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FEASIBILITY TEST ON STORAGE TANK AT PT ABC USING ASME/FFS-1 METHOD

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ABSTRACT

Keywords: storage tank; fitness for service; corrosion rate.

In the operation of oil and gas exploration and exploitation, safety is crucial as it is related to asset safety, environmental safety, and human resource safety. Storage tanks play a crucial role in the process of exploring and exploiting crude oil, serving as storage facilities for liquids in large volumes. These storage tanks are susceptible to corrosion as the materials used in their construction are typically made of steel. Uncontrolled corrosion can weaken or destroy parts of the tank system, leading to holes or structural failures that may release stored products into the environment, resulting in material losses and potential fatalities. One method for assessing the viability of pressure equipment such as pressure vessels, storage tanks, and piping systems is Fitness for Service (FFS). FFS is a quantitative engineering evaluation conducted to demonstrate the structural integrity of a component in operation, even if it has experienced damage, defects, or cracks. Guidelines in FFS procedure manuals can be used to make decisions regarding "continued/repair/replacement" to ensure that components experiencing damage or defects can continue to operate for a specified period. The thickness measurements on the storage tank show that the lowest thickness is found in course 4, with a value of 4.32 mm, while the highest thickness is in the roof at 5.60 mm. The highest corrosion rate is detected in the roof with a value of 0.100 mm/year, and from this corrosion rate value, an estimated remaining life of 20 years for storage tank T-10 is obtained. In assessing the feasibility or Fitness for Services of the storage tank, it still meets the criteria specified by API 579.

Introduction

In oil and gas exploration and exploitation operations, safety is paramount regarding asset safety, environmental safety, and human resource safety (MARSUDI & Herlina, 2023). Storage tanks are crucial in petroleum exploration and exploitation as a storage place for large volumes of liquid. Storage tanks are prone to corrosion because the materials used in their manufacture are usually steel (Kharisma, Givari, & Mulyana, 2021).

Corrosion is one of the primary triggers of equipment failure risk in the oil and gas industry. When equipment failure occurs, some common incidents, such as process media leakage, partial equipment damage, and unscheduled unit closure, can occur in general. Uncontrolled corrosion can weaken or destroy parts of the tank system (Kadarisman, 2017). This can lead to holes or structural failures in the tank, releasing stored products

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into the environment and causing material and life losses. The costs caused by corrosion in industrialized countries are estimated at 3-4% of gross domestic product (Stiadi, Arief, Aziz, Efdi, & Emriadi, 2019). Gradual damage from corrosion and wear on metal surfaces used in major industrial plants can eventually result in decreased plant efficiency and, to the worst extent, plant closures. Therefore, to reduce the risk of failure and economic loss, a risk analysis against equipment corrosion failure will be carried out in advance (Mahardhika & Ratnasari, 2018). With the rapid development of the petrochemical industry, the role of oil tank storage is increasingly essential in oil storage. Thanks to the advantages of efficient use of steel, saving occupied space, and economical construction, large-scale atmospheric storage tanks are widely used. This large-scale oil tank has a high potential risk (Suwetty, 2022). Once there is a leak in the oil storage tank, it causes severe environmental pollution and the risk of fire and casualties (Primalasita & Sa’diyah, 2022).

One method of feasibility testing on pressurized equipment such as pressure vessels, stockpiling tanks, and piping systems is Fitness for Service (CANDRA, 2021). Fitness for Services is a quantitative engineering evaluation performed to demonstrate the structural integrity of a component in operation despite damage, defects, or cracks. The guidance in the FFS procedure manual can be used to make "advanced/repair/replacement" decisions to ensure that damaged or defective components can continue to operate for some time (Giacobbe et al., 2011).

Research Methods

The research method used in this paper refers to API 579 Fitness for Services. Vision Inspection involves monitoring equipment and structures using human senses such as sight, hearing, touch, and smell. In some cases, Visual Inspection is carried out with the support of devices such as low-power magnifiers, boroscopes, fiber optics, digital video borescopes, camera systems, and scouting robots. Although Visual Inspection is considered the most basic method of non-destructive testing techniques, it still plays an important role (Irwansyah, 2019).

