Corrosion Control Through Tank Pressure Management

Presenter:

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Vaporless Manufacturing, Inc.

Preserving Tanks, Equipment and Sumps Through Tank Pressure Management

Are Tanks Under Pressure?

Are Tanks Under Vacuum?

Why Would it Matter?

What the Heck are You Tanking about?

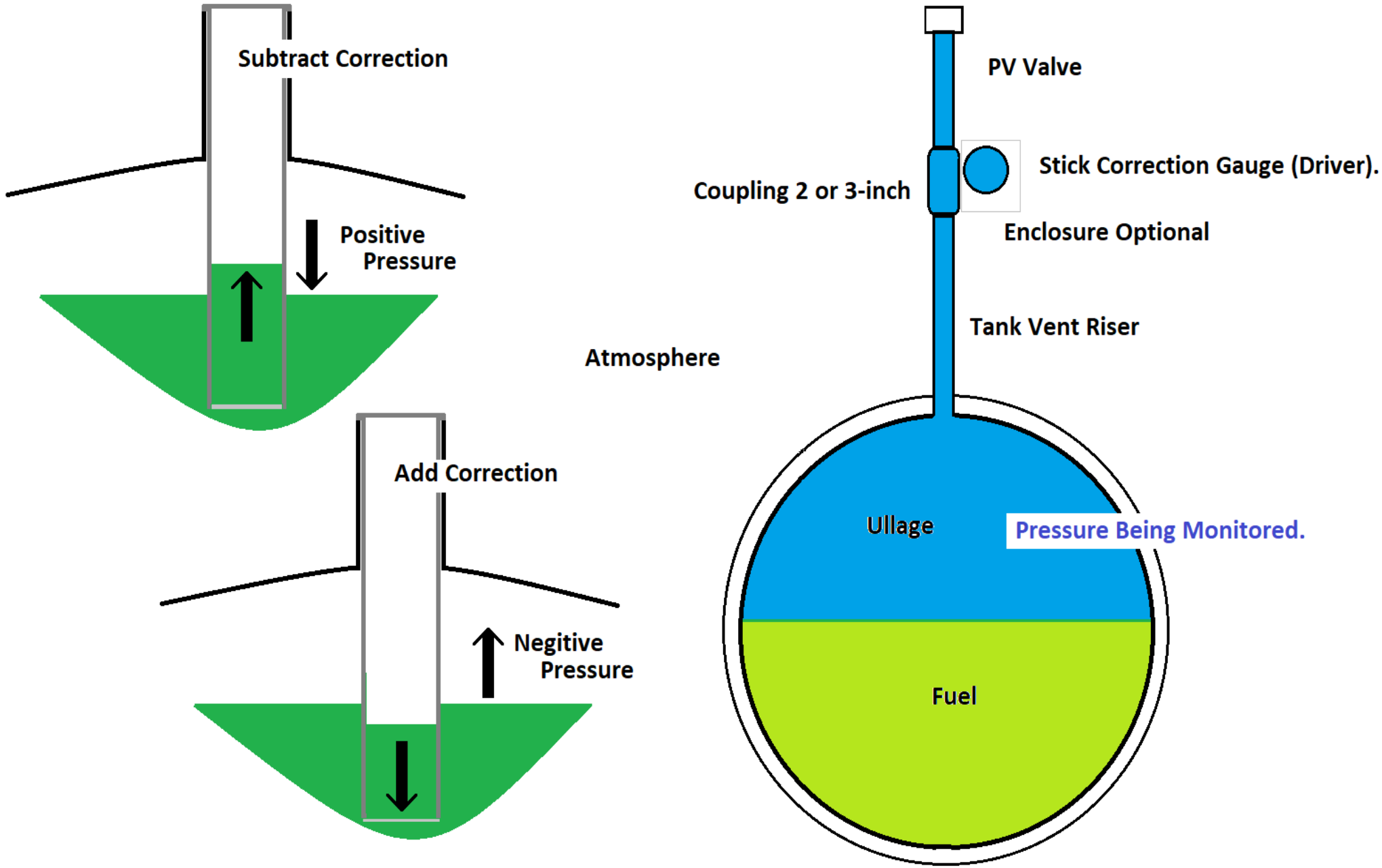
Tank Pressure Management Starts With; Tank Pressure Awareness

Today, when we sell fuel into ORVR equipped vehicles, or if there is no Stage 2 vapor recovery, no vapor returns to the UST/AST, we create a vacuum in the tank

- Fuel leaves tank, P/V valve isolates tank from atmosphere
- Vacuum generated is approximately 1”w.c. per nozzle
- P/V valves crack open @ (approx.) -3 to -9”w.c.

Why Does this Matter?

(Below we talk about Pressure in Tanks)


Subtract Correction
Positive Pressure
Add Correction
Negitive Pressure
PV Valve
Coupling 2 or 3-inch
Stick Correction Gauge (Driver).
Enclosure Optional
Tank Vent Riser
Atmosphere
Ullage
Pressure Being Monitored.
Fuel

Tank Under Vacuum

When you stick the fuel in the drop tube, the height of the fuel will be lower than the height of the fuel in the tank

How much lower?

