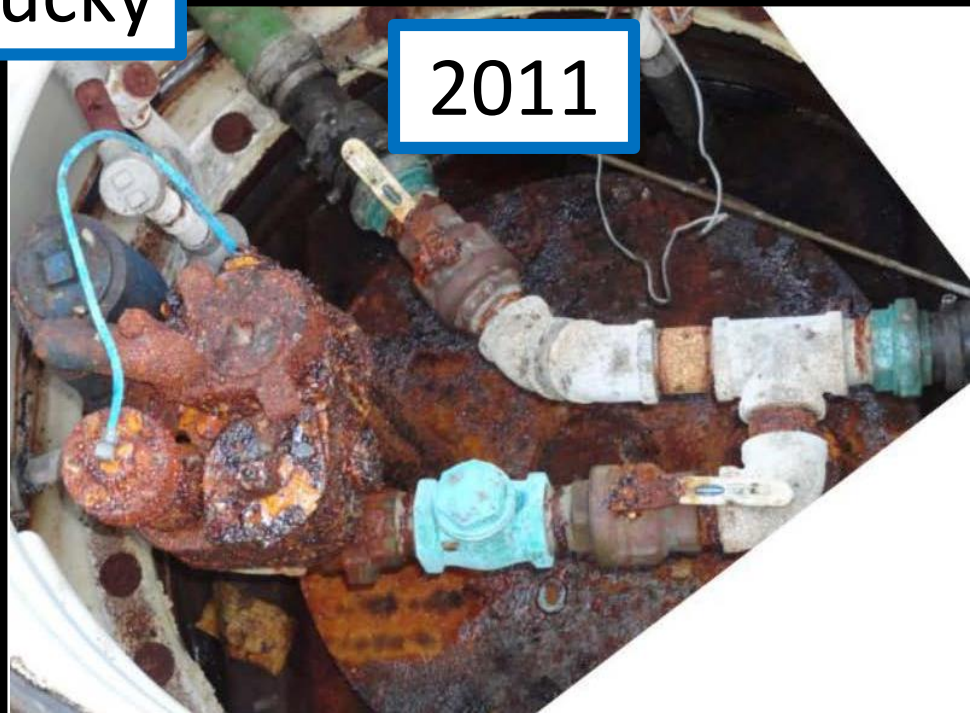
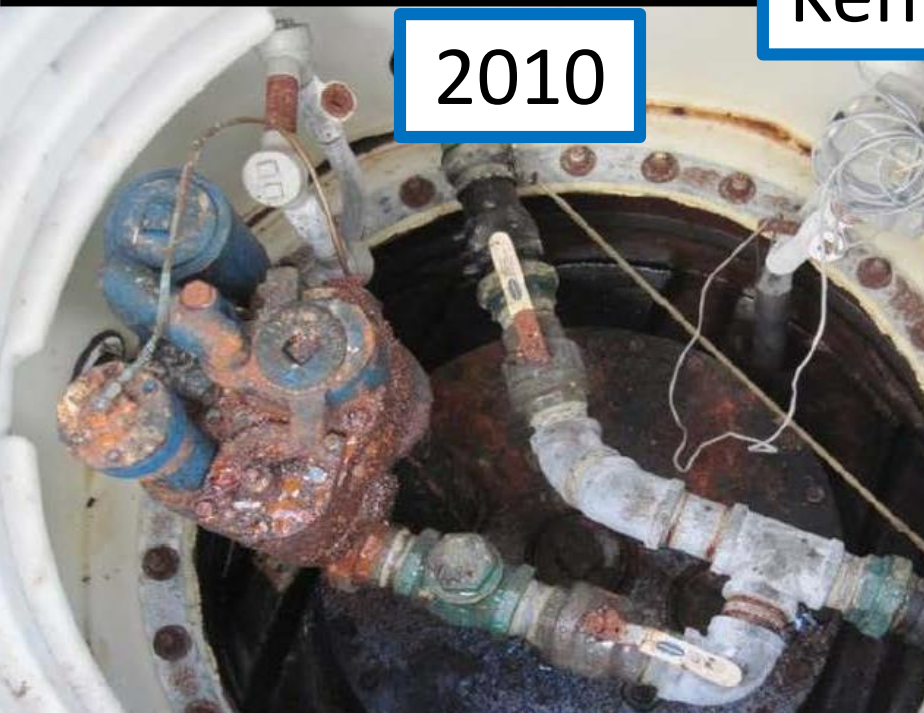
