Emerging Solutions for Biofuel-Induced Corrosion for ASTs & USTs

Mott-Smith
Consulting Group LLC

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

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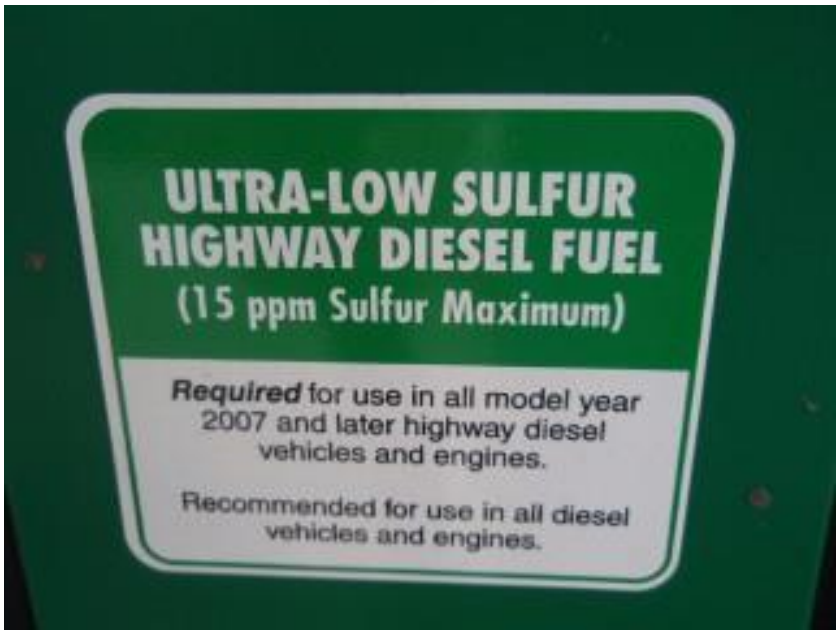
Alternative Fuels

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




ETHANOL TK 17

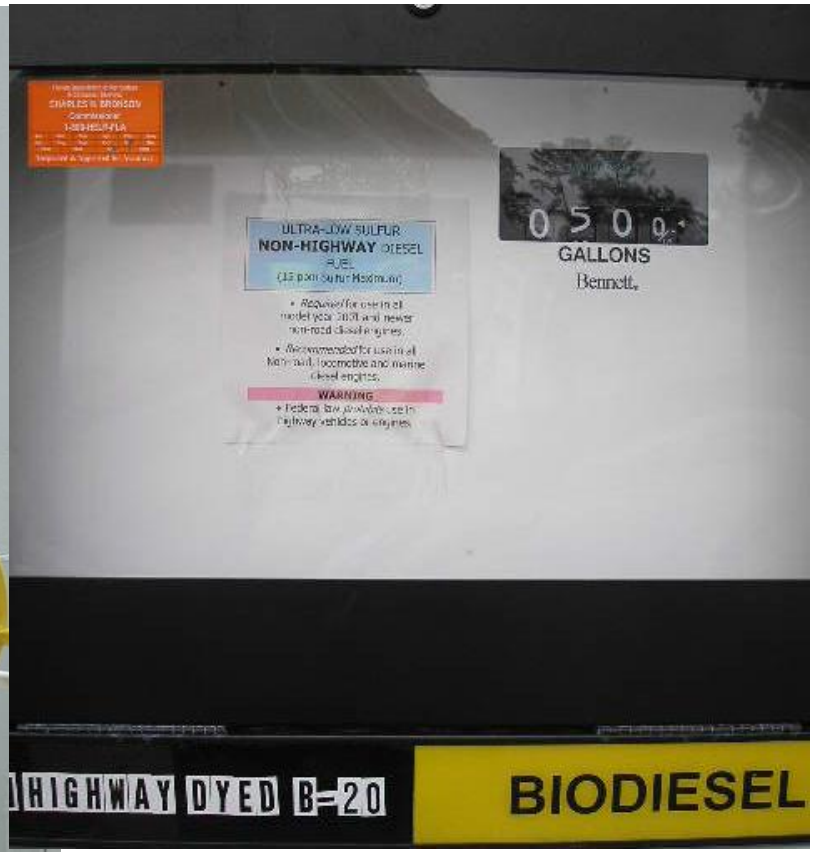
Why are we using Ethanol?
(from government sources)

