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1. TANK DESIGN DATA

1.1	TANK NO.	2ST-2TK-1190A~H
1.2	TYPE OF TANK	DOME ROOF TANK
1.3	ITEM NAME	NAPHTHA STORAGE TANKS
1.4	DESIGN CODE:	API 650 12TH ED, ADD 1 SEPT 2014 (APPENDIX F, G, H)

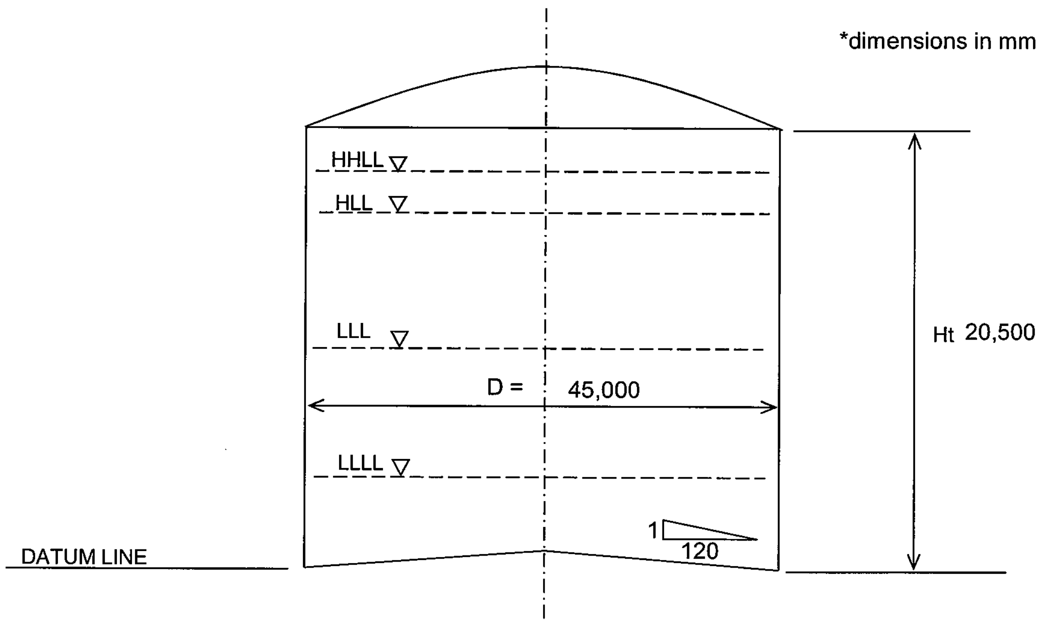
1.5 DESIGN DATA

1.5.1	NOMINAL CAPACITY	30,000.0	m^3
1.5.2	INSIDE DIAMETER	45.00	m
1.5.3	TANK HEIGHT	20.50	m
1.5.4	MAXIMUM FILLING HEIGHT	19.25	m
1.5.5	IN-FILLING RATE	2,000.00	m^3/h
1.5.6	EMPTYING RATE	310.00	m^3/h
1.5.7	PRODUCT DENSITY @ 20 °C	750	kg/m^3
1.5.8	CORROSION ALLOWANCE		
	SHELL (1st course)	1.50	mm
	SHELL (subsequent)	1.50	mm
	BOTTOM	1.50	mm
	RING OF SKETCH PLATE	1.50	mm
	ROOF	1.50	mm
1.5.9	DESIGN LIQUID HEIGHT	19.25	m
1.5.10	DESIGN SPECIFIC GRAVITY	0.750	
1.5.11	INTERNAL PRESSURE		
	DESIGN CONDITION	0.588	kPa g
		60.0	mm H20
	OPERATING CONDITION	0.118	kPa g
		12.0	mm H20
	TEST CONDITION	0.588	kPa g
		60.0	mm H20
1.5.12	EXTERNAL PRESSURE		
	DESIGN CONDITION	0.245	kPa
		25	mm H20
	OPERATING CONDITION	0	kPa
		0	mm H20
1.5.13	TEMPERATURE		
	DESIGN CONDITION	60.00	°C
	OPERATING CONDITION (MIN/ MAX)	19.6/ 31.2	°C
1.5.14	FLASH POINT	< 38	°C
1.5.15	DESIGN WIND SPEED *(3 sec gust wind speed)*	36.00	m/sec
1.5.16	SEISMIC DESIGN		
	SEISMIC ZONE	N/A	
	LATERAL FORCE COEFFICIENT	N/A	
	IMPORTANCE FACTOR	N/A	
	SITE COEFFICIENT	N/A	
1.5.17	TYPE OF ROOF	ALUMINUM GEODESIC DOME ROOF	
1.5.18	FRANGIBLE ROOF	NO	