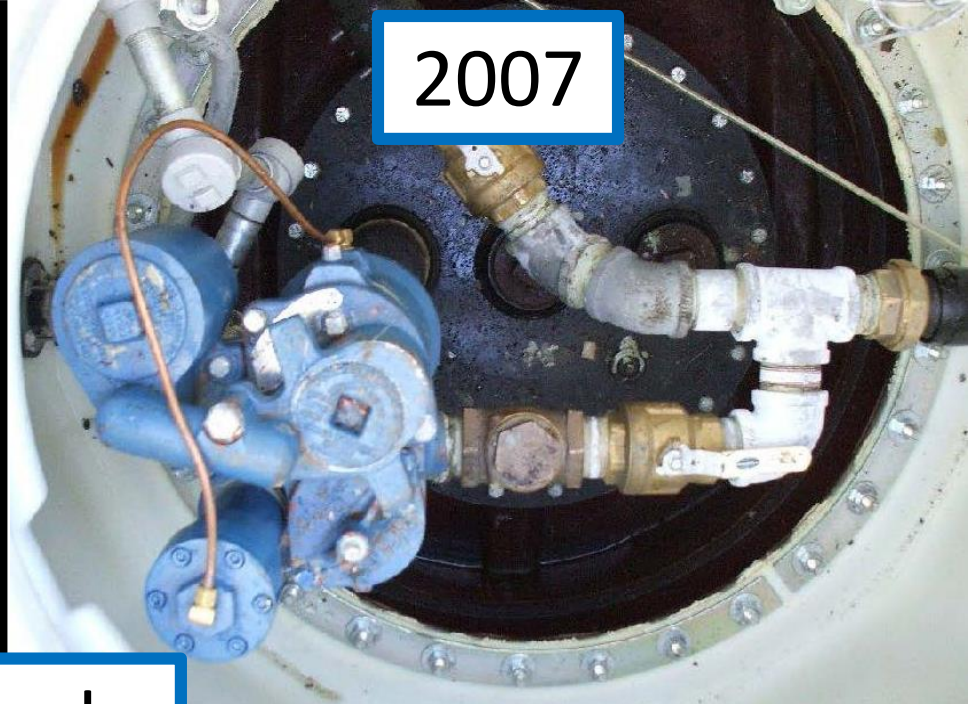
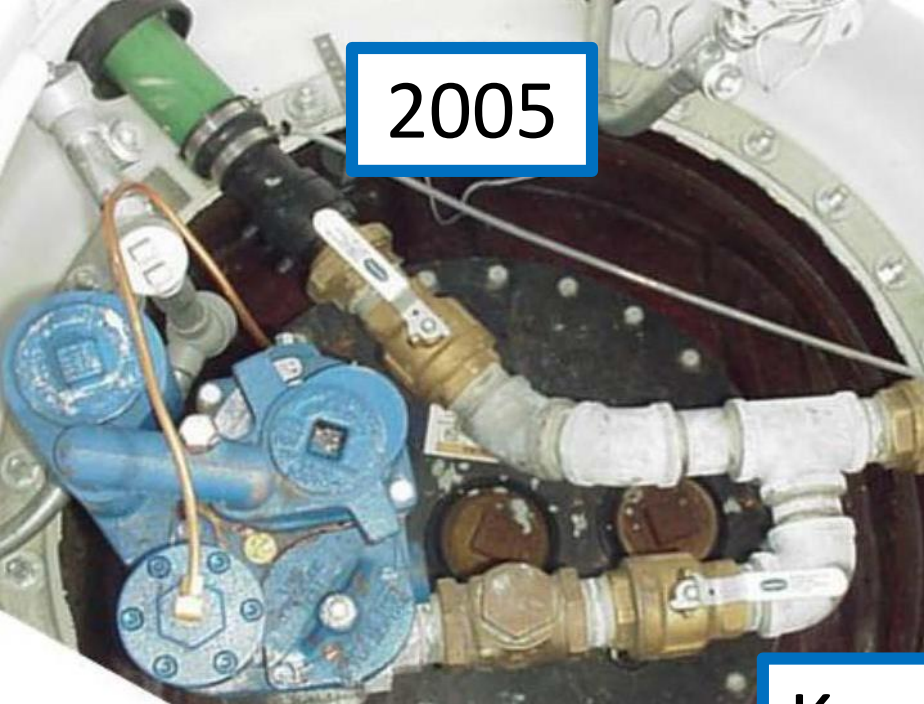


