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Fiberglass Storage Tank Inspection Procedures Gain Traction in the US

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Introduction

After 13 years in the making, the Fiberglass Reinforced Plastics Institute (FRPI) published the first comprehensive fiberglass aboveground storage tank (AST) inspection procedures in the United States in 2018. These procedures were developed into standards that enable AST owners and their inspectors to manage assets more cost-effectively while meeting the objectives of the US Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and State Agency regulations.

US Federal and State regulations related to the storage of hazardous substances, such as hydrochloric acid (see **Figure 1**), were enacted decades ago to ensure environmental protection and worker safety. These regulations require ASTs to be inspected following the most recently promulgated Recognized and Generally Accepted Good Engineering Practices (RAGAGEP). FRPI inspection procedures are the most recent RAGAGEP per EPA guidance and OSHA interpretation, providing owners and inspectors a means of compliance with laws.

Figure 1. Hydrochloric acid tank.

The FRPI inspection procedures were developed to be consistent with the American Petroleum Institute (API) 653 Standard - Tank Inspection, Repair, Alteration and Reconstruction [1]. API 653 was introduced in 1991 to help tank owners manage assets and comply with earlier versions of US Federal and State laws. Like API 653, FRPI procedures help owner-operators responsibly manage their assets and optimize operating costs, while mitigating the risks of environmental and safety incidents by improving minimum inspector expertise, inspection consistency, and equipment reliability.

This article highlights common challenges with fiberglass AST inspection that can help owner-operators and other stakeholders stay out of harm's way. Furthermore, the standardized FRPI inspection procedures are introduced, with follow-up examples of how the use of these standards can improve the effectiveness of fiberglass AST inspections.

Recurring Problems

The absence of comprehensive fiberglass AST inspection procedures has caused commercial challenges that have led to asset integrity issues for fiberglass AST owners over decades. The long-term absence of procedures has been problematic, a sense of acceptance has set in, and these matters have cost the industry hundreds of millions of dollars in lost opportunity.

Finding someone to inspect fiberglass ASTs has generally not been a challenge for owner-operators. The bigger problem has been obtaining consistently valuable inspection determinations from inspectors, where the root cause of this problem is seeded in the fact that industry has not had generally accepted and comprehensive fiberglass AST inspection procedures available. The absence of standardized procedures has caused inspection companies to independently develop private practices that may work for some, but have often proved inconsistent from inspector to inspector and caused hardship for owner-operators.

The US fiberglass AST industry is a 70-year-old fragmented niche business estimated to be less than one-tenth the size of the 165-year-old steel tank industry. This small fiberglass AST segment is represented by 11 nonprofit industry organizations, including:

- American Composites Manufacturers Association (ACMA, legacy CFA and SPI)
- American Petroleum Institute (API)
- American Society of Mechanical Engineers (ASME)
- American Water Works Association (AWWA)
- Association for Materials Protection and Performance (AMPP, legacy NACE)
- ASTM International (ASTM)
- Dual Laminate Fabrication Association (DLFA)
- Fiberglass Reinforced Plastics Institute (FRPI)
- Fiberglass Tank & Pipe Institute (FTPI)
- Materials Technology Institute (MTI)
- Technical Association of the Pulp and Paper Industry (TAPPI)

Bid #												
Tank Inspections												
			Bidder A		Bidder B		Bidder C		Bidder D		Bidder E	
locations	tank size (gallons)	quantity	each	total	each	total	each	total	each	total	each	total
#1	3,000	1	$850.00	$850.00	$1,950.00	$1,950.00	$2,260.00	$2,260.00	$590.00	$590.00	$1,138.00	$1,138.00
#2	3,500	2	$950.00	$1,900.00	$1,950.00	$3,900.00	$7,575.00	$15,150.00	$590.00	$1,180.00	$1,138.00	$2,276.00
#3	6,250	3	$1,050.00	$3,150.00	$1,950.00	$5,850.00	$7,575.00	$22,725.00	$642.00	$1,926.00	$1,138.00	$3,414.00
#3	6,090	1	$1,050.00	$1,050.00	$1,950.00	$1,950.00	$2,260.00	$2,260.00	$642.00	$642.00	$1,138.00	$1,138.00
#6	6,000	2	$1,050.00	$2,100.00	$1,950.00	$3,900.00	$7,575.00	$15,150.00	$642.00	$1,284.00	$1,138.00	$2,276.00
#6	2,000	2	$800.00	$1,600.00	$1,950.00	$3,900.00	$2,260.00	$4,520.00	$445.00	$890.00	$1,138.00	$2,276.00
#8	2,500	2	$800.00	$1,600.00	$1,950.00	$3,900.00	$2,260.00	$4,520.00	$521.00	$1,042.00	$1,138.00	$2,276.00
7	TOTAL	13		$12,250.00		$25,350.00		$66,585.00		$7,554.00		$14,794.00

