NISTM

National Institute for Storage Tank Management

How VCI's Can Prevent Corrosion for AST and UST System Components

Presented by David Durling, Zerust Oil & Gas

Efim Lyublinski, Monique Posner, Terry Natale,

Yefim Vaks, Ronnie Singh, Kelly Baker, Gautam Ramdas

Northern Technologies International Corporation, USA

Marcelo Schultz

Petrobras, Brazil

Marshall Mott-Smith

Mott-Smith Consulting

NTI

Zerust OIL & GAS

AGENDA

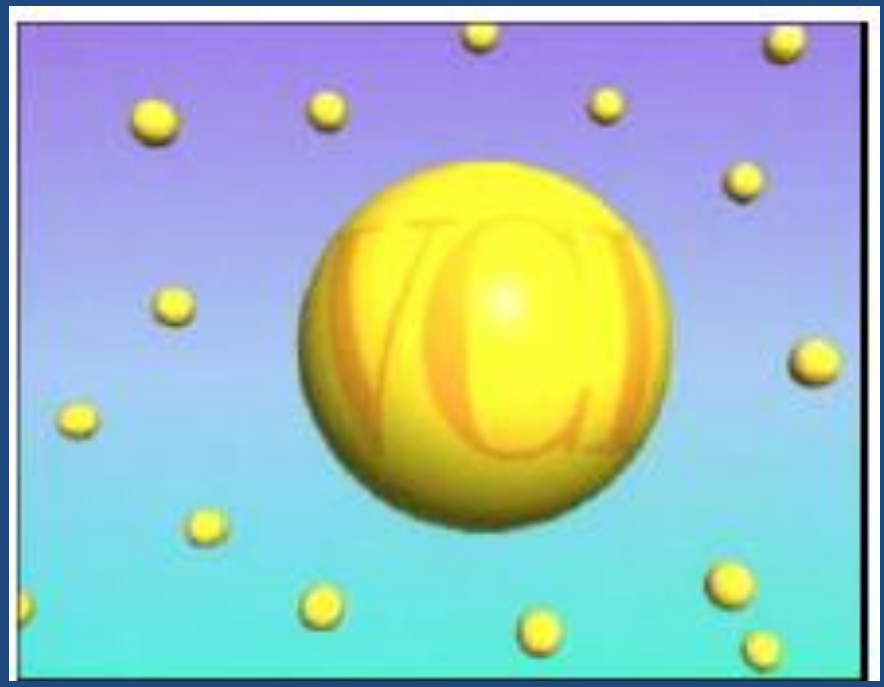
- Introduction
- What are VCIs
- Industry Applications
- Delivery Systems Document
- Tank Floors – Several Options
- Tank Roofs
- Pipelines
- Intro to Ethanol Corrosion
- Questions

Definition - VCI

Vapor Corrosion Inhibitors

Also referred to as Volatile Corrosion Inhibitors

- A class of corrosion inhibiting compounds which have vapor pressures higher than that of air.
- This results in the release of vapor molecules of inhibitor into the air.



Definition – Con't

Different Mechanisms for Different Purposes

Passivators

- Anodic inhibitors that shift the metal potential in the positive direction
  - Direct – anions react with the metal surface and become part of the passive film (chromates, nitrites)
  - Indirect – improve adsorption of the dissolved oxygen on the metal surface to enable oxygen to passivate the metal surface (phosphates, silicates)

Barriers

- Act as a barrier layer between the metal and the environment, adsorption can be either physical (electrostatic) or chemical (sharing electrons)
  - Organic – coat the surface with an oily layer
  - Inorganic – inhibitor reacts with the environment to precipitate insoluble products (phosphates, silicates, bicarboantes)

Scavengers

- Eliminate dissolved oxygen from a closed system (neutral or alkaline pH) (sulfite)
- Inhibitor reacts with acidic gases in air space (ReCast-R1)

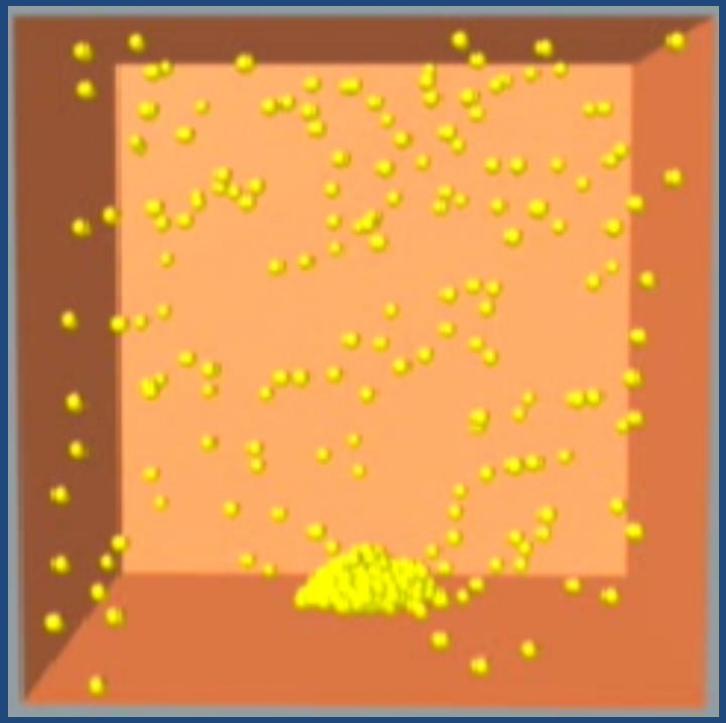
Neutralizer

- Reduces the concentration of H^+ ion in solution

Definition Con’t

VCI molecules fill space and deposit on all surfaces.

- Can work for immersed surfaces
- Not a ‘coating’
- Does not change the metallurgy
- Not permanent
- Can be painted/welded
- Non-toxic
- Can be designed for the service exposure



Many forms of VCI

What's the difference?

1. **Self-fogging Flash Corrosion Inhibitor (FCI™) technology**
   - High vapor pressure, low vapor density
   - Fast acting flash corrosion inhibitor
   - Fills vapor spaces immediately
   - Highest volume of protection per weight of active ingredient
   - Navigates complex systems
2. **Long-term Vapor Corrosion Inhibitor (VCI) protection**
   - Slower evolving, long-term vapor corrosion inhibitor
3. **Long-term Soluble Corrosion Inhibitor (SCI) protection**
   - Contact corrosion inhibitors activated when water present
   - Chloride "neutralizer"

Automotive industry – 30+ years

Not "NEW" Technology

Clean, environmentally friendly

Requires no cleaning prior to assembly

VCIs have been sold through major retailers for years

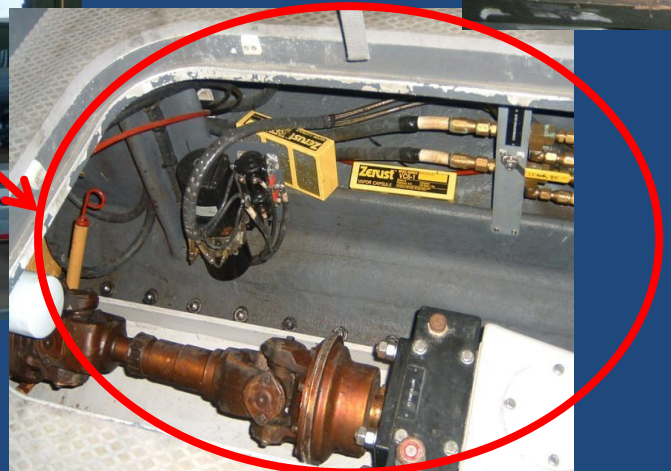
Several ‘consumer market’ products you can try

- Lowes
- Cabellas
- Flambeau
- Kobalt
- …others

Some consumers are more demanding than others …

US Navy SEALS

VCI capsules in the engine housing



US Marines in Iraq

VCI gun sleeves

Managing Corrosion

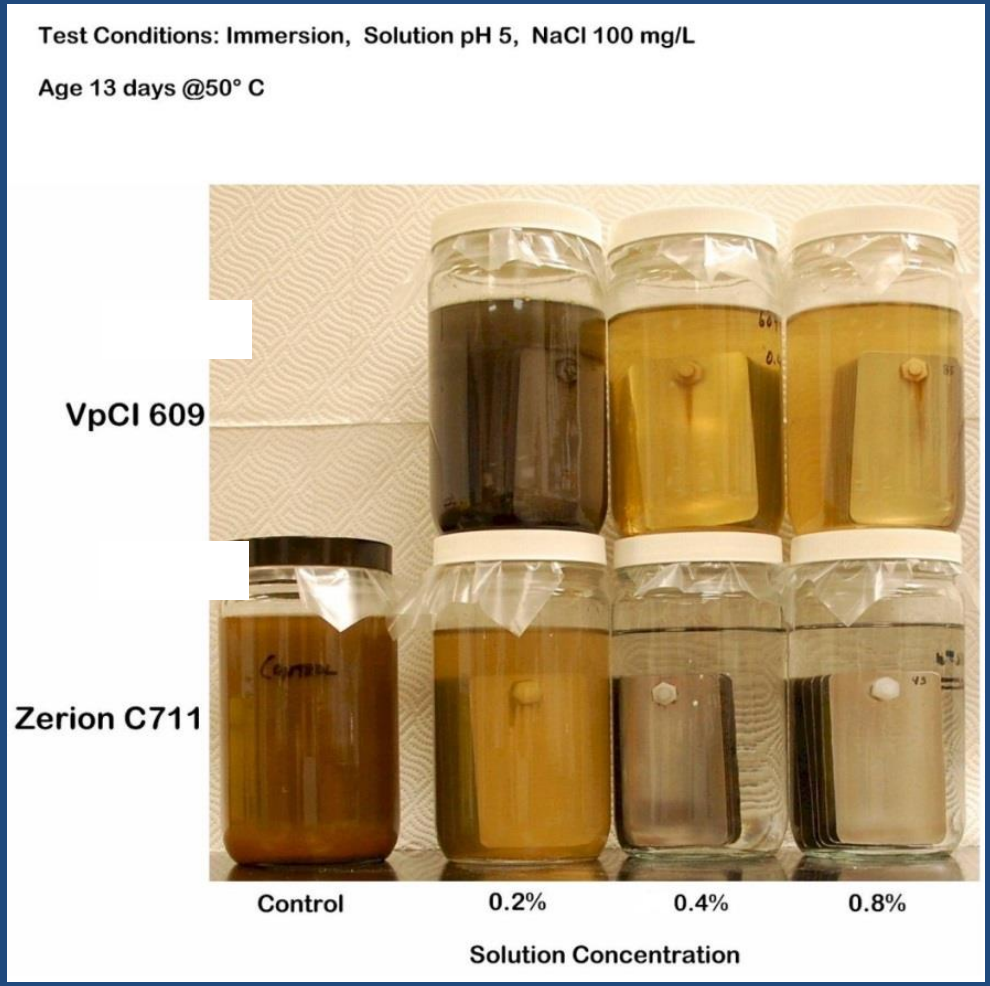
Corrosion cannot be eliminated, it's mechanism can only be slowed

Immersion Test

Concentration & Formulation Matter

Test Conditions:

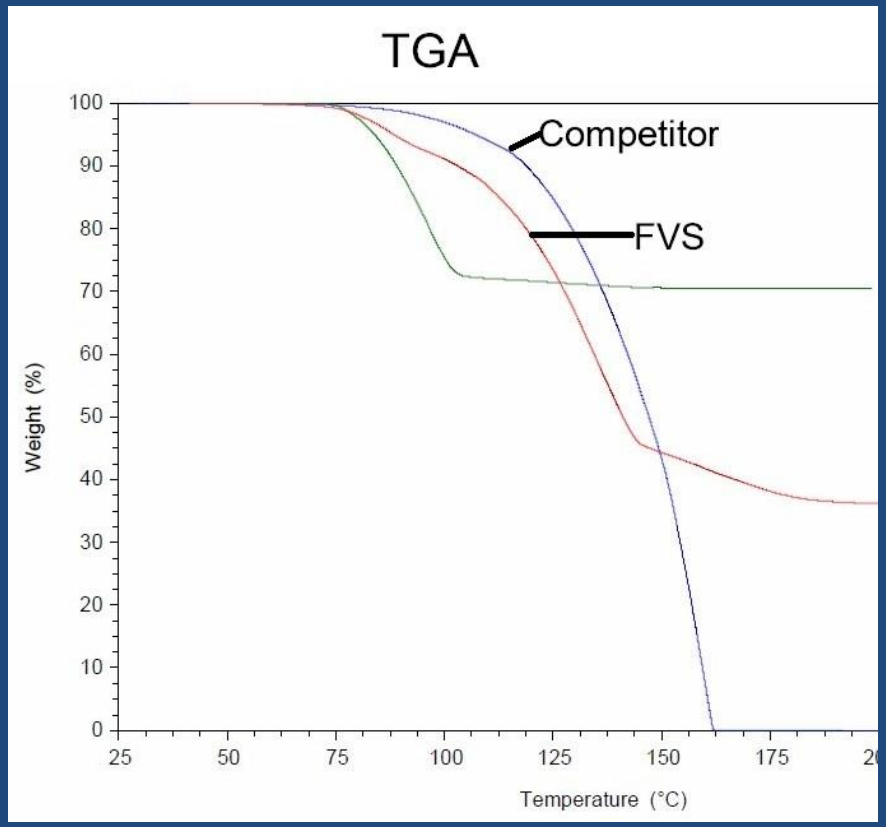
- Immersion
- Solution pH 5
- NaCl 100mg/L
- Age 13 days @ 50°C