Tennessee - March 2010



Tennessee - August 2010





Kentucky



# Diesel vs. Gasoline

## Mississippi



Installed 8-07 - Photos 3-12

Same Facility - Same Equipment – Same Day- Different Sumps



**What's this “whirlybird” doing here with the tank vents?**



Kentucky



# What's this open pipe doing here?



Kentucky



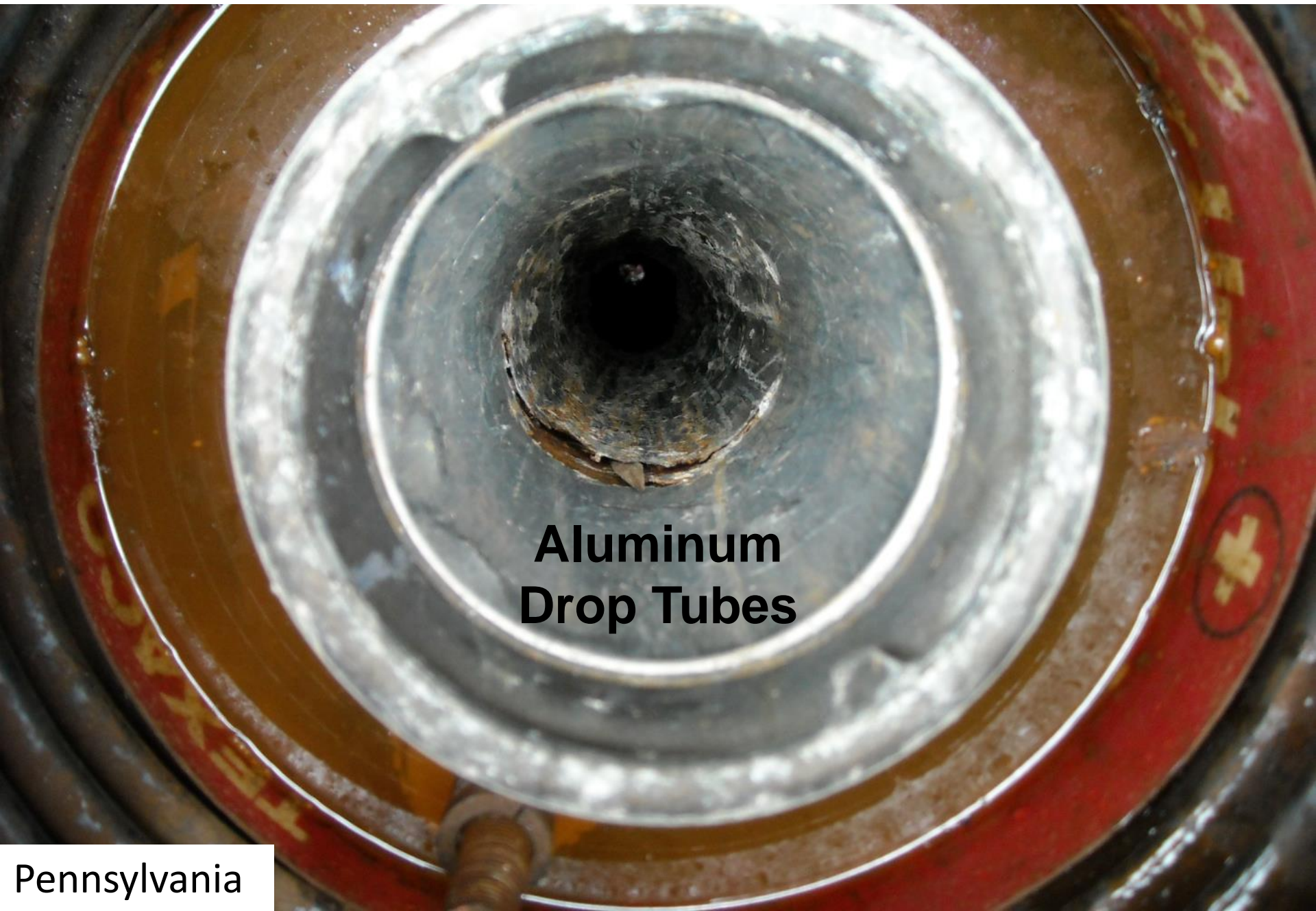
# Other Problem Areas – ATG Equipment



Evidence of vapor leaks



What other components could be affected by corrosion?