Tank Under Vacuum

Remember, P/V valves hold -3 to -10”w.c.?

(Maybe more, depending on model)

-9”w.c. = -9 x 1.25 = -11.25” of gasoline

11.25” of gasoline in the middle of a 10’ diameter, 12,000 gl. tank equals 1512 gl.

Do you think a driver could accidently overfill a tank due to a “Uncorrected” stick reading?

Is there a way to “Correct” the reading? - Yes

Tank Under Vacuum

Is Your Tank Not Holding / Showing Vacuum?

The tank is Porous, a nice way of saying it is leaking air / vapor

Tank Pressure Awareness

When the station is not dispensing fuel, the air is busy becoming saturated hydrocarbon vapor

This pressurizes the tank

Tanks Under Pressure

P/V valves hold +2.5 to +6”w.c.

(Maybe more, depending on P/V valve)

6”w.c. = 6 x 1.25 = +7.5” of gasoline

7.5” of gasoline in the middle of a 10’ diameter, 12,000 gl. tank equals 875 gl.

A driver could “see” more fuel than is actually in tank unless there is a way to “correct” the reading

Take-aways of Tank Pressure Awareness

Long Ago, Far Far Away, we use to install Stick Correction Gauges to reconcile this issue

Maybe it is time to reinstall such devices?

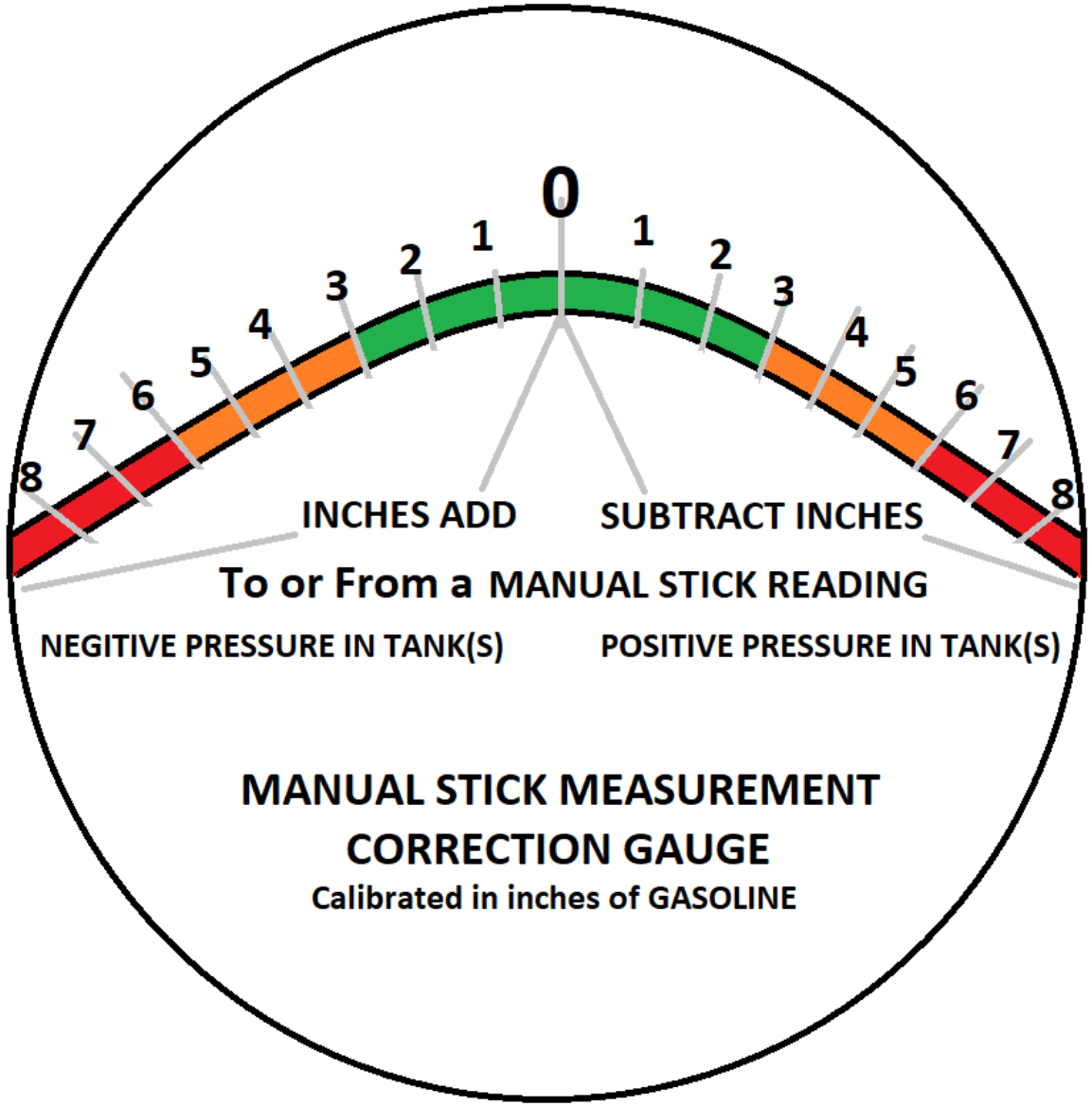
Remember, they are a simple device that also helps determine if the tank is porous or tight