1.6 MATERIALS

1.6.1	SHELL PLATE	A573 Gr.70 (COURSE 1~6) A283 Gr. C (COURSE 7&8)
1.6.2	RING OF SKETCH BOTTOM PLATE	A573 Gr.70
1.6.3	BOTTOM PLATE	A283 Gr.C
1.6.4	ROOF PLATE	ALUMINUM
1.6.5	STRUCTURE	A36 OR EQ.
1.6.6	FLANGE	A105
1.6.7	NOZZLE NECK	A106 Gr.B

2. TANK CAPACITY



INSIDE DIAMETER	D = 45,000	mm
TANK HEIGHT	Ht = 20,500	mm
HIGH HIGH LQUID LEVEL	HHLL = 19,000	mm
HIGH LIQUID LEVEL	HLL = 18,750	mm
LOW LIQUID LEVEL	LLL = 3,000	mm
LOW LOW LIQUID LEVEL	LLLL = ---	mm

NOMINAL CAPACITY 30000.0 m^3

3. SHELL DESIGN

(AS PER API 650 ; PARA. 5.6.4)

As per API 650; Appendix F. 2:
In case of design pressure more than 1 kPa, the design liquid height, H, shall be increased by the quantity P/(9.8G) when calculating shell thickness.

In this case, as the internal design pressure is less than 1 kPa, terms " P/9.8" & "P/9.8G" in equations as shown in following 3.1 FORMULA FOR SHELL PLATE THICKNESS shall be ignored.

3.1 FORMULA FOR SHELL PLATE THICKNESS

EQUATION OF PRELIMINARY VALUES OF BOTTOM-COURSE THICKNESS

DESIGN CONDITION

$$t_{pd} = \frac{4.9 \times D \times \left[(H-0.3) \times G + \dfrac{P}{9.8} \right]}{Sd} + C.A$$

HYDROSTATIC TEST CONDITION

$$t_{pt} = \frac{4.9 \times D \times \left[(H_{test}-0.3) + \dfrac{P_t}{9.8} \right]}{St}$$

EQUATION OF BOTTOM-COURSE THICKNESS

DESIGN CONDITION

$$t_{1d} = \left[1.06 - \frac{0.0696D}{\left(H + \dfrac{P}{9.8G}\right)} \sqrt{\frac{\left(H + \dfrac{P}{9.8G}\right)G}{Sd}} \right] \left[\frac{4.9 \times D \times G \times \left(H + \dfrac{P}{9.8G}\right)}{Sd} \right] + C.A$$

HYDROSTATIC TEST CONDITION

$$t_{1t} = \left[1.06 - \frac{0.0696D}{\left(H_{test} + \dfrac{P_t}{9.8}\right)} \sqrt{\frac{H_{test} + \dfrac{P_t}{9.8}}{St}} \right] \left[\frac{4.9 \times D \times \left(H_{test} + \dfrac{P_t}{9.8}\right)}{St} \right]$$

EQUATION OF SECOND-COURSE THICKNESS

CASE 1: $\dfrac{h_1}{(r \times t_1)^{0.5}} \leq 1.375$; t2 = t1

CASE 2: $\dfrac{h_1}{(r \times t_1)^{0.5}} \geq 2.625$; t2 = t2a

CASE 3: $1.375 < \dfrac{h_1}{(r \times t_1)^{0.5}} < 2.625$; $t_2 = t_{2a} + (t_1 - t_{2a})\left[2.1 - \dfrac{h_1}{1.25(rt_1)^{0.5}} \right]$

REMARK:

1. *t2a is corroded thickness of the second shell course which calculated based on " EQUATION OF UPPER SHELL COURSE THICKNESS" as following (mm).*
2. *h1 is the height of the bottom shell course (mm)*
3. *r is the nominal tank radius (mm)*

EQUATION OF UPPER SHELL COURSE THICKNESS

DESIGN CONDITION

$$t_{dx} = \frac{4.9 \times D \times \left(H - \frac{x}{1000}\right)G}{Sd} + C.A$$

HYDROSTATIC TEST CONDITION

$$t_{tx} = \frac{4.9 \times D \times \left(H_{test} - \frac{x}{1000}\right)}{St}$$