62% of Next Lowest Bid!

Figure 2. NYS bid comparison.

Over the years, some organizations have talked about developing comprehensive standardized fiberglass AST inspection procedures with acceptance/rejection criteria. To quote an ACMA article, *The Toughness of Tanks*, "the best way to advance the use of composites in the tank market is for industry experts to work together with their peers, as well as engineers, designers, consultants, and others in the market" [2]. Evidence of earlier collaboration can be seen in MTI, TAPPI, FTPI, and FRPI prior works.

In 1999 MTI and TAPPI published the first guides for in-operation FRP AST inspection. MTI's was titled "Field Inspection of FRP Equipment and Piping" [3]. TAPPI's was titled "Guidelines for Inspecting Used FRP Equipment," and then updated in 2016 to "Best Practice for Inspecting Used Fiber-reinforced Plastic (FRP) Equipment" [4]. In 2007, FTPI published their guide, "Recommended Practice for the In-service Inspections of Aboveground Atmospheric Fiberglass Reinforced Plastic (FRP) Tanks and Vessels," which was withdrawn from the industry in 2017 [5].

These early guides for in-operation fiberglass AST inspection provided introductory materials and damage mechanisms insight. However, they did not get into detailed step-by-step inspection procedures including objective calculations supporting remaining useful life, suitability for continued service, and next inspection interval determinations. They also did not address minimum inspector qualification schemes characterized by API 653. The later recommended practice that was withdrawn in 2017 was largely dependent on problematic practices such as damage mechanism assessment following ASTM D2563 visual defect classifications for new non-corrosion equipment parts and D2583 Barcol hardness testing [6,7]. These circumstances gave rise to owners developing internal standards to fill in for the historic absence of fiberglass AST inspection standards plus protect themselves from commercial and asset integrity issues.

The following fiberglass AST case histories present evidence of typical problems encountered by operators and mechanical integrity engineers. These recurring issues with inspections put owners and other stakeholders in harm's way.

Problem Case 1 – Inspection Bid Fiasco

Most request for price (RFP) solicitations for fiberglass AST inspection bids are poorly written. The inspection purpose, scope, test plan, plus required assessments and determination methods are often not detailed. In this case, there were no comprehensive inspection procedures to draw into a contract through the RFP specification either.

For reference, here is a typical example of a New York State municipality bid specification in the US:

> "Scope of Work: The division has thirteen aboveground tanks listed below requiring inspection in accordance with the New York State Department of Environmental Conservation (NYS DEC) Chemical Bulk Storage Rules and Regulations. The inspection must meet the specifications of Title 6 NYCRR Part 598.7 (c) - Five Year Inspection. Based on the inspection, an assessment and evaluation must be made of system tightness, structural soundness, corrosion, wear, foundation weakness, and operability."

Here are the NYS DEC Rules and Regulations that the municipality's RFP points to:

> "Part 598.7 Aboveground tank systems - inspection. (c) Five-year inspections: (1) By December 22, 1999, the owner or operator must inspect aboveground piping systems and all aboveground tanks. The inspection must be consistent with a consensus code, standard or practice and be developed by

a nationally recognized association or independent testing laboratory and meet the specifications of this subdivision. Based on the inspection, an assessment and evaluation must be made of system tightness, structural soundness, corrosion, wear, foundation weakness and operability."

