REINHOLD ENVIRONMENTAL ®

2022 Reinhold/PCUG Round Table Presentation

Hosted by Duke Energy in the Charlotte Sheraton/Le Meridien Hotel, Charlotte, NC on June 27-28, 2022

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Safe, Non-Intrusive Anhydrous Ammonia Tank Inspections

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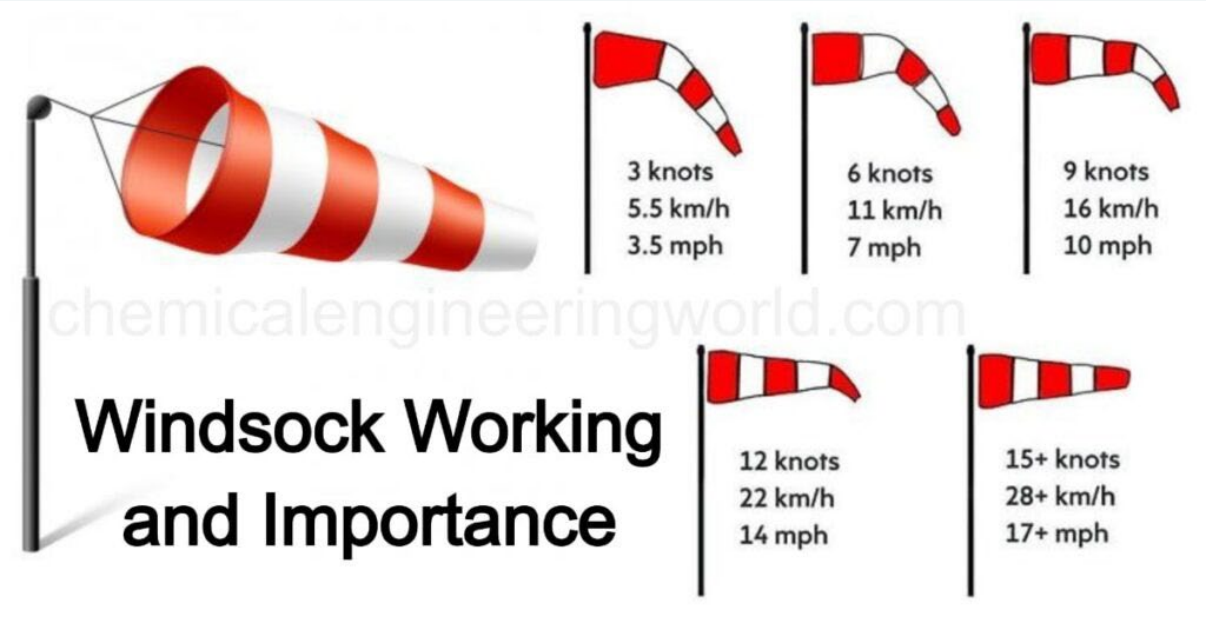
June 27, 2022

Safety First



Today's Agenda

1 Ammonia Usage

2 Storage

3 Inspection Techniques

4 Questions & Answers

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NO_x Formation

Nitrogen is naturally occurring in the air
- ~78% composition
- combustion of fossil fuels creates NO_X
- high temperatures aid formation

NO_X are greenhouse gases and need to be converted back to non-harmful species before being released back into the environment

