

ABOVEGROUND STORAGE TANKS CONTAINING LIQUID FERTILIZER

RECOMMENDED MECHANICAL INTEGRITY PRACTICES

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During the 1990's a series of costly aboveground fertilizer tank failures prompted companies to begin an aggressive assessment of large tanks in their inventory in an effort to determine whether these tanks were fit for service. In addition, as a result of these failures, several state regulatory agencies began to examine current regulations for the aboveground storage of liquid fertilizer, and, where no regulations existed, to consider promulgating such regulations.

The Fertilizer Institute (TFI) is the national trade association representing the fertilizer industry. At the direction of the TFI's Executive Committee, a Tank Integrity Work Group was established in September 2000 to review the issue of inspection and maintenance of large non-pressurized liquid fertilizer tanks. In 2001, TFI issued *Aboveground Storage Tanks of Liquid Fertilizer – Recommended Inspection Guidelines* representing the consensus of the Tank Integrity Working Group, which set forth suggested, uniform industry inspection and maintenance guidelines.

As the result of a large catastrophic liquid fertilizer tank failure on Nov. 12, 2008, in Chesapeake, Va., the U.S. Chemical Safety and Hazard Investigation Board (CSB) conducted an investigation and issued a report on its findings and recommendations. Among the recommendations was for TFI to do more outreach to encourage the use of its guidelines and to encourage its members who contract for liquid fertilizer storage to incorporate the use of its guidelines in contracts. In view of the CSB recommendation and at the direction of TFI's Executive Committee, a UAN Working Group was convened in 2009 to review, and where appropriate, update the guidelines.

As recognized, site-specific conditions may require deviations from these guidelines. Ultimately, it is the responsibility of the tank owner and operator, in consultation with an authorized inspector, to implement the appropriate inspection and maintenance protocols to ensure tank integrity. TFI, including its members, the members of the Tank Integrity Task Force, the 2009 UAN Working Group, the inspectors and the companies and organizations that employ them, in furnishing or distributing this information, do not make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or utility; nor do they assume any liability of any kind whatsoever resulting from the use or reliance upon any information, material or procedure contained herein, including but not limited to any claims for damages, loss or injury regarding health, safety, environmental effects or performance.

In general, the Tank Integrity Work Group and the UAN Working Group recommend that all new tanks should be designed and built to American Petroleum Institute (API) Standard 650 and

inspections of existing tanks should be based upon API Standard 653, but with modifications for the unique characteristics of a tank storing liquid fertilizer. API Standard 653 can be used as a general guideline for inspection of any aboveground storage tank. For example, tanks that were not built to API Standard 650 criteria or that have been modified subsequently such that they now do not comply with API Standard 650, may still be inspected under the API Standard 653 inspection guidelines. Whether or not the tank was built to API Standard 650 criteria, inspectors of aboveground storage tanks should advise whether the owner/operator may continue service without modification or whether the owner/operator must make repairs to the tank or have the tank further evaluated prior to continuing service.

The following practices, as written, pertain specifically to tanks constructed of carbon or stainless steel or aluminum. Tanks utilizing alternate methodologies or materials should be designed and constructed in accordance with standards substantially similar in scope to that of API Standard 650. These tanks should be maintained and inspected based upon standards related to the original construction standard. The scope of inspections should be based upon the related standards, or in their absence, API Standard 653 should be used as a general guideline. The tank inspection should include a recommendation regarding suitability for continued service. The inspection types and frequencies found in these practices should be followed. The construction, repair, maintenance and inspection considerations, as well as the recordkeeping recommendations contained herein still apply and should be followed as applicable to the alternate design.

1.0 PURPOSE

- 1.1 To provide the fertilizer industry with a suggested, uniform program to evaluate the condition of large (100,000 gallons or greater) non-pressurized aboveground liquid fertilizer storage tanks.
- 1.2 These practices represent the knowledge and experience of professional technical personnel in the fertilizer industry.
- 1.3 These practices do not address refrigerated liquid ammonia storage tanks.

