TANK SPECIFICATIONS

A storage tank was inspected and several through holes were observed in the bottom plates and annular plates. In the present condition, the tank no longer can be used safely in the specified operational conditions. The inspector recommends repairs to the affected areas. But even with all the repairs, there is a concern about the level of risk needed for the tank to run for another 5 years. An RBI study was done, and here is an estimate of the risk of the tank serviceability as per API 580 & 581.

Diameter: 10.7m

Product Stored: Crude Oil

Roof: Fixed

Liquid Height: 13 meter

Type of soil: Coarse sand

Year of construction: 1971

Product specific gravity: 0.84

Internal pressure: Atmospheric

Bottom/ annular plate thickness: 7.5mm / 10mm.

Roof plate thickness: 6mm.

Shell plate thickness: 10mm to 6mm (bottom to top shell course)

No of shell courses: 8 nos.

Material of construction: Not known (assumed to be ASTM A 36)

Release prevention barrier = No

PROBABILITY OF FAILURE

The equation for probability of failure is this

$$P_f(t) = gff \cdot D_f(t) \cdot F_{MS}$$

+++++++DETERMINE GFF ++++++++++++

STEP 1. We determine the total generic failure frequency Gff from Part 2, Table 4.1, and from this table or from Equation (3.220).

Table 4.1 – Suggested Component Generic Failure Frequencies (gff)[1 thru 8]

Equipment Type	Component Type	gff as a Function of Hole Size (failures/yr)				gff_{total} (failures/yr)
		Small	Medium	Large	Rupture	
Compressor	COMPC	8.00E-06	2.00E-05	2.00E-06	0	3.00E-05
Tank650	TANKBOTTOM	7.20E-04	0	0	2.00E-06	7.20E-04

$$gff_{tot} = \sum_{n=1}^{4} gff_n \quad (3.220)$$

Gffsmall = 7.2E-4
Gffrupture = 2e-6
Gfftotal = 7.2E-4

+++++++DETERMINE Df(t) ++++++++++++

STEP 1 – Determine the number of inspections, and the corresponding inspection effectiveness category using paragraph 5.5.2 for all past inspections. Combine the inspections to the highest effectiveness performed using paragraph 4.4.3.

These paragraphs will lead us to table 5.10 for tank bottoms. For the sake of the example, we´ll assign a D inspection effectiveness Category

Table 5.10 – Guidelines for Assigning Inspection Effectiveness – Tank Bottoms

Inspection Category	Inspection Effectiveness Category	Soil Side	Product Side
		a. Floor scan 90+% & UT follow-up b. Include welds if warranted from e. Cut coupons	a. Commercial blast b. Effective supplementary light c. Visual 100% (API 653) d. Pit depth gauge e. 100% vacuum box testing of suspect c. Scrape test
D	Poorly Effective	a. Spot UT b. Flood test	a. Broom swept b. No effective supplementary lighting c. Visual 25-50% Coating or Liner: a. Sponge test <50

STEP 2 – Determine the time in-service, age, since the last inspection thickness reading, t_{rd} .

$$age = 46$$

STEP 3 – Determine the corrosion rate for the base metal, $C_{r,bm}$, based on the material of construction and process environment, seeAnnex 2.B.

Let´s use a corrosion rate of 0.07 mm/y.

$C_{r,bm}$ = Long term corrosion rate = 0.07mm/y

STEP 4 – Determine the minimum required wall thickness, $t_{\min}$, per the original construction code or using API 579, Appendix A. If the component is a tank bottom, then in accordance with API 653 [11], $t_{\min}= 0.1\ in$ if the tank does not have a release prevention barrier and $t_{\min} = 0.05\text{in}$ if the tank has a release prevention barrier.

The tank has no release prevention barrier

Then $t_{\min}$= 0.1

STEP 5 – For clad components (not our case)

STEP 6 – Determine the A_{rt} parameter using Equation (2.13) or (2.14), based on the *age* and t_{rd} from STEP 2, C_{r}. from STEP 3, $t_{\min}$ from STEP 4

We will use the equation for components without cladding, and for components where the cladding is corroded away at the time of the last inspection (i.e. $age_{rc}=0$)

$$A_{rt} = \max\left[\left(1-\frac{t_{rd} - C_{r,bm}\cdot age}{t_{\min} + CA}\right),\ \ 0.0\right] \qquad (2.13)$$

$$A_{rt} = \max\left[\left(1-\frac{7.5-0.07*46}{2.54}\right), 0.0\right] = 0.68$$

STEP 7 – Determine the base damage factor for thinning, D_{fB}^{thin} , using Table 5.11 or Table 5.12, as applicable, based on the number of, and highest effective inspection category from STEP 1, and the A_{rt} parameter from STEP 6.