The primary problems with this RFP are the inspection purpose, scope, and test plan were not specific, plus there has been no consensus code, standard, or practice that clearly defines the scope, test plan options, assessment and evaluation to be performed. This RFP led to an inspection bid fiasco, where an unqualified inspector was awarded the work at 62% of the next lowest bid and 11% of the highest bid. Please refer to **Figure 2**.

Problem Case 2 – Tank Replaced Too Soon

In this case, three inspection reports for a sodium hypochlorite tank spanning a 20-year period of tank life were audited for an owner. The first report was completed at 11 years of service, the second at 16 years, and the third at 19 years. All three reports indicated signs of normal inner surface resin attack, while the third report at year 19 also indicated minor veil erosion. No other damage mechanisms were reported. At year 16 the tank was declared in good condition, yet, the next inspection interval was reduced to three years. In year 19, it was declared not fit for continued service and replaced in year 20.

The 0.096 inch (2.438 mm) inner corrosion barrier (ICB) was structural, erosion was at most 0.010 inches (0.254 mm) deep, and ICB permeation was estimated at 0.035 inches (0.889 mm). There was essentially no remarkable inner corrosion barrier change in degradation from year 11 to 19 (see **Figure 3**). Over 19 years, the degradation rate averaged approximately 0.002 inches (0.051 mm) per year. In simple terms, this indicates permeation may theoretically reach the structural layer in about 30 years after year 19. This tank was replaced too soon.

Problem Case 3 – Catastrophic Failure

In this case, a 43-year-old 20,000-gallon acetic acid tank bottom suffered a catastrophic failure, spilling its contents into marginal containment. Under the NYS DEC Chemical Bulk Storage Rules and Regulations in the US, this tank had been undergoing inspections at 5-year intervals. Because it had a capacity greater than 10,000 gallons, the tank was also subject to inspection under a qualified engineer and, where necessary, an internal inspection among other suggested scope should be considered. The regulations are assumed to prevent failure, assuring environmental protection and safety.

A critical inspection zone for fiberglass ASTs is the bottom knuckle area. Finite element analysis shows the high stress zone in red (see **Figure 4**). Over time, with resin attack, permeation and stress, the bottom adjacent to the knuckle radius typically shows signs of degradation. Although possibly difficult to see, but easily considered if the inspector is properly qualified and following a detailed inspection procedure, this known failure mode could appear as inner corrosion barrier crazes and/or suggest evaluation of stress corrosion modulus decay. This catastrophic tank failure could have been prevented.

Figure 3. Comparison of inspection reports.

Figure 4. Catastrophic failure of acetic acid tank.

Fiberglass AST Standardized Inspection Practices

A means of problem mitigation has been long overdue for the fiberglass AST industry. API 653 has set precedence, suggesting the development, implementation and administration of a set of industry standardized inspection procedures, training, and minimum inspector qualification parameters can yield superior results. Commercialization of a similar tank inspection model would be a good solution for inspection of fiberglass ASTs too.

Standards development talks started at FRPI in 2005 for fiberglass AST inspection procedures and a steering council of nine industry members was established in 2016. The council was initially tasked with refining an 11-page prospectus for standardized procedures, as well as establishing an overarching scheme for the scope of standards and certification of inspectors. The council unanimously agreed that this scheme would reflect proven elements of API 653 and, most importantly, incorporate the unique nature of fiberglass construction materials.

The FRPI steering council was composed of a balanced group of professionals. It included one international tank owner, three manufacturers, four consulting firms, plus an FRPI representative. The mix of council backgrounds included five fiberglass subject matter experts, two of which were professional engineers, plus a global asset inspection leader, five company presidents and two vice presidents. The tank owner and one consultant member were API 653 certified inspectors. US Federal and State regulators were also consulted on various subjects.

Authors of the article referenced earlier, *The Toughness of Tanks*, under the subsection titled Collaboration Is Key To Market Growth, went on to say "ultimately, sharing ideas and knowledge rather than working in individual silos remaining tight lipped about your expertise will benefit the entire composites industry" [2]. The 11 industry organizations identified earlier in this article represent a number of these "silos," where FRPI steering council legacy experience includes high-level involvement in 10 of these 11 organizations dating back to 1958.