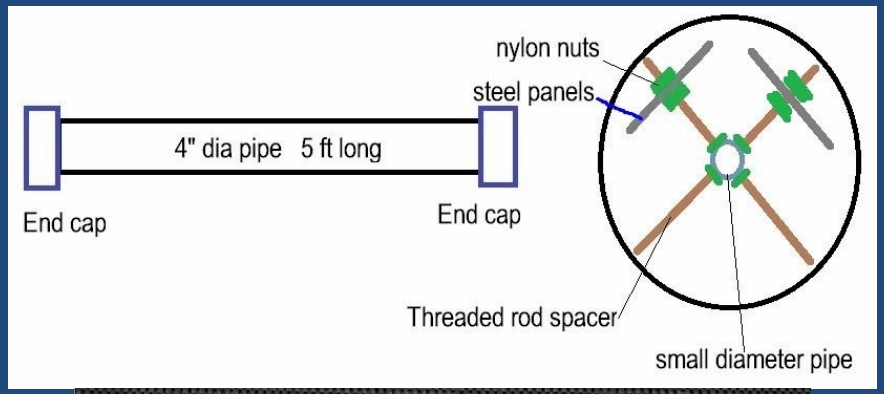


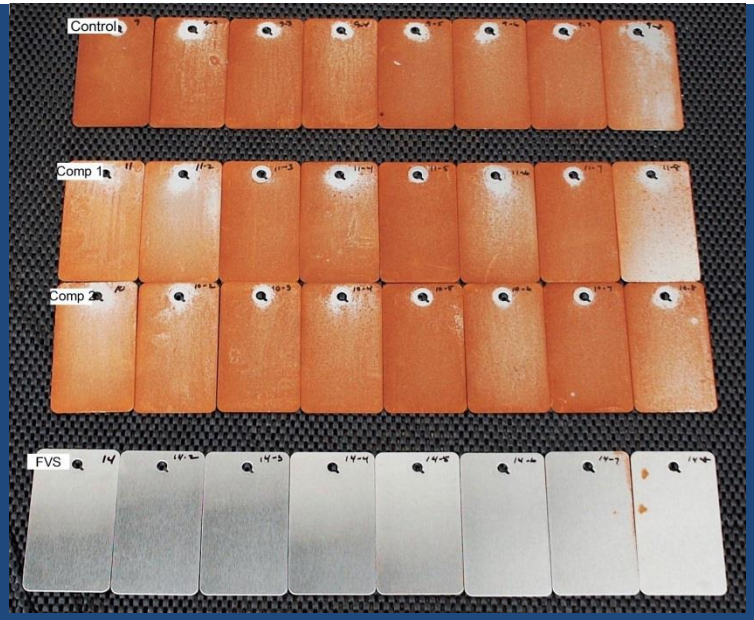
Vapor Pressure

Time and Distance

FVS formulation will evolve the VCI at a faster rate







Applications!

How can VCI be used in Oil & Gas?

Low Temperature Flanges.

- Proprietary dual layer plastic film
- Impregnated with a VCI to enclose flanges, bolts and weld joints
- Average 2+ year life.

Long Term Corrosion Protection

Vapor Capsules

Numerous applications

Protection of Electrical & Electronic Control Panels and Safety Switch Boxes

Applications!

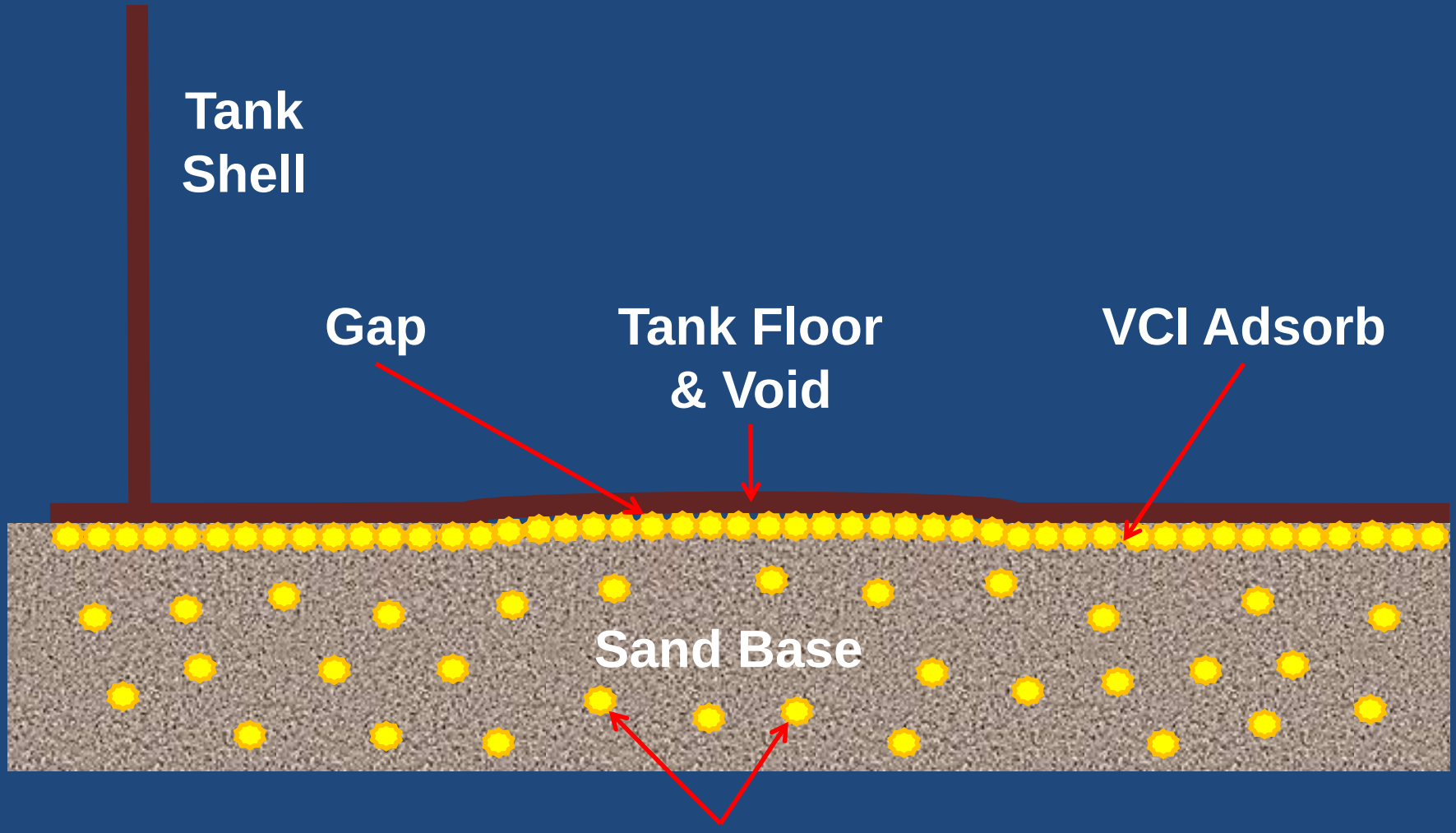
Tank Floors!
Underside

Floor Configurations

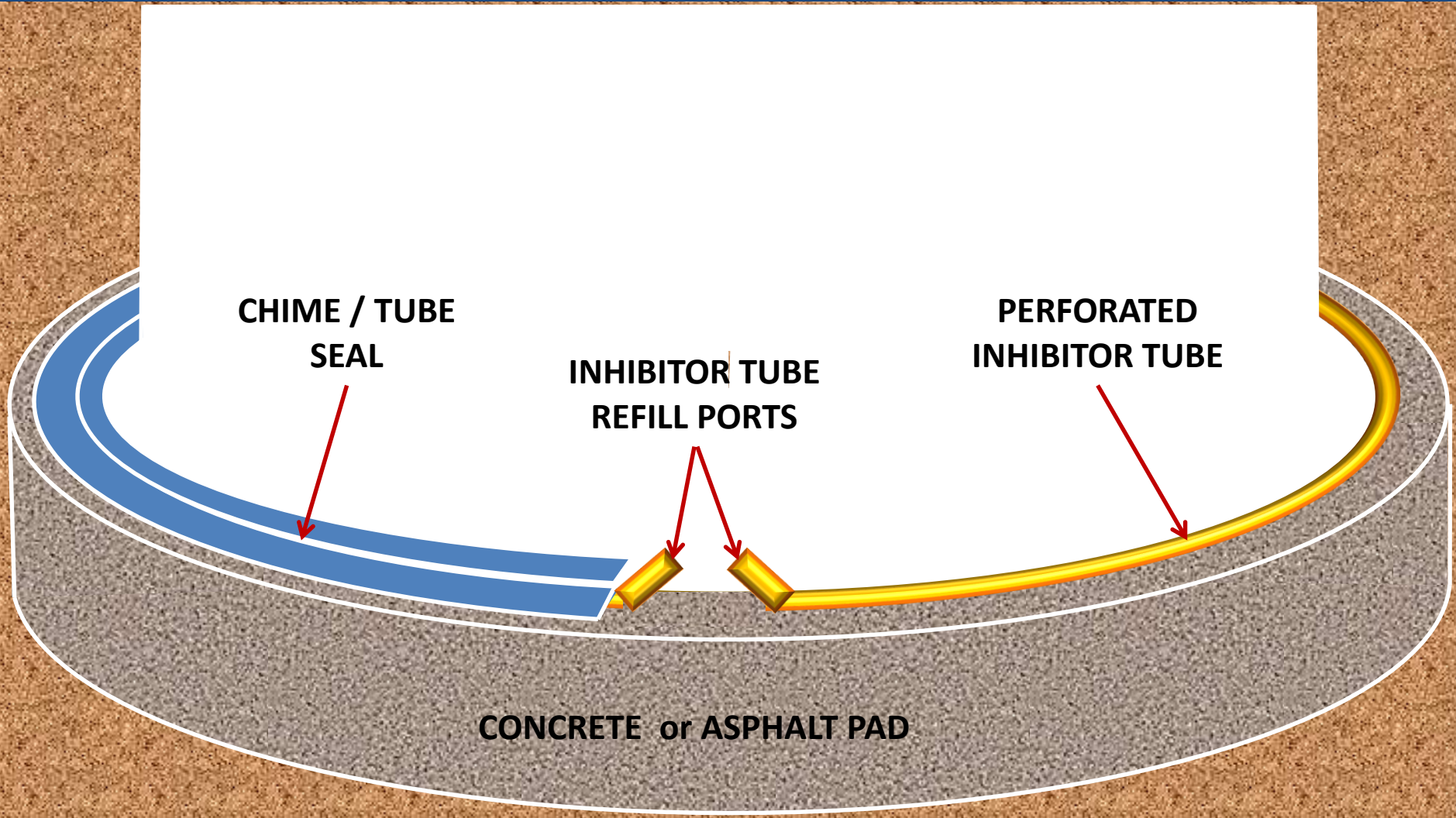
New/Existing – In Service/Out of Service

Tank Soil Side Bottom Protection Matrix					
	Cathodic Protection	**VCI/SCI**	**Liquid VCI**	**Powder VCI**	**Suggested VCI / SCI System**
Sand Base w/ Liner	Yes	Yes	Yes	Yes	**- Ring-Wall Injection System - Dry Underside Tube System - Internal Flood System - Dry External Ring System - Wet External Ring System**
Sand Base w/o Liner	Yes	Dry System Only	No	Yes	**- Dry Underside Tube System - Dry External Ring System**
Concrete/Asphalt	No	Yes	Yes	Yes	**- Dry External Ring System - Wet External Ring**
Double Bottom w/Liner	Effectiveness determined by sand depth	Yes	Yes	Yes	**- Ring-Wall Injection System - Dry Underside Tube System - Internal Flood System**
Double-Bottom w/o Liner	Effectiveness determined by sand depth	If original floor has no penetrations (?)	If original floor has no penetrations (?)	Yes	**- Dry Underside Tube System - Ring-Wall Injection System? - Internal Flood System?**
Chloride Contaminated Sand Base w/ Liner	Yes	Yes	Yes	No	**- Chloride Remediation System**