2.0 DEFINITIONS

Aboveground Storage Tank (AST) – Any storage tank, 100,000 gallons or greater, used for liquid fertilizer that is flat bottom, cylindrical, vertical with a fixed roof and constructed of carbon steel, stainless steel or aluminum.

API – The American Petroleum Institute is the national trade association representing the petroleum industry in areas of exploration and production, transportation, refining and marketing.

API 650 – Standard 650 of the American Petroleum Institute, titled, “Welded Steel Tanks for Oil Storage.”

API 653 – Standard 653 of the American Petroleum Institute, titled, “Tank Inspection, Repair, Alteration and Reconstruction.”

Authorized Inspection Agency – One of the following types of organizations that employ certified API AST inspectors:

1. The inspection organization operated by the jurisdiction in which the AST is operated;
2. The inspection organization operated by an insurance company licensed or registered to provide AST insurance at the location in question;

3. An owner/operator organization that maintains its own inspection activities relating to ASTs it controls; or
4. An independent organization (company or individual) that contracts AST inspection services to an owner/operator as allowed by the local jurisdiction using API Authorized Inspectors.

Authorized Inspector – An employee of an Authorized Inspection Agency that is certified as an AST Inspector per API 653 requirements.

Baseline Inspection – An initial, complete API 653 out-of-service internal and external inspection performed to establish the condition of an existing AST and to determine the AST's suitability for continued service.

Bladders – A non-adhering liner physically attached to the AST and constructed of synthetic material to provide physical separation of liquid product from the tank bottom and shell. Bladders are constructed of materials that are compatible with the contact materials.

Coatings – An applied lining material that is chemically/physically bonded to the substance being covered. Coatings include, but are not limited to, paint, epoxy coatings (such as coal tar epoxy and epoxy phenolic), attached fiberglass coverings and other such products.

In-house Inspector – The designated representative of the owner/operator organization who is responsible for various quality control and assurance functions should be knowledgeable of the storage facility operations, the tank and the characteristics of the product stored.

Liquid Fertilizer – A non-pressurized mixture of water and one or more compounds of nitrogen, phosphorus or potassium that is produced and stored in commerce as a source of plant nutrients.

RBI – Risk-based inspection using a methodology acceptable to the authorized inspector

and an experienced storage tank engineer.

Soil-Side – The exterior side of bottom plate regardless of what they come in contact with.

3.0 SCOPE

- 3.1 This document represents suggested minimum recommended practices for the inspection and maintenance of ASTs used to store liquid fertilizer and constructed of carbon or stainless steel, or aluminum.
- 3.2 These practices shall not be used in conflict with any jurisdictional requirements. If any of the recommended practices are less stringent than any statute or regulation, the statute or regulation shall govern. If these practices are more stringent than the requirements of the statute or regulation, these practices should be followed.
- 3.3 For ASTs used to store liquid fertilizer, and known to be built to API 650 (or its predecessor API 12C), the minimum acceptable external or internal inspection criteria should be in accordance with the guidelines and recommendations of API 653. In addition, consideration should be given to other ancillary criteria as itemized in Sections 4, 5, 6 and 7 regarding fertilizer-specific issues.
- 3.4 For ASTs used to store liquid fertilizer and of unknown design, or built to known criteria other than API 650, inspection criteria should be in accordance with the guidelines and recommendations of API 653 to the extent possible. An authorized inspector, or an authorized inspector in conjunction with an experienced storage tank engineer, may modify the inspection in consideration of original construction details that do not meet API 650 design criteria. The result of the inspection should be equivalent to the API 653. In addition, consideration should be given to other ancillary criteria as described in Sections 4, 5, 6 and 7 regarding fertilizer-specific issues.
- 3.5 The frequency and extent of inspection of ASTs used to store fertilizer will depend on operating conditions and history, past inspections, repair history or other conditions of an individual tank, and should follow the practices given in Section 8 and, at the discretion of the AST owner or operator, may take into account RBI criteria as outlined in API 580 and API 581.

- 3.6 A tank owner may determine that additional or modified inspections are necessary based on operating conditions and history, past inspections, repair history or other conditions of an individual tank.