- 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…

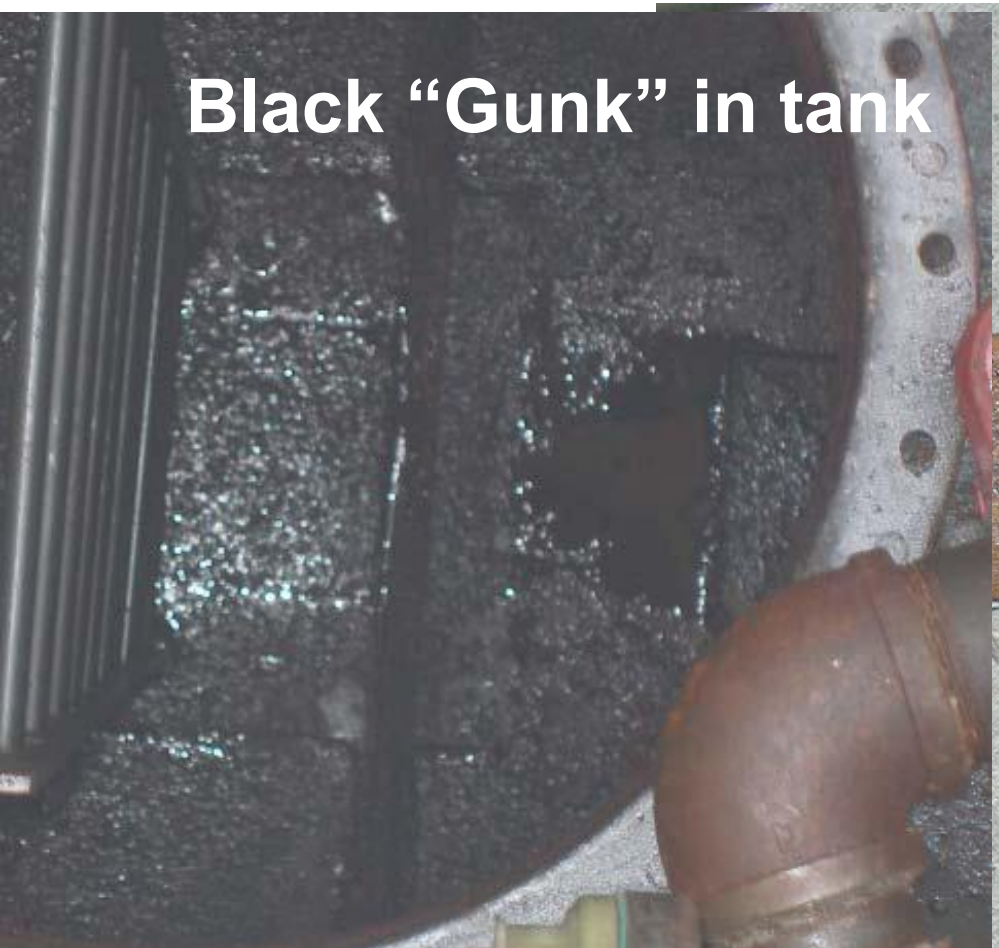
1. Ethanol does not burn that much cleaner than regular gasoline
2. Using Ethanol leads to an energy drop-off
3. Using Ethanol competes with food crops and increases food costs
4. Chemically-speaking, Ethanol wants to become water
5. Phase Separation
6. Some older fiberglass systems are not compatible
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



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

Iowa

Florida (e10)

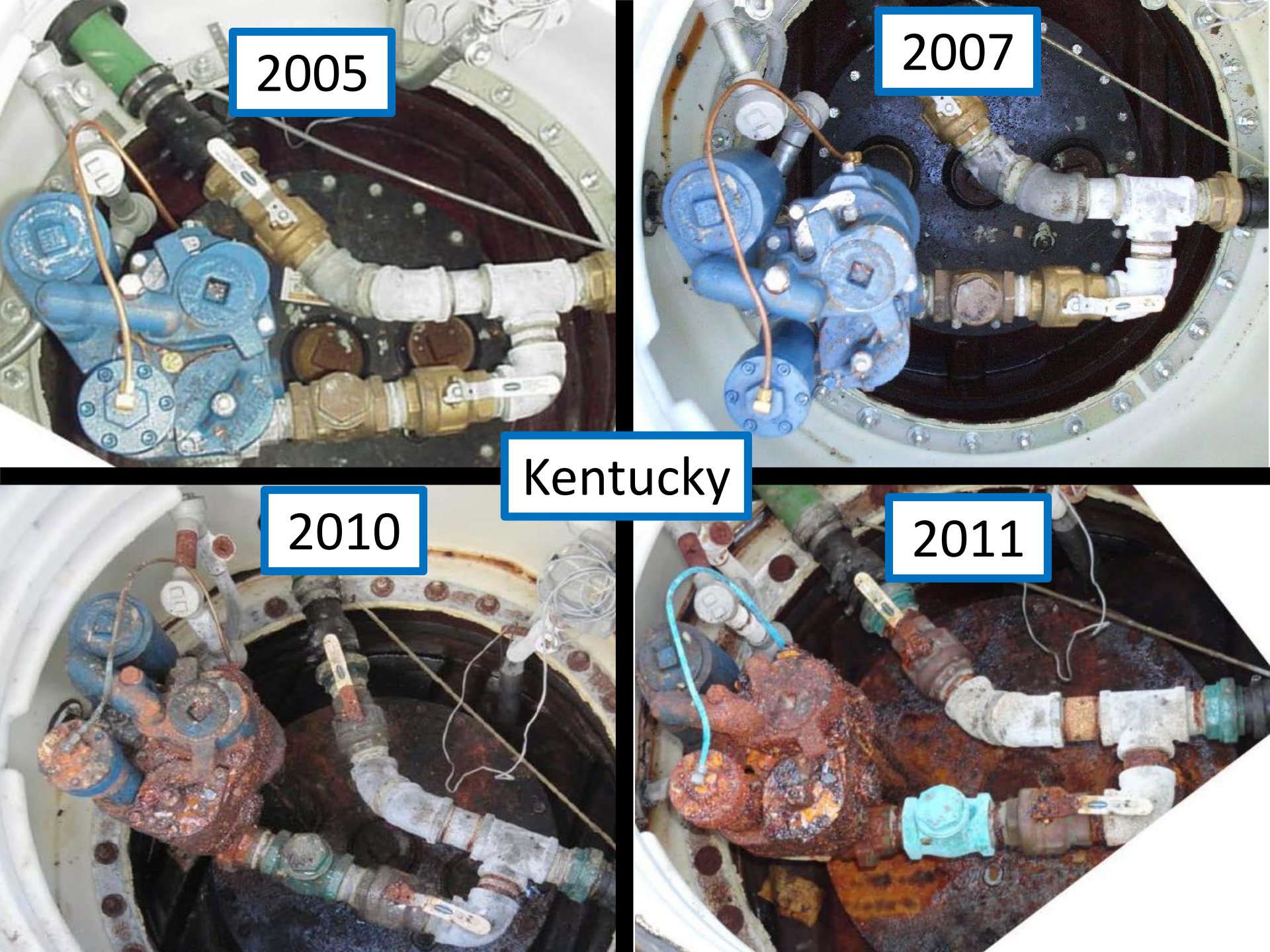
Florida (e10)