The FRPI standardized procedures are founded on 70 years of US industry collaboration. While original works of the Institute, they incorporate expertise contributed by dozens of "silos." Work by others of noteworthy mention was also checked against FRPI procedures, updated, corrected, and expanded where necessary. This work includes the MTI, TAPPI, and FTPI initial guides for in-operation AST inspection previously referenced plus the following:

- Mallinson's book in 1988, *Chemical Plant Design with Reinforced Plastics*, which was updated from the original 1969 edition [8].
- SPI conference paper in 1981, *Stress Effects on Degradation of Chemically Resistant FRP* [9].
- TAPPI conference paper in 1991, *Safety and the Environment Versus FRP Process Equipment Standards*, including an industry-wide equipment failure study [10].
- NOGA publication in 1997, 055 - *Norwegian Oil and Gas Recommended Guidelines for NDT of GRP Pipe Systems and Tanks* [11].
- Reichhold publication in 2009, *An Inspection Guide for Fiber-Reinforced Plastic (FRP) Equipment* [12].
- MTI publication in 2011, *Guide for Repair and Alteration of FRP Equipment* [13].
- Energiforsk publication in 2016, Handbook for The Inspection of Fibre-reinforced Plastic [14].

The final work product evolving out of the FRPI steering council was FRPI Standard Practice 8310, plus four companion practices: SP1010, SP1020, SP1030, and SP1040. The following is an introduction summarizing key elements of these practices for fiberglass AST inspection.

SP8310 Inspection Procedure Administration

The SP8310 Licensed Aboveground Storage Tank Inspector Certification standard was published to help detect, predict, and prevent AST leaks, spills, and discharges that may result in:

1. Unplanned capital investment before normal end of life replacement.
2. Premature failure causing owner operator cost overruns.
3. Injury and loss of life.
4. Environmental damage to land, air, waterways, and adjoining shorelines.

SP8310 Part 1, General, contains the Body of Knowledge references that span API, ASTM, ASME, and AWWA standards pertinent to fiberglass AST materials of construction and fabrication details [15]. It also draws in FRPI companion standards SP1010, SP1020, SP1030, and SP1040 for installation and in-operation inspection guided by checklists provided in Appendices A and B of SP8310. Collectively, these standards establish a basis of AST design and consistency among inspection procedures.

SP8310 Part 2, Inspection Practice Areas, includes guidance for inspection and test plan development, determinations to be made, and report writing. Determinations required involve AST history research and laminate benchmarking, estimating laminate degradation rates, and remaining useful life plus developing suitability for continued service and next inspection interval claims. Formulas for calculating rates of degradation and time remaining are provided, where the methodology is similar to API 653.

SP8310 Part 3, Inspector Qualifications, and Part 4, Inspector Certification and Licensing, support the commercial administration of this standard. As with API 653, candidate inspectors desiring certification under SP8310 are required to meet minimum personal and employment qualifications to sit for a certification exam. These areas cover details for vetting education and experience, exam involvement, credentialing, licensing, award, renewal, denial, termination, appeals process, code of ethics, plus other general conditions governing inspector certification.

SP1010 Laminate Identification

Identifying laminates that an AST is constructed of is essential for materials verification and traceability work necessary for determinations required under SP8310. Metal and thermoplastic materials are reasonably easy to identify given standardized nomenclature for specific grades or types. As an example, we have A36 Carbon or 316 Stainless Steel for metal and Polyethylene or Polypropylene for thermoplastic. However, for fiberglass, it is more difficult. Most inspectors simply report their material identification simply as fiberglass reinforced plastic (FRP).

