Title:	Fitness-for-Service Reference Updates	**Agenda Item # 653-1015**
Date:	11/14/2023	
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Purpose:	1. Update API Standard 653 to align document fitness-for-service references and definitions with API 579-1/ASME FFS-1. 2. Revise text to explicitly reference fitness-for-service assessment, where appropriate.	
Source:	Task Group on Aboveground Storage Tank Fitness-for-Service	
Revision:	0	
Impact:	Provide clarity on fitness-for-service references and assessment opportunities.	
Rationale:	The proposed errata and editorial changes are intended to align API Standard 653 with API 579-1/ASME FFS-1. Additionally, references that implicitly refer to fitness-for-service assessment (i.e., stress analysis, rigorous evaluation) are revised to provide a clear reference for fitness-for-service assessment. Proposed changes in red font.	
Proposed verbiage:	**Section 2—Normative References** API ~~Recommended Practice~~ 579-1/ASME FFS-1, *Fitness-For-Service* **Section 3—Terms and Definitions** **3.15** **fitness-for-service assessment** ~~A methodology whereby flaws contained within a structure are assessed in order to determine the adequacy of the flawed structure for continued service without imminent failure.~~ Quantitative engineering evaluation that is performed to demonstrate the structural integrity of an in-service component that may contain a flaw or damage, or that may be operating under a specific condition that might cause a failure. **Section 4—Suitability for Service** **4.3.3.6** As an alternative to the procedures described above, any thinning of the tank shell below minimum required wall thickness due to corrosion or other wastage may be evaluated to determine the adequacy for continued service ~~by employing the design by analysis methods defined in Section VIII, Division 2, Appendix 4 of the ASME Code; or~~ through a fitness-for-service assessment in accordance with API 579-1/ASME FFS-1.~~, Section 4, Section 5, or Section 6, as applicable. When using the ASME criteria, the stress value used in the original tank design shall be substituted for the Sm value of Division 2, if the design stress is less than or equal to the lesser of 2/3Y (specified minimum yield strength) or 1/3T (specified minimum tensile strength). If the original design stress is greater than 2/3Y or 1/3T, then the lesser of 2/3Y or 1/3T shall be substituted for Sm.~~ **4.3.5 Distortions** **4.3.5.1** Shell distortions include out-of-roundness, buckled areas, flat spots, dents, and peaking and banding at welded joints.	

4.3.5.2 Shell distortions can be caused by many conditions such as foundation settlement, over- or underpressuring, high wind, poor shell fabrication, or repair techniques, and so forth.

4.3.5.3 Shell distortions shall be evaluated in accordance with API 579-1/ASME FFS-1 on an individual basis to determine if specific conditions are considered acceptable for continuing tank service and/or the extent of corrective action.

4.3.6 Flaws

Flaws such as cracks or laminations shall be thoroughly examined and evaluated in accordance with API 579-1/ASME FFS-1 to determine their nature and extent and need for repair. If a repair is needed, a repair procedure shall be developed and implemented. The requirement for repairing scars such as arc strikes, gouges, or tears from temporary attachment welds must be evaluated on a case-by-case basis. Cracks in the shell-to-bottom weld shall be removed.

4.3.8 Shell Welds

The condition of the tank shell welds shall be evaluated for suitability for service using criteria from this standard, the as-built standard, or fitness-for-service assessment per API 579-1/ASME FFS-1. Typical shell weld conditions are listed below with their required evaluation and/or repair actions. Repair procedures are given in 9.7.

4.4 Tank Bottom Evaluation

4.4.5.4 Unless a fitness-for-service assessment ~~stress analysis~~ is performed, the minimum bottom plate thickness in the critical zone of the tank bottom defined in 9.11.1.2 shall be the smaller of one-half the original bottom plate thickness (not including the original corrosion allowance) or 5 0 % of $t_{\min}$ of the lower shell course per 4.3.3.1 but not less than 0.1 in. Isolated pitting will not appreciably affect the strength of the plate.