$$N_2 + O \longrightarrow NO + N$$

$$N + O_2 \longrightarrow NO + O$$

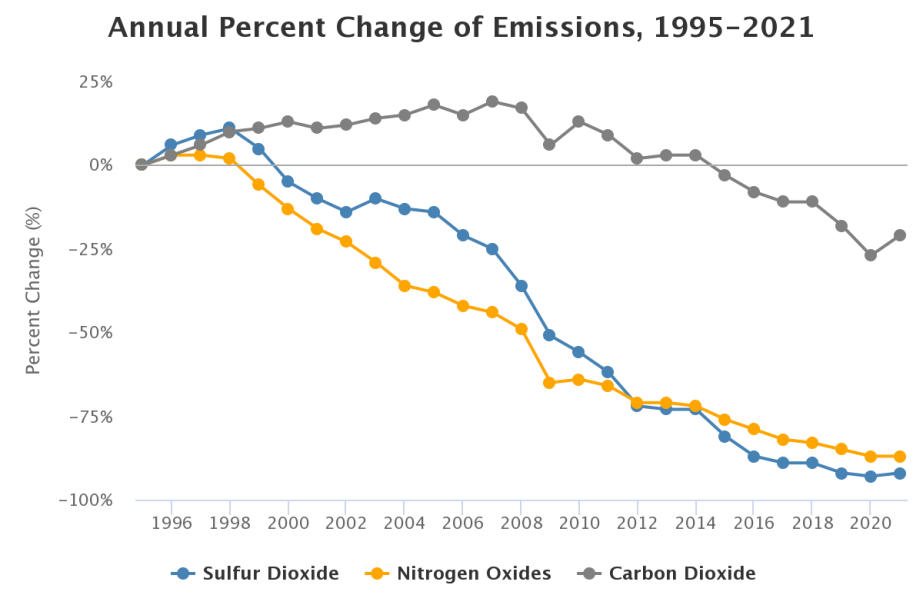
$$N + OH \longrightarrow NO + H$$

NO_x, SO_x, & PM Reduction

The EPA regulates the emissions of greenhouse gases into the environment under ARP, CSAPR, and MATS

Plants over 40MW have been outfitted with Air Pollution Control equipment designed to reduce PM, SO_X, & NO_X

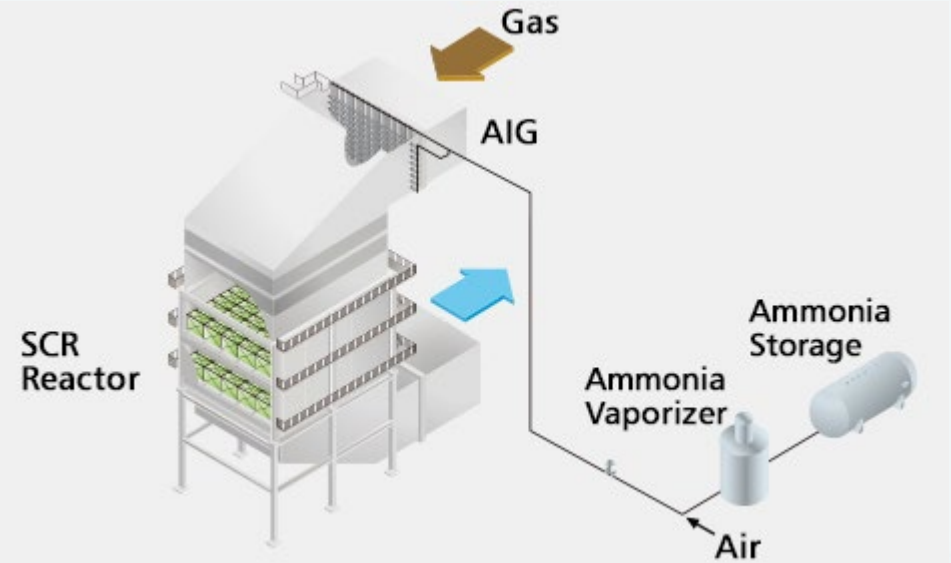
- Selective catalytic reactors (SCR)
- Electrostatic precipitators (ESP)
- Baghouses
- Wet & dry scrubbers



Ammonia Usage against NO_x

Within the selective catalytic reactor (SCR), ammonia is used to breakdown NO_X to N_2 and H_2O via a vanadium catalyst

$$NO_X + NH_3 \xrightarrow{\text{Vanadium}} N_2 + H_2O$$



Ammonia Storage

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Ammonia The Chemical

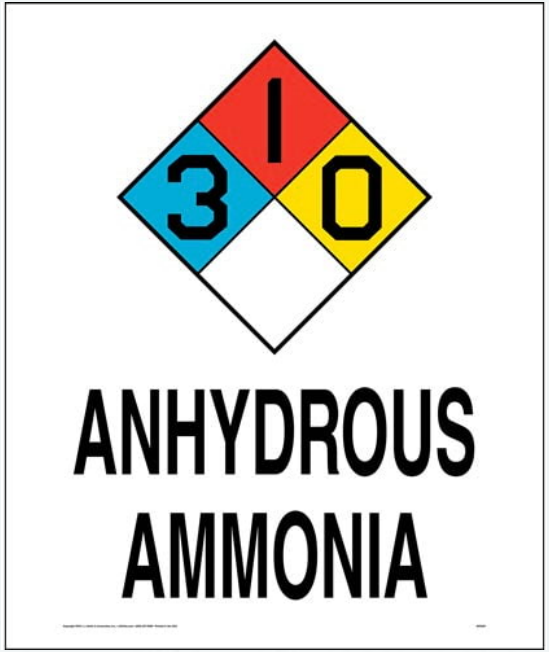
Anhydrous ammonia is a gas above -28°F (-33°C) unless under high pressure

Health Hazard (blue): 3
- Extreme danger
- IDLH of 300 ppm (0.03%)

Fire Hazard (red): 1
- Above 200°F
- LEL of 16%

Instability (yellow): 0
- Stable

Special (white): none



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Ammonia Storage

Power plants typically have two bullet tanks between 30,000-90,000 gallons (110k-340k liters) capacity