SP1010 Part 2, Qualifying, and Part 3, Quantifying Laminate

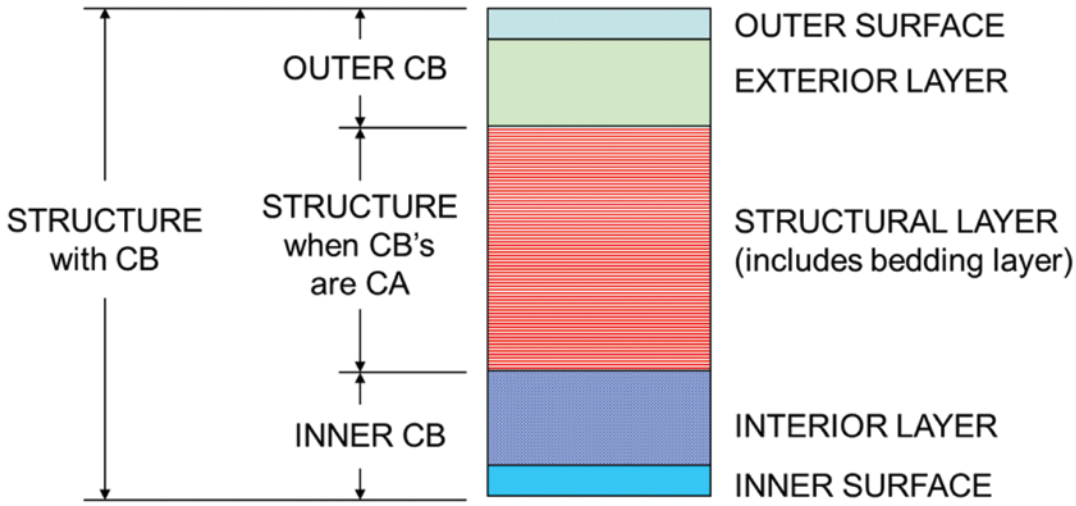

Figure 5. Cross section of laminate.

Identification, provide a procedure to identify, describe, and illustrate the laminate design basis [16]. This procedure puts ASTM and ASME material standards into action, where laminates are described by classifications, composition plus visual observations of reinforcement textures and sequence, inner surface mold impressions, outer surface patterns, and polymer components. Recognizing and correctly characterizing laminates by layer is a cornerstone of AST inspection (see **Figure 5**).

SP1020 Visual Imperfections

Identifying imperfections in originally consolidated AST component laminates visually, whether allowable or those that escaped inspection as the AST was shipped for installation, is also essential for determinations required under SP8310. Laminating events such as blisters, burned areas, edge exposure, gaseous bubbles, pits, porosity, resin pockets, voids, wet-out inadequacies, and wormholes plus mechanical events such as chips, cracks, crazes, delamination, fractures, and scratches can have a profound effect on rates and extent of laminate degradation.

SP1020 Part 2, Qualifying, and Part 3, Quantifying Visual Imperfections, provide a procedure to identify, describe, and illustrate imperfection evidence that affects laminate performance characteristics [17]. This procedure puts ASTM and ASME material quality control standards into action, where the imperfections found in a laminate and their impact on laminate performance can be assessed in consideration of its SP1010 design basis determination. Recognizing and correctly characterizing laminate quality by layer is another cornerstone of AST inspection.

SP1030 Damage Mechanisms

Identifying mechanisms that cause damage to an AST in operation is central to determinations required under SP8310. Visual observations such as resin attack, permeation, blisters, glass attack, resin glass interface attack, erosion, secondary bond attack, scratches, chips, edge and interlaminate delamination, crazes, linear and star cracks, fractures, deformation, discoloration, charring plus thermal mud, stress, and shock cracks show evidence of normal aging, mechanical and/or temperature events that can significantly affect AST integrity.

SP1030 Part 2, Qualifying, and Part 3, Quantifying Damage Mechanisms, provide a procedure to identify, describe, and illustrate damage evidence observed [18]. This procedure puts SP1010 and SP1020 into action, where the damage found in a laminate and its impact on laminate performance can be assessed. Recognizing and correctly characterizing damage by layer is yet another cornerstone of AST inspection. Damage assessment is also coordinated with SP1040 Integrity and Leak Testing plus SP8310 for damage rate and time remaining calculations.