4.4.5.7 Unless a fitness-for-service assessment ~~stress analysis~~ is performed that considers future expected corrosion until the time it can be inspected, repaired, or replaced, the following criteria applies:

- the thickness of the projection of the bottom plate beyond the shell as measured at the toe of the outside bottom-to-shell fillet weld shall not be less than 0.10 in., and
- the projection of the bottom plate beyond the outside toe of the shell-to-bottom weld shall be at least 3/8 in.

4.4.6 Minimum Thickness for Annular Plate Ring

4.4.6.1 Due to strength requirements, the minimum thickness of annular plate ring is usually greater than 0.10 in. Isolated pitting will not appreciably affect the strength of the plate. Unless a fitness-for-service assessment ~~stress analysis~~ is performed, the annular plate thickness shall be in accordance with 4.4.6.2 or 4.4.6.3, as applicable.

Section 5—Brittle Fracture Considerations

5.3.10

Step 9—An evaluation can be performed to establish a safe operating envelope for a tank based on the operating history. This evaluation shall be based on the most severe combination of temperature and liquid level experienced by the tank during its life. The evaluation may show that the tank needs to be re-rated or operated differently; several options exist:

a) restrict the liquid level;

b) restrict the minimum metal temperature;

c) change the service to a stored product with a lower specific gravity;

d) combinations of Items a), b), and c), above.

The owner/operator could perform ~~can also~~ ~~make~~ a more rigorous fitness-for-service assessment ~~analysis~~ to determine the risk of failure due to brittle fracture using API 579-1/ASME FFS-1. ~~by performing a fracture mechanics analysis based on established principles and practices. The procedures and acceptance criteria for conducting an alternative analysis are not included in this standard.~~

Annex B
(normative)
Evaluation of Tank Bottom Settlement

B.2 Types of Settlement

B.2.3 Edge Settlement

B.2.3.1 Edge settlement occurs when the tank shell settles sharply around the periphery, resulting in deformation of the bottom plate near the shell-to-bottom corner junction. Figure B.6 illustrates this settlement.

B.2.3.2 The equation given in B.3.4 can be used to evaluate edge settlement. Alternatively, a ~~rigorous stress analysis~~ fitness-for-service assessment in accordance with API 579-1/ASME FFS-1 can be performed. ~~can be carried out for the deformed profile.~~ The determination of the deformed profile should take into consideration the following.

B.2.4 Bottom Settlement Near the Tank Shell

B.2.4.1 Figure B.8 illustrates bottom settlement near the tank shell.

B.2.4.2 The equation given in B.3.3 can be used to evaluate settlement near the tank shell. Alternatively, a ~~rigorous stress analysis~~ fitness-for-service assessment in accordance with API 579-1/ASME FFS-1 can be performed. ~~can be carried out for the deformed profile.~~

B.3 Determination of Acceptable Settlement

B.3.1 General

For existing tanks with history of successful service, it may be possible to accept greater settlement and distortion of the foundation from a true plane than new tank construction standards allow. Each tank must be evaluated based on service conditions, materials of construction, soil characteristics, tank foundation design, and tank service history. The methods discussed in following sections are not mandatory and approximate the maximum permissible settlement. However, experience has shown that if settlements exceed the following requirements, further assessment or repair is required. A more rigorous fitness-for-service assessment can be performed per API-579-1/ASME FFS-1.

	B.3.2.4 If measured out-of-plane settlement exceeds the applicable limits described in B.3.2.1 or B.3.2.2, a fitness-for-service assessment ~~more rigorous evaluation~~ may be performed to determine the need for repairs. This fitness-for-service assessment ~~evaluation~~ should be performed ~~done~~ in accordance with API-579-1/ASME FFS-1 by an engineer experienced in tank settlement analysis. ## B.4 Repairs **B.4.1** If it is determined that settlements have occurred which are beyond the permissible limits established in the previous sections, then consideration should be given to performing a fitness-for-service assessment per API-579-1/ASME FFS-1 or making repairs. ~~or a rigorous stress analysis should be performed to evaluate the deformed profile.~~