Operating Pressure: 265 psi (18.3 bar)

Delivery: railcar or truck

Safety: Locate windsocks around the plant for effective evacuation in case of accidental release of ammonia

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Storage Information

Construction of ammonia bullet tanks:
- API 510 code
- ASME Section VIII standards

Materials of construction:
- SA-516 (ideal)
- SA-455 (suitable)
- SA-212 (discontinued)

Corrosion allowances:
- Tank construction dependent
- 0.000” to 0.0625” (0.00mm to 1.59mm)
- Check U-1 and nameplates

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single Chamber, Completely Shop-Fabricated Vessels Only)
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by East Fabricators, Inc. 1063 Haining Rd., Vicksburg, Ms. 39180
(Name and address of manufacturer)

2. Manufactured for LaRoche Ind., 1260 Iroquois Dr. #108, Naperville, ILL 60563
(Name and address of purchaser)

3. Location of installation same as above
(Name and address)

4. Type Horiz. (Horiz. or vert., tank) | 15198 (Mfgr's serial No.) | None (CRN) | D-15198 (Drawing No.) | 5390 (Nat'l. Bd. No.) | 1999 (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 1998 (Year)

to 1999 (Addenda (Date)) | None (Code Case Nos.) | None (Special Service per UG-120(d))

6. Shell: SA516-70 (Matl. (Spec. No., Grade)) | .625 (Nom. Thk. (in.)) | .0625 (Corr. Allow. (in.)) | 6'-0" ID (Diam. I.D. (ft. & in.)) | 34'-0" (Length (overall) (ft. & in.))

7. Seams: Type 1 (Long. (Welded, Dbl., Sngl., Lap, Butt)) | Full (R.T. (Spot or Full)) | 100% (Eff. (%)) | 1175 (H.T. Temp. (°F)) | 2hrs. (Time (hr)) | Type 1 (Girth (Welded, Dbl., Sngl., Lap, Butt)) | Full (R.T. (Spot, Partial, or Full)) | 4 (No. of Courses)

8. Heads: (a) Matl. SA516-70 (Spec. No., Grade) (b) Matl. SA516-70 (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	End	.2735	.0625	36	None	None	None	36	NOne	Concave
(b)	End	.2735	.0625	36	None	None	None	36	None	Concave

If removable, bolts used (describe other fastenings) None
(Matl., Spec. No., Gr., Size, No.)

9. MAWP 265 psi at max. temp. 115 °F

Min. design metal temp. -20 °F at 265 psi. Hydro., pneu., or comb. test pressure 397.5 psi.

API 510 Code

6.5.2 On-stream Inspection

6.5.2.1 At the discretion of the inspector, an on-stream inspection may be substituted for the internal inspection in the following situations:

a. When size or configuration makes vessel entry for internal inspection physically impossible.
b. When vessel entry for internal inspection is physically possible and all of the following conditions are met:

1. The general corrosion rate of a vessel is known to be less than 0.005 in. (0.125 mm) per year.
2. The vessel remaining life is greater than 10 years.
3. The corrosive character of the contents, including the effect of trace components, has been established by at least five years of the same or similar service.
4. No questionable condition is discovered during the External inspection.
5. The operating temperature of the steel vessel shell does not exceed the lower temperature limits for the creep-rupture range of the vessel material.
6. The vessel is not subject to environmental cracking or hydrogen damage from the fluid being handled.
7. The vessel does not have a non-integrally bonded liner such as strip lining or plate lining.

6.5.2.2 If the requirements of 6.5.2.1b are not met, the next inspection shall be an internal inspection. As an alternate to the above limits, an on-stream inspection can be performed if an RBI assessment (per 6.3) determines that risk associated with the vessel is acceptably low and the effectiveness of the external NDE technique(s) is adequate for the expected damage mechanism. This assessment should include a review of past process conditions and likely future process conditions.

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Accidental Ammonia Release

Video from Youtube:

Case Study

Non-intrusive Inspection For Ammonia Tanks

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API 510 External Inspection

Anhydrous Ammonia Tank

Goal

API 510 Inspection – External in lieu of internal for the next interval

Challenges

UT readings covered about 15-20% of the shell
Spot check of weld seams

Result

Localized corrosion and wall thinning
Cracking and flaws identified along weld seams