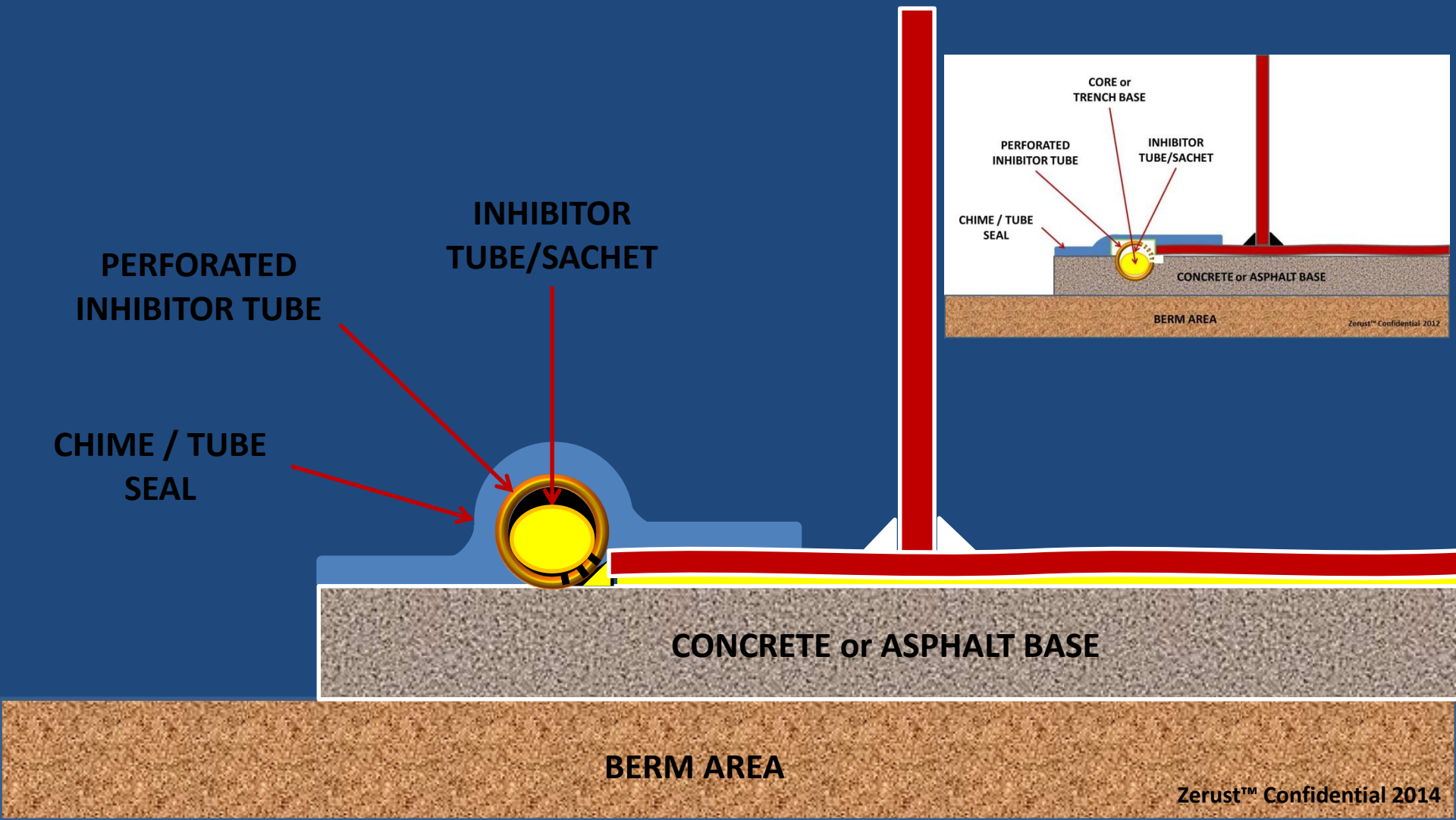
VCI Effect Under Tank Floors



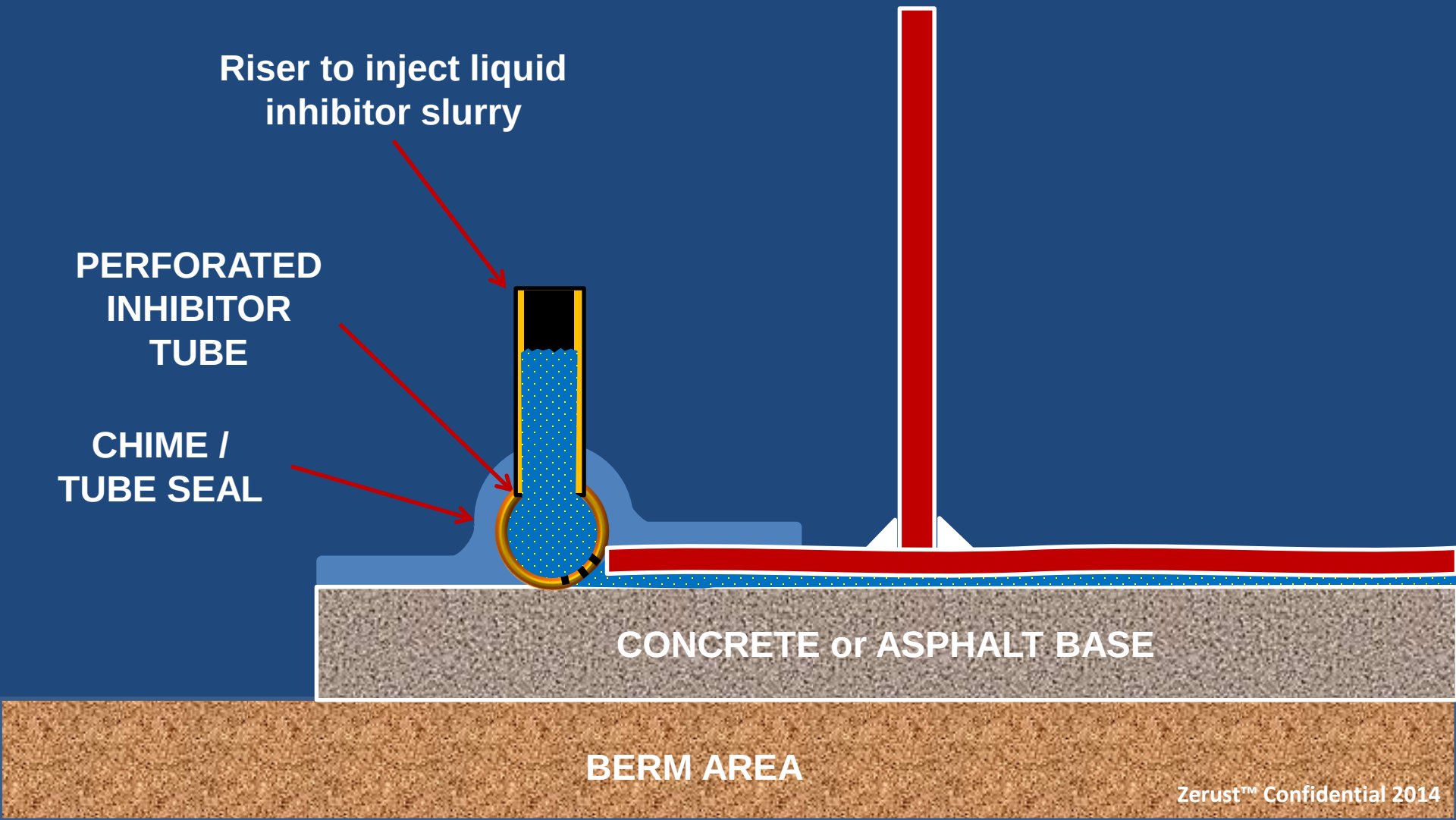
External Ring System



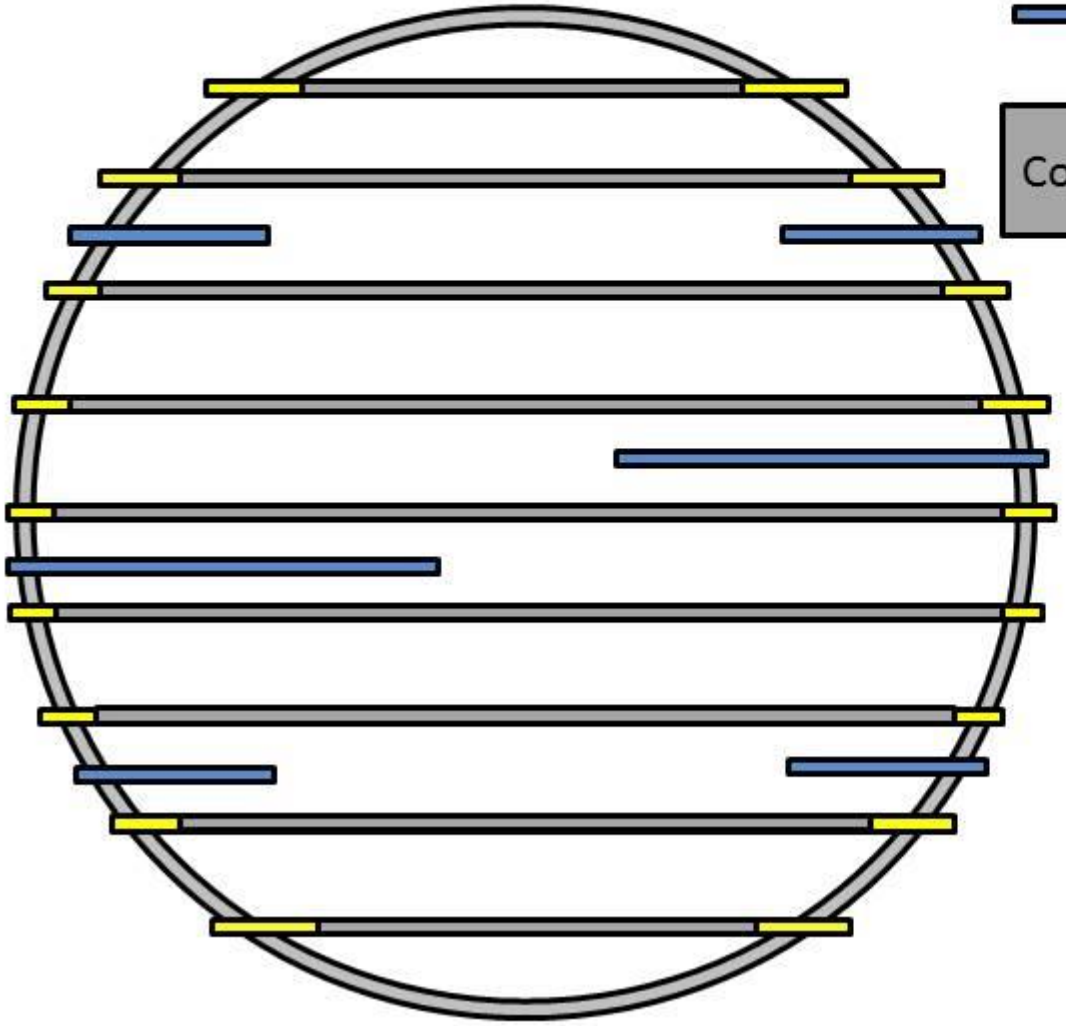
Cross-Section of Ring System



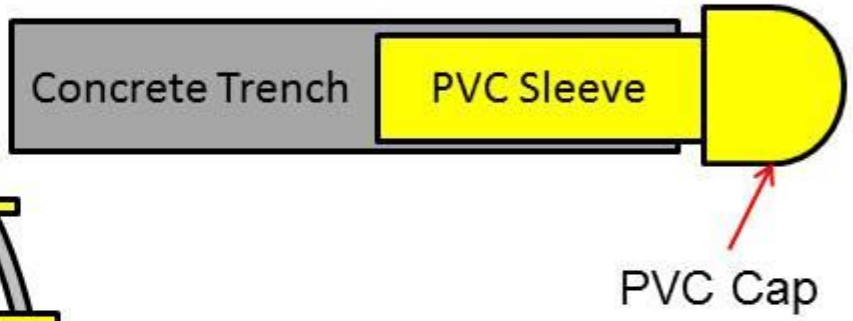
SSB "Chime Flood" System Schematic Cross-Section