4.0 CONSTRUCTION, REPAIR, MAINTENANCE AND INSPECTION CONSIDERATIONS

4.1 Exterior Considerations

- 4.1.1 The owner should consider painting the storage tanks a light or reflective color to reduce radiant heating, particularly when increased temperatures in the vapor zones are a concern.
- 4.1.2 Carbon steel tanks should be painted to minimize corrosion.
- 4.1.3 Tanks should be set on a proper foundation to prevent moisture or debris from gathering at the base of the tank (e.g., set above grade, drainage away from tank). Base material should not be allowed to build up above the level of the tank bottom edge. For new tank construction, foundation materials should avoid gravel bases as this can be a source of accelerated corrosion on the soil side of the tank bottom. Sand bases with an impressed current or preferably concrete foundation are the best for limiting soil side corrosion.
- 4.1.4 Tanks set on a concrete foundation should be sealed around the tank bottom to foundation interface to provide a moisture barrier. The sealant should be a flexible type that allows for temperature expansion and contraction of the tank with respect to the foundation.
- 4.1.5 When making repairs to the tank shell, the qualification of welding procedures should be based upon the standard to which the tank was originally built. When the original standard of construction is unknown, the qualification of welding procedures should be based upon API 653, including the impact toughness requirements of API 650.
- 4.1.6 Shell repair materials should be selected according to the standard to which the tank was originally built. When the original standard of construction is unknown, repair materials should be selected

according to the requirements of API 653, and the impact toughness requirements of API 650.

- 4.1.7 Insulation and insulation jacket should be maintained to prevent moisture from entering. The owner/operator should be knowledgeable of the type of insulation in existing systems or systems to be built. Moisture and certain types of insulation can cause corrosion under insulation (CUI). For example, non-halide free fiberglass insulation contains chlorides which, in contact with moisture, can cause accelerated corrosion of carbon and stainless steels.

4.2. Interior Considerations

- 4.2.1 The condition of the welds and weld heat-affected zones (HAZs) are of particular concern because these areas tend to be more commonly affected by exposure to liquid fertilizers.
- 4.2.2 Corrosion of the soil side of the tank bottom is a potential problem area and should be considered for additional inspection. For new tank construction, foundation materials should avoid gravel bases as this can be a source of accelerated corrosion on the soil side of the tank bottom. There are methods for identifying sub-surface corrosion issues when the interior looks good – such as ultrasonic thickness (UT) testing, Magnetic Flux Leakage (MFL) scanning, or cutting out test coupons.
- 4.2.3 When performing an internal inspection, residue and sludge should be pumped out and the bottom should be cleaned and dried thoroughly.
- 4.2.4 Roofs and rafter joints of internally supported tank roofs should be inspected. Vapors can cause corrosion at the rafter/roof joint and weaken the integrity of the roof.
- 4.2.5 When a tank is to have a bladder installed or a coating applied, all protrusions should be mechanically ground to a smooth round edge to prevent defects in the bladder or coating. All weld defects should be corrected before any bladder is installed or coating is applied.

- 4.2.6 Tank owners/operators should consult with product manufacturer/supplier to insure product compatibility with tank construction and appurtenance materials.
- a. Copper and brass should not be used in tank construction or in appurtenances where they will come in contact with liquid fertilizer.
 - b. Aluminum is not compatible with some liquid fertilizers, including but not limited to, phosphate-based liquid fertilizers or liquid fertilizers containing potassium chloride.
 - c. Unlined carbon steel tanks are generally not acceptable for storage of acidic solutions (pH below 6.0). An exception to this would be solutions of high concentration (e. g. above 93 percent concentration sulfuric acid).

5.0 BLADDERS/COATINGS

5.1 General

- 5.1.1 Complete data on the bladder or coating, including the manufacturer of the material, its corrosion resistance properties, date of installation, method of attachment and installation contractor, should be maintained as part of the permanent record on the tank.
- 5.1.2 The condition of the bladder or coating may need to be established during internal inspection as a means of assessing continuing integrity. Additional or alternative internal inspection criteria may need to be established where such bladders or coatings are known to be present.