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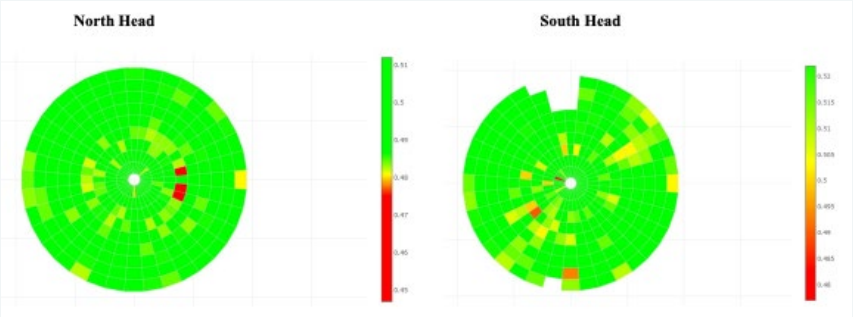
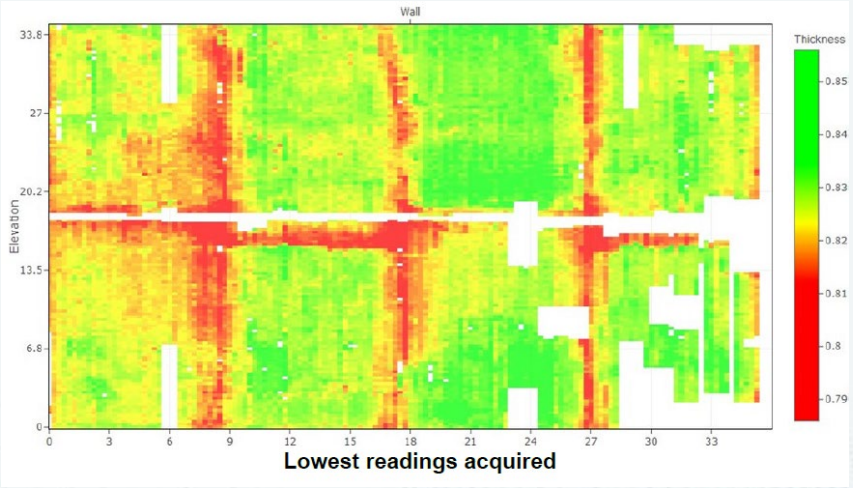
BASE METAL INSPECTION

Anhydrous Ammonia Tank

- Tank shell and heads inspected with **Rapid Ultrasonic Gridding**
- **Determined corrosion rate and remaining life**
- Used automated and manual **Phased Array UT** to inspect for cracking along 100% of accessible weld seams and HAZ
    - Circular seams, long seams, and nozzles
    - **No cracking detected** along weld seams





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ROBOTIC METHODS: BASE METAL

Rapid Ultrasonic Gridding

- Identifies and quantifies **general corrosion**
- Up to 24 ultrasonic testing (UT) transducers
    - **240 readings/second**
    - Frequency 5-10MHz
- High speed corrosion mapping
    - **Travels 30 feet/minute**
    - 2D and 3D C-scan corrosion maps
- Onboard camera for visual inspection
    - **Deployment outside line of sight**
    - Stored HD imagery
- Climbable and steerable, limited access requirements

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ROBOTIC METHODS: BASE METAL

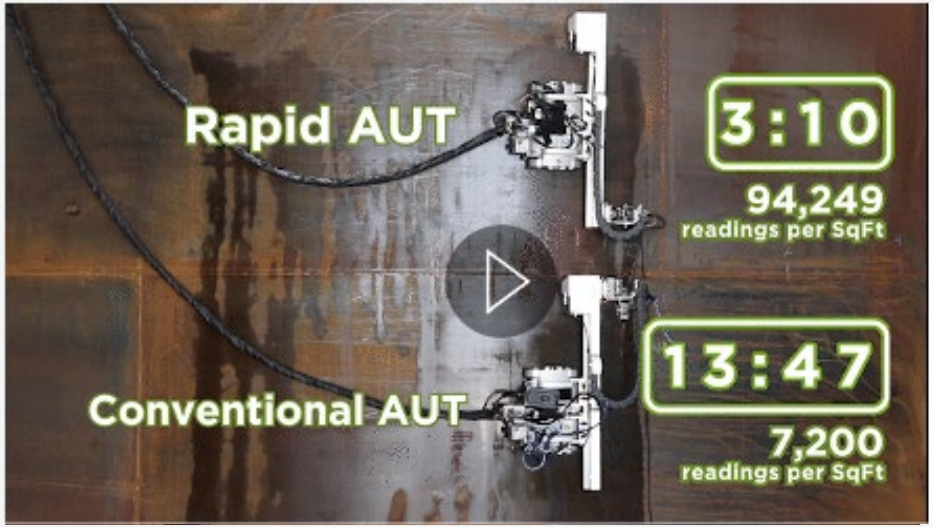
Rapid AUT

5x Faster

10x More Data

THAN CONVENTIONAL AUT

- High-definition **corrosion mapping**
- Quantifies localized **corrosion and pitting**
- Steerable robot equipped with a **dual linear phased array probe**