**Aluminum  
Drop Tubes**



# Corrosion on Aluminum Drop Tubes



Minnesota







# Corrosion on Ball Float Valve Overfill Protection Equipment



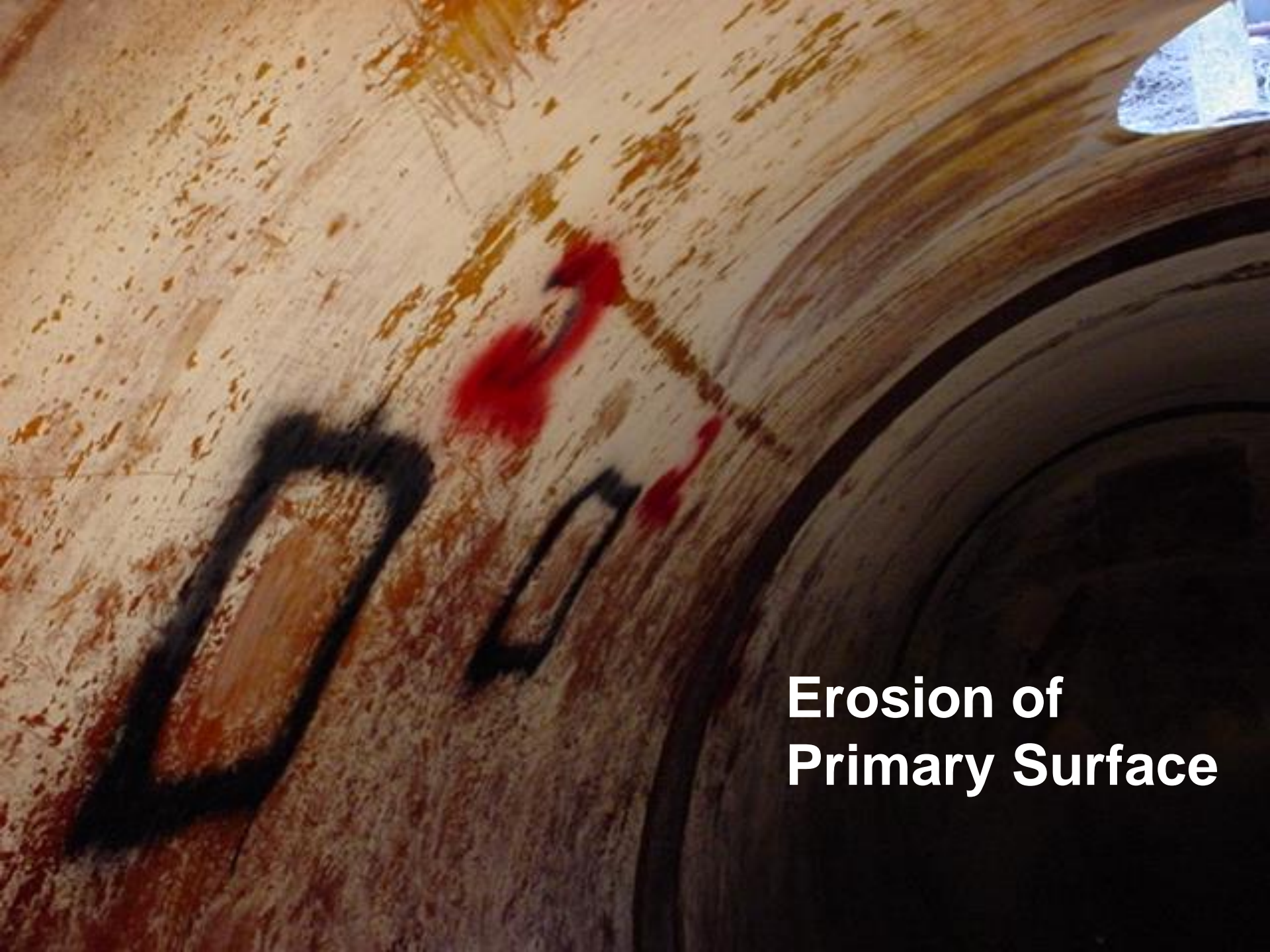
Mississippi





**Observations with Older Single-wall  
Fiberglass Tanks in E-10 Service for  
less than Two Years**





**Erosion of  
Primary Surface**



**Cracking**







**Internal erosion, wicking and delamination**





**Delamination of gel coat**

2006 7 25



BLISTERS  
↓ T-3

**Blisters on sidewall**



# Ethanol-Free Gasoline Has Become a Marketing Tool





# Advertising Ethanol-Free Fuels





CONTAINS  
NO ETHANOL

# Reg-90 Octane Marine Fuel

PUSH TO  
SPEAK  
WITH  
ATTENDANT

**WARNING**  
Improper use may cause a  
hazardous condition:  
• Avoid static hazards  
• Return of nozzle  
• In case of fire do not  
remove nozzle  
• No smoking/ extinguish  
all flames  
• Licensed drivers only  
• Do not top off  
Pumper for protected  
equipment  
*Ready*

Shell  
**Marine Fuel**

\$ Per Gallon (including tax)

4.759

Shell  
**Marine Fuel**

REGULATED OCTANE RATING  
BY-STATE METHOD

**90**

PUSH HERE



# Recent National EPA/State Regulator Field Study with Ethanol Corrosion

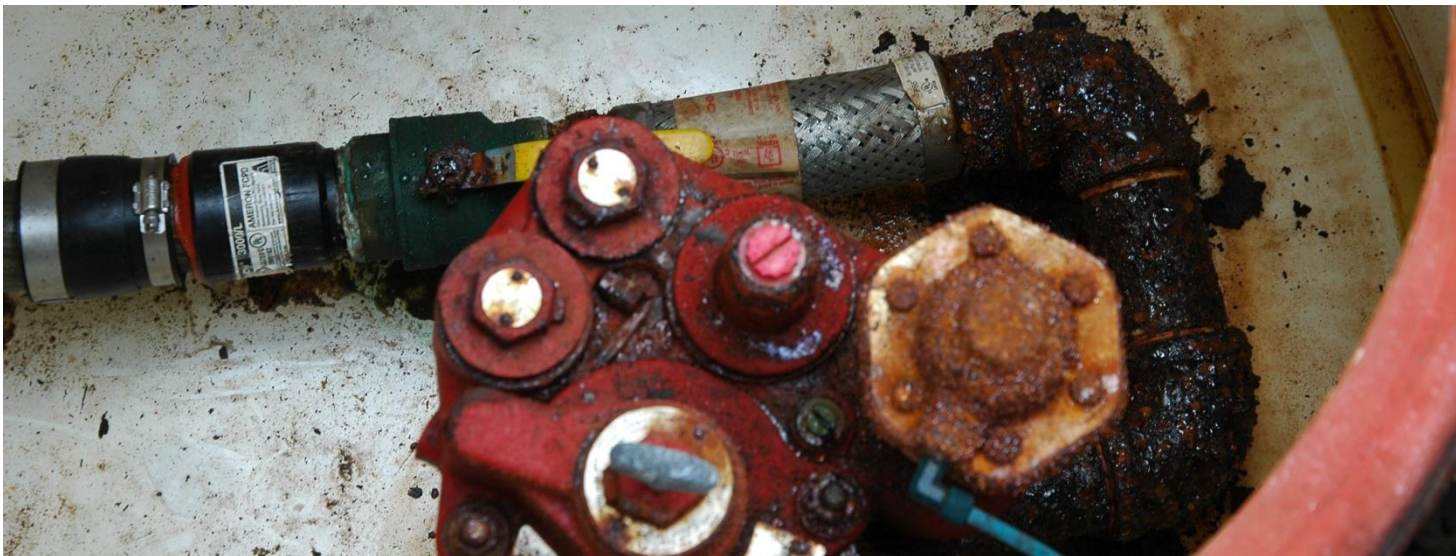
- EPA provided sampling kits
- Passive diffusion samplers were placed in piping sumps to measure the concentrations of ethanol and acetic acid
- Data came from Florida (35), Tennessee (13), Illinois (6), Wisconsin (4), California (2), and Iowa (1)
- 27 RUL, 2 MUL, 26 PUL, 5 E-85, and One Diesel





# Findings

- Many sumps had high concentrations of Ethanol or Acetic Acid
- No significant difference between RUL & PUL
- Corrosion worse in sumps with high concentrations
- Corrosion worse in sumps with water
- For Ethanol to cause corrosion in a sump, there must be ethanol, bacteria, and water
- Eliminating one of these could prevent corrosion?





