Composite storage tank industry steps up to US regulations

Features

Gary L Arthur, president of the Fiberglass Reinforced Plastics Institute in the US explains how the composite industry set out standards in response to regulations enacted to protect all stakeholders from reinforced plastic storage tank failures.

The United States Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) promulgated laws impacting the composite storage tank industry as the 21st century was gaining momentum. These laws were motivated by catastrophic tank failures and addressed the absence of consensus standards for inspection of tanks in petroleum and highly hazardous chemical applications. Developing and implementing best practices for determining tank remaining useful life, suitability for continued service and next inspection intervals has been of keen interest.

Storing petroleum and chemicals is a critical operation throughout the world. Although chemicals are not flammable and explosive in nature like oil and gas, they are very corrosive and can cause injury, fatalities and environmental damage if not safely contained. Composites are the material of choice most often for aboveground storage tanks (ASTs) in chemical service due to their excellent corrosion resistance. Composite ASTs are substantially smaller in storage capacity than steel ASTs for storing oil for example, where regulations and industry standards development had focused more on larger oil applications. Consequently, composite ASTs in chemical service had not been a focus point and have been at risk.

By 1999, the EPA and OSHA laws had about a decade of development behind them and a strong foothold in the US. This spawned a demand for recognized and generally accepted good engineering practices pertaining to tank inspection determinations, or what is known today as RAGAGEP. While the mature steel storage tank industry stepped up quickly with robust inspection standards in the early 1990's, the relatively young composites tank industry was slow to respond.

Regulators get attention

A coalition of special interest groups in the US, formed under the name Environmental Justice and Health Alliance for Chemical Policy Reform, published a report in 2014 entitled *Who's in Danger* (EJHACPR 2014). This report was a demographic analysis of chemical disaster vulnerability zones throughout the US. A total of 18,764 chemical spills were reported. Over 134 million Americans were identified as living under the threat of leaks and spills emulating from 3,433 facilities. The Alliance filed a lawsuit against the EPA in July 2015 stemming from this research, claiming EPA was negligent in protecting citizens, as a result of not responding to mandates by Congress in 1972 to issue regulations aimed at mitigating risks in the chemical industry in the same way that they had in the petroleum industry.

The EPA responded to the US District Court for the Southern District of New York in 2018 with a proposed rulemaking that pertains to the issuance of additional Clean Water Act Hazardous Substance regulations. In doing so, the EPA presented a study they conducted to see if the need for a new rule was justified (EPA 2019). This study identified 285,867 chemical releases reported to the National Response Center from 2007 to 2016, 9,416 of which impacted water in EPA's jurisdiction, while 3,140 reached water and 2,491 of this number were from non-transportation sources where 117 – or 4.7% – of these resulted in evacuations, injuries, hospitalizations, fatalities, waterway closures or supply contamination. Based on EPA's analysis and a framework of existing regulations plus overall multiple statutory and regulatory requirements established under different Federal authorities, the EPA is not proposing additional regulatory requirements at this time.

The existing framework EPA points to includes work by itself and OSHA. The work of these regulators was initially motivated by the 1988 Ashland oil spill and 1989 Phillips 66 chemical complex explosions in the US. Lessons learned spawned the EPA Spill Prevention, Control and Countermeasure Guidance for Regional Inspectors (SPCC), OSHA Process Safety Management of Highly Hazardous Chemicals (PSM) and EPA Risk Management Program (RMP) regulatory efforts. By the beginning of the 21st century these efforts became law and today they are referred to as EPA 40CFR112 SPCC, OSHA 29CFR1910.119 PSM and EPA 40CFR68 RMP.

EPA and OSHA rules at law today form a framework characterizing AST inspection requirements including standards, inspection and test plans plus accountability. Program elements cover employee participation, process safety information and hazard analysis, operating procedures, training, contractors, pre-startup safety review, mechanical integrity, hot work permits, management of change, incident investigation, emergency planning and response, compliance audits plus trade secrets. These elements include establishing periodic documented inspection intervals, officially training and qualifying inspectors plus developing written inspection and testing procedures that must be followed. About twenty states then followed on to these Federal mandates with parallel requirements and some taking a broader, deeper more specific stance on chemical applications.

Composite tank inspection standards

The composite tank industry has historically made limited progress with developing full-fledged robust sustainable inspector training and qualification practices in response to the EPA and OSHA rules at law. Niche industry organizations with well-intended professionals supporting the pulp and paper, petroleum and chemical processing industries had made noteworthy efforts towards responding to these EPA and OSHA mandates from 1999 through 2016. However, practices published were lean on technical content and administration programs and were found to have several remarkable errors and omissions; had fallen significantly short on enabling industry controlled sustainable practices: and had not been significantly updated in over a decade.