SP1040 Integrity and Leak Testing

Identifying nondestructive and/or destructive test methods for investigating the extent of damage an AST may have undergone is guided by damage mechanisms anticipated or found, and possibly other factors such as owner or regulatory requirements. Proper selection is instrumental in making sound determinations under SP8310. Methods may include visual inspection, Barcol hardness measurement, sounding plus testing through hydrostatic pressure, acoustic emission, ultrasonic thickness, advanced ultrasound, infrared thermography, microwave, and/or core specimen work.

SP1040 Part 2, Qualifying, and Part 3, Quantifying Integrity and Leak Testing, provide a procedure to identify advantages, disadvantages, and limitations of the 15 test methods described, and then engage an appropriate method that best satisfies the inspection and test plan established under SP8310 [19]. This procedure puts SP1030 into action and enables further assessment of multiple mechanisms such as stress corrosion modulus decay, where the damage found in a laminate and its impact on laminate performance can be further evaluated.

Consensus Document Status

The US fiberglass AST industry is small in comparison to the steel tank industry and so are the industry organization consensus communities that help guide it. Today, the FRPI community that has evolved since 2003 and guided by the steering council surpasses the size and expertise of several fiberglass communities supporting other prominent US industry organizations.

The FRPI Standard Practice 8310 was reviewed by US Patent and Trademark Office (USPTO) attorneys during the 2020 COVID-19 Pandemic. On November 3, 2020, FRPI was issued a registered certification mark certificate for "Storage Tank Inspection Services" conducted under SP8310. This certification mark certifies inspection services are performed by an inspector who has met SP8310 with respect to experience, education, employment, and passage of an exam, and is under a license agreement mandating compliance with SP8310.

FRPI standards have now been reviewed and are accepted by well over 100 mechanical integrity inspectors and asset managers in six countries. One-third of certified FRPI 8310 inspectors are licensed Professional Engineers. Tank owners and independent inspection plan writers represent leading company names in the chlorine, chemical, pulp and paper, pharmaceutical, agricultural, and water treatment industries. Several domestic and international owners plus inspection service providers employ FRPI 8310 inspectors and promote these standards. US Federal and State regulators have also reviewed and acknowledged these standards as RAGAGEP.

Per OSHA's official interpretation published to their Regional Administrators on May 11, 2016, regarding their enforcement policy under OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals regulation, FRPI standards are RAGAGEP. SP8310 meets Example 2 Consensus Documents given USPTO vetting, whereas SP1010, SP1020, SP1030, and SP1040 meet Example 3 Non-consensus Documents. OSHA has clarified that example numbers are not intended to reflect a hierarchy of RAGAGEP.

Standards Solve Problems

The industry began the development of steel tank inspection standards in the 1990s and has grown accustomed to not having fiberglass AST inspection standards. The MTI, TAPPI, and FTPI guidance documents published at the turn and beginning of the 21st century were more of an introduction to fiberglass inspection than a comprehensive set of procedures to follow. This gap in comprehensive inspection standards has been long overdue to be backfilled with decades of lessons learned.

The FRPI SP8310, SP1010, SP1020, SP1030, and SP1040 standards solve problems created by the historical absence of fiberglass AST inspection standards. These standards enable inspectors to consistently follow comprehensive inspection procedures for objectively determining AST end-of-life criteria, remaining useful life, suitability for continued service, and future inspection intervals. The procedures also allow in-service external and out-of-service internal inspection, as dictated by owner/inspector inspection and test plans governed under SP8310.

The list of problems solved for AST owners and other stakeholders is too long to cover in one article. Some problems at the top of the list that have been solved include:

- Not knowing by what means to determine how long fiberglass ASTs last.
- No bar to establish minimum required inspector knowledge, capabilities, and experience.
- Short inspection intervals, unfounded repairs, and premature AST replacement.

Determining how long fiberglass ASTs last is a big subject. The basis starts with a general understanding of ASTM and ASME safety factors incorporated in new AST designs. These factors directly address loss of AST laminate strength that occurs in operation. This phenomenon was referenced in a 1981 technical paper, titled *Stress Effects on Degradation of Chemically Resistant FRP*, wherein the 10:1 safety factor is broken down to identify 45% accounts for fatigue, creep, stress and chemical attack [7]. FRPI SP1030 and SP1040, in conjunction with SP8310 determination procedures, provide criteria for determining end of life.