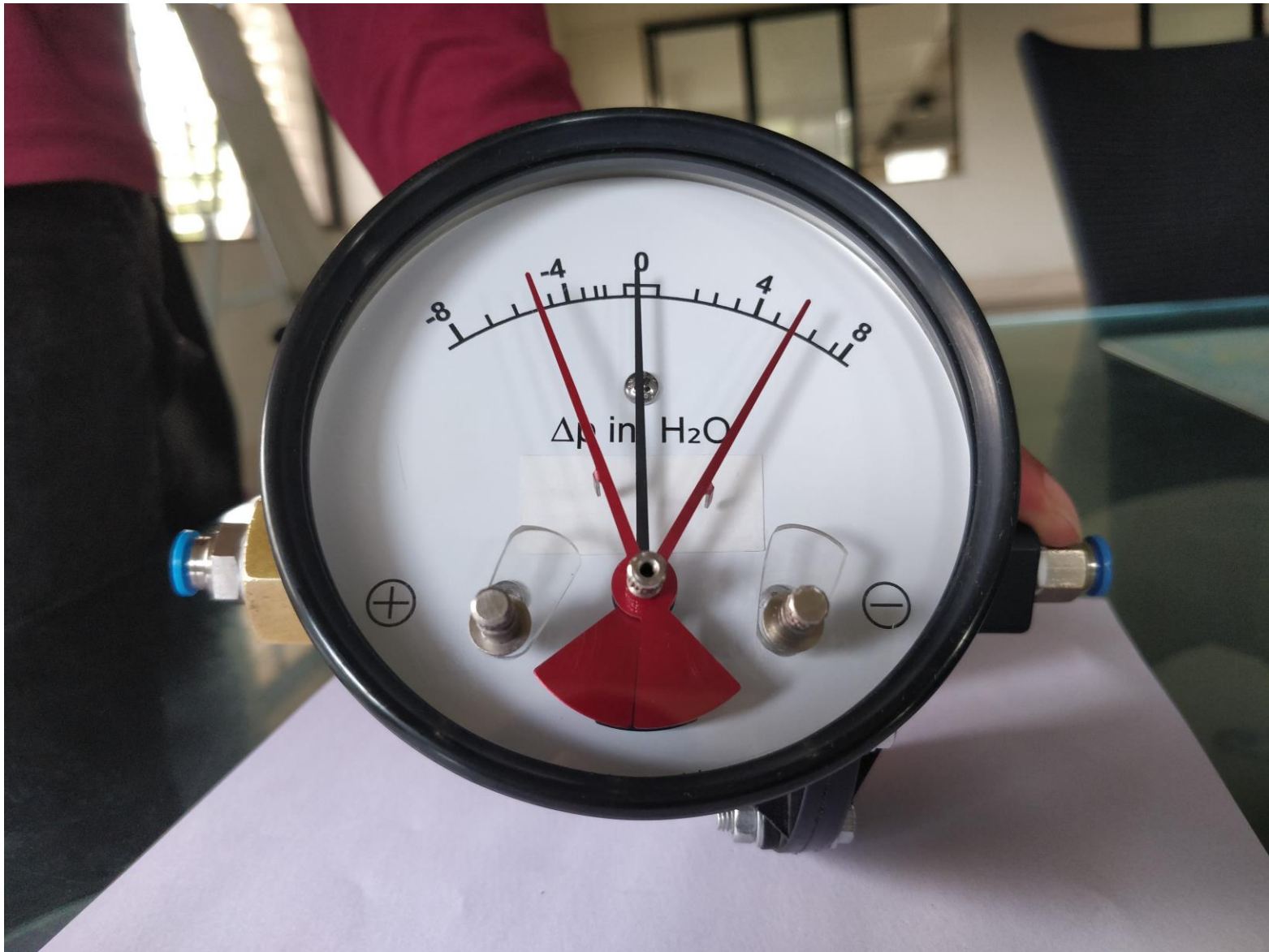
Petroleum Vapor Intrusion Prevention

Stick Correction Gauge

Must be calibrated for Gasoline to accurately reflect inches of fuel actually in tank

Diesel fuel different




-8
-4
0
4
8
Δp in H₂O
⊕
⊖

Corroded Mag Float

The other method to determine tank level, rely upon the tank monitor

Retentivity

Take-aways of Tank Pressure Awareness

Tanks “Breath”

Tanks are “inhaling” ambient air during dispensing

The air becomes Petroleum Saturated Hydrocarbons

The water vapor in the air condenses on the tank surface (ullage) allowing / encouraging biologicals to grow

More on this below

Take-aways of Tank Pressure Awareness

Tanks “Breath”

Tanks are “exhaling” petroleum saturated hydrocarbon for extended periods of time (2 - 4 hours) after busy stations are not busy in the evening

- This vapor is “missing” fuel for otherwise tight, well calibrated sites.

