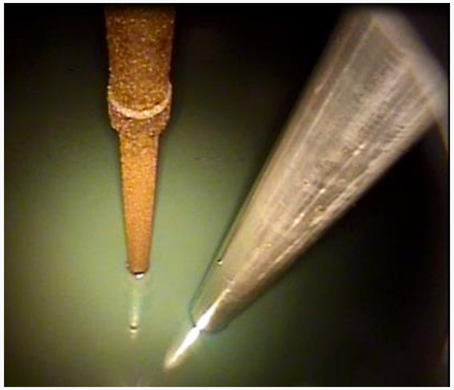
Corrosion in Underground Storage Tanks (USTs) Storing Diesel

Summary, Findings, and Impacts of EPA's July 2016 Research

Why Research Corrosion in USTs Storing Diesel?

- Reports began around **2007**



- **Internal** metal components – (often STP shaft)
- **Severe and rapid** onset
- **Unidentified cause**
- Extent not fully understood – **before this research, or after**
- *Appearance different and impacts more severe than corrosion in sump spaces of USTs storing gasoline/ethanol blends*

Key points from the research

- Research showed corrosion in most USTs studied. Owners may not be aware it is affecting their UST system

- Corrosion may impact equipment functionality in a couple of ways, and could pose a risk of release of fuel to the environment

- Metal components in steel and fiberglass tanks

Investigation of Corrosion-Influencing Factors - Released July 2016

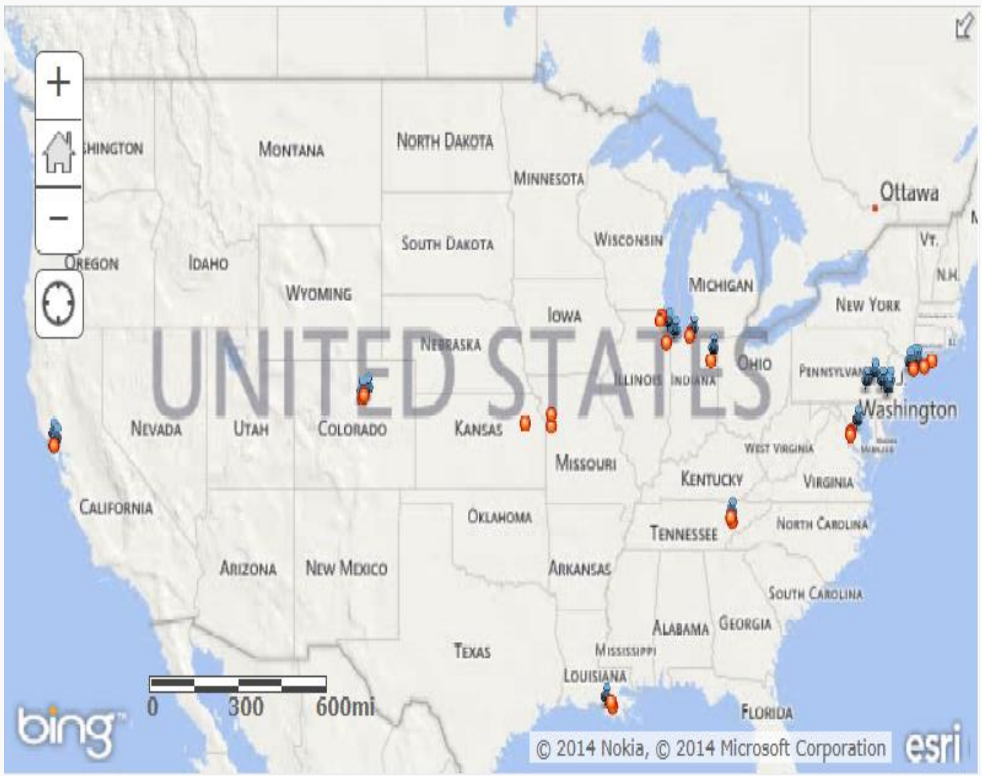
Research Goals:

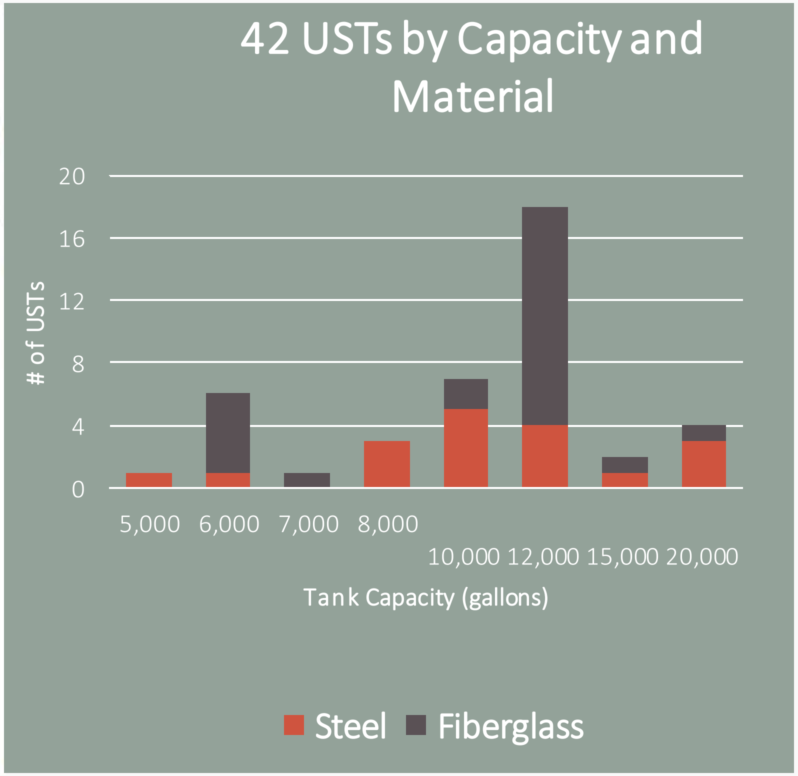
- To better **understand the extent** of the problem and identify potential risks
- Identify **any correlations or predictive factors** among UST systems with severe or minimal corrosion

Timeline of Research and Review Process:

- **Field and lab work** – completed spring 2015
- **Stakeholder review** of initial draft – summer 2015
- **Peer-review** – winter 2015-16

Investigation Locations and Tank Population





Diverse UST Sample Population

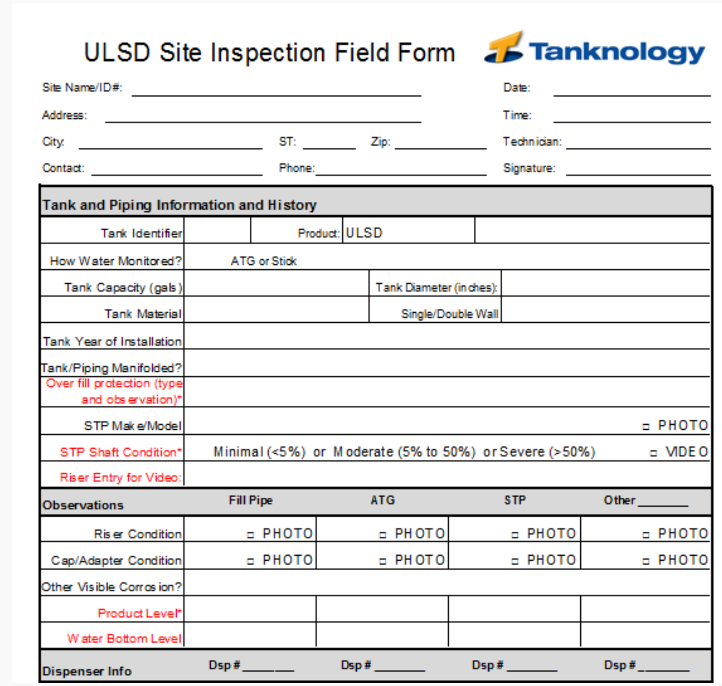
- **Many locations**
  - 42 sites
  - 24 fiberglass, 16 steel, 2 steel coated
  - 8 of 10 have steel and fiberglass in cluster
- **8 different owners**
  - Government, retail, fleet
  - Single and multiple site
  - Large range of fuel throughputs and suppliers
- **Diverse USTs**
  - 1 – 29 years in service
  - 5,000 to 20,000 gallons in capacity
  - Different product storage histories
  - Various approaches to maintenance