Florida (e10)

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

Tennessee - March 2010

Tennessee - August 2010


2005
2007
Kentucky
2010
2011

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

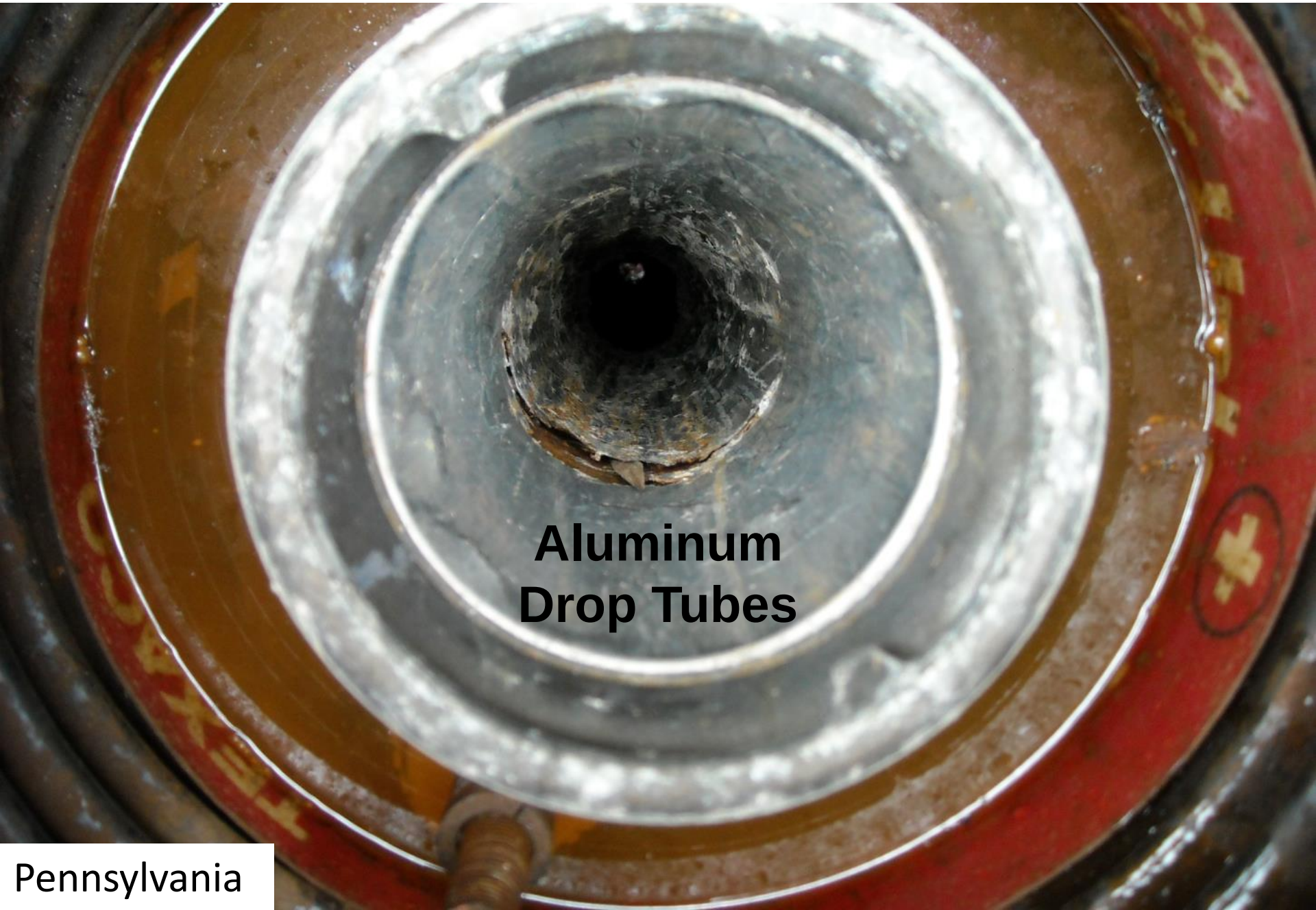
What's this open pipe doing here?

Kentucky

Other Problem Areas – ATG Equipment

Evidence of vapor leaks

What other components could be affected by corrosion?