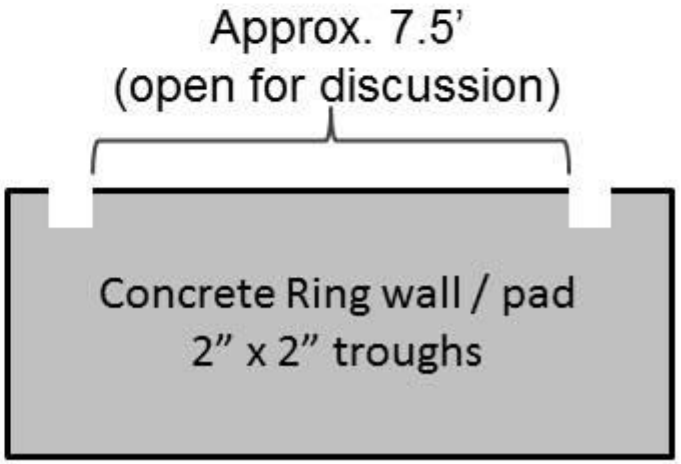


SSB New Floor Trench System



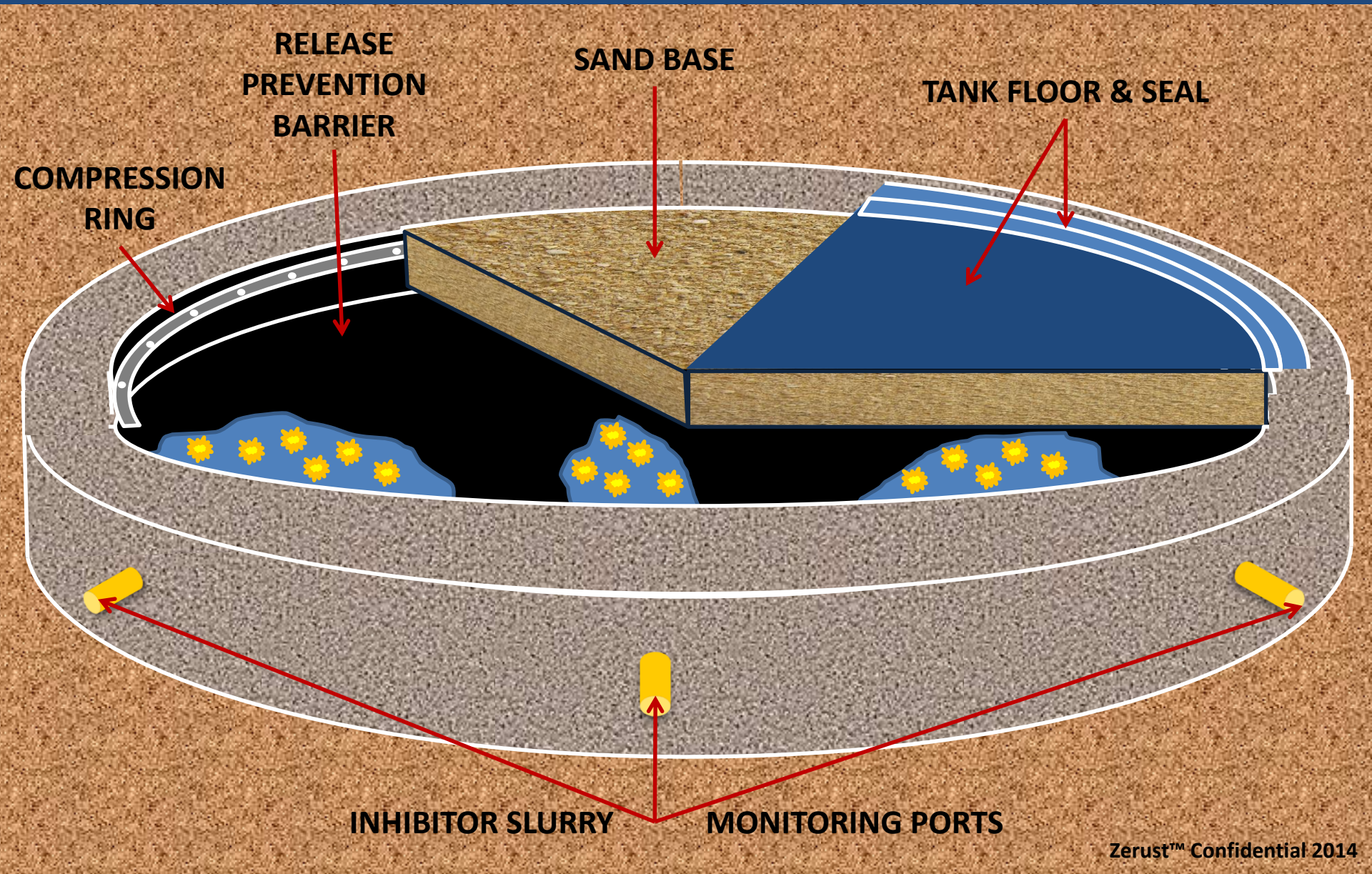
ER Probe / Coupon Ports





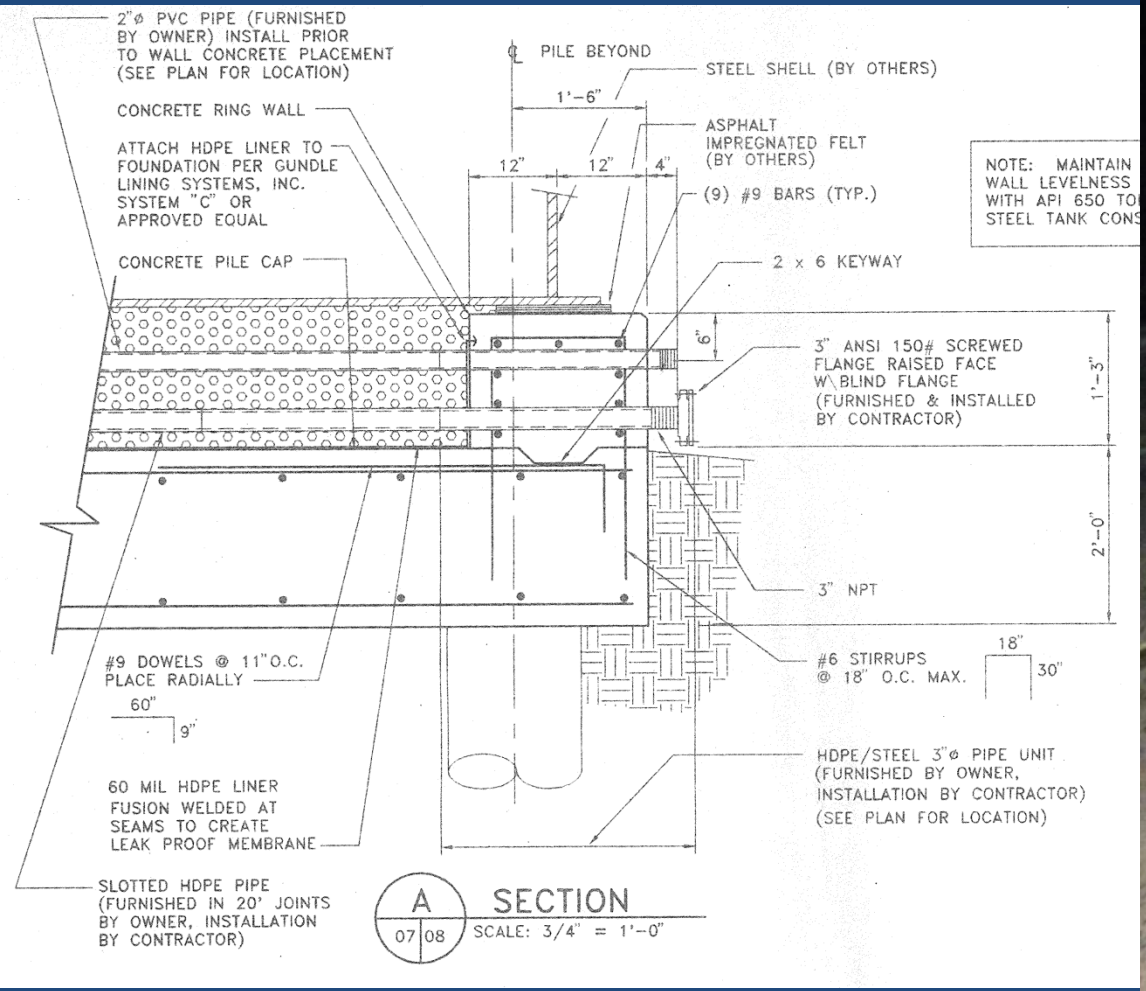
Parallel Tubes

SSB Flood Delivery System

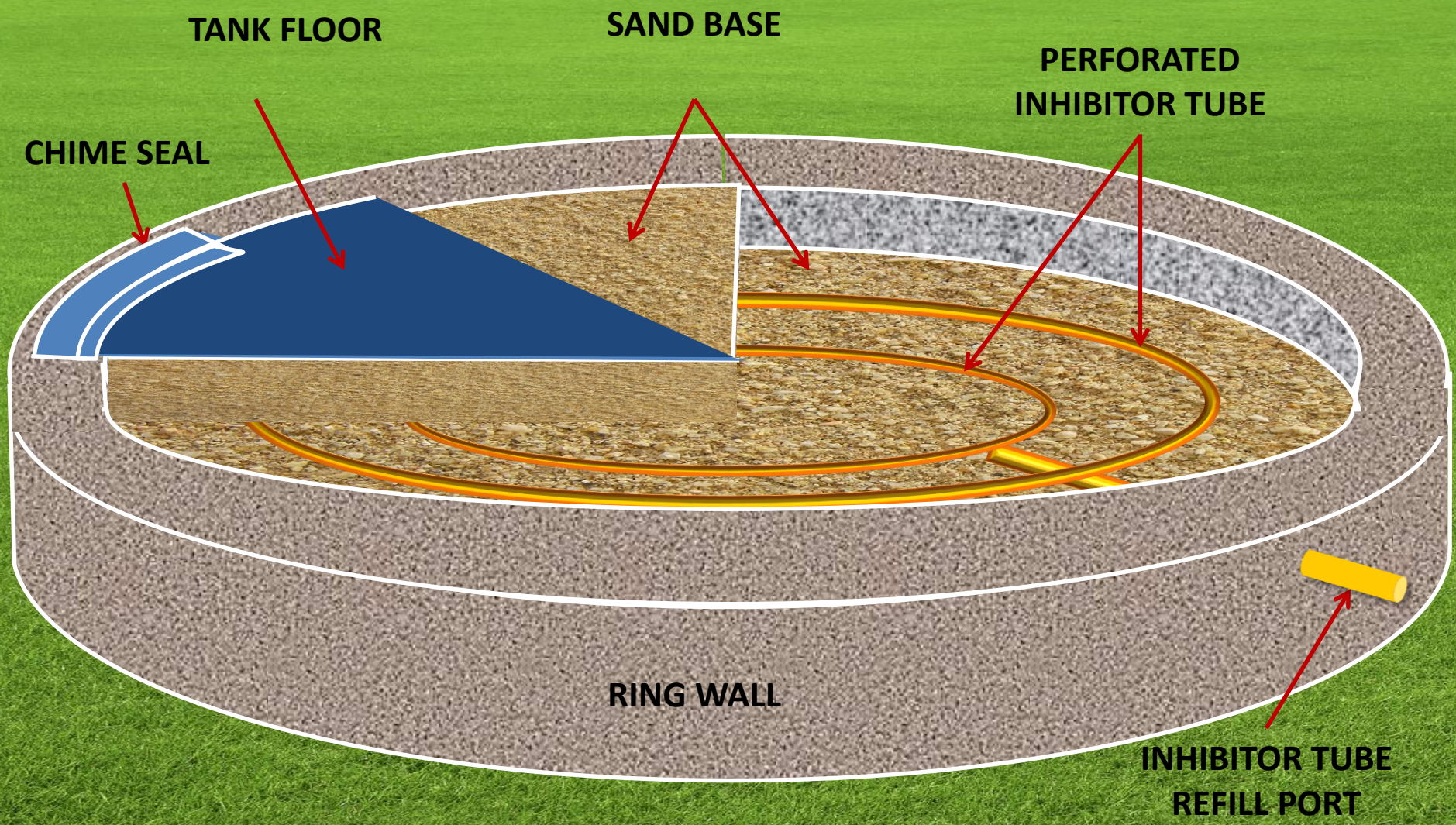


Injection Options

Ring Wall OR Floor Plate



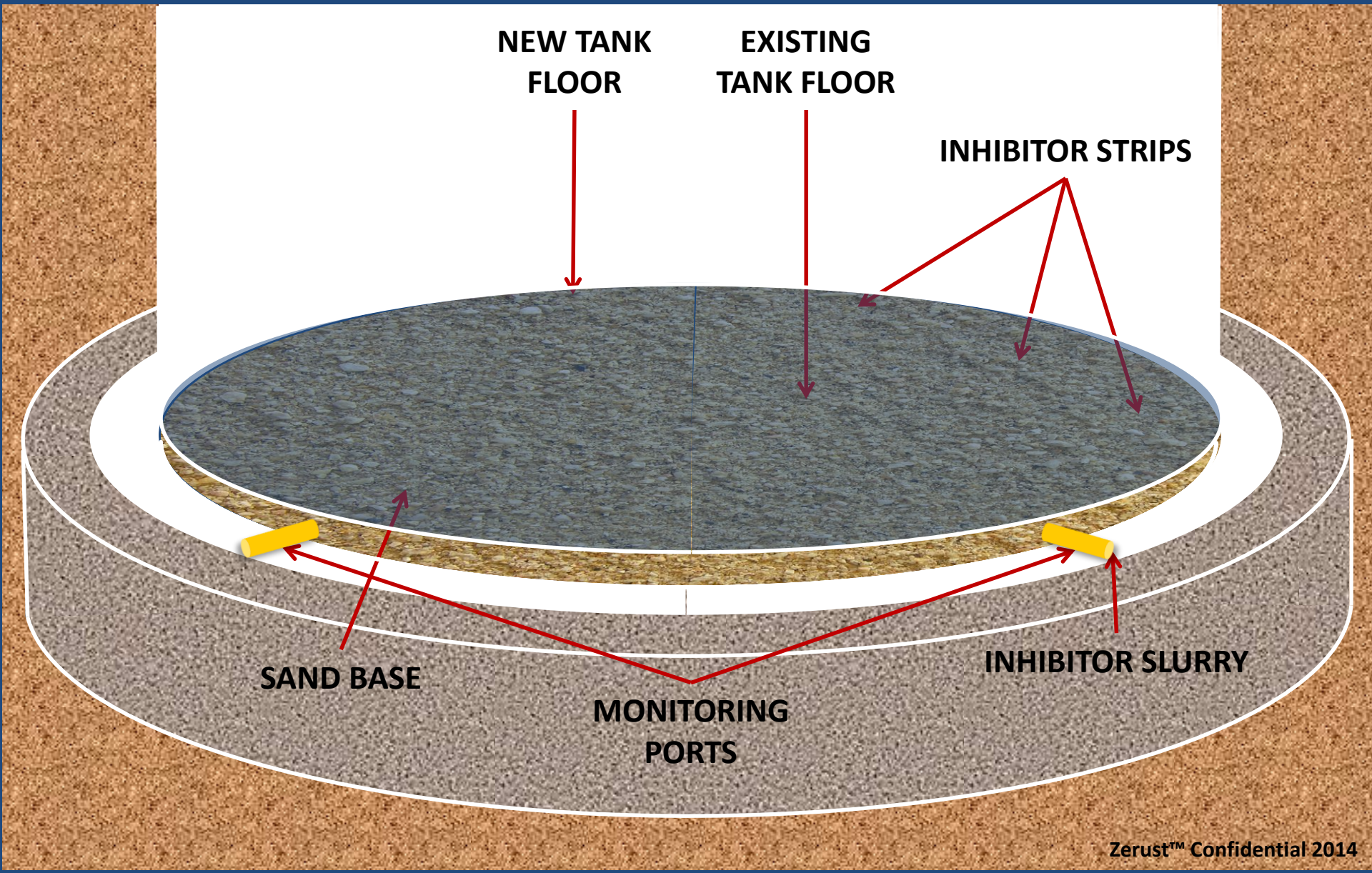
SSB Internal Flood System



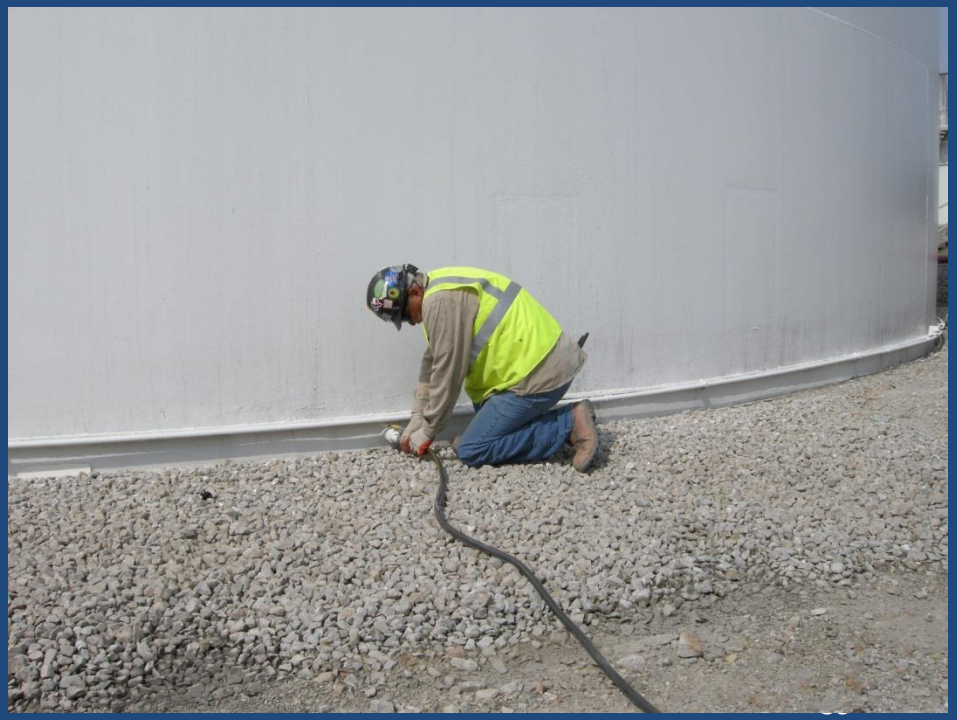
Video of Under Floor Tube System

Pipes Installed

SSB Double Bottom System



Double Bottom Injection



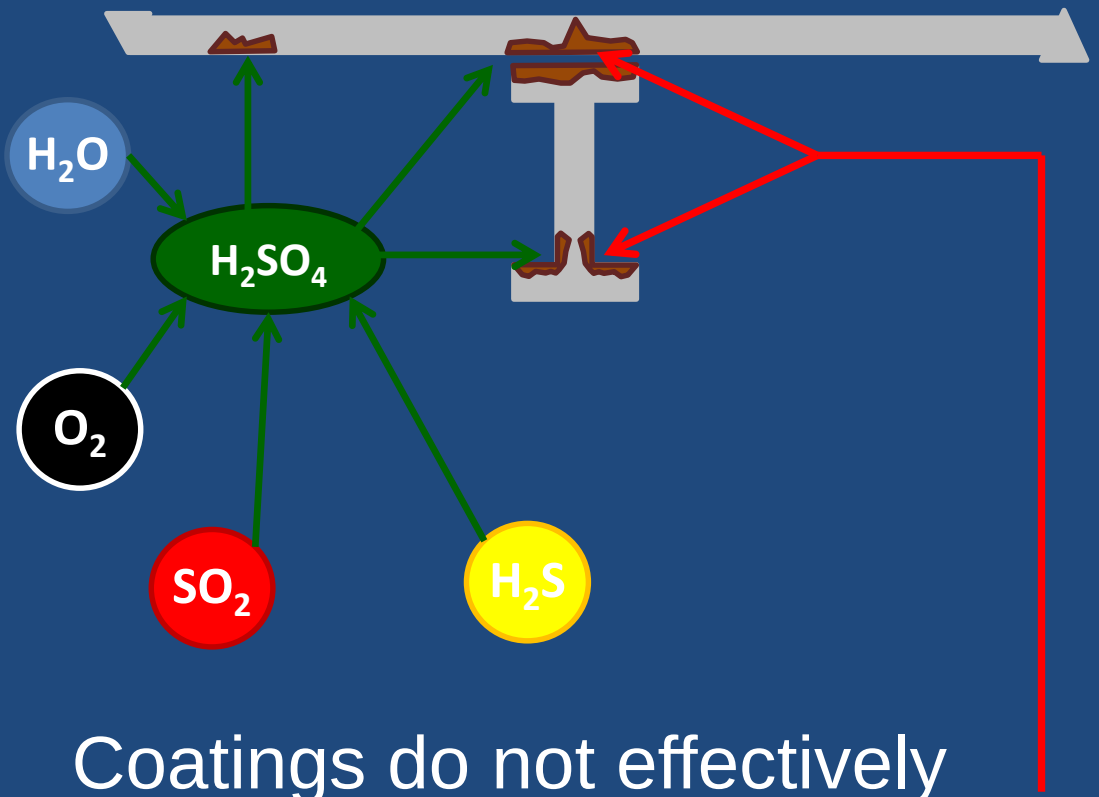
Applications!

Tank Roofs!