The bar is set and the playing field is leveled for the minimum inspector expertise required under FRPI SP8310. Part 3, Inspector Qualifications, establishes minimum personal requirements around the level of education coupled with hours of fiberglass experience and minimum employment requirements. Part 1.3, Body of Knowledge, coupled with Part 3.4, Certification Exam, requires inspectors to be in possession of an appropriate fiberglass AST standards library and to retain working familiarity with 75% of the applicable inspection content. This replaces earlier MTI, TAPPI, and FTPI practices, especially independently developed private spinoff practices from FTPI 2007-1.

Short inspection intervals, unfounded repairs, and premature AST replacements are starting to become hardships of the past. The following fiberglass AST case histories present actual evidence of typical successes owners, inspectors, and other stakeholders are experiencing from the use of FRPI standardized procedures. Collectively, the procedures help manage assets more cost-effectively by eliminating inadequately justified inspection intervals, repairs, and replacement, plus related operations downtime and other consequential damages.

Success Case 1 – Inspection Interval Extended

Two inspection reports for twin sodium hypochlorite tanks were audited for an owner, where reports were completed after 14 years of service. Both external and internal inspections were conducted. Reports indicated signs of normal inner surface resin attack and permeation, with minor veil erosion reported in a couple of isolated areas of the knuckle radius and full bottom drain nozzle neck of T3 (see **Figures 6** and **7**). No other damage mechanisms or leaks were reported. The tanks were declared in good condition, with the next inspection interval set at one to three years.

The 0.116 inch (2.438 mm) inner corrosion barrier (ICB) was nonstructural, and the T3 erosion was at most 0.030 inches (0.254 mm) deep. Over the 14 years, the T3 thickness loss averaged approximately 0.002 inches (0.059 mm) per year. In simple terms, this indicates complete inner corrosion barrier erosion may theoretically reach the structural layer in about 43 years. While a 43-year ICB remaining life is reasonably too long, a one-to-three-year inspection interval was too frequent at this degradation rate. The interval was reset to five years, saving the owner the cost of at least two inspections.

Success Case 2 – Repairs Averted

Five inspection reports for a quintuplet of sodium hypochlorite tanks were audited for an owner, where the reports were all completed at five years of service. Both external and internal inspections were conducted. Photos in the reports showed numerous corrosion barrier inner surface dashed elongated circles drawn with a yellow marker identifying what were simply claimed to be damaged areas (see **Figure 8**). No other damage mechanisms or leaks were reported. The tank bottoms were declared to be heavily damaged and required relining before going back into service.

The report photos clearly show signs of inner surface normal aging for five year old tanks in sodium hypochlorite service. The owner was advised to obtain a second opinion from a qualified inspector adhering to inspection procedures. The second inspection found the tanks were in very good condition with only early signs of inner surface resin attack of a 0.192 inch (4.877 mm) nonstructural inner corrosion barrier. The tanks were returned to service with a five-year inspection interval, saving the owner downtime plus about $275K in unnecessary repair costs.

Success Case 3 – Remaining Life Extended

Two inspection reports for twin aluminum sulfate tanks were audited for an owner, where the reports were completed at 36 years of service. Both external and internal inspections were conducted following a side manway field installation. Photos in the reports showed a like-new inner corrosion barrier inner surface condition, with some alum staining. No other damage mechanisms or leaks were reported. The tanks were declared to be in good condition, with the next inspection interval set at two and a half years based on an assumed tank design life of 40 years.

Inspection report auditing was accompanied by an onsite tank inspection training exercise and core specimen evaluation using the side manway cutout saved. The internal inspection found the shell and bottom inner surface fully intact, as evidence of the like-new shiny surface plus shell mylar and bottom tape mold imprinting was observed. No other damage was noted. Glass content testing also revealed an inner surface veil was present and tensile testing proved the shell to be two and a quarter times stronger than the minimum design (see **Figures 9** and **10**). The tanks were given a 15-year estimated remaining useful life and set to a five-year inspection interval. This reassessment saved the owner about $400K over imminent tank replacement.