Pennsylvania

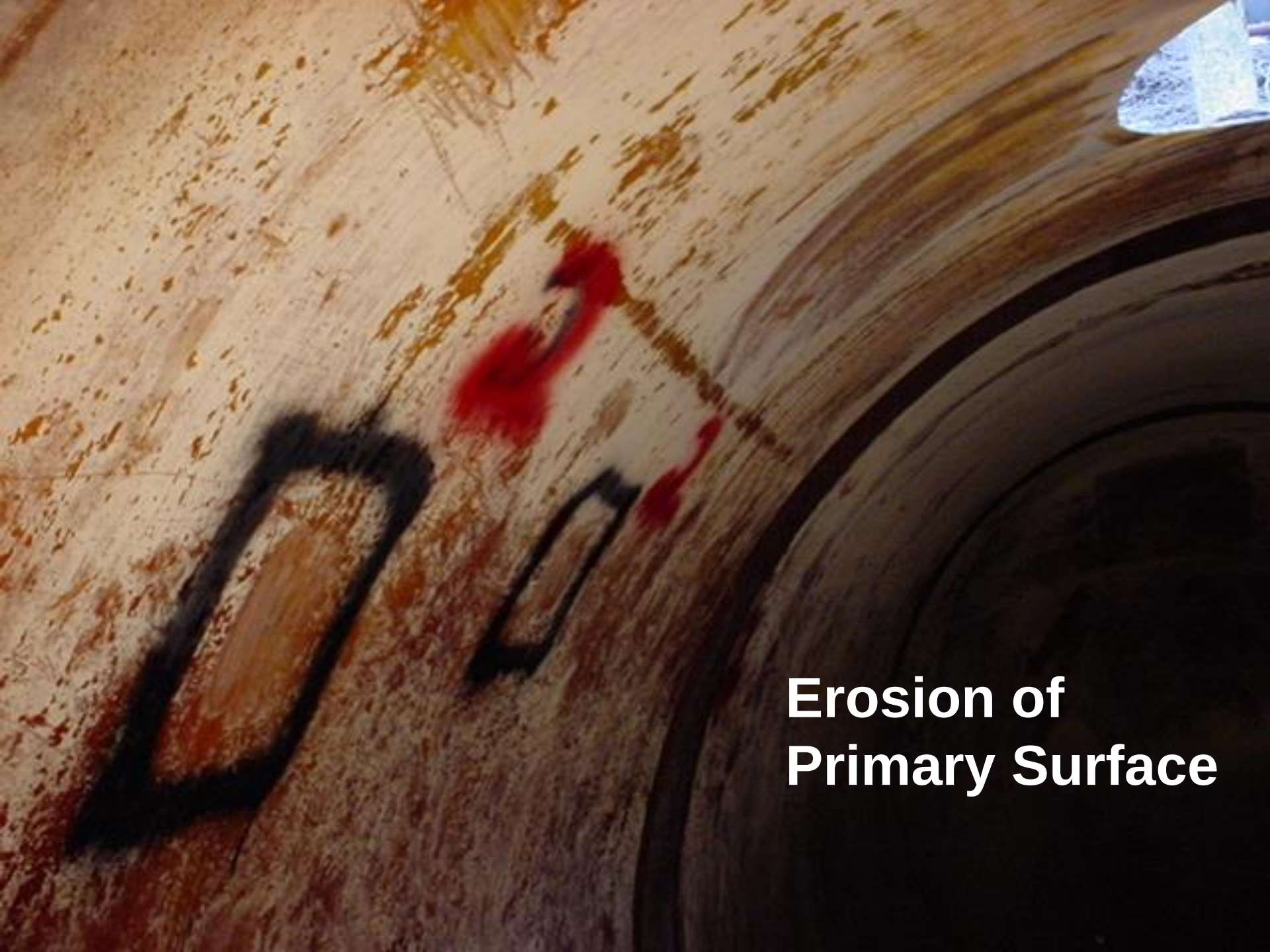
Corrosion on Aluminum Drop Tubes

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

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
Refer to posted warnings
Shell
Marine Fuel
$ Per Gallon (including tax)
4.759
Shell
Marine Fuel
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

Ethanol SUCKS