Conformity Evaluation for Landfill Tanks (T-10) involves assessing the integrity and calculating remaining service life through analysis of construction data and results of recent inspections in the field. The data used include specifications and technical information about the equipment, visual observations, and thickness measurements (Haqi, 2018). The inspection results are processed into data input to conduct a Residual Service Life Assessment. This evaluation methodology consists of three methods: evaluation of equipment strength by referring to API Std. 650, API Std. 653, and API 579-1 / ASME FFS-1.

a. API 579-1/ASME FFS-1 : Fitness-For-Service
API Std. (650). & Std. 653 : Design calculation standards for tanks

The one-foot method calculates the required thickness at a design point 0.3m (1ft) above the base of each shell course. The minimum thickness f the shell plate than the formula:(10–12).$\mathrm{t_d} = \frac{2.6D(H-1)G}{\mathrm{S_d}}$ $C\mathrm{t_t} = \frac{2.6D(H-1)}{\mathrm{S_t}}$

$$t\min = \frac{2.6(H-1)DG}{SE} \qquad t_{min} = \frac{2.6\ HDG}{SE}$$

TMIN	The minimum acceptable thickness, in inches, for each *course* is calculated using the above formula. However, the time should not be less than 0.1 inches for each *tank course.*
D	The nominal diameter of the tank, in feet.
H	The height of the base of the shell course, *taking into account* the maximum liquid level when calculating *the shell course*, in ft; or the *height of the base L from the lowest point of the base L* locally thinned area to *the maximum liquid level.*
G	*Specific gravity*
S	The maximum clearance voltage in lbf/in2 and the clearance voltage in the shell are shown in Table 4-1 of API 653.
And	*Joint efficiency* on tanks, using Table 4-2 API653

Calculate the corrosion rate and remaining service life on storage tanks. This statistical approach can be used to determine examination intervals. The corrosion rate can be calculated by the following equation:

Long Term

$$Corrosion\ Rate\ (LT) = \frac{tinitial - tactual}{time\ between\ tinitial\ and\ tactual\ (years)}$$

Short Term

$$CapCorrosion\ Rate\ (ST) = \frac{tprevious - tactual}{time\ between\ tprevious\ and\ tactual\ (years)}$$

The remaining life of the service tank (in years) is calculated according to the following formula:

$$Remaining\ Life = \frac{tactual - trequired}{corrosion\ rate}$$

Where :

CR : Corrosion rate(mm/yr)
t.prev : Previous thickness (mm)
t.act : Actual thickness(mm)
t.nom : Nominal thickness (mm)

Acceptance Criteria by FFS-1 API 579 are as follows in Table 1.

Table 1
FFS Level 1Acceptance Criteria

Assessment Parameter	Level 1 Acceptance Criteria
Average Measured Thickness from Point Thickness Readings (PTR)	Determine t_{min} using MFH, S_a $t_{am} - FCA_{ml} \ge t_{min}$
Average Measured Thickness from Critical Thickness Profiles (CTP)	Determine t_{min} using MFH, S_a $t^s_{am} - FCA_{ml} \ge t_{min}$
MFH from Point Thickness Readings (PTR)	Determine MFH_r using $\left(t_{am} - FCA_{ml}\right)$, S_a $MFH_r \ge MFH$
MFH from Critical Thickness Profiles (CTP)	Determine MFH_r using $\left(t^s_{am} - FCA_{ml}\right)$, S_a $MFH_r \ge MFH$
Minimum Measured Thickness	$\left(t_{mm} - FCA_{ml}\right) \ge \max\left[0.6 t_{min}, t_{lim}\right]$ $t_{lim} = \max\left[0.2 t_{nom}, 2.5\ mm\ (0.10\ inches)\right]$

Where:

FCA_{ml}	Future Corrosion Allowance applied to the region of metal loss.
MFH	Maximum Fill Height of the undamaged tank.
MFHr	reduced maximum fill height of the damaged tank.
t_{am}	average measured wall thickness of the component based on the point thickness readings (PTR) measured at the time of the inspection.
team	average measured wall thickness of the component based on the longitudinal CTP determined during the inspection.
slim	limiting thickness.
tom	The component's nominal or furnished thickness is adjusted for mill under tolerance as applicable.
tin	the minimum required wall thickness of the component

Results and Discussion

Oil storage tank PT. ABC, made from low carbon steel type A36, which has been in operation for more than 20 years, is the equipment to be researched. This study used the method to visually evaluate UT's thickness in storage tanks. Each plate pass and storage tank's roof have thickness data taken (Supardi, 2015). Document review is carried out at the beginning of the research to obtain technical design data and other supporting data. Once done, the technical data described in Table 2 is obtained.