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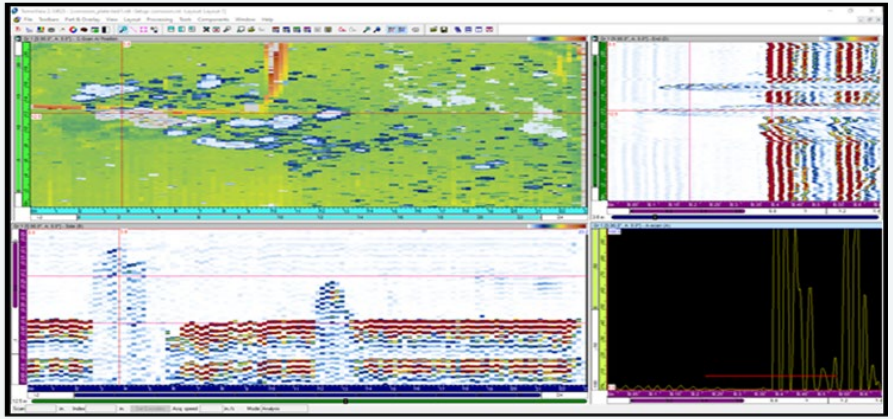
DATA IMAGING

Rapid AUT

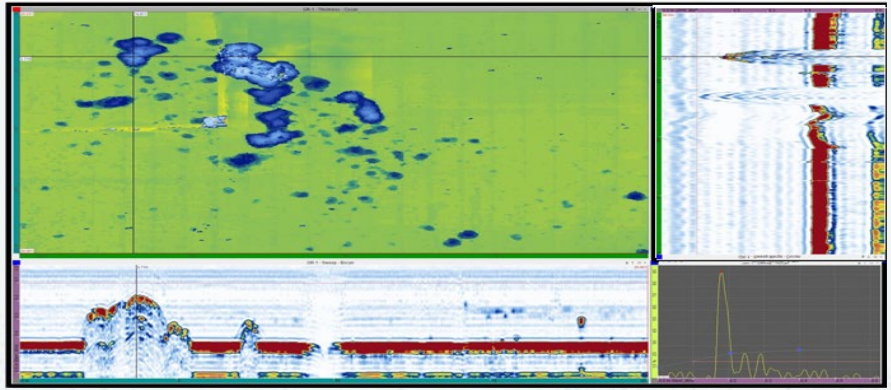
High data density (over 94,000 UT readings/ft^2) provides dense data

Accurate robotic positioning for **repeatability and reproducibility**

Digital data delivery allows for the transfer and assessment of large files



Conventional AUT



Rapid AUT

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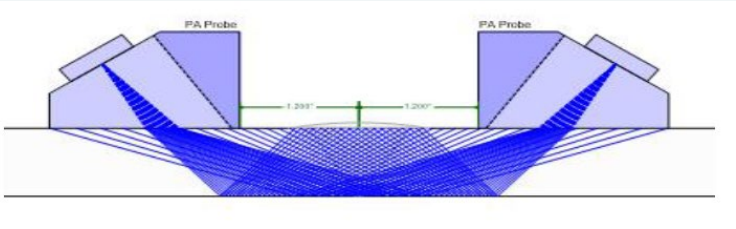
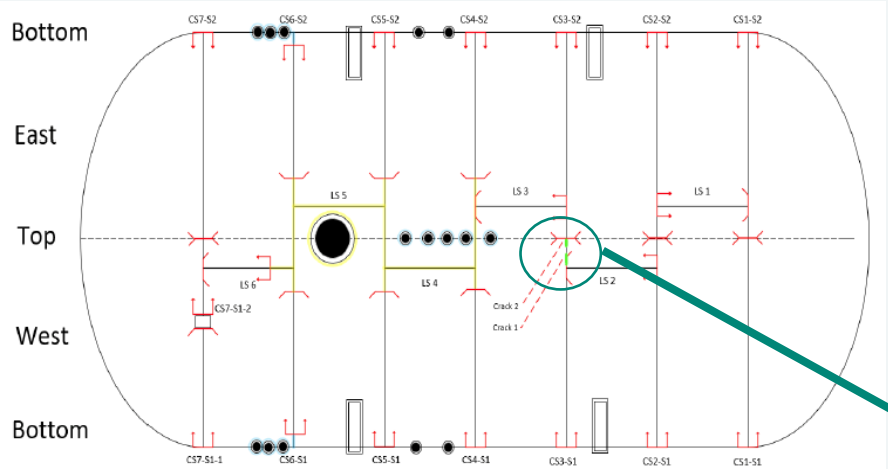
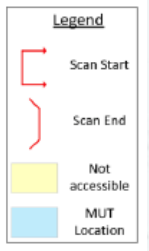
WELD SEAMS & HAZ INSPECTION