Vapor Corrosion Inhibitor Testing and Ethanol Corrosion Prevention Efforts…

- More Field Trials
- Invite Participation
- Future considerations:

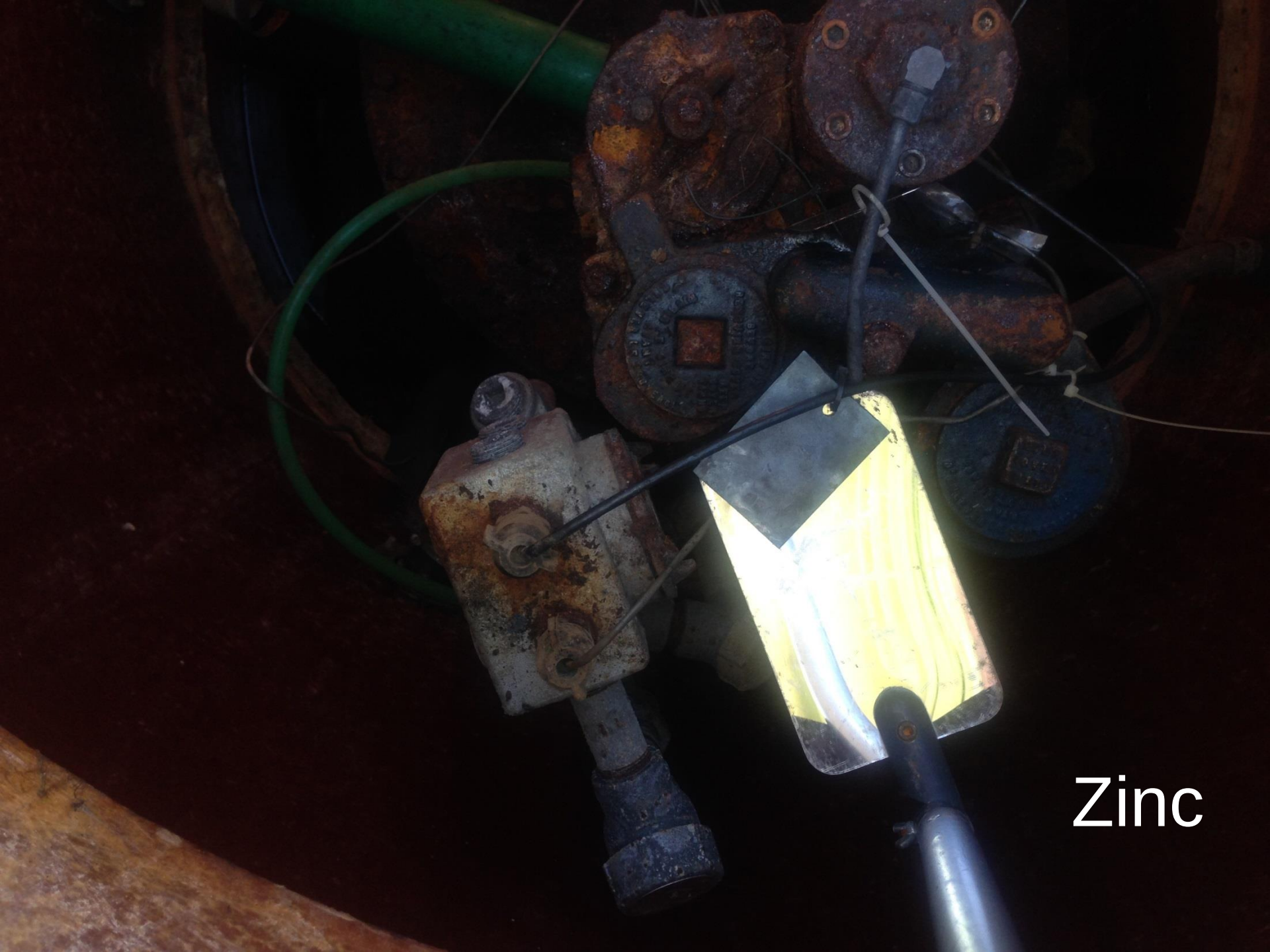
1. VCI media and levels
2. Tightness of sumps
3. Tightness of piping connectons
4. Existing rust, manual removal of corrosion
5. Surface penetrants and coatings
6. Venting of vapors
7. Combinations of the above