Take-aways of Tank Pressure Awareness

Severe Tank Over-pressurization

We will not be covering the severe over-pressurization that can occur when Stage 1 Vapor Recovery:

- Is not hooked up
- Vapor Recovery Equipment is defective
- Two drops are delivered into tanks with manifolded vents
- Is delivered into tanks with Ball Float Overfill Protection

Pressures are exceeding 5 psi on tank bottom

Aggressive Corrosion in Tanks, Sumps, and Equipment

- Nationwide since 2007, reports of severe equipment degradation
- Often times rapid onset
- Internal tank and component corrosion
- Sump corrosion and sump component corrosion

How serious is the STP sump corrosion?

STP sump picture from Edwin C. French IV, Senior Env. Compliance Specialist, Storage Tank Section, Leon County, Florida

Corrosion Damage

- Drop tubes that cannot be removed
- Submersibles that cannot be removed
- High filter replacement, metal granules
- Higher Meter drift and replacement
- Higher Blender Valve failure
- Overfill prevention failure
- Sticking tank probes
- Bungs spinning in fiberglass tanks
- Failing, sticking shear valves
- Primary Tank Failure

Aggressive Corrosion

Not Caused by Phase Separated Fuel

Phase Separated Fuel is a separate issue

- Out of Spec Fuel
- Highly Acidified Phase

Cause of Phase Separated Fuel?

- To much suspended or entrained water

What contributes to suspended or entrained water?

Condensation of Water Vapor in Tank Ullage

What Happened Around 2007?

- Lower sulfur in diesel, ULSD, from 500 ppm to 15 ppm
- Increased use of bio blended fuels

What (also) Happened Around 2007?

- Different Refining Techniques
- Different Fuel Stocks
- Reduction of Water Use – Reuse of Water
- New Fuel Formulations
- Ultra Low Sulphur Gasoline – everywhere in USA by end of 2017

Independent Research and Reports

Battelle Memorial Institute Report for the Clean Fuel Alliance 09/05/2012

ULSD Corrosion Hypotheses Investigation

The project final hypothesis for this investigation is that corrosion in systems storing and dispensing ULSD is likely due to the dispersal of acetic acid throughout USTs. It is likely produced by Acetobacter bacteria feeding on low levels of ethanol contamination. Dispersed into the humid vapor space by the higher vapor pressure (0.5 psi compared to 0.1 psi for ULSD) and by disturbances during fuel deliveries, acetic acid is deposited throughout the system. This results in a cycle of wetting and drying of the equipment concentrating the acetic acid on the metallic equipment and corroding it quite severe .