Cone roof supports!

Continuity of coatings?

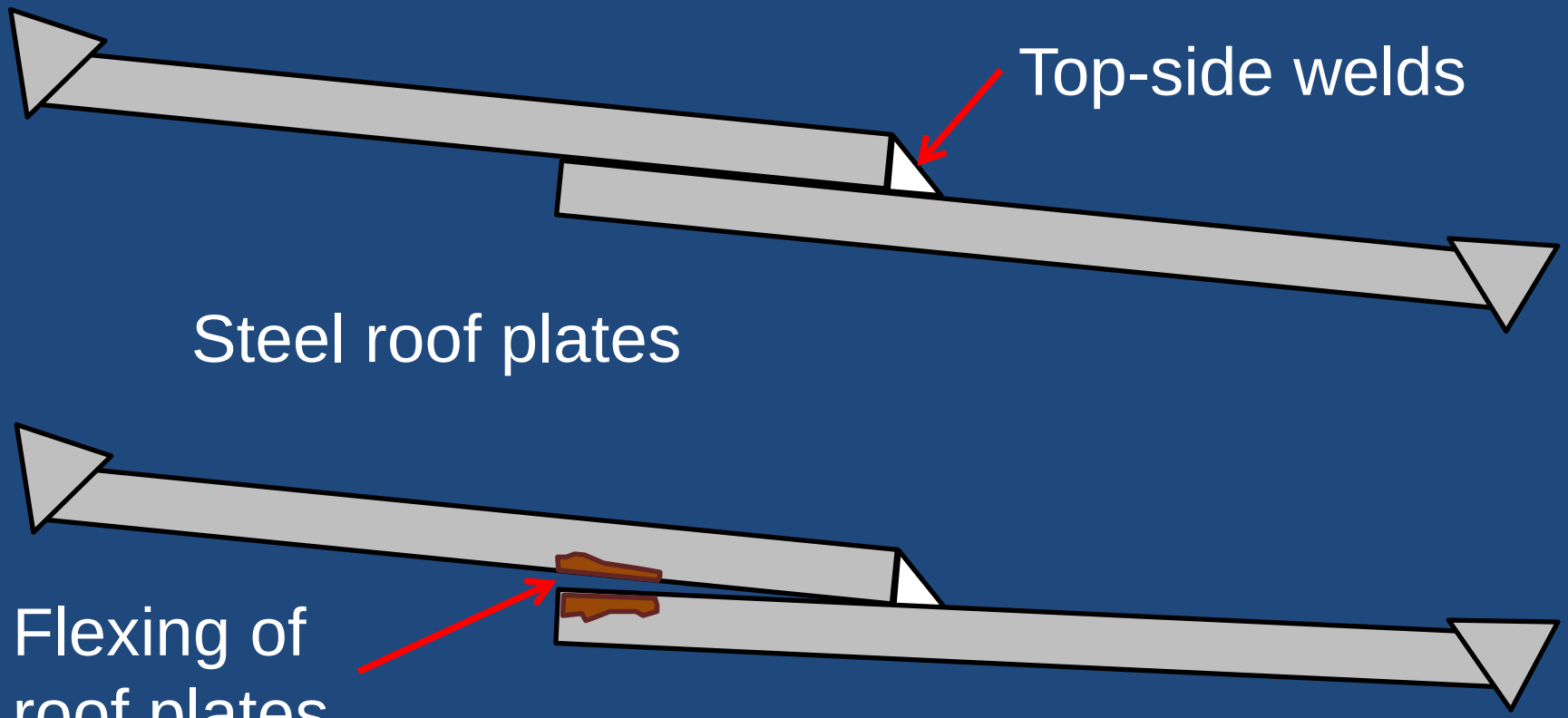
Tank roof and support beam



Coatings do not effectively cover all surfaces

Cone roof plates

Welded on top-side, and flex.



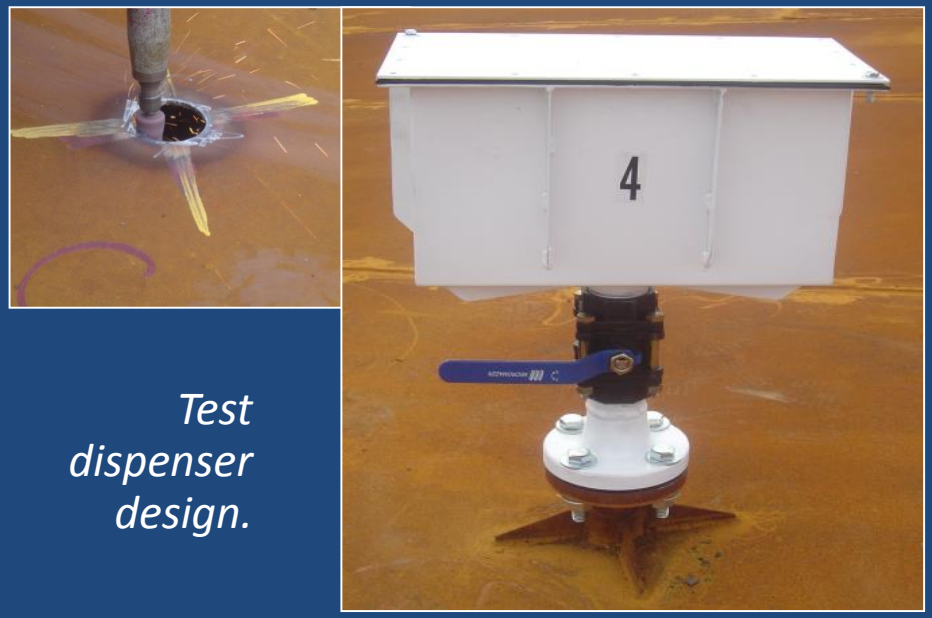
Allows for crevice corrosion

Examples of AST Roof corrosion

Internal acid gas vapors cause underside corrosion

Mitigate roof underside corrosion

The delivery system!



Test dispenser design.

New dispenser design.

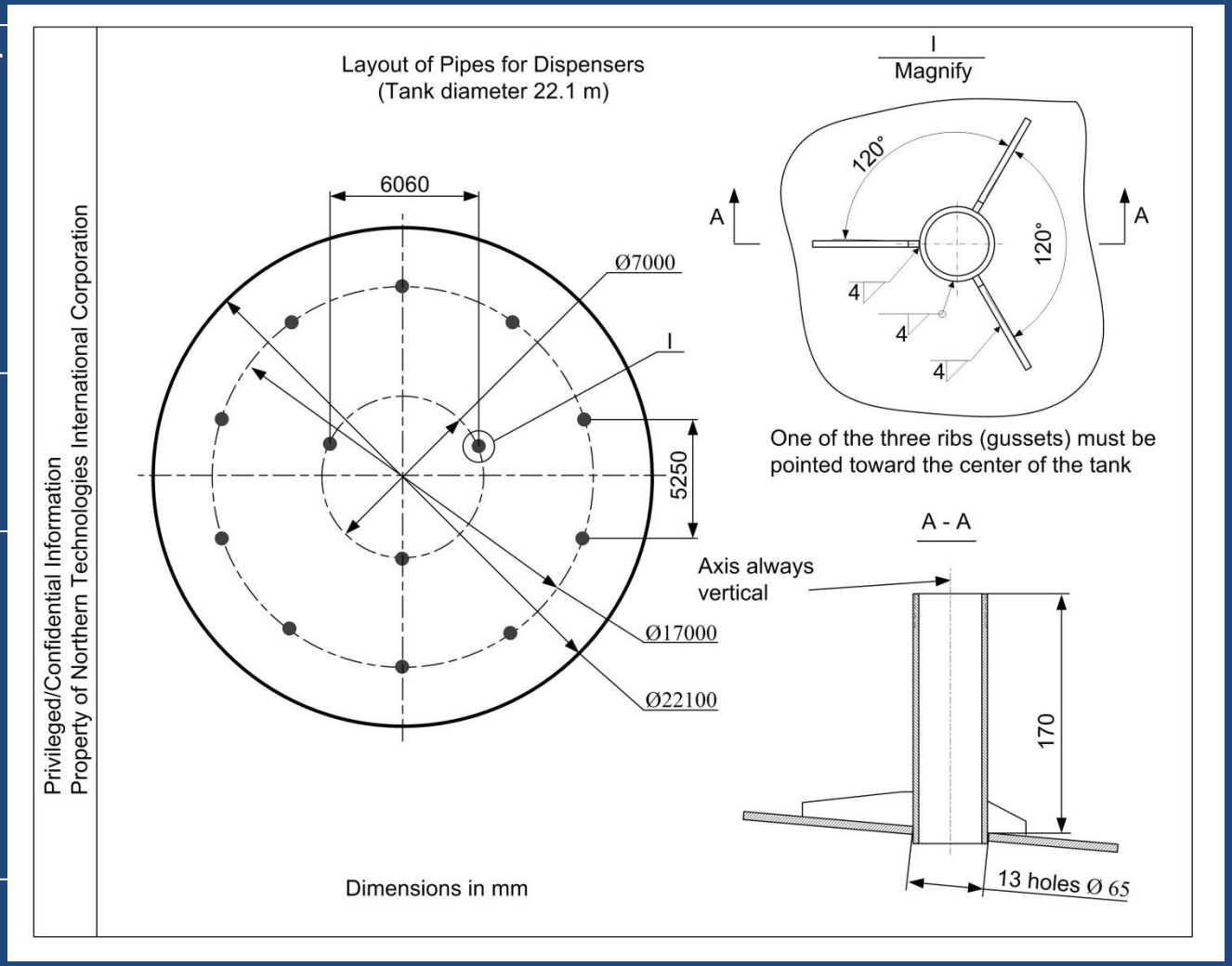
Inhibitor levels can be monitored and replenished while the tank is “In-Service”.