Recent Field Studies for Remedies

Zerust Vapor Corrosion Inhibitors


Copper

Brass & Copper


Zinc

Ethanol Vapor Saturation…


Spray


Before


Iron Ox
After

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Ultra-Low Sulfur Diesel

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)

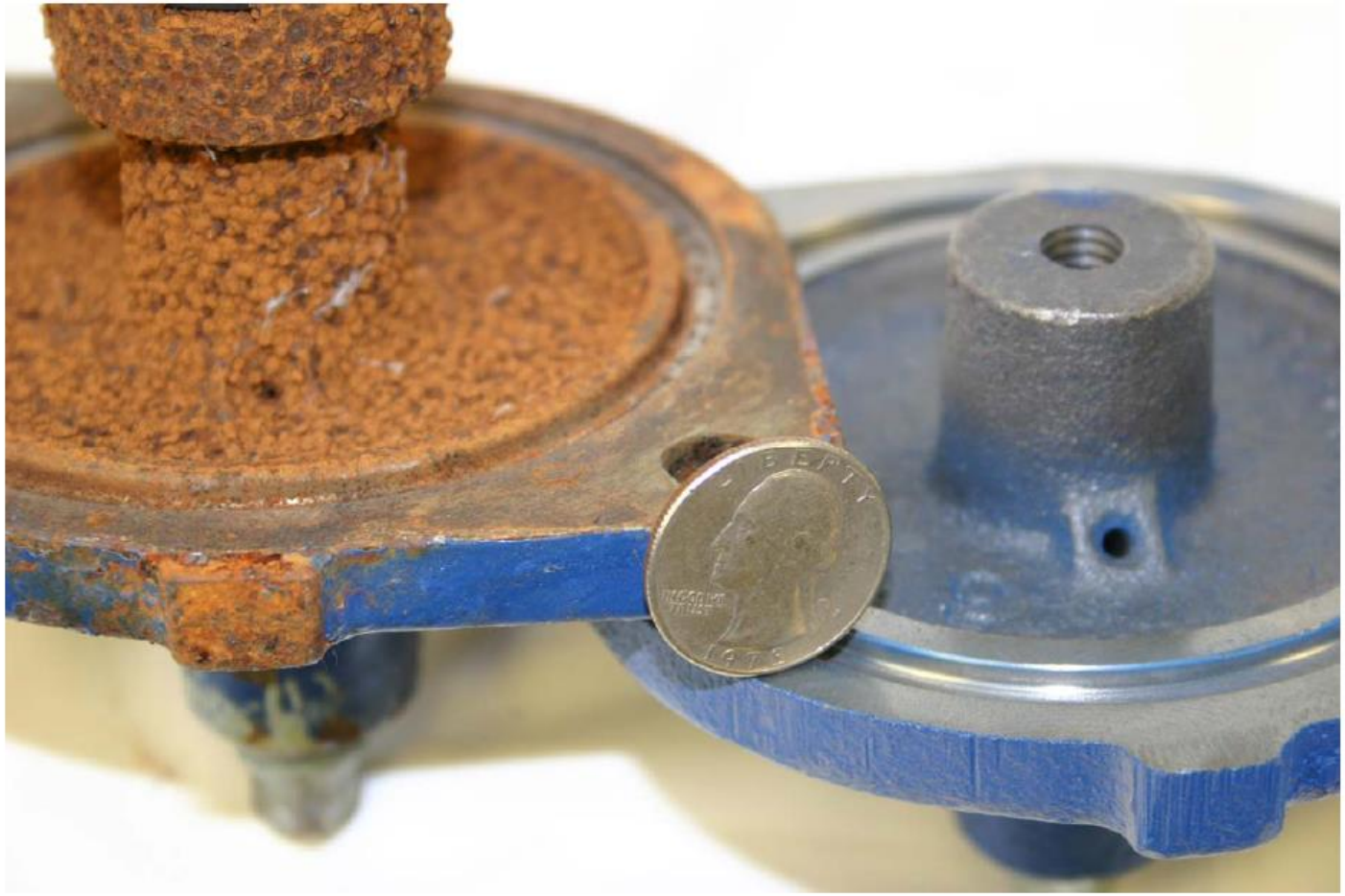
STP column pipe inside FRP tank