# Other Problems

- Warranties for UST and AST Fuel System Components
- Vehicle Warranties
- Concerns with traditional problems from ethanol fuel use such phase separation, degradation of soft metals, increased filter replacement, and the scouring effect on fuel tanks
- UST & AST owner acceptance
- Consumer confidence





# Vapor Corrosion Inhibitor Testing and Ethanol Corrosion Prevention Efforts...

- More Field Trials
- Invite Participation
- Future considerations:
  1. VCI media and levels
  2. Tightness of sumps
  3. Tightness of piping connectons
  4. Existing rust, manual removal of corrosion
  5. Surface penetrants and coatings
  6. Venting of vapors
  7. Combinations of the above



# Recent Field Studies for Remedies





# Zerust Vapor Corrosion Inhibitors







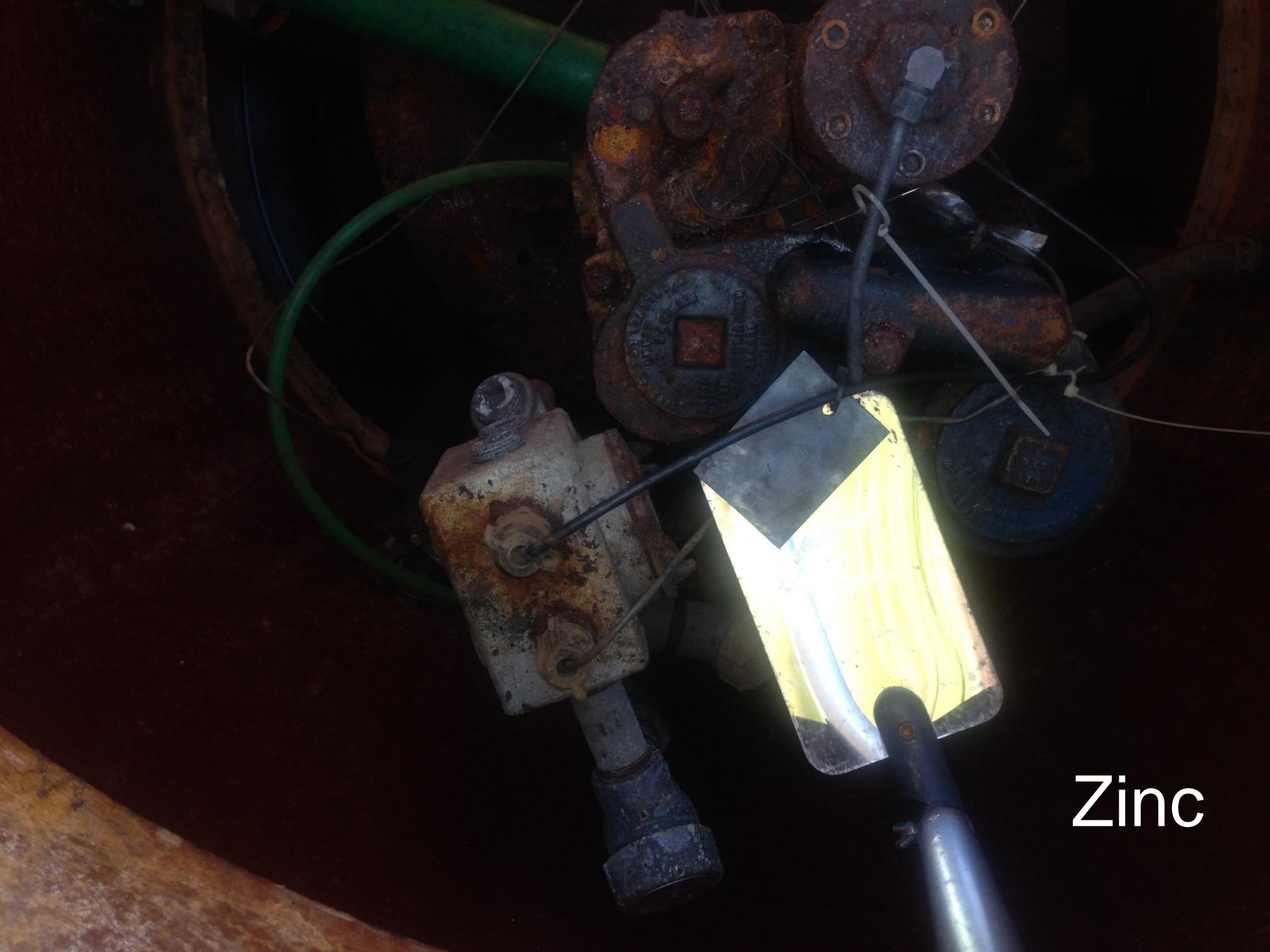
Copper



# Brass & Copper







Zinc



# Ethanol Vapor Saturation...







Spray



**Before**





**Iron Ox**

**After**





# Vapor Corrosion Inhibitor Testing and Ethanol Corrosion Prevention Efforts...

- More Field Trials
- Invite Participation
- Future considerations:
  1. VCI media and levels
  2. Tightness of sumps
  3. Tightness of piping connectons
  4. Existing rust, manual removal of corrosion
  5. Surface penetrants and coatings
  6. Venting of vapors
  7. Combinations of the above



# Ultra-Low Sulfur Diesel

**ULTRA-LOW SULFUR  
HIGHWAY DIESEL FUEL  
(15 ppm Sulfur Maximum)**

*Required* for use in all model year  
2007 and later highway diesel  
vehicles and engines.

Recommended for use in all diesel  
vehicles and engines.