3.2 DESIGN DATA

TANK DIAMETER	D =	45	m
TANK HEIGHT	Ht =	20.5	m
MAX. DESIGN LIQUID LEVEL	H =	19.25	m
HYDROTEST LIQUID LEVEL	H_{test} =	19.25	m
DESIGN SPECIFIC GRAVITY	G =	0.75	
SPECIFIC GRAVITY OF TEST LIQUID	Gtest =	1	
INTERNAL DESIGN PRESSURE	P =	0.588	kPa
EXTERNAL DESIGN PRESSURE	Dpext =	0.245	kPa
TESTING PRESSURE	P_t =	0.588	kPa

SHELL MATERIAL		A573 Gr.70	
MIN. TENSILE STRESS	Ft =	485	MPa
MIN. YIELD STRESS	Fy =	290	MPa
MAX. ALLOWABLE STRESS	Sd =	193	MPa
MAX. ALLOWABLE HYDROSTATIC TEST STRESS	St =	208	MPa
SHELL MATERIAL		A283 Gr.C	
MIN. TENSILE STRESS	Ft =	380	MPa
MIN. YIELD STRESS	Fy =	205	MPa
MAX. ALLOWABLE STRESS	Sd =	137	MPa
MAX. ALLOWABLE HYDROSTATIC TEST STRESS	St =	154	MPa
CORROSION ALLOWANCE	C.A =	1.5	mm (1st Course)
	C.A =	1.5	mm (Subsequent Course)

3.3 CALCULATION AND RESULT

Course	Course Height (m)	Material	Design Thickness		Hydrotest Thickness		tmin	tused
			Sd (MPa)	td (mm)	St (MPa)	tt (mm)	(mm)	(mm)
1	2.56	A573 Gr.70	193.00	17.74	208.00	20.09	20.09	21.00
2	2.56	A573 Gr.70	193.00	15.22	208.00	16.90	16.90	18.00
3	2.56	A573 Gr.70	193.00	13.07	208.00	14.25	14.25	15.00
4	2.56	A573 Gr.70	193.00	10.93	208.00	11.60	11.60	13.00
5	2.56	A573 Gr.70	193.00	8.80	208.00	8.97	8.97	10.00
6	2.56	A573 Gr.70	193.00	6.67	208.00	6.35	8.00	8.00
7	2.56	A283 Gr.C	137.00	5.83	154.00	5.06	8.00	8.00
8	2.58	A283 Gr.C	137.00	2.85	154.00	1.58	8.00	8.00
9								
10								
11								
12								
13								
14								
15								
16								

4 BOTTOM PLATE

4.1 BOTTOM PLATE THICKNESS

MIN. NOMINAL THICKNESS (AS PER API 650 ; PARA. 5.4.1) — $t_{b\ MIN}$ = 6.00 mm

CORROSION ALLOWANCE OF BOTTOM PLATE — CA_{btm} = 1.50 mm

MIN. BOTTOM PLATE THICKNESS AS PER API 650:

t_{b1} = 6.00 + 1.50 = 7.50 mm

MIN. BOTTOM PLATE THICK. REQUIRED BY CLIENT — t_{b2} = 8.00 mm

USED THICKNESS — $t_b = \max(t_{b1}, t_{b2})$ = 8.00 mm

4.2 ANNULAR BOTTOM PLATE THICKNESS (AS PER API 650 ; PARA. 5.5)

ANNULAR BOTTOM PLATE THICKNESS CALCULATION

PRODUCT STRESS

$$S_{td} = \frac{td - CA_{ba}}{t - CA_{ba}} \times Sd$$

S_{td} = 160.73 MPa

HYDROSTATIC TEST STRESS

$$S_{tt} = \frac{tt}{t} \times St$$

S_{tt} = 198.99 MPa

MAXIMUM STRESS IN FIRST SHELL COURSE

St = max (Std, Stt) — St = 198.99 MPa

WHERE:

1ST COURSE SHELL PLATE TH'KNESS	t =	21.00	mm
1ST COURSE SHELL DESIGN TH'KNESS	td =	17.74	mm
1ST COURSE SHELL HYDRO. TEST TH'KNESS	tt =	20.09	mm