Pump connection corroded thru


In service less than one year
STP Column Pipe

Problems with Ultra Low Sulfur Diesel and Steel Components

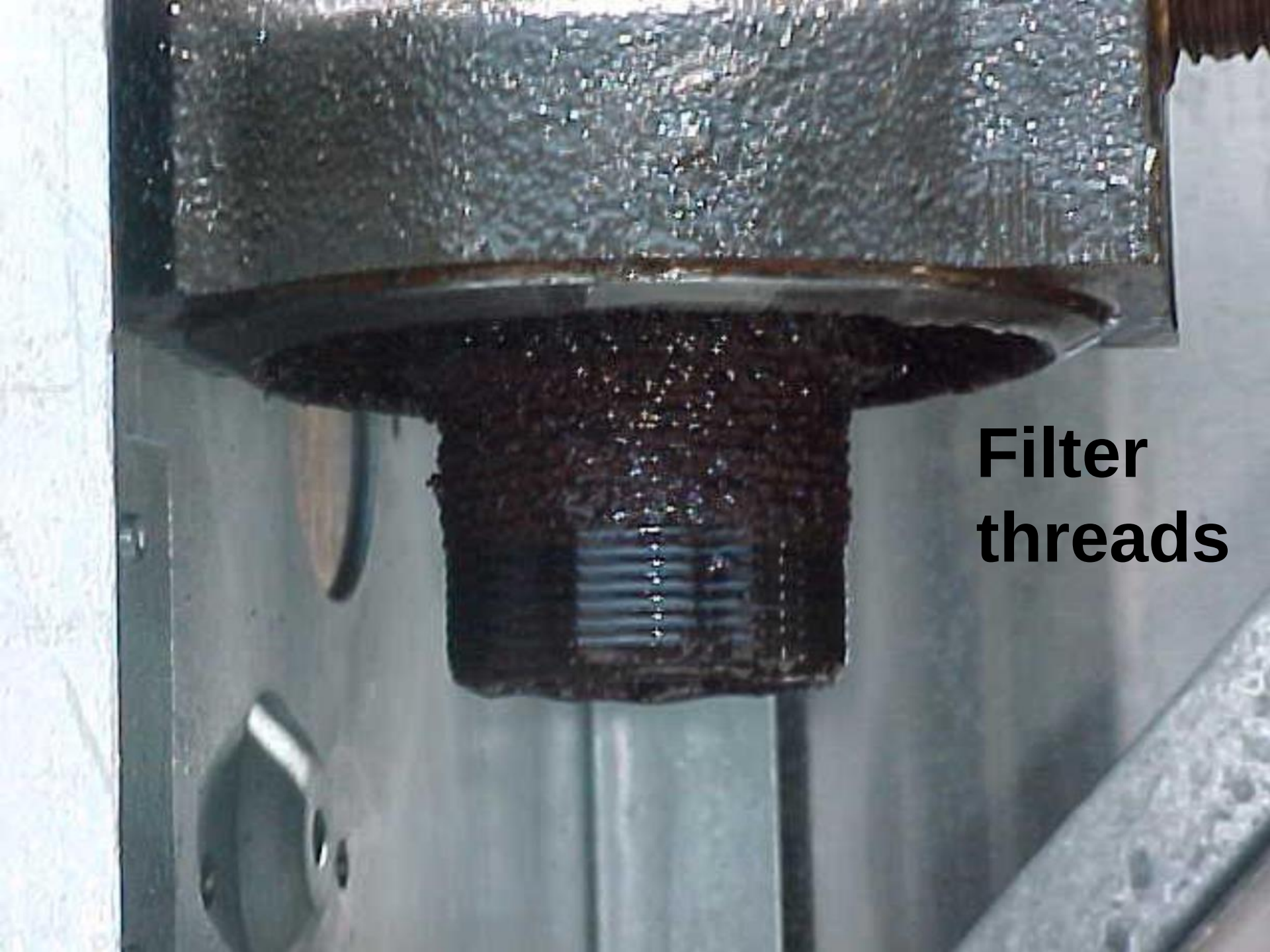
FE Petro Equipment



Old vs New

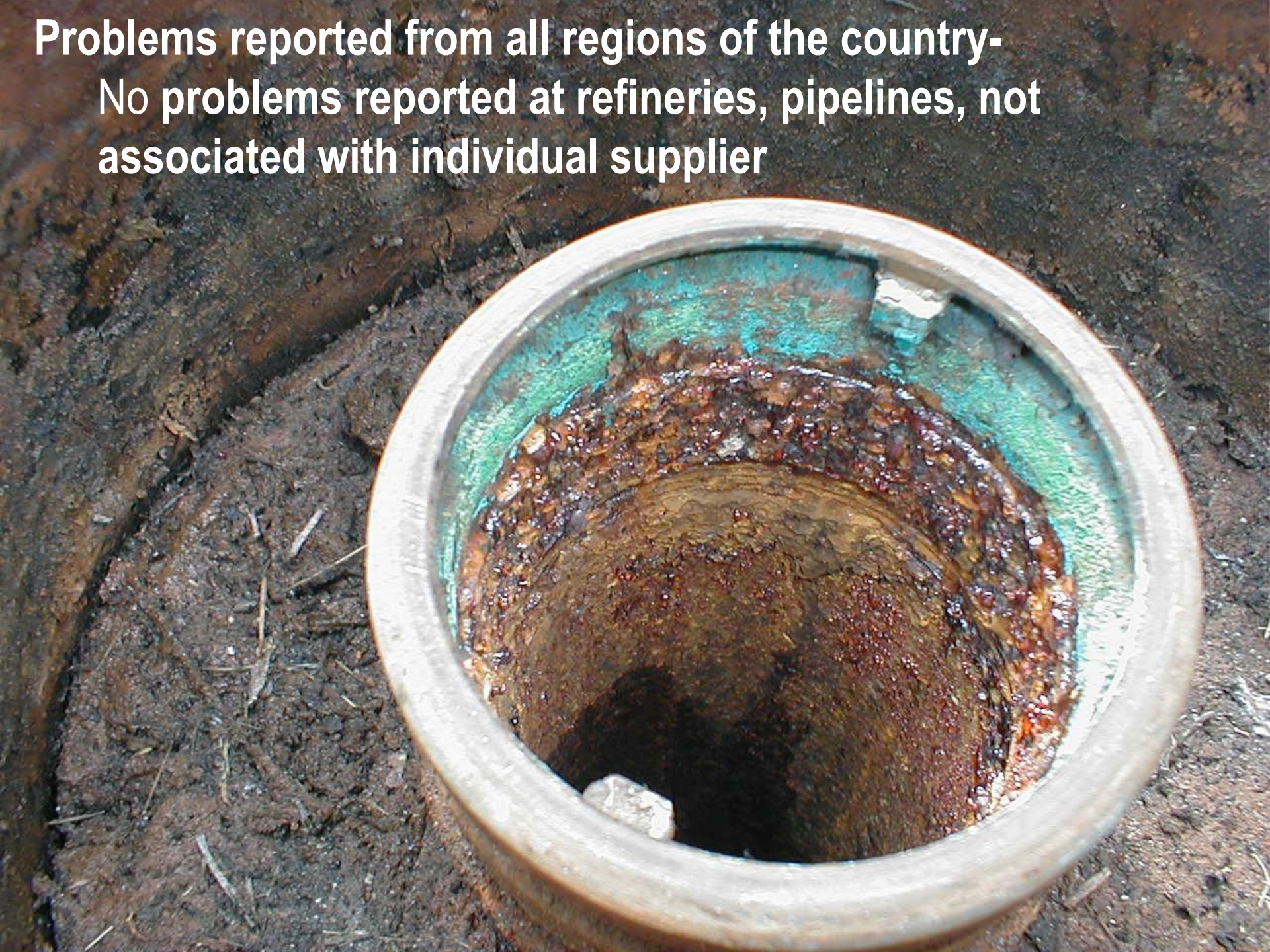
Corrosion, Pitting

Leak detection equipment not functioning


Filter
threads


Strainer

“Coffee Grounds”