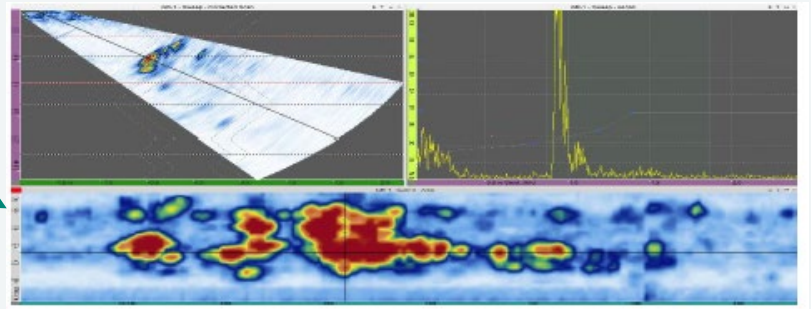
Anhydrous Ammonia Tank







PAUT Image, CS3-S1



Flaw Type	Depth	Height	Length	Start	Stop
Crack	0.598"	0.295"	5"	193"	198"

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ROBOTIC METHODS: WELD SEAMS AND HAZ

Phased Array & TOFD

- **Detect and size cracks, corrosion, flaws, and discontinuities** along weld seams and the heat affect zones (HAZ)
- **Steerable platform and onboard camera** allows for remote deployment
- **100% of the weld scan is captured digitally** for review and recordkeeping

6	500
INCHES/SECOND	LINEAR FEET/SHIFT

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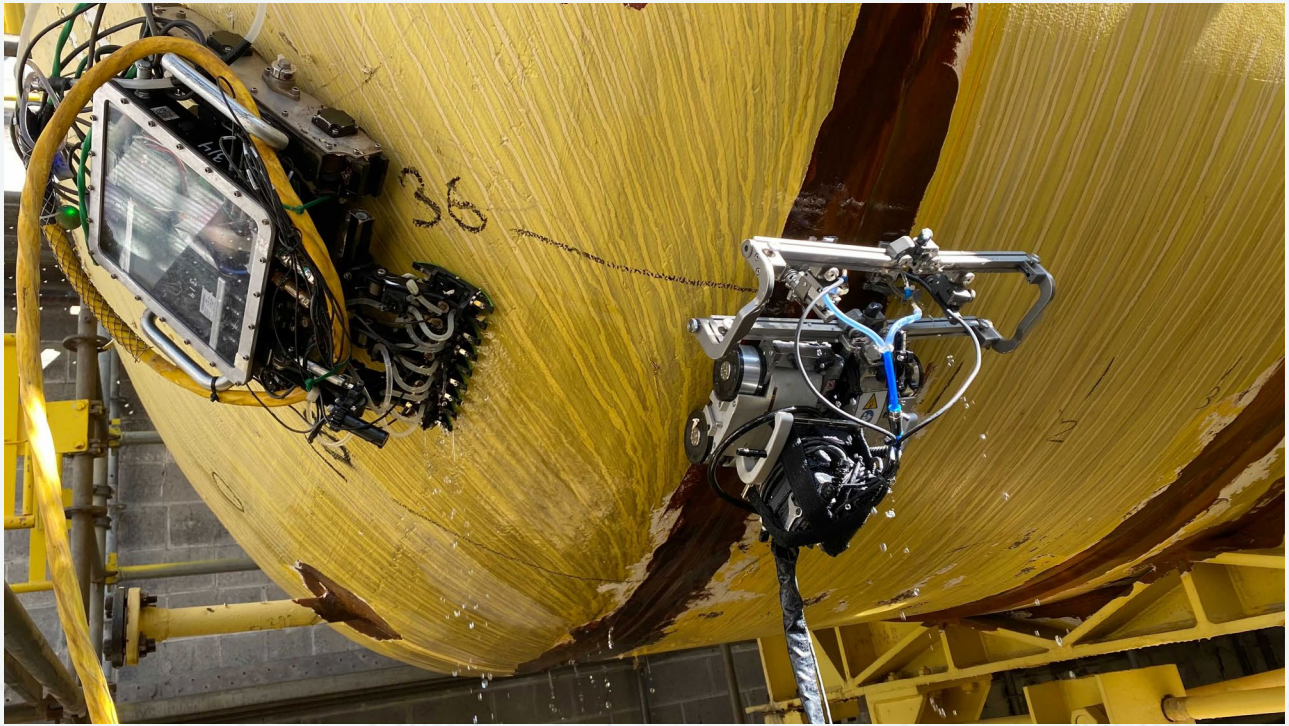
DATA IMAGING