5.2 Integrity Criteria for Tanks with Bladders

- 5.2.1 Tanks with bladders already installed should have an initial baseline inspection by an API authorized inspector within two years of acceptance of this guideline.

- 5.2.2 Tanks with bladders that do not have leak detection systems in place between the bladder and the tank bottom and shell should have the bladder inspected within two years after the initial installation and, if no failure indications are found, at five-year intervals thereafter. The inspection should be conducted by the original bladder installer or by personnel experienced with bladder installations. The inspection should include, but is not limited to, the Bladder Inspection Criteria of Appendix A.
- 5.2.3 Tanks with bladders that have leak detection systems should have the bladder inspected at five year intervals. The inspection should be conducted by the original bladder installer or by personnel experienced with bladder installations. The inspection should include, but is not limited to, the Bladder Inspection Criteria of Appendix A.
- 5.2.4 Tanks should be inspected by an API authorized inspector and bladder manufacturer representative within five years of any repair of a bladder leak unless the tank is inspected prior to bladder repairs.
- 5.2.5 External inspections should be conducted on the same schedule as for tanks without bladders (see Section 8).
- 5.2.6 Following any leak repair, the bottom of the tank under the bladder should be flushed with clean water to remove corrosive product.
- 5.2.7 If a new bladder is installed or a bladder repair is made, the bladder manufacturer should provide oversight during the installation or repair and witness integrity testing of the bladder before the tank is put into service.
- 5.2.8 All tanks should have an initial inspection by an API authorized inspector immediately before the installation of a bladder unless they are new construction and were previously inspected in accordance with the new construction standard.

5.3 Integrity Criteria for Tanks with Coatings

- 5.3.1 Tanks with coatings already applied should have an initial baseline inspection by an API authorized inspector within two years of the acceptance of this guideline.
- 5.3.2 Tanks with coatings that do not have a leak detection system in place should have the coating inspected within two years after the application and, if no failure indications are found, at five year intervals thereafter. The coating inspection should be conducted by the original coating applicator or someone familiar with coating application. The coating inspection should be, but is not limited to, the Coating Inspection Criteria of Appendix B.
- 5.3.3 Such tanks should be internally inspected within five years of any repair of a coating leak.
- 5.3.4 External inspections should be conducted on the same schedule as for existing tanks without coatings (see Section 8).
- 5.3.5 If a leak occurs or the integrity of a coating is suspect, the area of concern should be cleaned until free of coating and product. The area should be inspected and repaired in accordance with the tank design specifications and or API 653 and the National Organization of Corrosion Engineers (NACE International). The area should be prepared and the coating applied according to the manufacturer's procedures.
- 5.3.6 All tanks should have an initial inspection by an API authorized inspector immediately before the application of a coating unless they are new construction and were previously inspected according to the new construction standard.

6.0 FLAMMABILITY

- 6.1 Fertilizers are generally non-flammable in nature. As such, provisions in API 653 regarding flammability may be modified according to the nature of the specific liquid fertilizers used in the tank except where liquid hydrocarbons are used as a fertilizer interface seal.

7.0 SPECIFIC GRAVITY

- 7.1 ASTs designed for liquid fertilizer storage utilize a product specific gravity usually exceeding 1.0. This difference in product gravity needs to be properly considered in the evaluation of any liquid fertilizer tank.

8.0 INSPECTIONS

8.1 Inspection Intervals

- 8.1.1 The following inspection frequency practices are suggested for liquid fertilizer ASTs. These practices are intended to be consistent with API 653:

- a. Baseline Inspection
 - i. For tanks that have been inspected by an API authorized inspector within the last ten years, the date of that inspection should become the “baseline inspection” date for purposes of these practices so long as the inspection met the definition of “baseline inspection” in Section 2.0.
 - ii. For tanks that have not been inspected by an API authorized inspector within the last ten years, a baseline inspection should be conducted by an API authorized inspector within two years of adoption of these practices.
- b. Monthly visual, “walk around” inspections should be conducted by an in-house inspector.
- c. The tank should be given a visual external inspection by an API authorized inspector at intervals not greater than the lesser of five years or the interval established by the corrosion rate in accordance with API 653.
- d. Internal Inspections:

- i. For all tanks, the interval between internal inspections by an API authorized inspector should not exceed ten years unless an RBI evaluation is performed on the tank by qualified personnel and concludes that a longer inspection interval is acceptable.
 - ii. For non coated tanks or tanks without bladders, an internal inspection using the API 653 checklist should be conducted by an API authorized inspector at frequencies recommended by API 653 or RBI assessment.
 - iii. For tanks with bladders or coatings, an internal inspection should be conducted by an API authorized inspector at frequencies recommended by API 653 or RBI assessment.
- e. All leak detection systems should be monitored on at least an annual basis.

8.2 Inspectors

8.2.1 The baseline inspection should be performed by an API authorized inspector.

8.2.2 The monthly visual and yearly external inspections can be performed by an in-house inspector.

8.2.3 All formal internal and external API 653 inspections should be performed by an API authorized inspector.

8.3 Suitability for Service

8.3.1 All tanks storing liquid fertilizer should be evaluated to confirm that the tank is suitable for continued service. Specifics to consider include but are not limited to: inspection reports, shell thickness, joint efficiencies and the specific gravity of the product stored.

9.0 RECORDKEEPING

9.1 When a tank is evaluated, repaired, altered or reconstructed in accordance with these practices, the following information, as applicable, should be made a part of the owner/operator's records for the tank:

9.1.1 Calculations for:

- a. Component evaluation for integrity, including brittle fracture consideration;
- b. Re-rating (including liquid level); and
- c. Repair and alteration considerations.

9.1.2 Construction, repair and alternation drawings.

9.1.3 Additional support data including, but not limited to, information pertaining to:

- a. Inspections (including component thickness readings);
- b. Material test reports/certification;
- c. Tests performed/results;
- d. Radiographs and radiograph inspection reports;
- e. Brittle fracture considerations;
- f. Original tank construction data (date, original standard);
- g. Location and identification (owner/operator's number, serial number);
- h. Description of the tank (diameter, height, service);
- i. Design conditions (liquid level, specific gravity, allowable stress and unusual design load);
- j. Shell material and thickness by course;
- k. Tank perimeter elevations;
- l. Construction completion record;
- m. Basis for hydrostatic test exemption; and

- n. Document the foundation type the tank sits on.
- 9.2 Detailed monitoring records on the tank leak detection system should be maintained for the life of the tank.

10.0 REFERENCES

API 575. "Inspection of Atmospheric and Low Pressure AST's"

API 650, "Welded Steel Tanks for Oil Storage," current edition.

API 653, "Tank Inspection, Repair, Alteration and Reconstruction," current edition, and tank inspection checklist including Appendix C.

API 580, Risk Based Inspection

API 581, Risk Based Inspection Technology

Occupational Health and Safety Administration (OSHA), 29 CFR 1910.146

Appendix A

Bladder Inspection Criteria

The tank bladder inspection should include, but is not limited to, the following:

- a. Establish suitability for personnel entry per OSHA guidelines;
- b. Check bladder flexibility;
- c. Visually inspect bladder for signs of discoloration and surface cracking;
- d. Visually inspect bladder support system for compliance with original installation;
- e. Check all bladder interface connections (flanges, roof columns, manways, etc.);
- f. Check sump boot and boot-to-bottom weld;
- g. Check all leak monitoring port valves;
- h. Verify that operating liquid level has not exceeded bladder design height; and
- i. Exercise extreme care while inspecting and when entering or exiting tank.

Appendix B

Coating Inspection Criteria

The tank coating inspection should include, but is not limited to, the following:

- a. Establish suitability for personnel entry per OSHA guidelines;
- b. Check for cracks, bubbling, peeling, discoloration;
- c. Consider an “electric arc” holiday test that can locate defects not detectable to the eye;
- d. Inspect the transition area from coated to non-coated shell (flanges, roof columns, manways, etc.);
- e. Inspect sump boot;
- f. Inspect coatings across dissimilar materials of construction; and
- g. Exercise extreme care while inspecting and when entering or exiting tank.