# Ultra Low Sulfur Diesel



Submersible Pump & Riser  
(Left hand side is aluminum;  
Right hand side is steel)



Submersible Pump Head  
(in vapor space -- never  
contacts fuel)



STP column pipe inside FRP tank





# Pump connection corroded thru



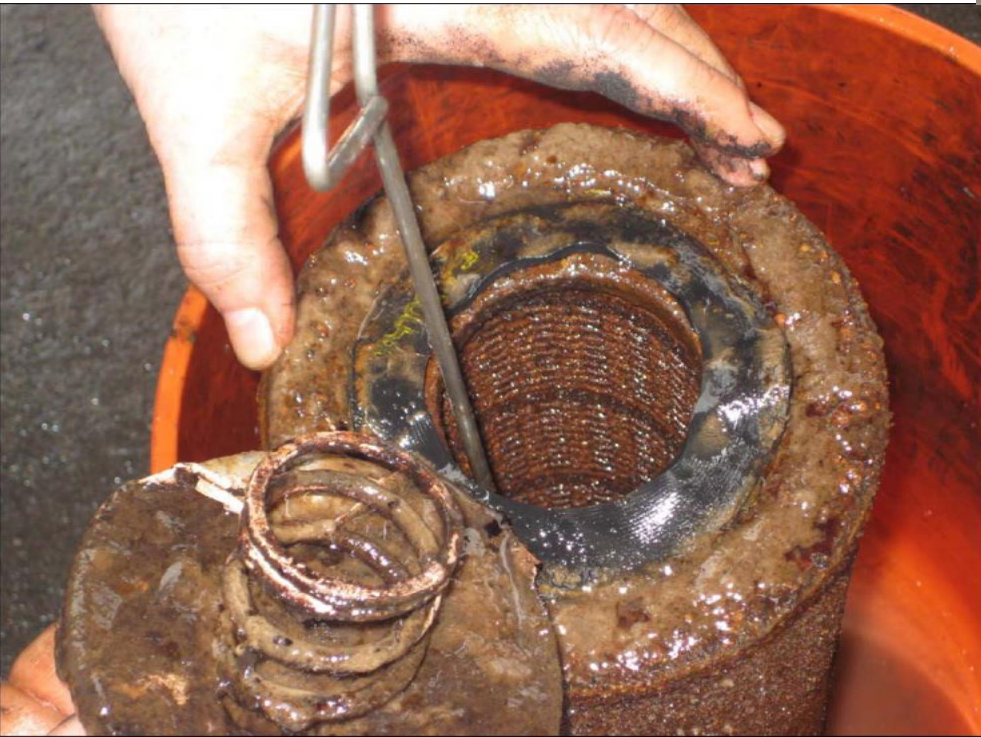




In service less than one year  
STP Column Pipe



# Problems with Ultra Low Sulfur Diesel and Steel Components





# FE Petro Equipment



Old vs New  
**Corrosion, Pitting**



Leak detection equipment not functioning





A close-up photograph of a metal component, possibly a filter or a part of a machine. The component has a cylindrical shape with a threaded section. The threads are covered in a dark, granular material, which appears to be a filter or debris. The background is a light-colored, textured surface.

**Filter  
threads**



**Strainer**





**“Coffee Grounds”**





**Problems reported from all regions of the country-  
No problems reported at refineries, pipelines, not  
associated with individual supplier**