Molecular vapor pressure disperses the inhibitor from cannisters installed during a tank shutdown.

Dispenser Placement

- 22.1m = 72.5ft Diameter
- Expected avg. cycling of 1 time per week
- Total Recommended Dispensers = 13

- 55m = 180ft Diameter
- Expected avg. cycling of 1 time per week
- Total Recommended Dispensers = 51



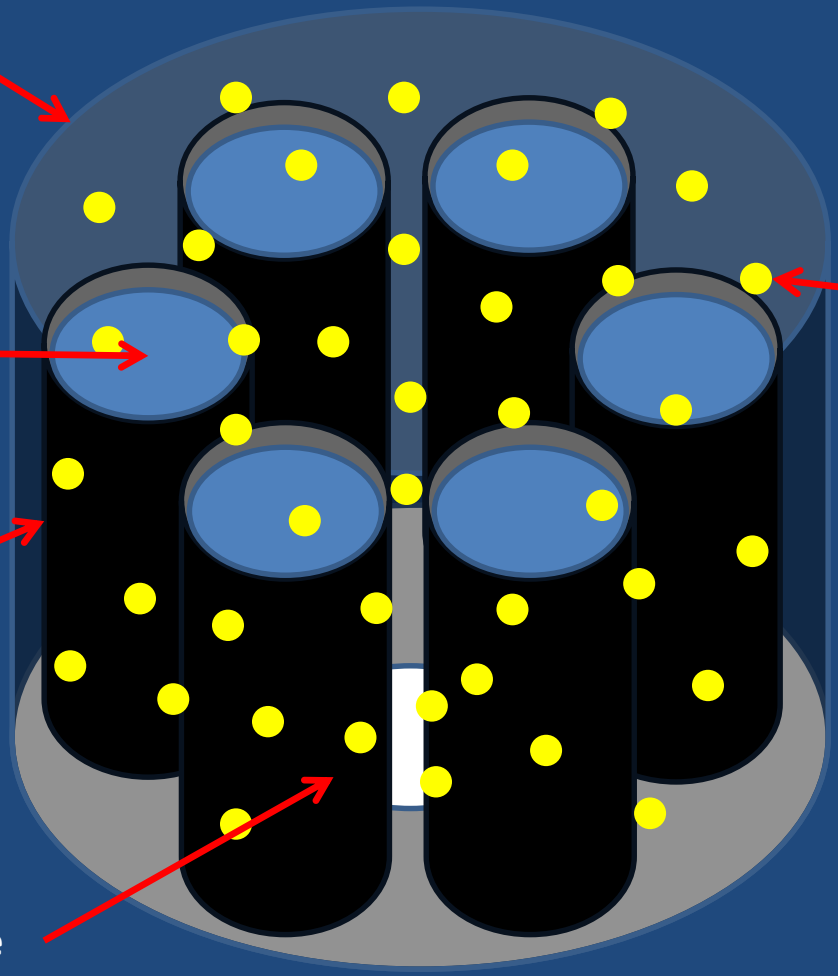
Roof System

Dispenser

Liquid VCI

VCI bottles

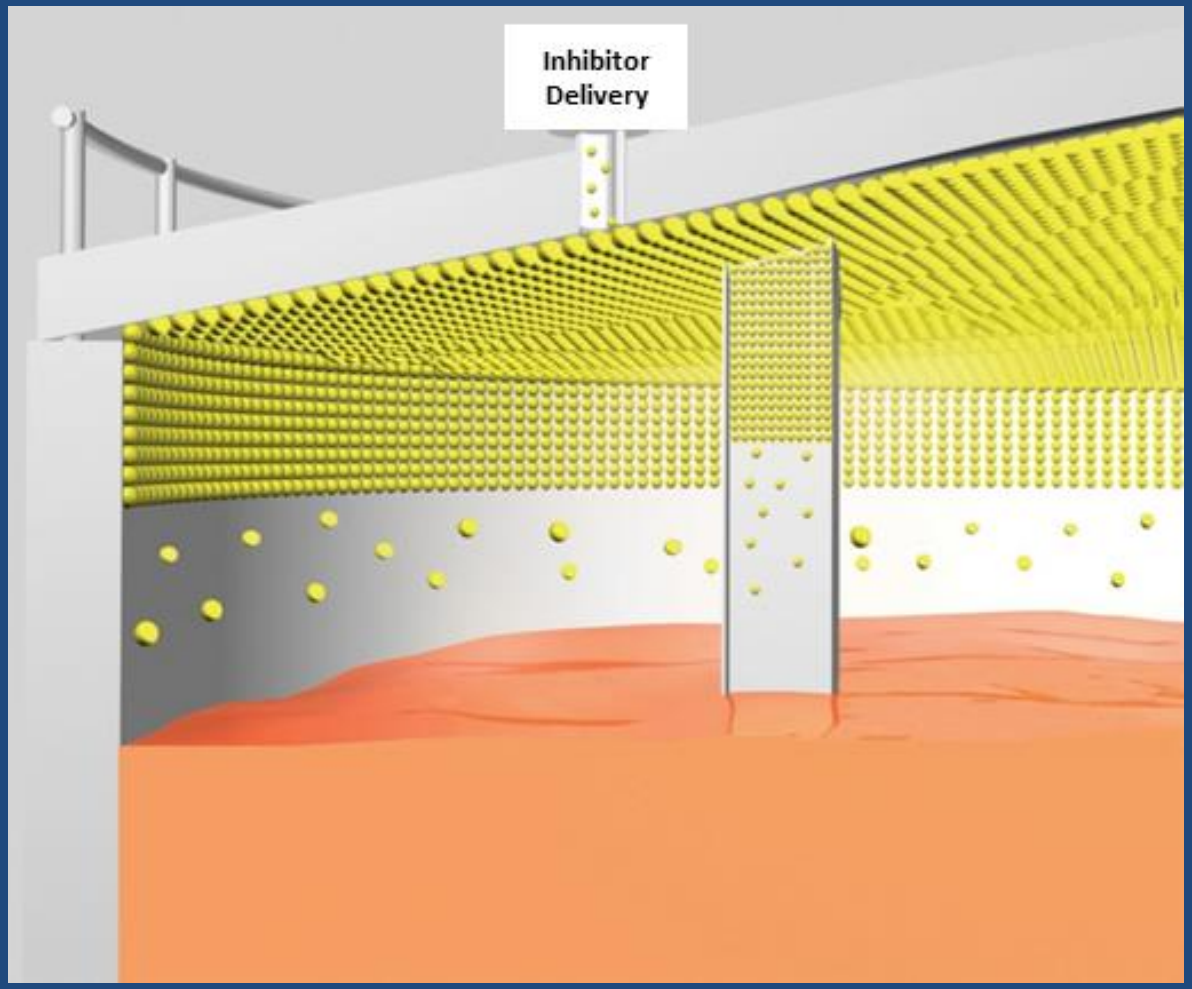
Nozzle to tank vapor space



1. Liquid VCI volatizes into a vapor.
2. Vapor pressure forces the VCI molecules down through the nozzle into the tank vapor space.

Mono-Molecular Barrier

VCI takes preference on steel surface

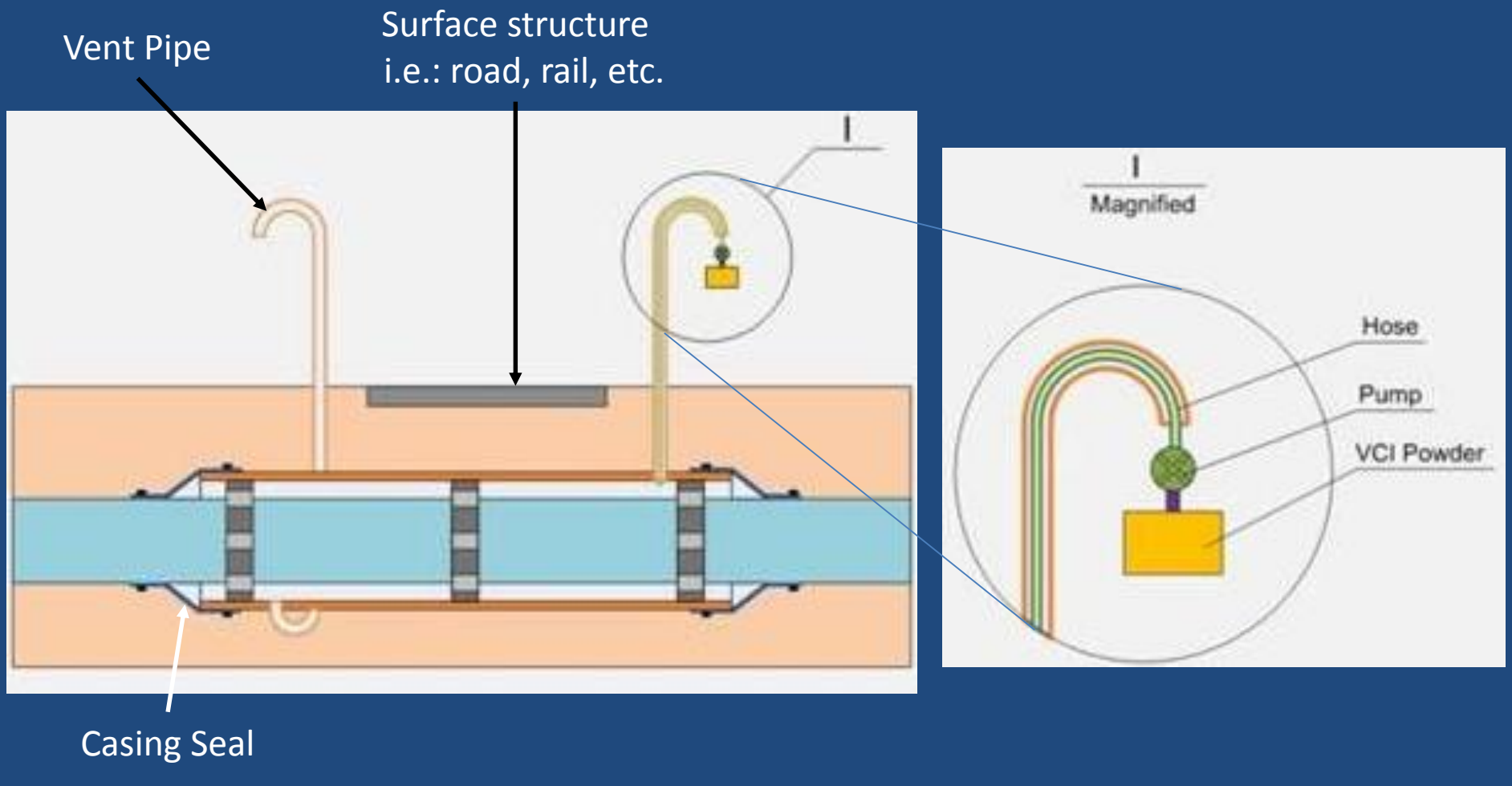


Applications!

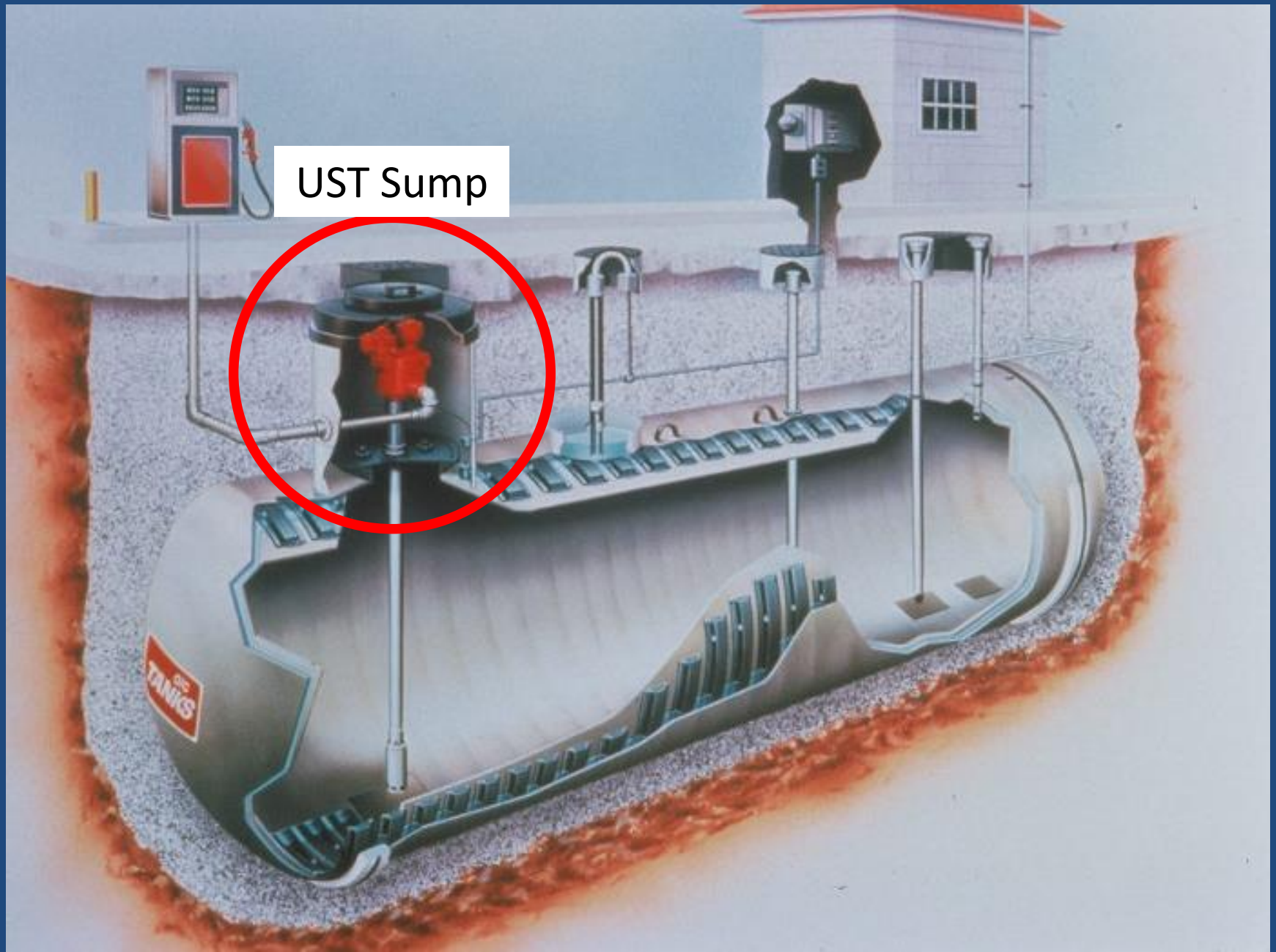
Other Applications!