MIN. ANNULAR BOTTOM PLATE TH'KNESS (AS PER API 650 ; TABLE 5 -1a) — $t_{ba\ MIN}$ = 7.00 mm

CORROSION ALLOWANCE — CA_{ba} = 1.50 mm

MIN. ANNULAR BOTTOM PLATE THICKNESS AS PER API 650:

t_{ba1} = 7.00 + 1.50 = 8.50 mm

MIN. ANNULAR BOTTOM PLATE THICKNESS REQUIRED BY CLIENT — t_{ba2} = 10.00 mm

USED ANNULAR BOTTOM PLATE THICKNESS — $t_{ba} = \max(t_{ba1}, t_{ba2})$ = 10.00 mm

4.3 ANNULAR BOTTOM PLATE MIN WIDTH (AS PER API 650 PARA. 5.5.2)

$$L_{a1} = 2 \times t_{ba} \times \sqrt{\frac{F_y}{2\Gamma GH}}$$ = 620.11 mm

WHERE:

G = 0.750 DESIGN SPECIFIC GRAVITY

MIN. RADIAL WIDTH OF ANNULAR BOTTOM PLATE L_{a2} = 600.00 mm
(AS PER API 650 PARA. 5.5.2)

MIN. RADIAL WIDTH OF ANNULAR BOTTOM PLATE L_{a3} = --- mm
REQUIRED BY CLIENT

$L_{a\,min} = \max(L_{a1}, L_{a2}, L_{a3})$ = 620.11 mm

USED WIDTH L_a = 1015 mm > $L_{a\,min}$ = 620.11 mm OK!

6 PRIMARY WIND GIRDER DESIGN (AS PER API 650; PARA. 5.9.6.1)

6.1 THE REQUIRED MINIMUM SECTION MODULUS OF PRIMARY WIND GIRDER IN cm^3

Z = (D^2 x H /17) x (V / 190)^2

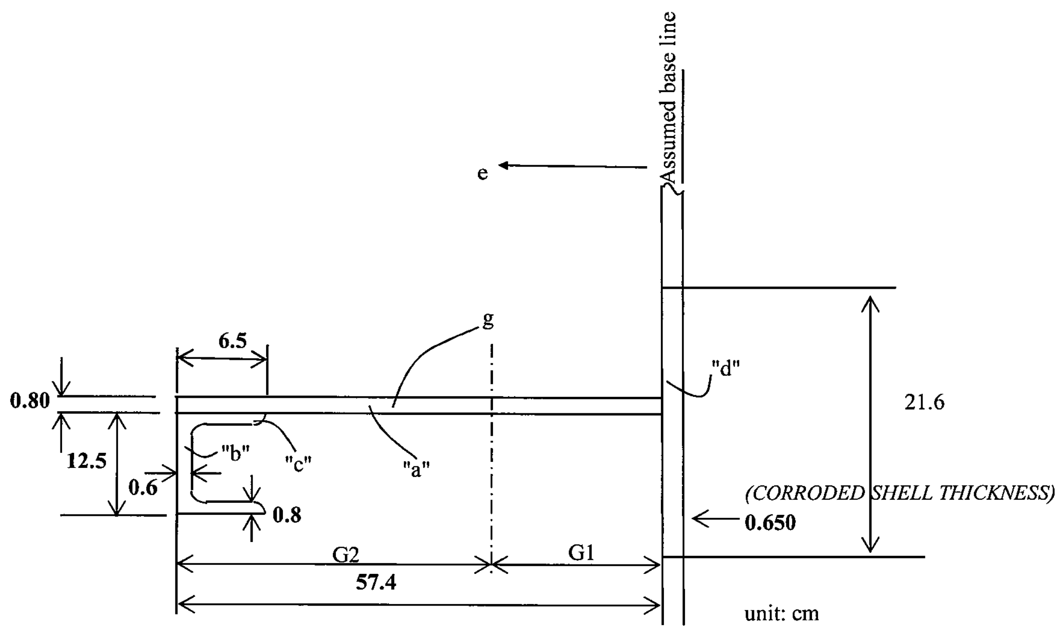
Where :

D = Inside diameter of tank	**45.00**	m
H = Height of tank	**20.50**	m
V = Design wind velocity	**36.00**	m/s
	129.60	km/h

Then , Zreq = 1,136 m3

6.2 THE PROVIDED SECTION MODULUS OF PRIMARY WIND GIRDER

TAKING THE DIMENSIONS OF THOSE IN FIGURE AND ACCORDING TO NOTATIONS BELOW, ACTUAL SECTION MODULUS OF PRIMARY WIND GIRDER, Zact IN cm^3