Regulatory Compliance Eased

The US EPA 40 CFR 68 Chemical Accident Prevention Provisions Subpart D Prevention Program Section 68.73(d)(2) and OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals Part 1910.119(j)(4)(ii) mandate AST inspection and

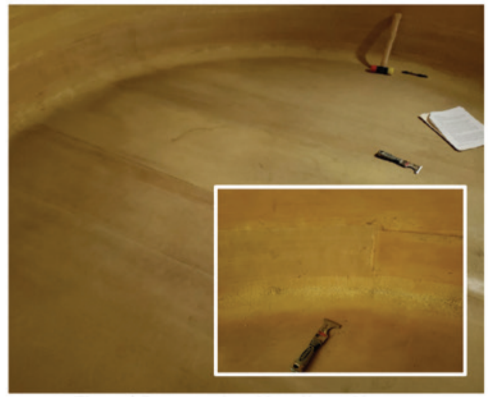

Figure 6. Damage to knuckle radius and bottom.

Figure 7. Tank drain damage.

Figure 8. Damage to tank bottom, knuckle, and lower shell.

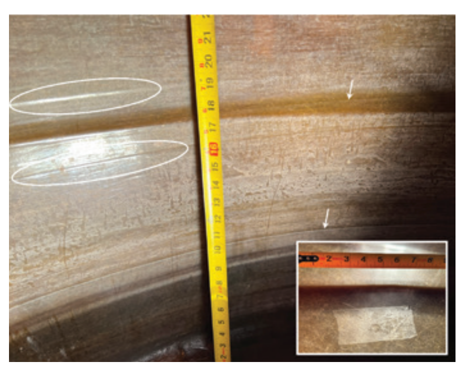

Figure 9. Imprinting of tank shell and bottom molds.

Figure 10. Remains of destructive test.

testing procedures shall follow RAGAGEP. Therefore, inspection in accordance with an industry standard can be a bonus for owners when the EPA and OSHA regional enforcement officers arrive at their facility to audit regulations compliance records.

It is important to note that in the US, independently developed private practices for fiberglass AST inspection are not RAGAGEP under EPA and OSHA interpretations. While owners may have had to rely on these practices in the absence of RAGAGEP for fiberglass AST inspection in the past, new standards now exist and it is in the owner's best interest to assess whether their internal procedures represent RAGAGEP before regulatory compliance officers start asking questions.

Just as important as improved cost-effective asset management and regulations compliance, if not more so, is inspection in accordance with an industry standard that lowers risk of exposure to environmental and safety incidents. Utilizing FRPI SP8310 and its companion standards eases regulatory compliance while enabling cost and risk reduction opportunities for all stakeholders.

Standards Not All Rosy

Establishing new rules like industry standards can be both a blessing and a curse. While it has been obvious for decades that comprehensive fiberglass AST inspection procedures and minimum inspector qualifications needed to be established in the US, implementing rules that govern those procedures and who qualifies to inspect fiberglass ASTs creates limitations accompanied by commercial unrest. The FRPI standardized procedures have some minor wrinkles in opinions between experts, but they will eventually get ironed out and the industry will continue to advance as a result.

Conclusion

FRPI's comprehensive inspection procedures for fiberglass ASTs reflect a broad compilation of industry expertise spanning 70 years. Contributors to the development of FRPI standards have come from all 11 industry organizations referenced in this article and many other "silos." While these standards are a consensus work in progress, they currently fill the historical gap in guidance for inspecting fiberglass ASTs, are bonafide RAGAGEP, and have gained traction in the US. As the authors of the article "The Toughness of Tanks" essentially said, industry is best served by sharing ideas and knowledge rather than continuing to work in individual "silos." The FRPI procedures were developed to help owner-operators responsibly manage their assets and optimize operating costs, while mitigating the risks of environmental and safety incidents by improving minimum inspector knowledge, inspection consistency, and equipment reliability. ■

For more information on this subject or the author, please email us at inquiries@inspectioneering.com.

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