CRC Report No. 667

Prepared by the

Cleanliness Panel

of the Diesel Performance Group

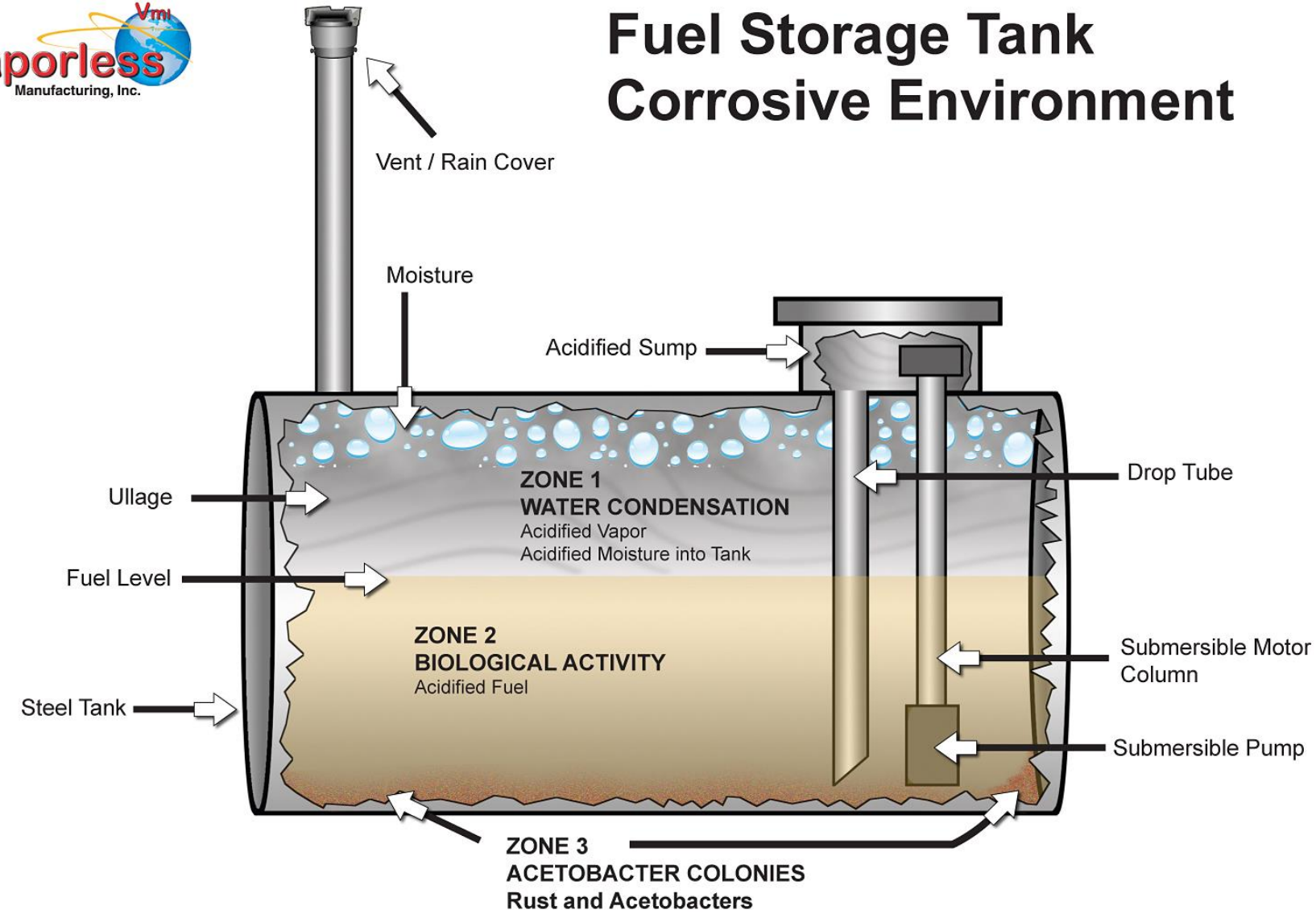
of the Performance Committee

of the Coordinating Research Council

September 2014

- The most abundant output of the microbial community is low molecular weight organic acids. Although these organic acids are not as aggressive as strong inorganic acids, they can readily react with inorganic substances to produce strong inorganic acids (hydrochloric, sulfuric and nitric, respectively).
- These strong inorganic acids can cause corrosion and degrade fuel quality.

Fuel Storage Tank Corrosive Environment



Submersible Motor Moves Debris through Fueling System

Causes Clogged Filters & Out of Calibration Meters

CRC 6.1.2 Ingredients for an aggressive corrosive electrolyte

The ingredients for an aggressive electrolyte exist within the USTs inspected for this study. Namely, available water, oxygen, acids, and aggressive species create an environment that would be expected to attack most of the materials used in USTs.

In addition, these environmental characteristics are specific to microbiological organisms that also contribute to the corrosive cycle in ULSD USTs.

The presence of water, microbial activity and a lack of sustaining corrosion inhibition can all lead to formation of corrosion products in fuel distribution systems.

If biodiesel is present in the fuel, water can have a more pronounced effect on the diesel fuel. Water is more soluble in a biodiesel blend as compared to a fuel with no biodiesel. Dissolved water in biodiesel can hydrate (or add water molecules to) the Fatty Acid Methyl Ester (FAME) molecules

- Dissolved water in biodiesel, usually in combination with other contaminants, can also lead to hydrolysis of biodiesel, where the molecule is degraded or broken apart, which can allow further reaction with other compounds to form salts, soaps or peroxides

- The change from Low Sulfur Diesel (LSD) to Ultra Low Sulfur Diesel (ULSD) and its associated handling since 2006 have led to increased fuel field problems. The increased use of FAME biodiesel blends has also contributed to higher incidences of corrosion in fuel systems, due in part to biodiesel's greater affinity for water, a higher susceptibility to microbial activity, and an increased solvency effect on pre-existing deposits

- Many different types of microorganisms are able to use diesel fuel as a food source
- Aerobic (require free oxygen) or anaerobic (only grow in the complete absence of free oxygen) bacteria are present
- Like all other life forms, **all microbes require the presence of water**

- These microbial organisms do not require large amounts of water.
- This explains why small spots of condensation on the walls of a tank are sufficient to support growth
- Viable organisms are found in the air, soil, and even in the fuel

Symptoms

From a motor column installed for 90 days

This is aggressive corrosion in the ullage, never under fuel

Typical of water condensation induced corrosion on tank ullage components

Corroded Mag Float

Incorrect level reporting

Corrosion in STP Sumps by:
John Wilson Ph.D., U.S. EPA ORD
And His Co-Authors 2013

There is a strong correlation between the presence of rust tubercles on the STP cast iron and the blue corrosion on the copper line connecting the leak detector and the concentration of ethanol and acetic acid in the *headspace* (ullage) of the tank.

- Microbes living in the tank bottom water commonly produce detergent-like molecules (i.e., biosurfactants). These biosurfactants generate an inverted emulsion of water in the fuel, distributing water into the fuel-phase and making fuel molecules more readily available as a source of food for the microbes.

Corrosion in STP Sumps by: John Wilson Ph.D., U.S. EPA ORD And His Co-Authors 2013

Approximatly 30 species of Acedobactor excreting acidic acid

Corrosion in STP Sumps by John Wilson Ph.D., U.S. EPA 2013

Corrosion in Ethanol Tanks and Sumps

The rust tubercles or the blue corrosion was associated with higher concentrations of ethanol or acetic acid in the air of the sump.