Data Collection on UST Conditions

Collect samples:

- Vapor
- Fuel
- Water bottom

Inspect with internal tank video



ULSD Site Inspection Field Form — Tanknology

Site Name/ID#: ____ Date: ____
Address: ____ Time: ____
City: ____ ST: ____ Zip: ____ Technician: ____
Contact: ____ Phone: ____ Signature: ____

Tank and Piping Information and History			
Tank Identifier		Product: ULSD	
How Water Monitored?	ATG or Stick		
Tank Capacity (gals)		Tank Diameter (inches):	
Tank Material		Single/Double Wall	
Tank Year of Installation			
Tank/Piping Manifolded?			
Over fill protection (type and observation)*			
STP Make/Model			▫ PHOTO
STP Shaft Condition*	Minimal (<5%) or Moderate (5% to 50%) or Severe (>50%)		▫ VIDEO
Riser Entry for Video:			

Observations	Fill Pipe	ATG	STP	Other ______
Riser Condition	▫ PHOTO	▫ PHOTO	▫ PHOTO	▫ PHOTO
Cap/Adapter Condition	▫ PHOTO	▫ PHOTO	▫ PHOTO	▫ PHOTO
Other Visible Corrosion?				
Product Level*				
Water Bottom Level				
Dispenser Info	Dsp # ______	Dsp # ______	Dsp # ______	Dsp # ______

Collect information on maintenance, throughput, fuel supply, biocide use, etc.

Sample Analyses

FUEL

Fuel Analysis Methods	Method Identifier	Determination of
Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration (Procedure B)	ASTM D6304[8]	Water Content
Determination of Density, Relative Density, and API Gravity of Liquids by Digital Density Meter	ASTM D4052[10]	Density
Acid Number of Petroleum Products by Potentiometric Titration	ASTM D664[11]	Total Acid Number
Determining Corrosive Properties of Cargoes in Petroleum Product Pipelines	NACE TM-172[12]	Corrosion Rating
Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration	ASTM D6217[13]	Particulates
Determination of Biodiesel (FAME) Content in Diesel Fuel Oil Using Mid Infrared Spectroscopy (FTIR-ATR-PLS Method)	ASTM D7371[14]	Biodiesel Content
Flash Point by Pensky-Martens Closed Cup Tester	ASTM D93[15]	Flashpoint
Determination of Free and Total Glycerin in Biodiesel Blends by Anion Exchange Chromatography	ASTM D7591[16]	Free and Total Glycerin
GC-MS Full Scan	Lab In-House Method	Unknowns of Interest
Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence	ASTM D5453[17]	Sulfur Content
Electrical Conductivity of Aviation and Distillate Fuels	ASTM D2624[18]	Conductivity
Determination of Short Chain Fatty Acids by Gas Chromatography-Mass Spectrometry (GC-MS)	Lab In-House Method	Acetate, Formate, Propionate, Lactate, Glycerate

Water

Water Bottom Analysis Methods	Method Identifier	Determination of
Ion Chromatography (IC) for short chain fatty acids	Modified EPA 300	Acetic, Formic, Propionic, Lactic Acids
IC Test for Free Glycerin	Lab In-House Method	Glycerin
Determination of Dissolved Alkali and Alkaline Earth Cations and Ammonium in Water and Wastewater by Ion Chromatography	ASTM D6919[19]	Cations (Sodium, Calcium, Magnesium, Potassium, Ammonium) and Anions (Chloride, Sulfate, Nitrate and Fluoride)
pH (Electric)	EPA 150.1[20]	pH
Conductance (Specific Conductance, umhos at 25° C)	EPA 120.1[21]	Conductivity
Nonhalogenated Organics Using GC/FID	SW846 8015B[22]	Ethanol and Methanol