Table 5.12 – Thinning Damage Factors for Tank Bottoms

A_{rt}	Inspection Effectiveness				
	E	1 Inspection			
		D	C	B	A
0.05	4	1	1	1	1
0.10	14	3	1	1	1
0.60	500	346	234	158	133
0.65	587	430	309	222	192
0.70	681	527	401	305	270
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.35	170	80	36	16	12
0.40	222	115	57	29	21

Then D_{fB}^{thin} =490 (interpolated)

h) STEP 8 – Determine the damage factor for thinning, D_f^{thin} , using Equation (2.15).

$$D_f^{thin} = \frac{D_{fB}^{thin} \cdot F_{IP} \cdot F_{DL} \cdot F_{WD} \cdot F_{AM} \cdot F_{SM}}{F_{OM}} \qquad (2.15)$$

The adjustment factors in Equation (2.15) are determined as described below.

1) Adjustment to Damage Factor for On-Line Monitoring, F_{OM}= 1 (Check the instructions in API 581)

Table 5.13 – On-Line Monitoring Adjustment Factors

Thinning Mechanism	Adjustment Factors as a Function of On-Line Monitoring, F_{OM}		
	Key Process Variable	Electrical Resistance Probes (See Note 3)	Corrosion Coupons (See Note 3)
Hydrochloric Acid (HCl) Corrosion / High Velocity	10 (20 if in conjunction / 10	10 / 10	2 / 1
Other Corrosion Mechanism	1	1	1

1. The adjustment factors shown above are estimates providing a measure of the relative effectiveness

2) And 3) Adjustment for Injection/Mix Points, F_{IP}=1 (We don´t have injection points at the bottom. Check the rest of the instructions in API 581)

4) Adjustment For Dead Legs, F_{DL} = 1 (We don´t dead legs. Check the rest of the instructions in API 581)

5) Adjustment for Welded Construction, F_{WD}– Applicable only to atmospheric storage tanks. If the component is welded (i.e. not riveted), then F_{WD} = 1

6) Adjustment for Maintenance in Accordance with API 653, F_{AM} – Applicable only to atmospheric storage tanks. If the tank is maintained in accordance with API 653, F_{AM} = 1. If not, F_{AM} = 5.

7) Adjustment for Settlement, – F_{SM} Applicable only to atmospheric storage tank bottoms. It is determined based on the following criteria:

Recorded settlement exceeds API 653 criteria – $F_{SM} = 2$

Recorded settlement meets API 653 criteria – $F_{SM} = 1$

Settlement never evaluated – $F_{SM} = 1.5$

Concrete foundation, no settlement – F_{SM} = 1

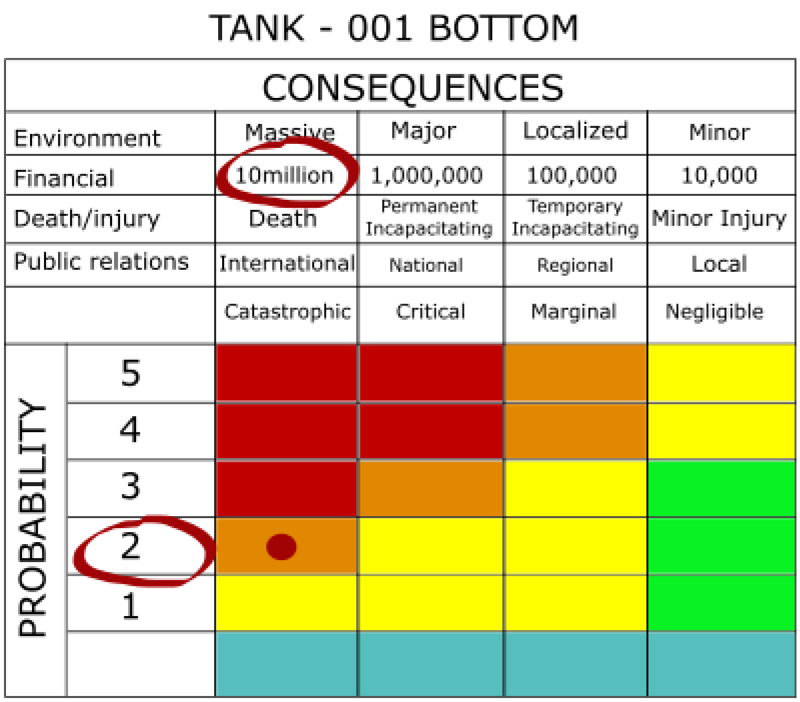
Then F_{SM} = 1

D_f^{thin} = 490* 1 * 1 * 1 * 1* 1 / 1= 490

Pf (t) 7.2e-4 * 490 * 1 = 35%

The Probability falls in a moderate value

Then, arranging the Probability of Failure with the consequence of Failure, the level of risk is Medium high



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