UT & PAUT



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API 510 Pressure Vessel Inspections

ADDITIONAL SERVICES & REPORTING

Historical Review

Provide guidance on external in lieu of internal qualifications, fitness for service, and RBI programs

Serviceability Assessment

MAWP determination, T_{min} assessment, inspection intervals, remaining life, and corrosion rate determination

Pre-Turnaround Planning

More high-quality data for decision making, targeted repair scope, and increased efficiency

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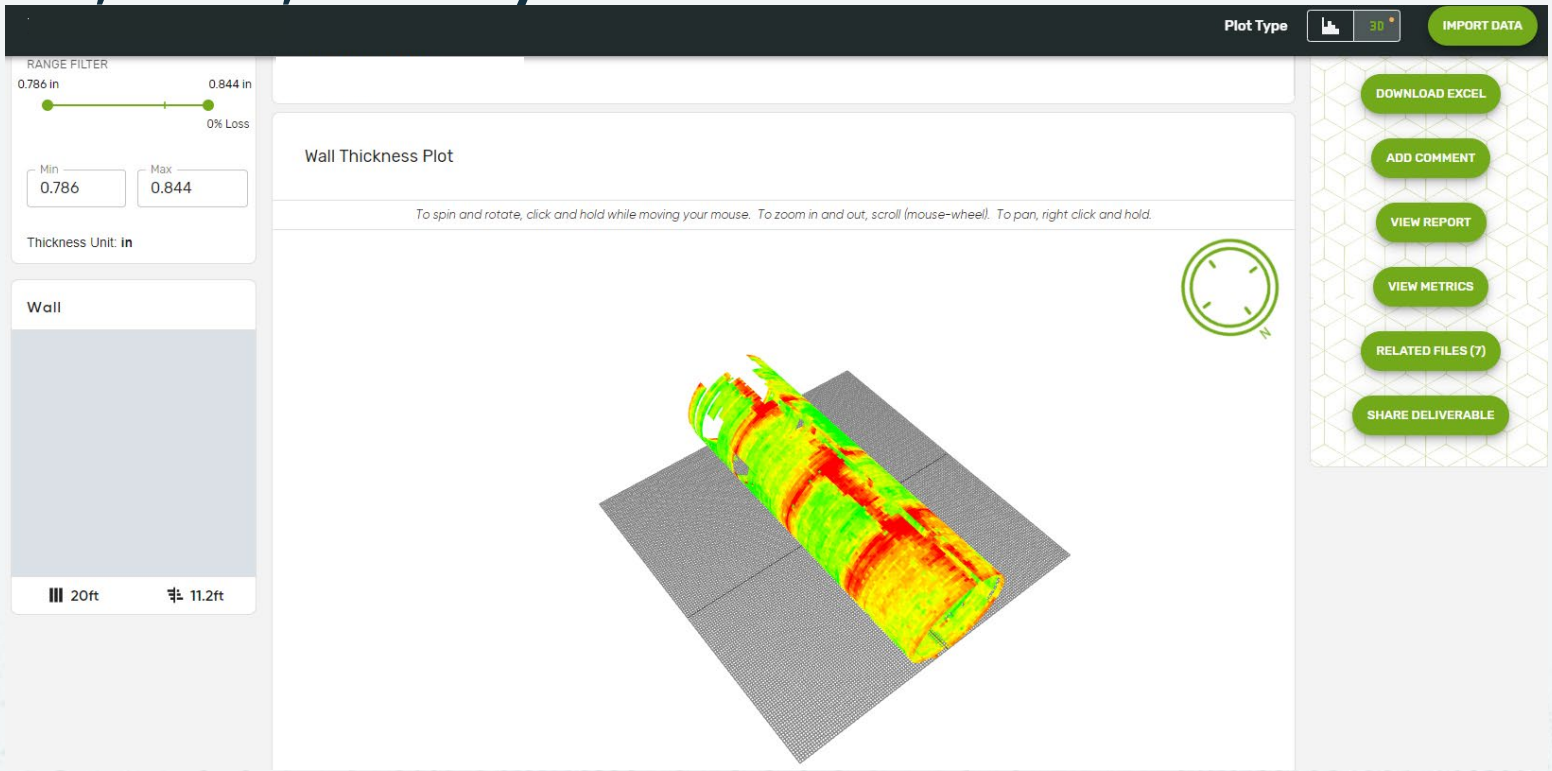
EVALUATION DATA