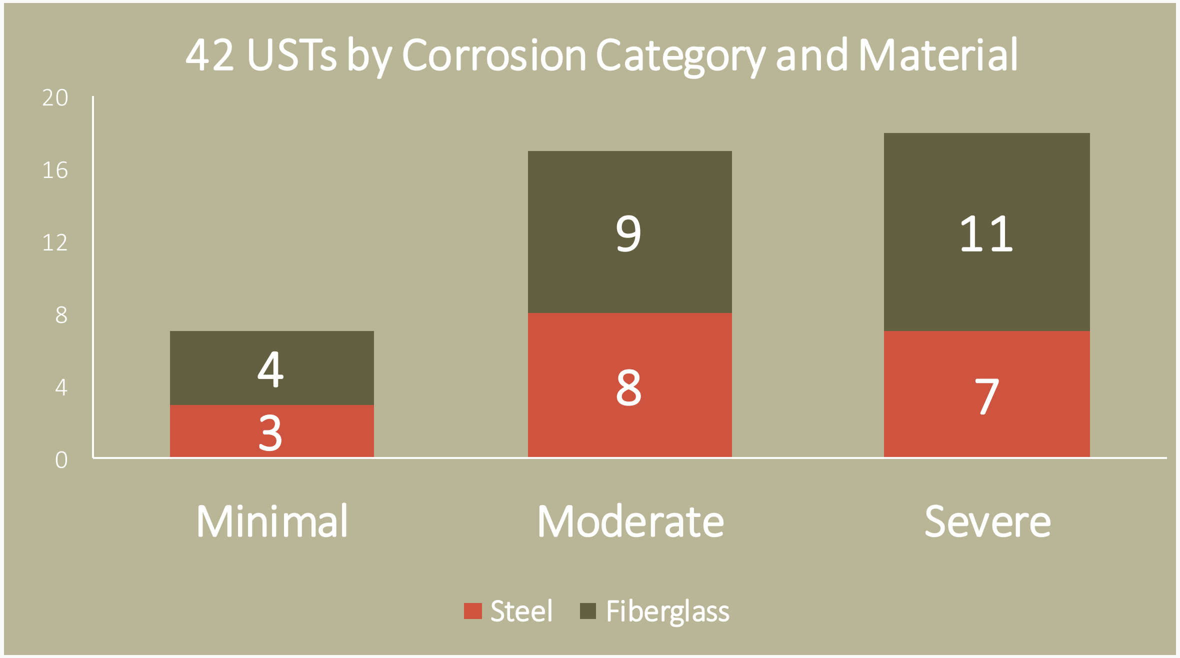
VAPOR

Vapor Analysis Methods	Method Identifier	Determination of
Ullage % Relative Humidity	Hygrometer used per manufacturer instructions	% relative humidity
Carboxylic Acids in Ambient Air Using GC-MS	ALS Method 102	Acetic, Formic, Propionic, and Butyric Acids
Determination of Lactic Acid in Ambient Air	Modified NIOSH 7903	Lactic Acid

Study Findings

- Corrosion more prevalent than anticipated – 83% had moderate or severe corrosion
- Many owners were not aware they had corrosion – sample was biased, but less than 25% initially believed they had corrosion
- No statistically significant predictive factors

Corrosion Prevalence in 42 USTs



Note: EPA asked for sites with corrosion, so sample is biased. But less than 25 percent of the sample population was aware of corrosion before investigation.