U.S. EPA ORD – 2013

For ethanol to cause corrosion, there are 3 components necessary: ethanol, bacteria to degrade the ethanol to acetic acid and water. Water provides the environment for the bacteria to live in and also is required for the actual chemical corrosion event.

Investigation Of Corrosion-Influencing Factors In Underground Storage Tanks With Diesel Service

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
EPA 510-R-16-001
July 2016

P. 59

- Industry documents suggest the removal of any water when found, possibly more often than owners have traditionally done in the past, should be considered to limit the potential for microbial growth in USTs storing diesel fuel.
- Regularly monitor and remove any water present in the UST
- Add nitrogen generating equipment to limit an oxygen rich atmosphere inside tanks

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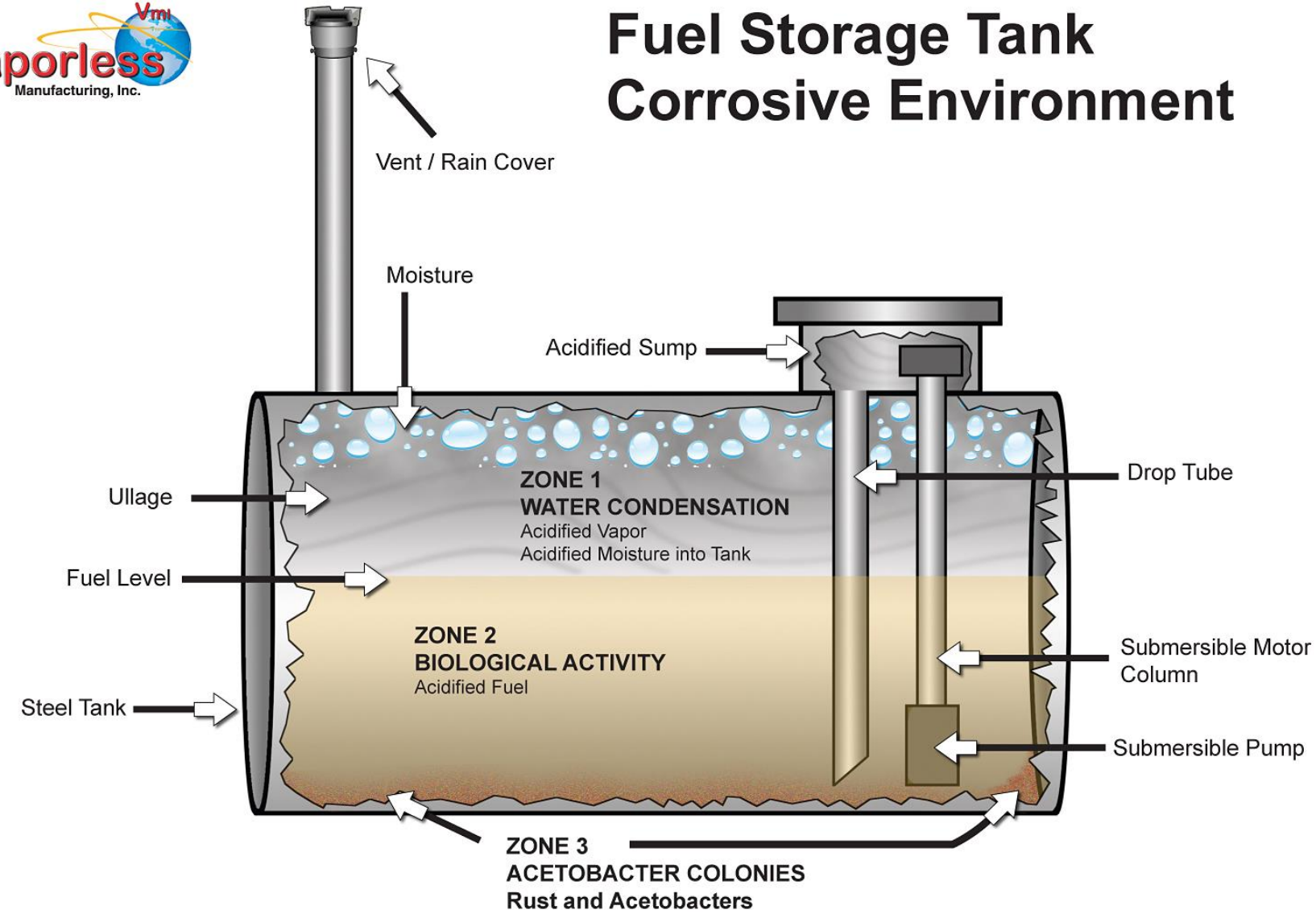
- “limiting oxygen in USTs through the use of nitrogen blanketing equipment in order to prevent the growth of microorganisms that require oxygen for survival show potential to limit corrosion in the vapor space of UST’s”
- “field experiences for laboratory research, which has hypothesized that MIC is likely involved in corrosion in USTs storing diesel and suggested limiting microbial populations is key to minimizing corrosion.”