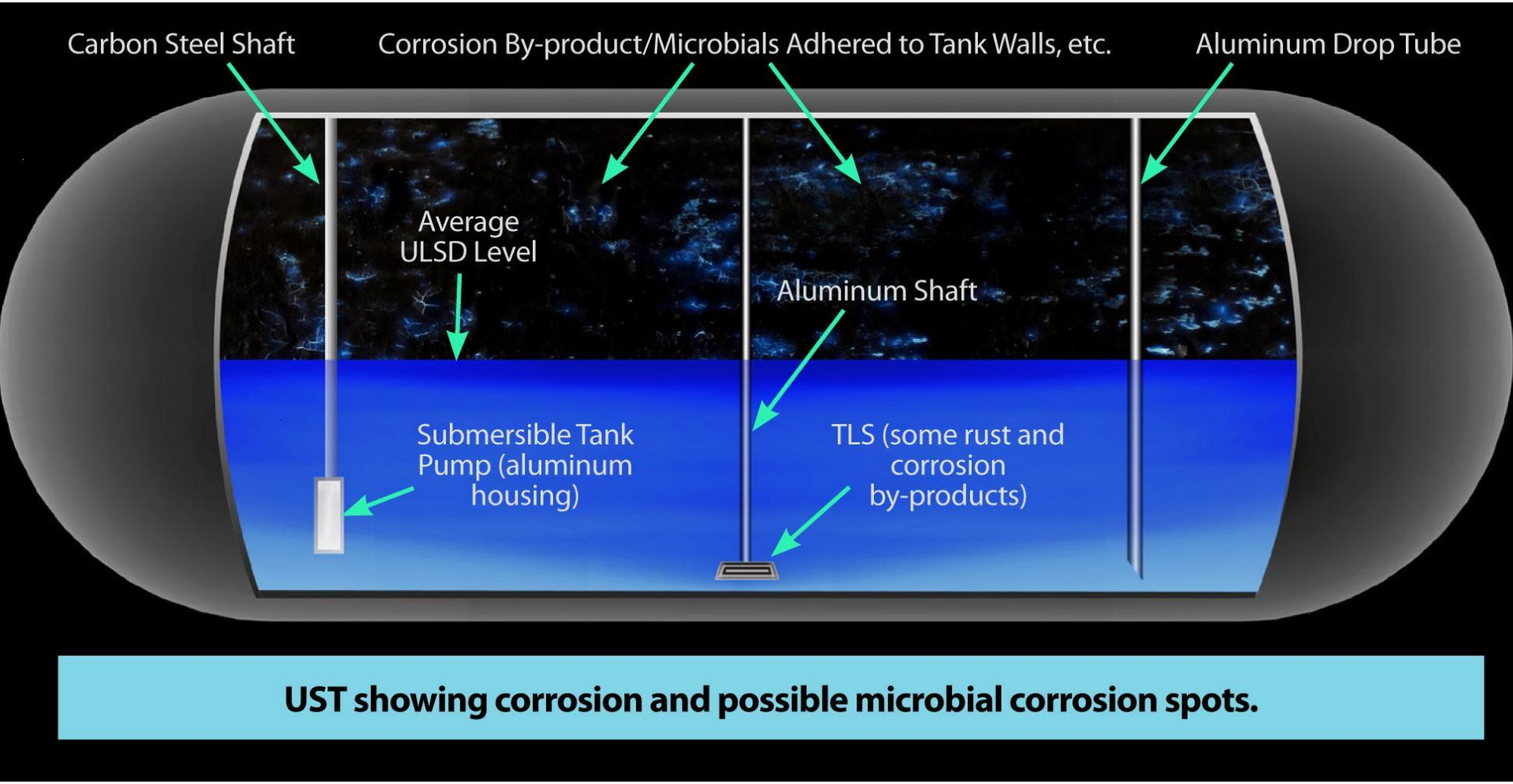


- **Problems reported from all regions of the country-**
  - No **problems reported at refineries, pipelines, not associated with individual supplier**

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

Website: 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

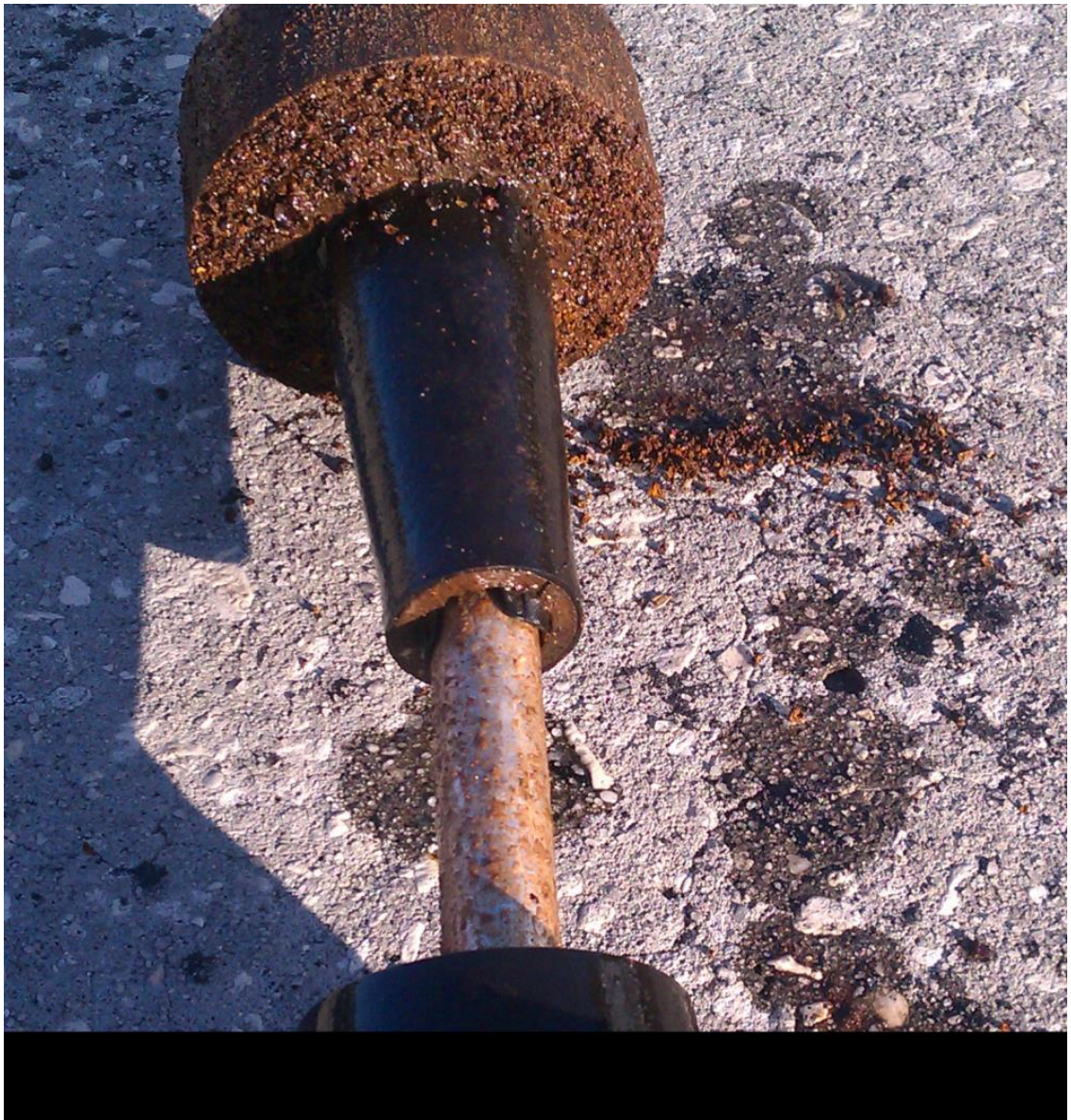
STI conducted own study

- 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

Questions?