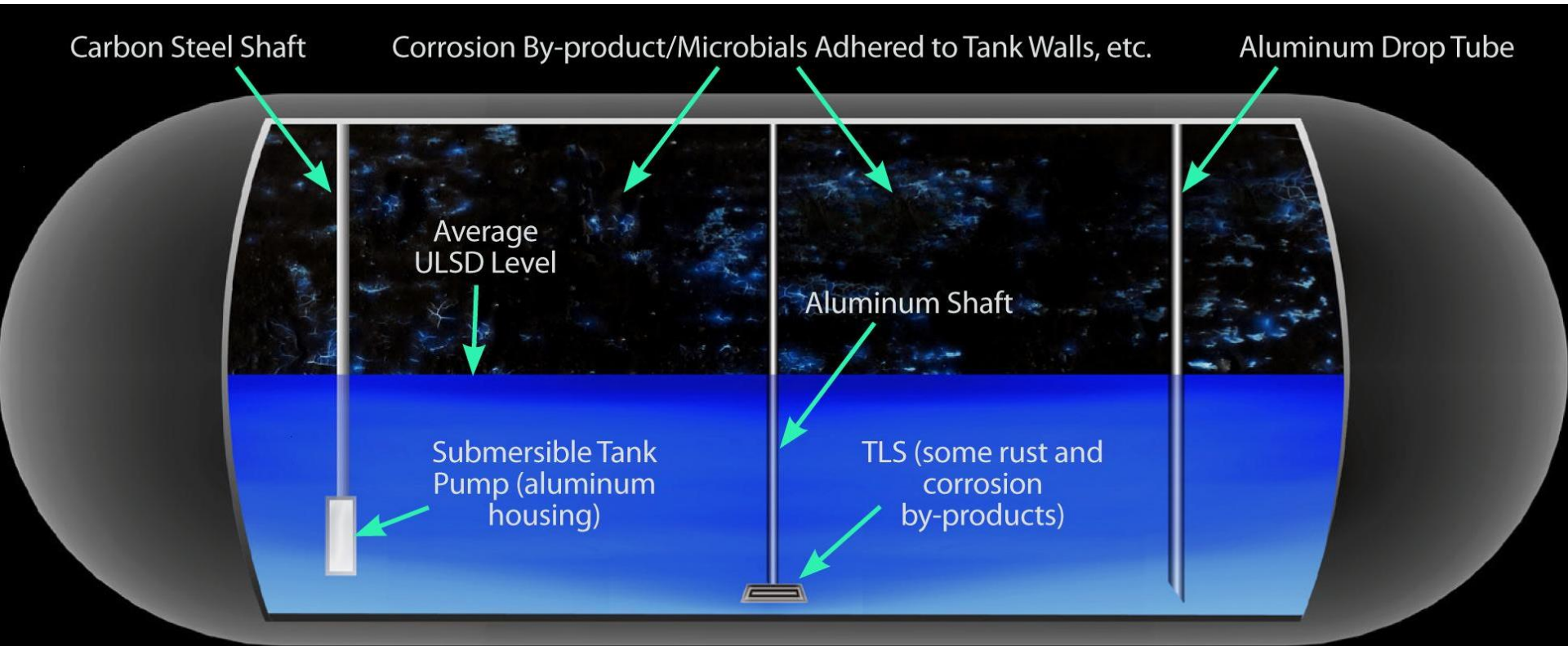


# Problems Observed

- Filters clogging/requiring more frequent replacement
- Seal/Gasket/O-ring deterioration
- STP replacement/Column pipe wear/Motor problems
- Tanks rusting/leaking (includes tanks of vehicles)
- Meter Failure
- Line leak detectors damaged or broken
- Automatic nozzle shutoff failure/shorter lifespan
- Tank probes malfunctioning
- Check valves not seating
- Shear valves not sealing/failing tests
- Swivels failing/shorter lifespan
- Dispenser leaks/failures/ premature replacement
- Solenoid valves clogged/failing
- Corrosion on the riser pipe
- Pipe failure



# ULSD Corrosion – UST Detail



**UST showing corrosion and possible microbial corrosion spots.**



# Likely Causes

- No one cause, but rather a mixture.....
- Microbial influence getting a lot of attention:
- Salt and other contaminants also a contributing factor?
- Corrosion inhibitor depletion (aka “soap”) theory – acidic additives form soaps if contacted with excessive tank water cations from salts or caustic:
- Poor housekeeping, no biological monitoring, improper application of biocides exacerbates problem



# The Clean Diesel Fuel Alliance

- Created in early 2006
- Participants include:
  1. Government
  2. Engine Manufacturers
  3. Marketers
  4. Refiners
  5. Marketers
  6. Equipment Producers

The screenshot shows the homepage of the Clean Diesel Fuel Alliance Information Center. The header features a banner with the text "Government - Industry - Consumers" and "Clean Diesel Fuel Alliance INFORMATION CENTER". Below the banner is a navigation bar with links: "> Skip Navigation", "> About ULSD", "> EPA Standards", "> EIA", "> ULSD Compliance", "> Media Room", and "> Contact Us". The main content area is divided into a left sidebar and a main body. The sidebar has a green background and contains links: "> Highway ULSD Fuel", "> Non-Road ULSD Fuel", "> Vehicle Performance", "> Environment & Health", "> Frequently Asked Questions", and "> Quicklinks to Member Web Sites". The main body has a light blue background with a cloud pattern. It features a large heading "Ultra Low Sulfur Diesel (ULSD) fuel and new engines and vehicles with advanced emissions control systems offer significant air quality improvement." Below this heading are four columns of text, each with a small image and a link. The first column is titled "Highway ULSD Fuel" and mentions EPA standards. The second column is titled "Non-Road ULSD Fuel" and mentions EPA standards for locomotive, marine, and non-road engines. The third column is titled "New Diesel Technology" and mentions Ultra Low Sulfur Diesel (ULSD) fuel. The fourth column is titled "Environmental Benefits" and mentions ULSD fuel along with new engine and emission control system technologies. At the bottom of the main body, there is a link "Para leer en español el folleto sobre diesel ultra bajo en azufre" and a link "Energy Tomorrow Radio Podcast on ULSD". There is also a small graphic of a fuel pump nozzle with the text "ULTRA-LOW SULFUR HIGHWAY DIESEL FUEL (15 ppm Sulfur Maximum)".

Government - Industry - Consumers  
**Clean Diesel Fuel Alliance**  
INFORMATION CENTER

> Skip Navigation > About ULSD > EPA Standards > EIA > ULSD Compliance > Media Room > Contact Us

> 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 sulfur content of diesel fuels.  
[Highway Diesel](#)

**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 construction equipment.  
[Non-Road 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](#)

**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](#)

**ULTRA-LOW SULFUR HIGHWAY DIESEL FUEL (15 ppm Sulfur Maximum)**  
Please refer to the label on the pump nozzle for more information.  
Remember to keep all pumps properly labeled (especially when refueling or replacing pumps).

Website: [www.clean-diesel.org](http://www.clean-diesel.org)



# Members of the Clean Diesel Fuel Alliance

- AAA
- Alliance of Automobile Manufacturers
- American Petroleum Institute
- American Trucking Associations
- Association of American Railroads
- Association of International Automobile Manufacturers
- Association of Oil Pipe Lines
- Diesel Technology Forum
- Engine Manufacturers Association
- Independent Liquid Terminals Association
- Manufacturers of Emission Controls Association
- National Automobile Dealers Association
- National Association of Convenience Stores
- National Association of Fleet Admins.
- NATSO, Inc., representing Truck Stops & Travel Plazas
- National Petrochemical & Refiners Association
- National Tank Truck Carriers, Inc.
- Petroleum Equipment Institute
- Petroleum Marketers Association of America
- Society of Independent Gasoline Marketers of America
- Steel Tank Institute
- Truck Renting and Leasing Association
- U.S. Environmental Protection Agency
- U.S. Department of Energy
- U.S. Energy Information Administration
- Western States Petroleum Association