Table 2
Tank Technical Data

Technical Data	
Tag Number	Storage Tank T-10
Construction Code	API 650
Year Build/Repair	1975/2018
Previous Inspection	2017
Year Inspection	2021
Nominal Diameter	7.468 m
Nominal Height	7.315 m
Design Liquid Level	6.937 m
Nominal Capacity	212,262 Bbl
Content	Oily Water
Specific Gravity	0.96
Max. Operating Temp.	93.3 °C
Shell Material	A36
Roof Material	A36
Roof type	Cone roof

After obtaining technical data on the equipment, I continued calculating the minimum thickness based on field inspections to conduct visual checks and UT thickness.

Table 3
Calculation of minimum Thickness and Corrosion Rate

No.	Plate Name	T Previous (mm)	T Actual min (mm)	T Actual Avrg (mm)	T Required (mm)	CR (mm/year)
1	Roof Plate	6,00	5,60	6,08	2,29	0.100
2	Bottom Plate	N/A	N/A	N/A	N/A	N/A
3	Course 1	4,57	4,40	4,82	2,54	0.043
4	Course 2	4,70	4,59	4,83	2,54	0.028
5	Course 3	4,42	4,35	4,82	2,54	0.018
6	Course 4	4,47	4,32	4,80	2,54	0.037

Calculations are performed based on the Acceptance Criteria for level 1 and level 2 based on Fitness for Services API 579.

a) Average Measured Thickness from Point Thickness Readings (PTR)

Course 1	4,65	mm	≥	2,54	mm	Satisfactory
Course 2	4,66	mm	≥	2,54	mm	Satisfactory
Course 3	4,65	mm	≥	2,54	mm	Satisfactory
Course 4	4,63	mm	≥	2,54	mm	Satisfactory

b) Maximum Fill Height (MFH) Required as Per table 4.6 API RP 579

$$MFH = \frac{tS}{4.9DG} + 0.3$$

Determine MFH_r using

$$\left(t^s_{am} - FCA_{ml}\right),\ S_a \cdot H_f$$

$$MFH_r \geq MFH$$

Course 1	23,03	m	≥	6,94	m	Satisfactory
Course 2	23,08	m	≥	5,11	m	Satisfactory
Course 3	23,03	m	≥	3,28	m	Satisfactory
Course 4	22,93	m	≥	1,45	m	Satisfactory

c) Minimum Measured Thickness

T_{lim} *of the component*

$$t_{lim} = \max\left[0.2\, t_{nom},\ 2.5\ mm\ (0.10\ inches)\right]$$

Course 1	slim	=	2,50	mm
Course 2	slim	=	2,50	mm
Course 3	slim	=	2,50	mm
Course 4	slim	=	2,50	mm

d) Minimum measured thickness of the component

$$\left(t_{mm} - FCA_{ml}\right) \geq \max\left[0.6 t_{min},\ t_{lim}\right]$$

Course 1	4,23	mm	≥	2,50	mm	Satisfactory
Course 2	4,42	mm	≥	2,50	mm	Satisfactory
Course 3	4,18	mm	≥	2,50	mm	Satisfactory
Course 4	4,15	mm	≥	2,50	mm	Satisfactory

From the hoarder's tangka calculation, the value is still at the minimum limit according to the acceptance criteria of API 579. Furthermore, the remaining life is calculated using API standard code 579, paragraph 4.

Table 4
Remaining life

Item	R_{life} (year)
Course 1	20
Course 2	20
Course 3	20
Course 4	20
Roof	20

Based on the remaining life calculation, the stockpiling tank's remaining service life is 20 years.

Conclusion

The thickness measurement results on the hoarder's tangka show that the lowest thickness is found in course 4, with a value of 4.32 mm, while the highest thickness is found on the roof at 5.60 mm. The highest corrosion rate was detected on the roof with a value of 0.100 mm/year, and from the corrosion rate value, the estimated service life of the remaining T-10 hoarder is 20 years. The fitness for services assessment of stockpiling tanks still meets the criteria required by API 579. Overall, the inspection results showed that there were no significant anomalies in PT ABC's T-10 hoarders that could have an impact on its operational safety. However, it is recommended to maintain the condition of the storage tank in order to continue to fulfill its service function.

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