With regulatory efforts predominantly focused on the oil and gas industry during the 1990s, the American Petroleum Institute (API) introduced API 653 Tank Inspection, Repair, Alteration and Reconstruction in 1991, API 580 Risk-based Inspection in 2002 and API 571 covering Damage Mechanisms in 2003. These efforts were supplemented by the Steel Tank Institute (STI), which published the SP001 Standard for the Inspection of Aboveground Storage Tanks in 2000. Both API and STI standards pertain to steel tanks as opposed to composites. There are over an estimated 5,000 steel tank inspectors trained and qualified now in the US alone. These steel tank inspection standards had set a precedence for standardization of inspection practices for the composite tank industry.

Composite ASTs at risk

Without considering consequential damages, it is estimated that composite AST premature failure costs industry over US$107 million per year. Composites are a complicated material in construction and all too often not given the respect they deserve by specifying engineers and job shop manufacturing operations. While composites have earned great respect and a position as the material of choice for numerous chemical applications, their performance is less predictable and state more difficult to assess than mass produced homogenous steel tank materials with isotropic properties available in common grades such as A36 Carbon Steel or 316 Stainless Steel. These circumstances are an important factor with regards to composite AST inspector expertise.

The most recent formal composite equipment premature failure study was conducted a few decades ago (Arthur 1991), where a total of 388 types (see Illustration 1) and 328 causes (see Illustration 2) of failure were captured. In looking at this research data for composite tanks and vessels, 52% of types of failure were attributable to laminating issues and 75% of causes to manufacturer deficiencies. Case histories compiled since have shown failure emerges year after year emulating a similar proportionality of types and cause as identified decades ago. Composite ASTs consist of multiple nonhomogeneous composite designs with anisotropic properties and no standard grades plus they are essentially handmade job-by-job. As a result, modes of failure are substantially different between steel and composites.

In looking at three different composite ASTs in similar 12.5% sodium hypochlorite service, it was found that the first pictured in Figure 1 required replacement within eighteen months of commissioning, the second in Figure 2 after seven years and the third in Figure 3 after sixteen years. To the specifying engineer who approved the tanks for installation, each looked the same, a minimum 25-year design life was expected and yet each performed so differently – to the surprise of the owner, leaving them with substantial extra costs in terms of inspection, repair and replacement.

Lessons learned through reliability centered maintenance case histories like those presented above lead to disqualification of the asset manager's Potential Failure to Failure, or P-F, curve concept shown in Illustration 3. The concept assumption for composite tank performance in similar service is that the time from potential failure point "P" to failure point "F" or the PF interval will provide confidence for predictive or condition-based maintenance. As one can see, this is not true with composite tanks. Therefore, it is essential that a well-qualified inspector understands composite failure mechanisms and their employers can identify such capable individuals in order to minimize failure risks for all stakeholders.

Composite industry steps up

In response to US Federal mandates under EPA SPCC and RMP and OSHA PSM protocols, AST owners have been required by law to prevent, prepare for and respond to petroleum and chemical related disasters. Additionally, composite AST failure modes are complicated and unpredictable. To meet these requirements at law and inspection challenges, inspectors must be trained and qualified under very specific terms to create accountability and achieve results. Consequently, the composites industry has needed to publish sustainable consensus standard practices that produce well-qualified inspectors.

The Fiberglass Reinforced Plastics Institute (FRPI), with the help of a balanced group of industry professionals making up the governing body, has finally answered the call, publishing a comprehensive robust standard practice for the education, qualification and administration of composite AST inspectors. It was published in October 2018 and is called SP8310 Licensed Aboveground Storage Tank Inspector Certification (SP8310). This standard practice addresses evolving regulations, precedence set by the steel industry and premature failure modes typical for composite ASTs. It received US Federal recognition in November 2020 and is the only composite industry consensus standard that enables compliance with tank inspection laws in the US.

Assuring composite ASTs are safe is in the best interests of all stakeholders. The US is now in position to stop engaging inspectors that simply appear to know something about composite ASTs and start employing certified and licensed FRPI 8310 Inspectors. SP8310 is the new tank industry RAGAGEP and a smart practice for all involved with composite tanks to engage. Finally, the composite storage tank industry steps up to US regulations.

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