# Clean Diesel Alliance Study

The Battelle/Tanknology proposal was chosen and funded by API, PEI, STI, NACS, PMAA, NATSO, AAR, and Ford

## *Theories Investigated*

- **Aerobic and anaerobic microbes** are producing byproducts that are establishing a corrosive environment in ULSD systems
- **Aggressive chemical species (e.g., acetic acid)** present in ULSD systems are facilitating aggressive corrosion; and
- **Additives** in the fuel are contributing to the corrosive environment in ULSD systems



# Test Sites

- **Chose 6 sites with similar throughput and history of issue:**
  - 1 site that does not show symptoms of corrosion
  - 5 sites with history of severe, rapidly induced corrosive symptoms
- **Sites in three states**
  - 2 in California
  - 3 in NY (including no symptoms site)
  - 1 in NC





# Site Inspections

- Feb 8-23: Inspected 6 sites
- Report Completed Late Summer 2012





# **Inspection Process Disassembled System**



# **Inspection Process Fuel Sampling**





# **Inspection Process Water Bottom Sampling**



# **Inspection Process Video Inside Tank and Vapor Sampling**





# Biological Analysis to Extract DNA





# ULSD Corrosion – Assessment



New steel  
corrosion coupon



After 3 months



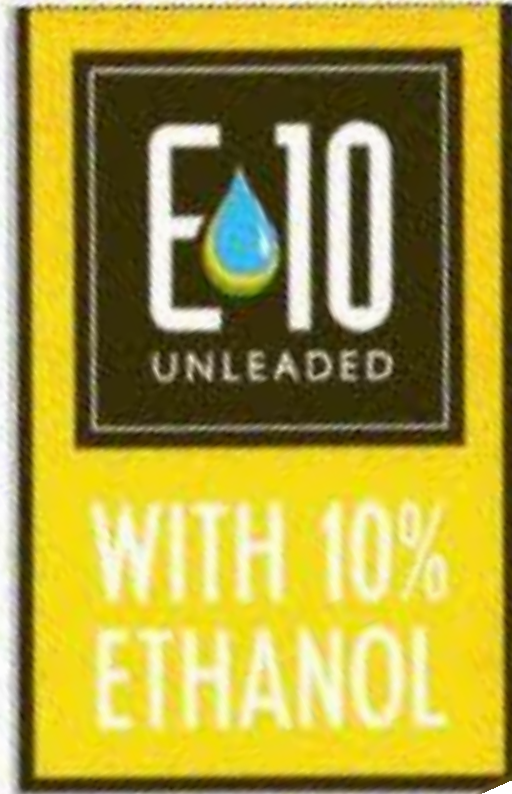
# So what did the Study Conclude?

- More studies are needed, but one of the causes of corrosion with ULSD systems is...





# Conclusion- The Source of the Problem...Ethanol!





# 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



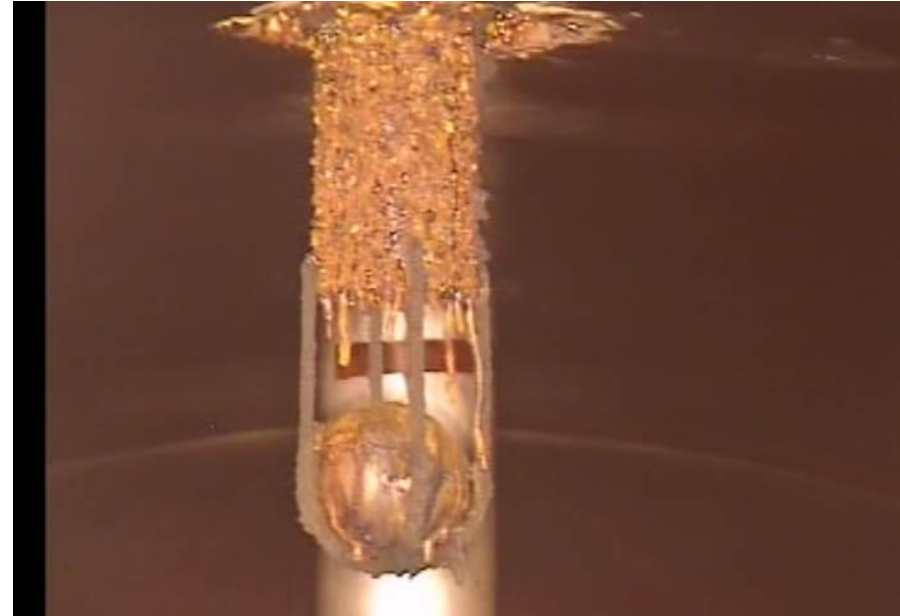
# Mixed Results

- Hypothesis that high acetate would indicate high corrosion
- Photos of risers don't indicate this
- Next step cameras inspected inside tanks at 3 locations



# STI Research

- Las Vegas service stations tanks under same owner
- FRP tank vapor control fitting – top right photo
- Steel tank vapor control fitting – bottom right photo



# Solutions, and What's Next?

- Clean Diesel Alliance may be funding another study
- ASTM and other industry professionals constantly in search of solutions
- Work with reputable fuel quality companies to provide biocides and other fuel treatment services and remedies to maintain fuel quality



# Bio-Diesel

- Many Bio-diesel plants shut down when the price dropped
- Problems with feedstocks and maintaining quality
- Problems with cold-flow and scouring effects on tanks
- Problems with “shelf-life”
- Expensive to refine
- Prone to microbial growth



photo: [propelbiofuels.com](http://propelbiofuels.com)

# Questions?

