Revise aboveground storage tank inspections

Quick review highlights recent addendums to API 653

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The American Petroleum Institute (API) published Standard 653, “Tank Inspection, Repair, Alteration, and Reconstruction,” in January 1991. This guidance document has a wide scope; it encompasses the maintenance, inspection, repair, alteration, and reconstruction of existing aboveground, atmospheric storage tanks constructed to API 650, and its predecessor, API 12C.

API 653 addresses suitability-for-service, repair and alteration of aboveground storage tanks. Since the original publication, this guidance document has undergone many changes. In December 1996, API published the Second Edition of API 653, the first major revision.¹ To improve operating performance and maintenance of these large tanks, API has since amended and made notable revisions to several sections of the second edition of API 653. The following checklist summarizes significant changes made in Addendum 1 (December 1996) and Addendum 2 (December 1997). Use this amended list to note concerns and possible revisions in your tank inspection program.

Section 2—Suitability-for-service. In paragraph 2.2.2, Addendum 2 adds a new requirement. Now, distorted roof support members shall be evaluated and repaired or replaced, in addition to corroded or damaged members.

Minimum thickness calculation for welded tank shell. Changes in paragraph 2.3.3, address how to calculate the minimum thickness for tank shells. According to Addendum 2, the minimum shell thickness formula now substitutes H for H-1 in the formula: 2.6 × DHG/SE. Why API made this change is not clear. The term, H-1, originated during the early days of tank design. It was recognized that the greatest hoop stress in a tank shell course was approximately 1 ft above the horizontal butt weld joining two shell courses, or 1 ft above the shell-to-bottom joint. This is due to the restraining effect of the joints on hoop strains. Since the shell thickness formula locates H at the bottom of a locally corroded area, rather than at a shell course butt weld, API may be recognizing this difference. However, the change is not consistent with tmin calculations for existing tanks containing no locally corroded areas where the H-1 term should apply as it does to new tank shell calculations. Substituting H for H-1 to makes the tmin calculation more conservative for uncorroded tanks.

Also added to Addendum 2 is a formula for calculating a maximum hydrostatic test height, based on the minimum thickness in the locally corroded area. It uses greater allowable stresses than that permitted for calculating product tmin.

Bottom thickness measurements. Addendum 1 adds three new paragraphs (2.4.7.5, 2.4.7.6 and 2.4.7.7) that clarify requirements for repairing tank floor pit repairs and specifying minimum dimensional requirements for the floor extension on the outside of the tank. Pit repairs are limited to pit welding, overlay welding and lap patching. Welding within the “critical zone” is still limited as before. The minimum thickness of the floor projection shall be at least 0.1 in. and shall extend a minimum of ¾ in. from the outside toe of the floor-to-shell weld.

Minimum thickness for annular plate ring. The minimum outside dimensional requirements specified in 2.4.7.7, for lap welded floor extensions, also apply to annular rings. This change is noted in Addendum 1.

Section 4—Inspection. Besides changing the title of the paragraph from Scheduled inspection to External inspection, paragraph 4.3.2.1. formalizes the requirement that the external inspection be conducted by an authorized inspector. This replaces paragraph 4.10, which defines inspector qualifications. API 653 now defines an authorized inspector as “... an employee of an authorized inspection agency that is qualified and certified to perform tank inspections under this standard.” Implicit in this requirement is that the authorized inspector must hold an API 653 certification.

Internal inspection. Paragraph 4.4.1.2 now requires the authorized inspector to review the tank NDE inspection results, in addition to conducting the visual inspections.

Section 7—Tank repair and alteration. Section 7 significantly departs from the original second edition; it now permits lap welded shell patch plates, within certain restrictions. The first and second editions of API 653 were overly conservative and prohibited shell

¹Revisions to the second edition of API 653 are listed in “Update aboveground storage tank inspections,” Hydrocarbon Processing, November 1996, pp. 51-52.
Lap patch repairs were not permitted to shell plates of any tank, based on brittle fracture considerations. However, Section 3—Brittle fracture considerations, explicitly states that brittle fracture of tanks with shell plates less than ⅜-in. thickness is not a concern. Addendum 1 remedies that conundrum.

Lap patch repair plates can now be used to repair tank shells less than ⅜-in. thick with certain restrictions on size, placement and dimensions. The following examples note changes within this section:

**Paragraph Revision**

7.3.1.3. Patch plates shall be the smaller of ⅜-in. thick or the thickness of the shell plate, but not less than ⅝ in.

7.3.1.4 Corners shall be rounded to a minimum 2-in. radius, except at the shell-to-bottom joint.

7.3.1.5 Lap patches may cross flush ground shell butt welds, provided that they extend at least 6 in. beyond the butt weld.

7.3.1.6 Lap patches may extend to, and intersect with, the external shell-to-bottom joint at a 90° angle.

7.3.1.7 Maximum dimensions are 48 in. x 72 in., and minimum dimensions are 6 in. x 8 in.

7.3.1.8 Shell openings cannot be positioned within a lap patch.

7.3.1.9 Shell plates under lap patches have to be ultrasonically inspected for plate defects and remaining thickness.

7.3.1.10 Lap patches cannot be placed over lap-welded or riveted shell seams, other lap patch plates, distorted areas or areas containing shell defects.

Also, lap welded patch plates can be used to close holes in shell plates due to corrosion or removal of shell penetrations. These patches must meet a host of requirements, defined in paragraphs 7.3.2.1 through 7.3.4.6, including the maximum ⅜ in. existing shell plate thickness criteria.

**Alteration of existing shell penetrations.** Addendum 2 revises old paragraph 7.9.2.2, with 7.9.2.2, and restricts removing of an existing reinforcing plate and adding a new one to unstress relieved assemblies.

**Repair of tank bottoms.** Addendum 2 adds a new paragraph—7.10.2.30—which revises 7.9.2.3. It adds spacing requirements (3 in. or 5ft.) between floor plate or annular ring welds and tank shell vertical welds for shell plates of unknown toughness.

**Hot Taps.** The hot tap requirements have been updated and tightened to reflect and clarify brittle fracture considerations in Addendum 1. Specifically, the new requirements add more restrictions when hot tapping tanks containing shell plates of unknown toughness greater than ⅜ in. that did not exist in the original second edition.

**Section 8—Dismantling and reconstruction.** Paragraph 8.3.2.2, covering reuse of existing tank bottoms, has been revised. It prevents removing the portion of the tank containing the floor-to-shell weld and the floor extension. The original second edition allowed the entire floor to be reused intact by removing the shell 12 in. above the shell-to-floor weld.

**Shells.** Shell plates ½ in. or thinner can now be cut, leaving part of the weld and all of the heat affected zone. The original second edition made no allowance for thin shell plates.

**Section 10—Examination and testing.** Paragraph 10.1.4.2 clarifies the inspection requirements for new, permanent attachments and attachments that have been removed on tanks with shell materials of Groups IV, IVA, V or VI. The previous paragraph included no inspection requirements for removed attachments. Also, the revised paragraph only permits the purchaser to substitute magnetic particle inspection with liquid penetrant inspection. This revision presumably recognizes the increased sensitivity of the magnetic particle method to detect defects in carbon steel material, compared with liquid penetrants.

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