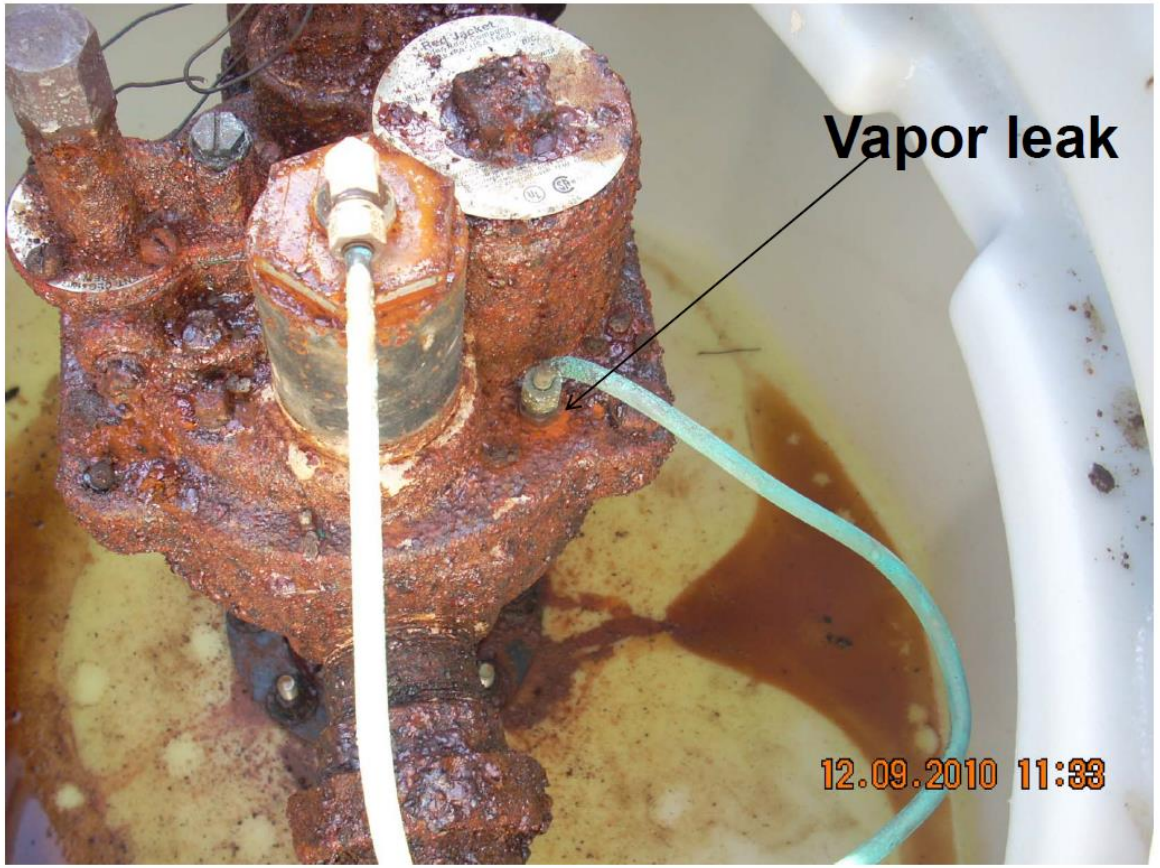
Fuel Storage Tank Corrosive Environment



Submersible Motor Moves Debris through Fueling System

Causes Clogged Filters & Out of Calibration Meters

Finding Vapor Leaks



This is the Interstitial Monitoring Access of a UST

Environmental Corrosion Control for Large Fuel Tanks and Reducing the Risk of Explosive Atmospheres

These protocols, taken from API 2000, are an API recommended practice. This method is employed at refineries, bulk fuel storage facilities, bulk fuel transfer terminals, and airports worldwide for over 8 years

How Nitrogen Blanketing Stops Aggressive Corrosion

- In the tank top; ullage
- In the fuel
- On the tank bottom
- In the sump

Nitrogen Blanketing
Stops Moisture Infiltration

The NBS prevents air (with water vapor) from being drawn into the UST

Dispensed product is replaced with dry nitrogen, not ambient air

Stop Moisture Infiltration

The dry Nitrogen can drop the relative humidity in the ullage from 80+ % to 5% or less RH

No water vapor, no condensation, no water in ullage, No moisture running off the side of the tank into fuel
No raining in the tank

Nitrogen Blanketing
Tank Ullage Monitoring

The use of Nitrogen reduces the Oxygen content in the UST Ullage

Aerobic bacterial growth is stopped

The ullage is no longer an explosive environment

The Second Tier of the NBS Tank Ullage Monitoring

To Stop:

Petroleum Vapor Intrusion – PVI

See the new EPA Regulations

Contamination to the ground, water and nearby structures due to Petroleum Hydrocarbons - PHC's that have been released or escaped from the UST ullage into the surrounding environment.