Reports, Tools, & Analytics



EVALUATION DATA

Serviceability Calculations

API 510 Corrosion Rate Determination (Shell)			
Current Inspection Year		2021	
Year of Construction		1999	
Age of Vessel		22	yrs
Minimum required thickness		0.550	in
Vessel No.		H-9	
Nominal Thickness (t nom)		0.625	in
Measured Wall Thickness			
Minimum Thickness Measured	t min	0.603	in
Corrosion Rate Long Term (LT):		**0.001000**	**in/yr**
Initial Installment Thickness	t initial	0.625	in/yr
Year of Construction		1999	yr
Minimum Thickness Measured	t min	0.603	in/yr
Current Inspection Year		2021	yr
Time between		22	yrs

Remaining Life (RL-LT):		**67.76**	**yr**
Actual Thickness	t actual	0.350	in
Minimum Required Thickness	t required	0.273	in
Corrosion Rate (LT)		0.001136	
Remaining Life		**67.76**	**yr**

Calculations:

Remaining Life (years) RL: = $\frac{\text{t actual - t required}}{\text{Corrosion rate}}$

Long Term Corrosion Rate (LT): = $\frac{\text{t initial - t actual}}{\text{time (years) between}}$

Short Term Corrosion Rate (ST): = $\frac{\text{t previous - t actual}}{\text{time (years) between}}$

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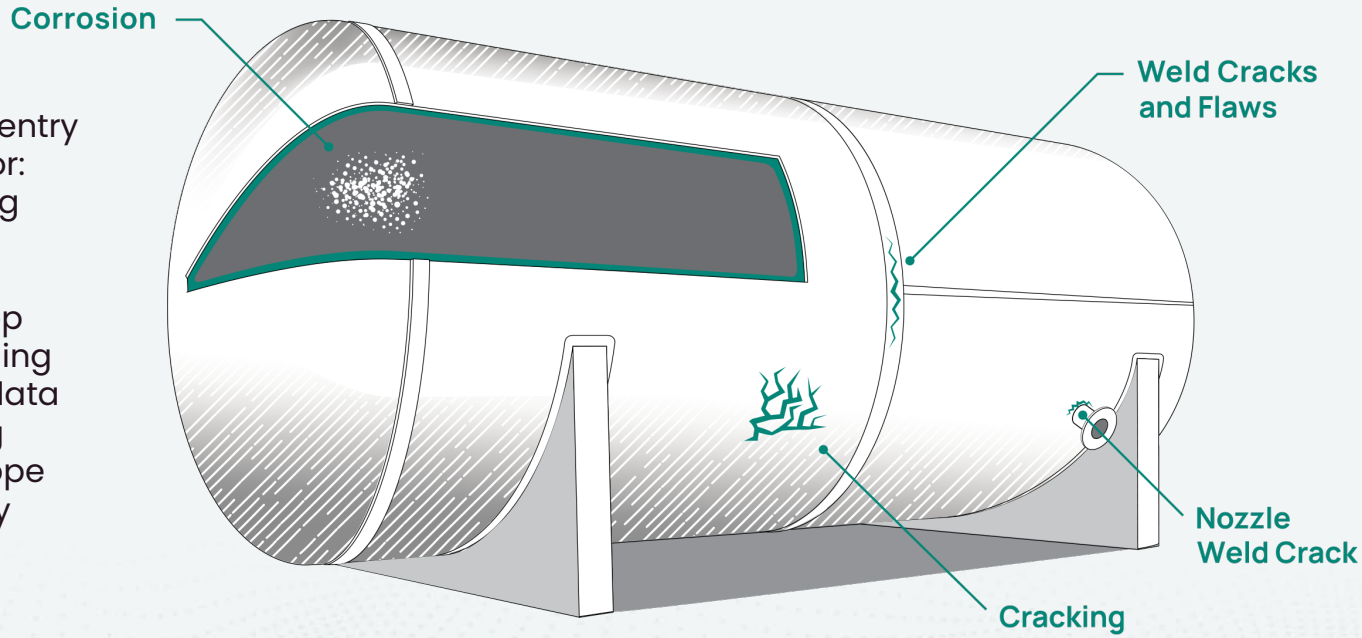
AMMONIA TANKS & PRESSURE VESSELS

Non-Intrusive Inspections

- ☑ Safer
  - No confined space entry
- ☑ Eliminates the need for:
  - Emptying & cleaning
  - De-gassing
  - Blinding
  - Internal surface prep
- ☑ Pre-turnaround planning
  - More high-quality data for decision making
  - Targeted repair scope
  - Increased efficiency



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Non-intrusive Ammonia Tank Inspections

BENEFITS of ROBOTIC METHODS

Safe

Reduce the need for scaffolding, ropes, or man lifts

Money Saving

Less downtime and targeted repairs

More Data

1,000x the data for repeatability and reproducibility

Speed

10x faster with less manpower

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Questions

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