Pipe Casings

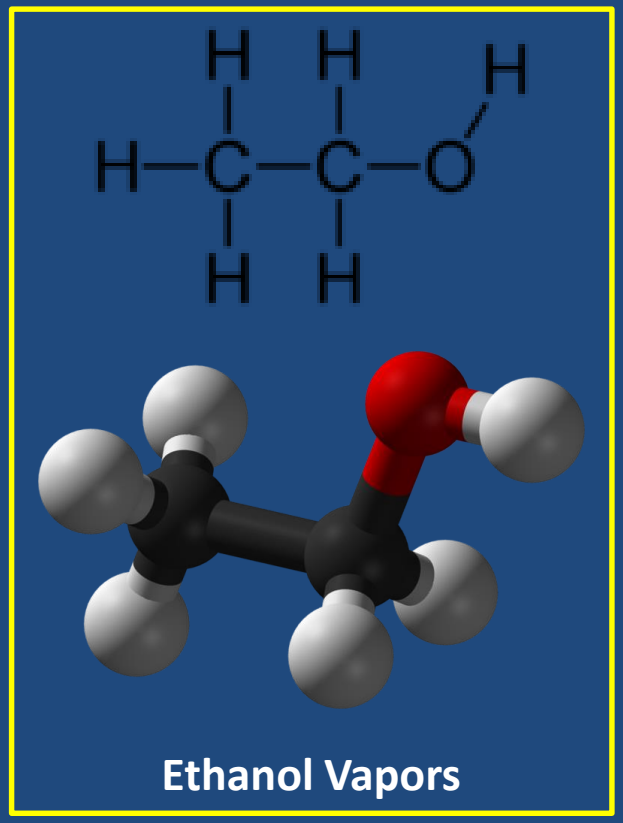
Long Term Corrosion Protection



UST System Components

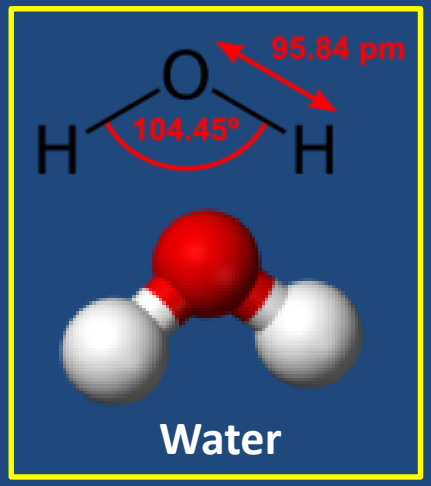


UST Vapor Space Chemistry



Ethanol Vapors

+

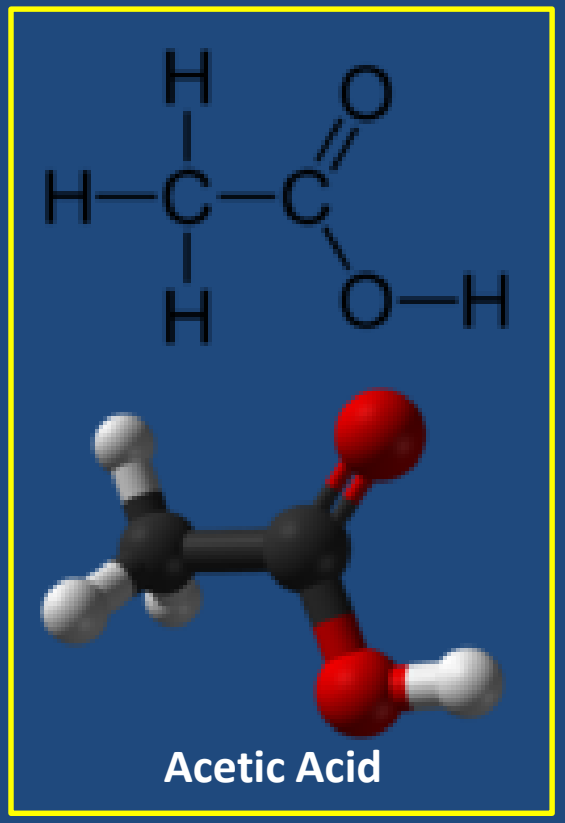


Water

+

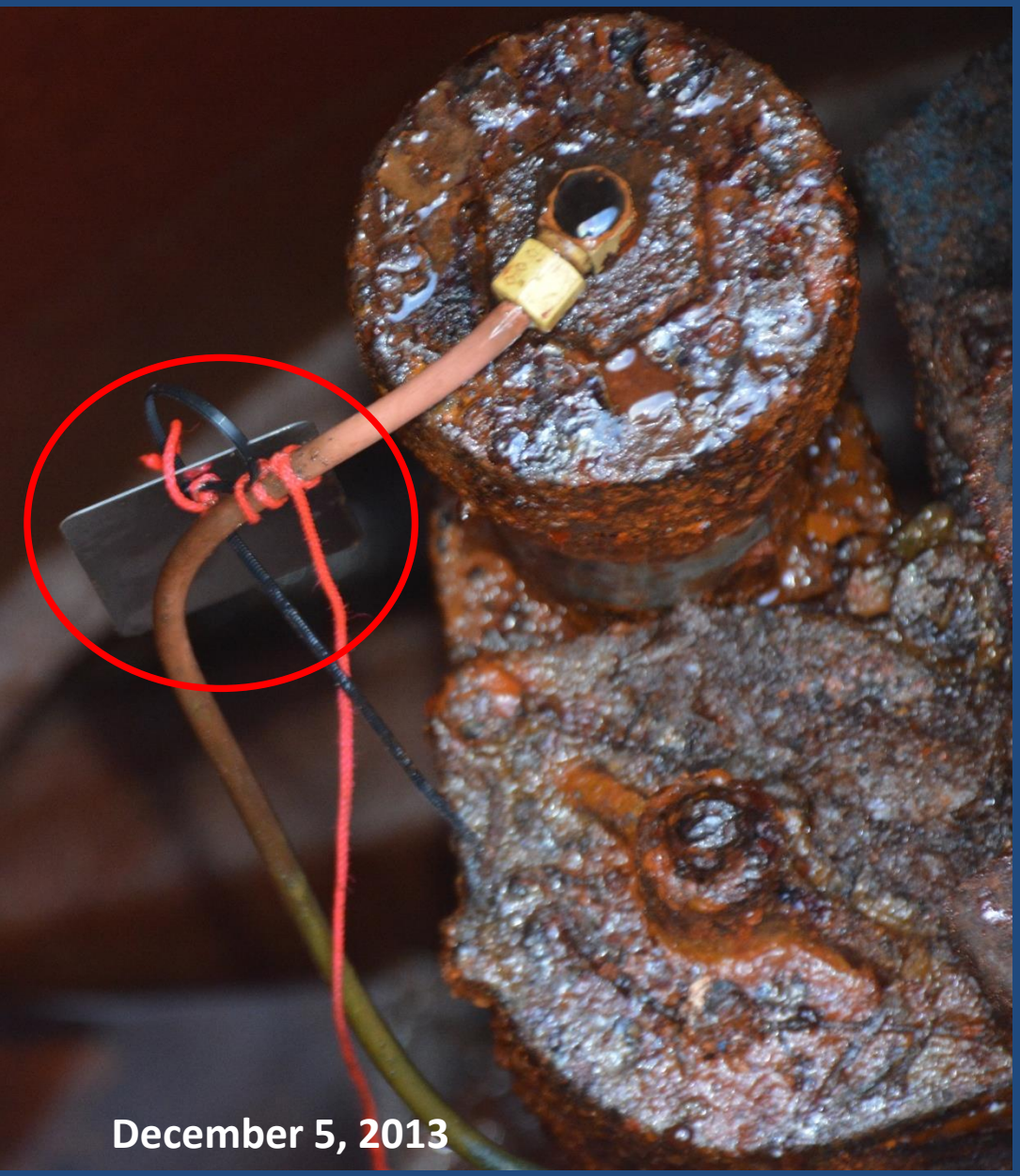
Bacteria

=



Acetic Acid

No Inhibitor

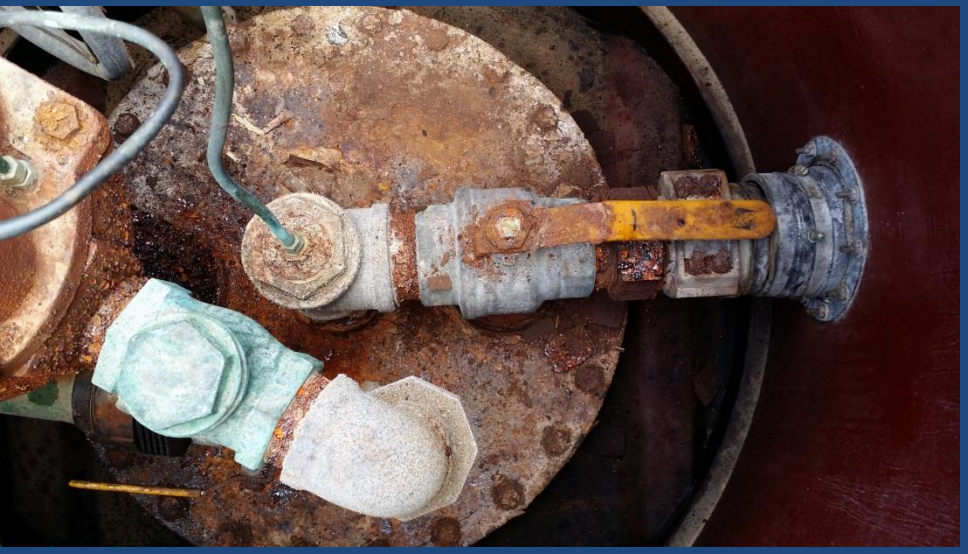


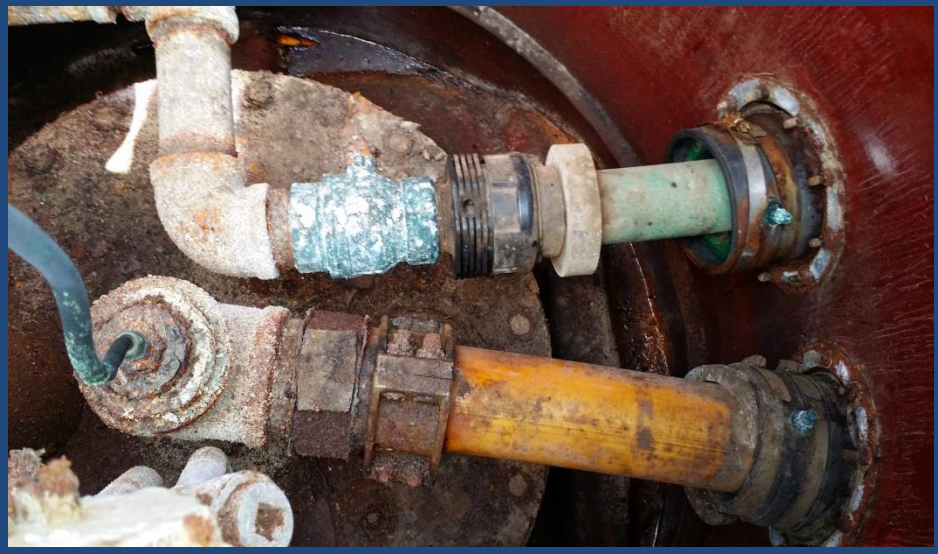
December 5, 2013

February 20, 2014

Current Test Locations in Texas

Current Test Locations in Texas





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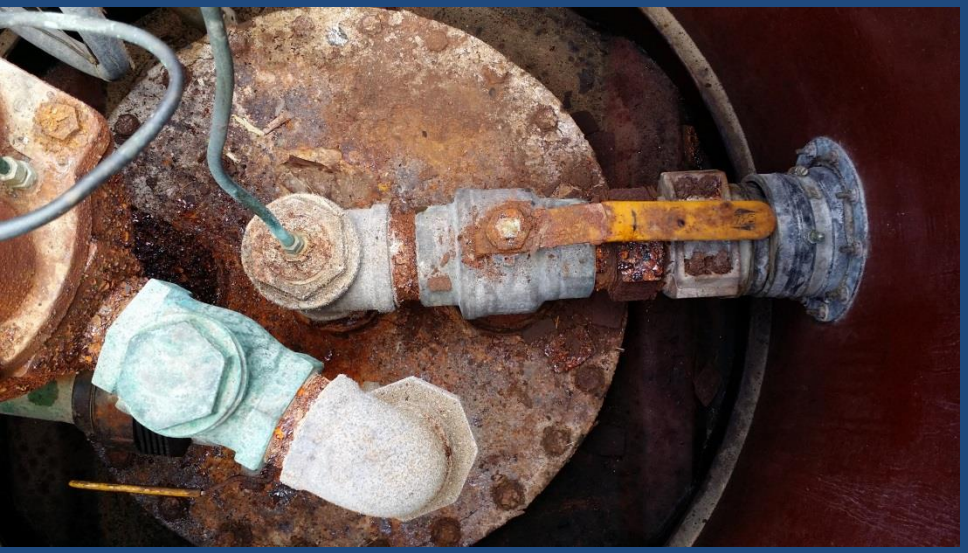