Red = steel Brown = Fiberglass (Total Population = 24 fiberglass, 18 steel)

Potential Risks to the Environment – Exposed Metals in the Vapor Space

- Release prevention equipment could corrode and fail to function
  - Corrosion on flapper valves could restrict movement and allow an overfill
  - Product level floats get stuck on corroded shafts and fail to signal a rising product level, fuel release, or water infiltration
  - Ball float valves – ball or cage may corrode
  - Line leak detectors could be failing performance testing at higher rates
  - Shear valves may jam

Potential Risks to the Environment (continued)– Bottoms of Tanks

- Metal components could potentially corrode through and possibly release fuel to environment
  - Diesel prone to collect water and sludge in bottom of tanks
  - Study results prompted conversations – heard handful of anecdotes of bottom repairs of primary walls of double-wall steel tank bottoms after leak to interstitial - sometimes a lack of leak detection alarms but fluid in interstitial space prompted further inspection

Takeaways

- Corrosion of metal components in UST systems storing diesel appears to be common.
- Many owners are likely not aware of corrosion in their diesel UST systems.
- The corrosion is geographically widespread, affects UST systems with steel tanks and with fiberglass tanks, and poses a risk to most internal metal components.
- Ethanol was present in 90 percent of 42 samples, suggesting that cross-contamination of diesel fuel with ethanol is likely the norm, not the exception.

Other Key Takeaways – Continued

- The quality of diesel fuel stored in USTs was mixed.
- Particulates and water content in the fuel were closest to being statistically significant predictive factors for metal corrosion, but causation cannot be discerned.
- MIC could be involved as hypothesized by previous research.
- EPA recommends owners visually inspect USTs storing diesel as part of routine monitoring.

From ASTM D975:

- **X6 | MICROBIAL CONTAMINATION**
- X6.1 ***Uncontrolled microbial contamination in fuel systems can cause or contribute to a variety of problems, including increased corrosivity*** and decreased stability, filterability, and caloric value. Microbial processes in fuel systems can also cause or contribute to system damage.
- X6.2 Because the microbes contributing to the problems listed in X6.1 are not necessarily present in the fuel itself, ***no microbial quality criterion for fuels is recommended***. However, it is important that personnel responsible for fuel quality understand how uncontrolled microbial contamination can affect fuel quality.
- X6.3 Guide D6469 provides personnel with limited microbiological background an understanding of the symptoms, occurrences, and consequences of microbial contamination. Guide D6469 also suggests means for detecting and controlling microbial contamination in fuels and fuel systems. Good housekeeping, especially ***keeping fuel dry, is critical*****.**

Takeaways

- **Microbiologically influenced corrosion (MIC) likely largely responsible** for the corrosion.
- **Eliminating water** is recognized as a key factor in preventing this corrosion.
- Unsure about **Emergency Generator Tanks** and **Aboveground Storage Tanks** – probably similar corrosion

Resources

- **Coordinating Research Council (CRC):**
  - *Report 672 - Preventive Maintenance Guide for Diesel Storage and Dispensing Systems* (http://www.crcao.org/reports/recentstudies2016/CRC%20672/CRC%20672.pdf)
  - *Report 667 - Diesel Fuel Storage and Handling Guide* (http://www.crcao.org/reports/recentstudies2014/CRC%20667/CRC%20667.pdf)
- **Clean Diesel Fuel Alliance:** *Guidance for Underground Storage Tank Management at ULSD Dispensing Facilities* (http://www.clean-diesel.org/pdf/GuidanceforUndergroundStorageTankManagement_FINAL.pdf)
- **Steel Tank Institute** - *R111 Storage Tank Maintenance Standard* (http://www.steeltank.com/Portals/0/Shop%20Fab/R111%20%20with%20updated%20cover.pdf)
- **ASTM D6469**, *Standard Guide for Microbial Contamination in Fuels and Fuel Systems* (http://www.astm.org/Standards/D6469.htm) (Note: this document is publicly available but must be purchased)

Additional Information

- EPA Office of Underground Storage Tanks Website
  https://www.epa.gov/ust

- EPA Office of Underground Storage Tanks Emerging Fuels Contact
  Ryan Haerer at haerer.ryan@epa.gov or
  202-564-0762