Nitrogen Blanketing
Tank Ullage Monitoring

The VMI NBS controller continuously monitors the tank ullage, insuring the tank top is tight to an equivalent of a Stage 2 Vapor Recovery Tightness

By blanketing the ullage with nitrogen, the nitrogen molecules (lighter than saturated hydrocarbons) prevent the saturated hydrocarbons from escaping through vapor passages

Nitrogen Blanketing
Tank Ullage Monitoring

To Reduce Fuel Loss

The VMI NBS controller continuously monitors the tank ullage, filling the ullage with nitrogen

By blanketing the ullage with nitrogen, nitrogen is the first gas to leave the tank, not saturated hydrocarbons

VMI has scaled a customized solution for tanks 50,000 gallons and less

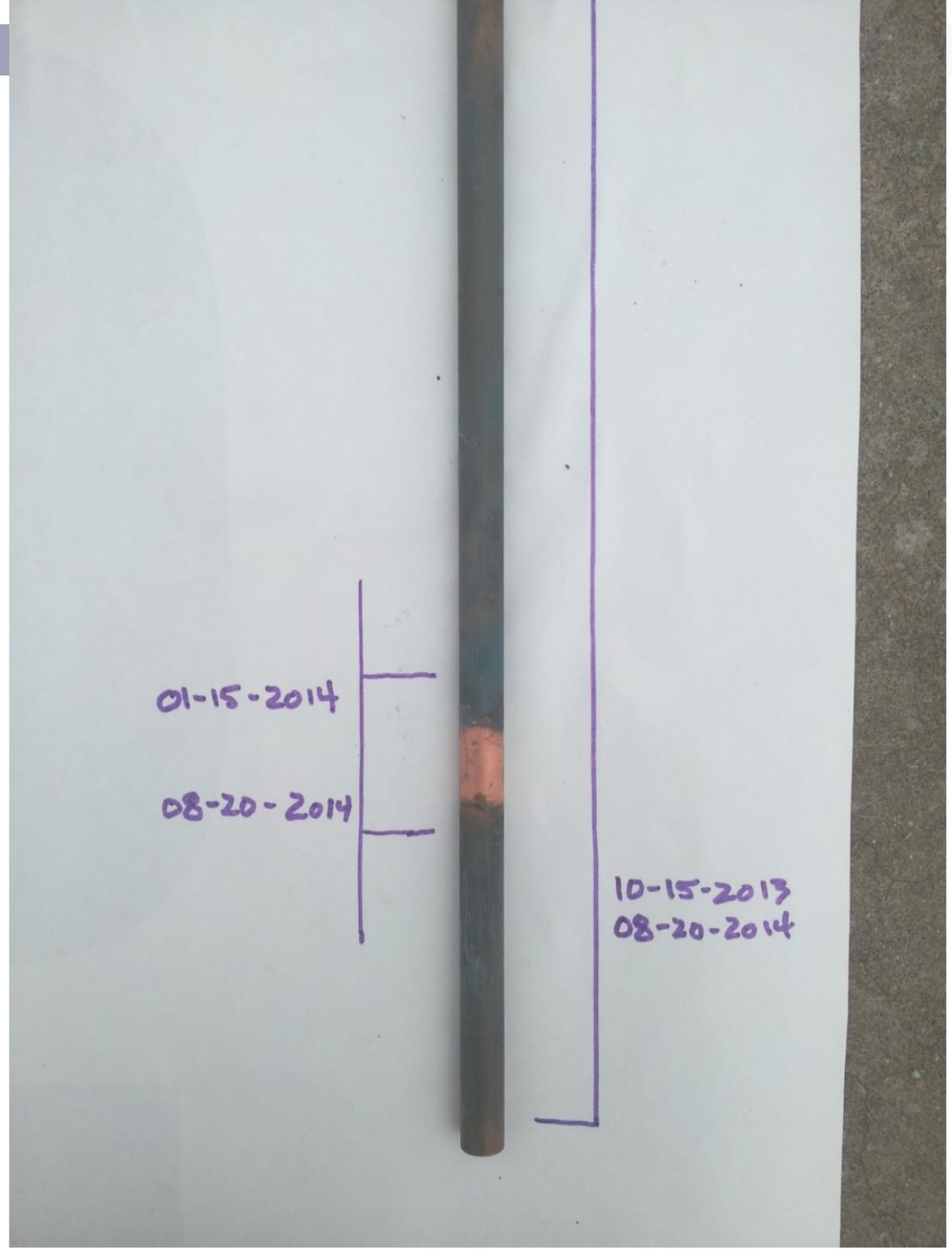
- P/V Valve
- Monitor tank vapor pressure to determine ullage pressure
- Deliver dry Nitrogen to replace the air drawn into the tank
- No moisture to condense
- No oxygen for bacteria

Faced with a tank that had corrosion so bad the submersible motor column broke off and fell to the bottom of the tank, was replaced, and rapidly corroded again (photos). The dispensers were replaced, the meters in the new dispensers had to be replaced, tank cleaning was regularly used along with biocide, the corrosion continued.

A nitrogen blanket system was installed

Note, 2 diesel tanks on site

- Copper coupon installed in tank vent 10/15/2013
- On 01/15/2014 after 3 months the tape was removed
- The coupon stayed in the tank for 7 more months without corrosion.




TUFF SHED

Alternative

- Monitor Fuel, test quarterly
- Add Biocide, Clean
- Continue to add Biocide, Clean and repair damages
- Repeat until “Antibiotic Resistance” effect occurs
- Does not reduce water in tank bottoms