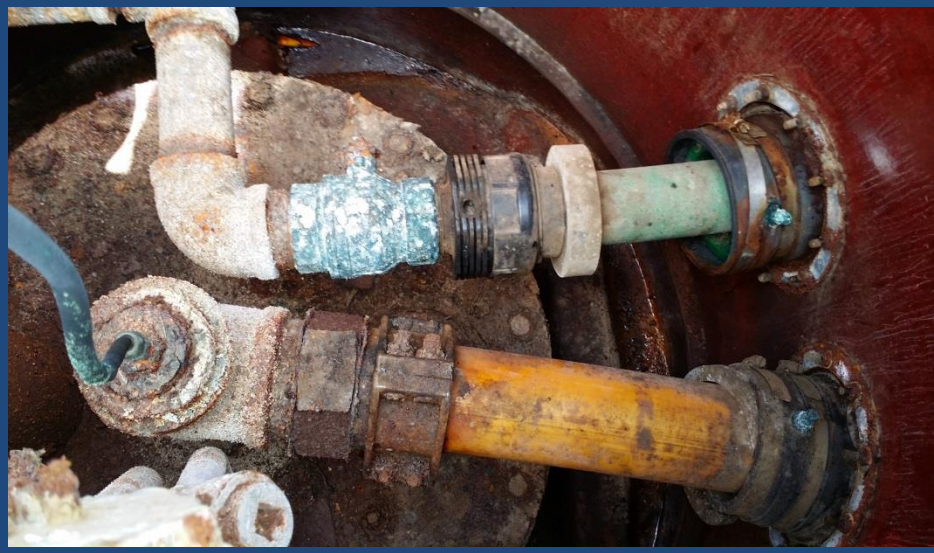

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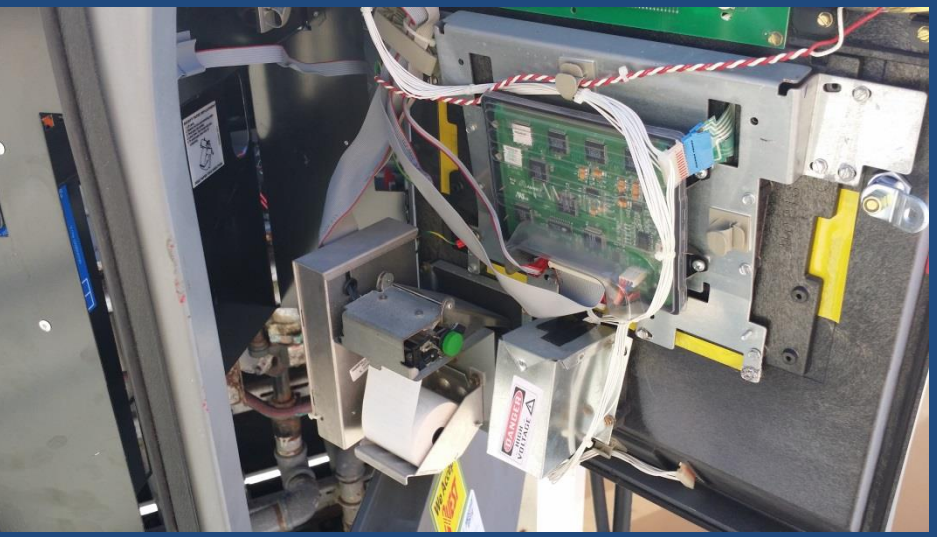
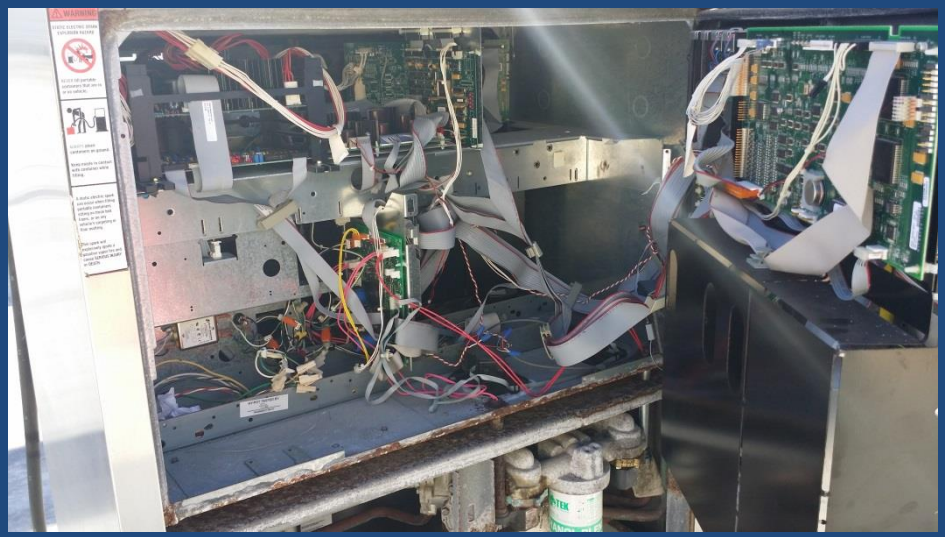
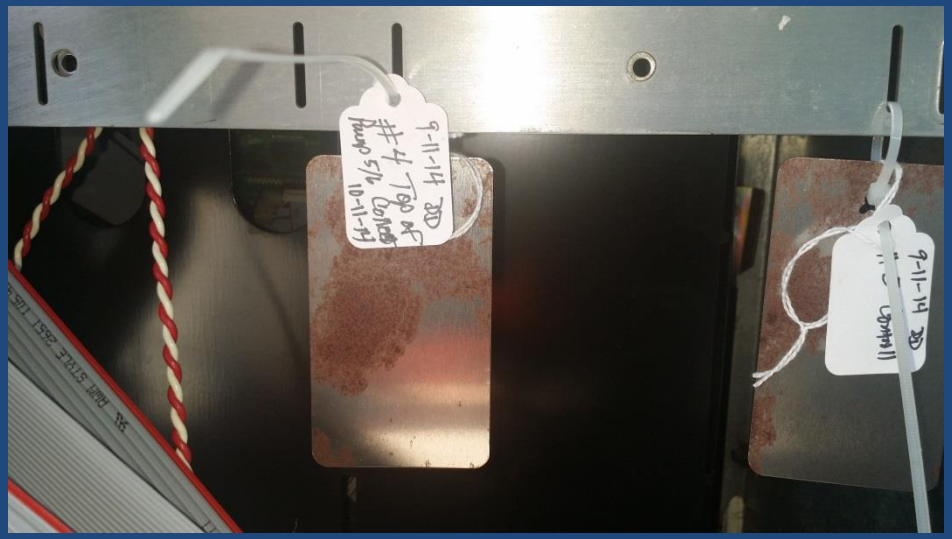
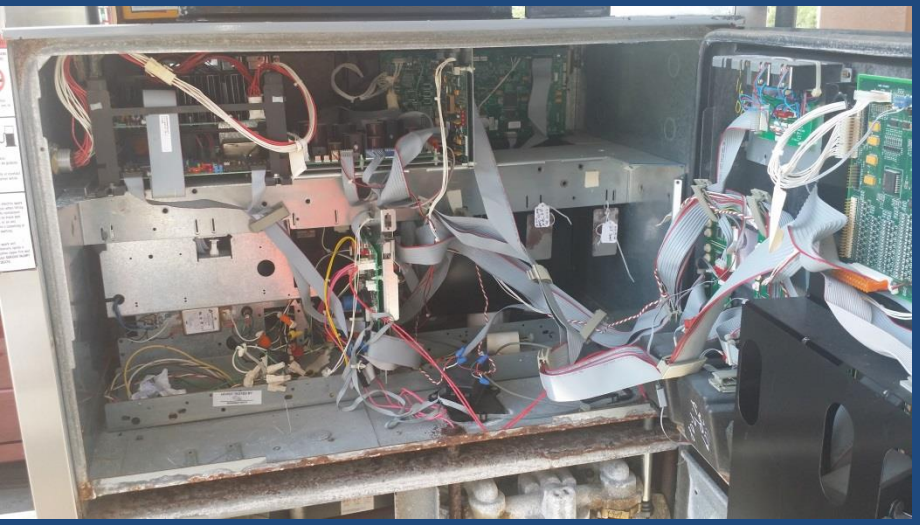




After 1 Month at Test Site in Texas





One other site in Texas
(this store is around 3 yrs old!)

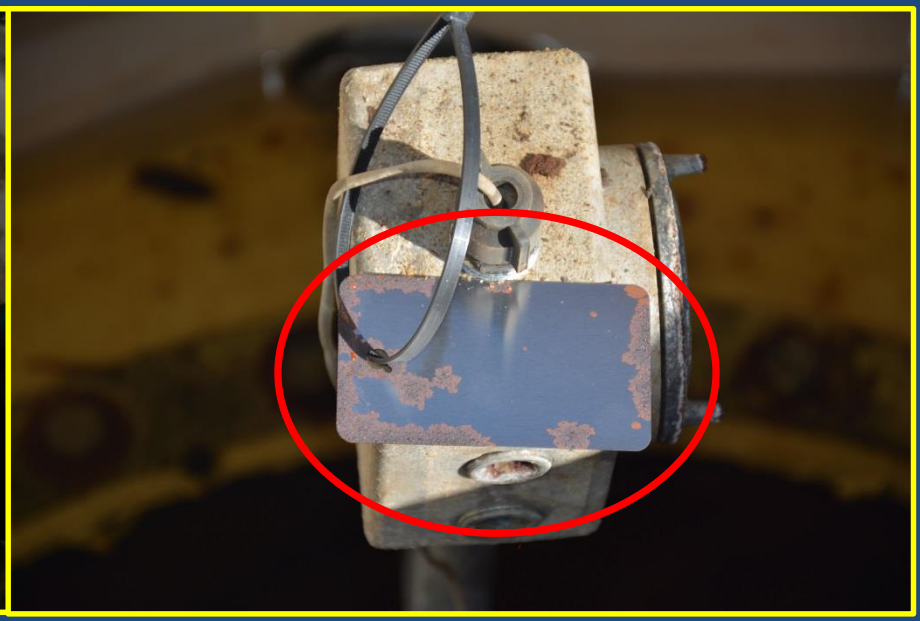
One other site in Texas
(this store is around 3 yrs old!)

One other site in Texas
(this store is around 3 yrs old!)

UST Control Sump

Coupon Only

December 5, 2013



January 16, 2014

Some Visible Surface Corrosion

UST Control Sump

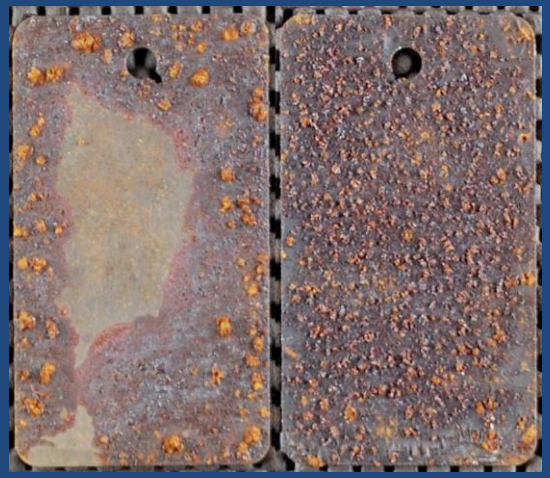
Coupon Only

December 5, 2013

January 16, 2014

Significant Surface Corrosion

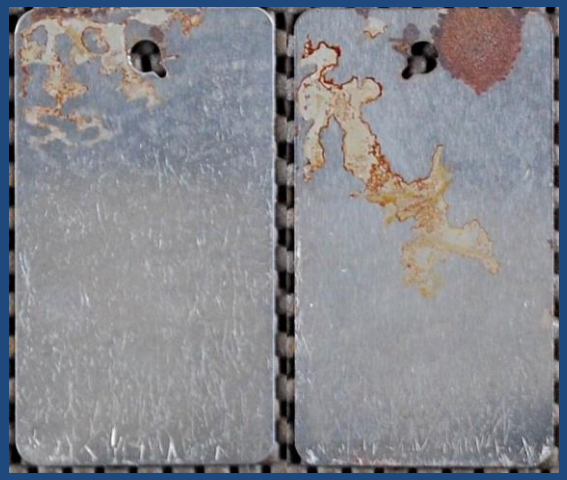
UST Test Sump

Site	March 2014 Packet Only	April 2014 Front Side Spray Only	May 2014 Front Side & Sump Spray
A			
B			

UST Test Sump

Site	March 2014 Packet Only	April 2014 Front Side Spray Only	May 2014 Front Side & Sump Spray
C			
D			

UST Test Sump

Site	March 2014	April 2014	May 2014
	Packet Only	Front Side Spray Only	Front Side & Sump Spray
E			
F			

Beta Test

- Relatively Clean Surface & Tightened Fittings

Annual Application

Monthly Application

Thank you!
Questions?

David Durling
ddurling@ntic.com
832-482-8781