

REMAINING LIFE AND INTEGRITY ASSESSMENT OF AN ATMOSPHERIC STORAGE TANK (T-125) BASED ON ULTRASONIC TESTING AND API 653 STANDARD

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Abstract

This paper presents a Fitness-for-Service (FFS) evaluation and Remaining Life (RL) prediction for the T-125 Atmospheric Storage Tank (AST), which stores Solar (Diesel) fuel at PT. XYZ. The study utilized data from Ultrasonic Testing (UT) conducted over an eight-year inspection interval (2016–2024) to quantify material loss due to corrosion. The analysis was performed strictly according to the guidelines of API Standard 653, 5th Edition. Key parameters, including Corrosion Rate (CR), Minimum Required Thickness (t_{min}), and RL, were calculated. While the 1st and 2nd shell courses and the roof plate possess acceptable integrity with RL values ranging from 32.6 to 73.12 years, the 3rd shell course was found to be non-compliant based on the comparison between its calculated minimum required thickness (2.2 mm) and the API minimum plate thickness requirement (2.54 mm). This assessment provides a scientific basis for maintenance planning, emphasizing the need for immediate attention to the 3rd course and continuous monitoring of the 2nd course, which exhibits the highest corrosion rate (0.06 mm/year).

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1. Introduction

Storage tanks are critical assets in the oil and gas industry, and their structural integrity is constantly challenged by degradation mechanisms, primarily corrosion. Uncontrolled corrosion can lead to catastrophic failures, resulting in safety hazards, operational downtime, and significant environmental damage [1]. To ensure continued safe operation, periodic inspection and integrity assessment of these assets are mandated by international standards.

The American Petroleum Institute (API) Standard 653 provides the established guidelines for the inspection, repair, alteration, and reconstruction of ASTs, offering a standardized approach for quantitative assessment of service suitability [2]. This study focuses on an in-depth integrity assessment of the T-125 atmospheric storage tank, a vertical, welded steel tank, by analyzing its corrosion history and projecting its remaining service life in compliance with API 653 criteria. The primary objective is to determine the current corrosion status, predict the tank's Remaining Life (RL), and identify any structural non-compliance based on thickness measurements.

2. Method

A. Data Collection: Ultrasonic Testing (UT)

Data was collected through Non-Destructive Testing (NDT), specifically Ultrasonic Testing (UT), which is the preferred method for accurate measurement of material thickness to monitor corrosion and erosion loss in steel structures [5]. Two sets of minimum thickness data were acquired: previous wall thickness from the initial inspection in 2016 and actual wall thickness from the current inspection in 2024. The elapsed time between

inspections (Δt) was 8 years. The minimum thickness values were recorded at designated Thickness Measurement Locations (TMLs) on the three shell courses and the roof plate.

B. Remaining Life and Corrosion Rate Calculation

The integrity parameters were calculated using the formulae obtained from API Standard 653:

1. **Corrosion Rate (CR):** The uniform metal loss rate was calculated by dividing the material loss by the inspection interval.

$$CR \left(\frac{\text{mm}}{\text{year}} \right) = \frac{T_{\text{previous}} - T_{\text{actual}}}{\Delta t(\text{years})} \quad (1)$$

Where: T_{previous} is minimum thickness measured from the previous inspection, T_{actual} is minimum thickness measured from the current inspection which shows the actual condition after experiencing metal loss due to corrosion during operation period, Δt is the time period between the previous inspection and current inspection.

2. **Minimum Calculated Thickness ($t_{\min}$):** The minimum required plate thickness for the shell courses, based on circumferential (hoop) stress, was determined based on APT 653[2].

$$t_{\min} = \frac{2.6(H-1)DG}{SE} \quad (2)$$

where: H is the liquid height (ft), D is the tank diameter (ft), G is the specific gravity (0.81 for Solar), S is the material allowable stress (psi), and E is the weld joint efficiency.

3. **Remaining Life (RL):** The predicted operational time until the plate thickness reaches the minimum required retirement thickness (t_{req}) was calculated. The minimum retirement thickness (t_{req}) is defined by the absolute minimum thickness specified by API 653 (which is 2.54 mm for shell plates and 2.286 mm for the roof) or the calculated $t_{\min}$, whichever is greater [2].

$$RL(\text{years}) = \frac{T_{\text{actual}} - T_{\text{req}}}{CR} \quad (3)$$

where: T_{actual} is minimum thickness measured from the current inspection which shows the actual condition after experiencing metal loss due to corrosion during operation period, T_{req} is the minimum thickness required as stated by API 653; and CR is the corrosion rate

3. Result and Discussion

A. Integrity Assessment Result

The core integrity parameters determined for the T-125 tank components are summarized in Table 1.

Table 1. Calculated Integrity Parameters and Fitness For Service (FFS) Status

Component	T_{actual} (mm)	CR (mm/year)	$T_{\min}$ (mm)	T_{req} (mm)	FFS Status	RL (years)
1st Shell course	4.0	0.05	7.9	2.54	Acceptable	37.2
2nd shell course	4.0	0.06	6.2	2.54	Acceptable	32.6
3rs shell course	3.9	0.025	2.2	2.54	Non acceptable	62.4
Roof plate	3.1	0.0125	3.1	2.286	Acceptable	73.12

B. Analysis of Corrosion and Remaining Life

On the shell Courses 1st and 2nd, both courses retain acceptable integrity. The measured current thicknesses (4.0 mm) are well above the API absolute minimum thickness (2.54 mm). However, the 2nd shell course exhibits the highest corrosion rate (0.06 mm/year) and the lowest RL (32.6 years) among all shell plates. This elevated corrosion rate is attributed to localized corrosion around the manhole area, where coating damage often occurs, facilitating greater exposure to atmospheric moisture and corrosive agents in the stored product [1].

Shell Course 3rd (Critical Finding): This course has the lowest measured tactual (3.9 mm) and the lowest CR (0.025 mm/year). Despite the actual thickness being greater than the API absolute minimum, the course is flagged as Non-acceptable because its calculated minimum thickness based on design load ($t_{min}=2.2$ mm) is compared against the mandatory API req of 2.54 mm. Although the tactual is 3.9 mm, the design calculation indicates a structural non-compliance based on the API 653 assessment criteria for fitness-for-service, suggesting a potential inadequacy in the original design input or an over-reliance on the stress calculation for this specific course [2]. This finding necessitates a thorough re-evaluation of the design basis parameters (e.g., allowable stress or joint efficiency) or application of an advanced FFS procedure (e.g., API 579-1) [3]. Roof Plate: The roof plate shows minimal corrosion (0.0125 mm/year) and the longest RL (73.12 years), affirming its robust current condition.

4. Conclusion

The integrity assessment of the T-125 storage tank, performed in accordance with API 653, indicates that the asset is largely fit for continued service but highlights one critical non-compliance issue and one high-risk area for monitoring.

1. The 3rd shell course is technically non-acceptable due to its calculated minimum required thickness (t_{min}) being below the API 653 absolute minimum plate thickness requirement (2.54 mm). A detailed engineering review is mandatory to confirm the basis of the t_{min} calculation and to determine if structural reinforcement or an FFS exemption is justified.
2. The 2nd shell course, despite having an acceptable RL of 32.6 years, exhibits the highest CR (0.06 mm/year), concentrated around the manhole. It is recommended to implement an aggressive maintenance plan for coating repair in this localized area and reduce the inspection interval for the 2nd course to manage this accelerated corrosion rate.
3. The tank's overall projected service life remains substantial, confirming that the current corrosion management program is generally effective, provided the identified structural and high-corrosion risks are mitigated promptly.

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