USED C-CHANNEL: C - 125 x 65 x 6/8

CORROSION ALLOWANCE CONSIDERED FOR SHELL PLATE: 1.50 mm

Notation :

"a", "b", "c", "d"= Denote each element of section.
A = Area of each element, in cm2
e = Distance to centroid of each element, in cm
g = Centriod of section
G1, G2 = Distance from centroid of section to extreme fibers, in cm
Is = Moment of inertia of each plane element with respect to vertical axis through its centriod , in cm4
I = Moment of inertia of total sections .
sum = Summation

Table: Section Modulus of Primary Wind Girder

	A	e	A*e	A*e^2	Is	A x G1^2
	(cm^2)	(cm)	(cm^3)	(cm^4)	(cm^4)	(cm^4)
"a"	45.9	29.4	1349.5	39674.1	12607.9	42321.3
"b"	7.5	58.5	438.8	25666.9	0.3	6915.2
"c"	10.4	54.8	569.9	31231.6	36.6	9589.1
"d"	14.0	0.3	4.2	1.3	0.5	12908.5
sum	77.8		2362.4	96573.9	12645.3	71734.1

G1 = sum (A x e) / sum(A) = 30.365 cm

G2 = 28.49 cm

I = sum (A x e^2) + sum (Is) - sum (A x G1^2)
= 37,485 cm^4

Zact = I / (greater G1 or G2)
= 1,234 cm^3 Zact>Zreq. OK

6.3 COMPARISON AND RESULT

SINCE Zreq = 1,136 cm^3 < Zact = 1,234 cm^3

THUS, THE PROVIDED PRIMARY WIND GIRDER IS ENOUGH.

7 STABILITY OF SHELL AGAINST WIND (AS PER API 650 ; PARA.5.9.7)

7.1 DESIGN DATA

ROOF TYPE ALUMINUM GEODESIC DOME ROC

DIAMETER OF TANK	D =	45.00	m
NOMINAL TOP SHELL THICKNESS	Tc =	8.00	mm
DESIGN WIND VELOCITY *(3 sec gust wind speed)*	V =	36.00	m/sec
	=	129.60	kph
DESIGN EXTERNAL PRESSURE	Pe =	25.00	mm H_2O
	=	0.245	kPa

7.2 SHELL TRANSFORMED HEIGHT (AS PER API 650 ; PARA. 5.9.7.2)

$$H_{TSi} = Hi * \sqrt{\left[\frac{ts_1}{t_{Si}}\right]^5}$$

$$H_{TS} = SUM\ (\ H_{TSi}\ )$$

WHERE, H_{TSi} ; TRANSFORMED WIDTH OF EACH SHELL (mm)

t_{s1} ; NOMINAL TOP SHELL COURSE THICKNESS (mm)

t_{si} ; NOMINAL SHELL THICKNESS (mm)

H_{TS} ; TOTAL TRANSFORMED WIDTH OF SHELL (mm)

Hi ; ACTUAL WIDTH OF EACH SHELL (mm)

TABLE 7.1 CALCULATION FOR TRANSFORMED SHELL HEIGHT

COURSE No.	Hi		t_{si}		t_{s1}		H_{TSi}	
1st	2,560	mm	21.00	mm	8.00	mm	229	mm
2nd	2,560	mm	18.00	mm	8.00	mm	337	mm
3rd	2,560	mm	15.00	mm	8.00	mm	532	mm
4th	2,560	mm	13.00	mm	8.00	mm	761	mm
5th	2,560	mm	10.00	mm	8.00	mm	1,465	mm
6th	2,560	mm	8.00	mm	8.00	mm	2,560	mm
7th	2,560	mm	8.00	mm	8.00	mm	2,560	mm
8th	2,580	mm	8.00	mm	8.00	mm	2,580	mm
9th								
10th								
11th								
12th								
13th								
14th								
15th								
16th								
	20,500	mm					11,024	mm

H_{TS} = 11,024 mm = 11.024 m

7.3 MIN. REQUIRED STIFFENER NUMBER.

$$H_{safe} = 9.47 * t \sqrt{\left(\frac{t}{D}\right)^3} \quad \left(\frac{190}{V}\right)^2$$

= 12.21 m

NUMBER OF INTERMEDIATE STIFFENER REQUIRED BASED ON H_{safe}

$$Ns + 1 = \frac{H_{TS}}{H_{safe}}$$

$$N_s = \frac{11.024}{12.21} - 1$$

= -0.10

No. OF STIFFENER = 'NIL' Nos. (at least)