Useful Calculation sheets (excel and mathcad files) for Design of Above Ground Storage Tanks

Item no	Title	Filetype
1	API 650- Storage Tank Design Calculation	Excel
2	Floating roof Storage Tank design as per API 650 including bleeder vent, roof drain and wight calculation	excel
3	Design of steel storage tanks- fixed roof with and without column	excel
4	Design Calculasion for fixed cone roof storage tanks	Excel
5	Foundation design of storage tanks	Excel
6	Seismiac base shear and overturning moment calculation for storage tanks	Excel
7	Dike Design for tank farm area	Excel
8	Cathodic Protection design calculations for fuel storage tanks	excel
9	API 650 Base Plate Design	Mathcad
10	API 650 Pipe Column Design	Mathcad
11	API 650 Rafter Design	Mathcad
12	API 650 Bleeder Vent Design	Mathcad
13	API 650 Internal Floating Roof Design	Mathcad
14	Shell Defelection and rotation due to nozzele forcess	excel
15	Basis for nozzle tank load check	Excel
16	Tank Pressure and Vacuum Protection calculation	excel
17	Tank heat loss calculation	excel
18	Material properties as per ASME III.1	excel

FIRST PAGE OF EACH CALCULATION FILES ARE AS BELOW:

Design of Storage Tanks

Project :	Design of Storage Tanks	Prepared:
Tank No:		Checked:
Date : :		Approved:
	API 650 11th Ed,June 2007,Add-2 Nov 2009	

Design Input Data

P	Design Int.pressure above atm	0.0 kPa	(0 psi) (0 mmWC)
Pex	Design External pressure	0.00 kPa	[Tank need not be designed for Ext.Press]
Ti	Design Internal temperature	65.00 °C	
Te	Design External temperature	47.00 °C	
	Working temperature	30.0 °C	
E	Joint efficiency	0.85	
D	Tank inside diameter	22.0 m	
H2	Height of tank shell	16.0 m	
H	Maximum design liquid level	16.000 m	
Ht	Test Liquid Level	16.000 m	
Vnom	Nominal capacity	6082 m³	
Vnet	Working capacity	6082 m³	
	Stored liquid	solution	
G	Specific gravity of the liquid	0.718	
Gins	Specific gravity of Insulation material	0.28	
CA	Corrosion allowance for shell	1.5 mm	
CAb	Corrosion allowance for bottom	0.0 mm	
CAr	Corrosion allowance for roof	0.5 mm	
thins	Insulation thickness	0.0 mm	

Materials

Shell Plate	IS2062GrB	Yield Stres:	250 MPa
		Tensile Stress :	410 MPa
Roof Plate	IS2062GrB	Yield Stress :	250 MPa
		Tensile Stress :	410 MPa
Bottom Plate	IS2062GrB	Yield Stress :	250 MPa
		Tensile Stress :	410 MPa
Top Angle/Stiffners	IS2062GrB	Yield Stress :	250 MPa
		Tensile Stress :	410 MPa

Shell courses details

	Shell Course Numbers		8 N°s	
W_1	Width of 1st shell course	Bottom	2000 mm	
W_2	Width of 2nd shell course		2000 mm	
W_3	Width of 3rd shell course		2000 mm	
W_4	Width of 4th shell course		2000 mm	
W_5	Width of 5th shell course		2000 mm	
W_6	Width of 6th shell course		2000 mm	
W_7	Width of 7th shell course		2000 mm	
W_8	Width of 8th shell course		2000 mm	Okay
W_9	Width of 9th shell course		0 mm	

STORAGE TANK DESIGN CALCULATION - API 650

1 .0 DESIGN CODE & SPECIFICATION

DESIGN CODE : API 650 11th Edition

1 .1 TANK

Item number	:	7061T-3901
Roof (Open/Close)	:	Close
Type of roof (Cone-roof / Dome-roof / Flat-roof / NA)	:	Floating Roof

1 .2 GEOMETRIC DATA

Inside diameter , Di (corroded) (@ 39,000 mm)	=	39,006	mm
Nominal diameter, Dn (new) (based on 1st shell course)	=	39,028	mm
Nominal diameter, Dc (corroded) (based on 1st shell course)	=	39,031	mm
Tank height (tan/tan), H	=	20,700	mm
Specific gravity of operating liquid , S.G. (Actual)	=	0.790	
Specific gravity of operating liquid , S.G. (Design)	=	1.00	
Nominal capacity , V	=	24736	m^3
Maximum design liquid level, HL	=	20,700	mm

1 .3 PRESSURE & TEMPERATURE

Design pressure	: Upper , Pu	(Atmospheric)	=	0.00	mbarg
	: Lower , Pl		=	0.00	mbarg Vac
Design temperature	: Upper , Tu		=	70	°C
	: Lower , Tl		=	-17	°C

1 .4 MATERIAL & MECHANICAL PROPERTIES

Component		Material	Tensile Stress St(N/mm²)	Yield Stress Sy(N/mm²)	Corrosion Allowance c.a.(mm)
PLATE					
Shell Plate	(Mat'l Code # 1) (bot)	A 516 GR. 65N	448.00	241.00	3.000
	(Mat'l Code # 2) (top)	A 516 GR. 65N	448.00	241.00	3.000
Annular Plate		A 516 GR. 65N	448.00	241.00	3.000
Bottom Plate		A 516 GR. 65N	448.00	241.00	3.000
Roof Plate		A 516 GR. 65N	448.00	241.00	3.000
STRUCTURE MEMBERS					
Roof structure (rafter,bracing,etc)		A 516 GR. 65N	448.00	241.00	3.00
Top Curb Angle		A 516 GR. 65N	448.00	241.00	3.00
Intermediate Wind Girder		A 516 GR. 65N	448.00	241.00	3.00

DESIGN OF STEEL STORAGE TANKS AS PER API-650

SELF-SUPPORTED CONE ROOF

DESIGN DATA

Service	HSD SERVICE	Allowable Design St
Capacity	21 KL	Allowable Test Stre
Type of tank	Self Supported Cone Roof	Specific Gravity of L
Dia of tank (feet)	10.004	Corrosion Allowance
Height of tank (feet)	9.512	
Slope of roof	1 : 5	
Slope of bottom	Flat Bottom	

Plate Data

Plate width (meter)	2.4390
Plate height (meter)	1.2195
Den. of mat. (Kg/m^3)	7850

INPUT
OUTPUT

SHELL

			By one foot method. See sec on page 3-7 of API - 6	
Course # from bottom of tank	Liq. height in tank (H) ft	Height of each Course mm	Design shell thickness (t_d) inches	Design shell thickness (t_d) mm
1	9.512	1219.512	0.126	3.211
2	5.512	1219.512	0.123	3.112
3	1.512	460.976	0.119	3.013

Note: According to sec. 3.6.1.1 min. thk.of tank of dia. <50ft should be 3/16 inches (4

Course # from bottom of tank	# of full plates in shell per course	Size of full plate in each course		# of partial plates in shell per course
		(Width) mm	(Height) mm	

CONTENTS:-

1) DESIGN DATA

Design Code	:	API 650, 10th Edition, Add.4 2005, Appendix F					
Client's Specs.	:	32-SAMSS-005, BD-407062 Rev.00C					
Fluid	:	FIRE / UTILITY / WASH WATER TANK					
Material	:	SA-516 Gr 70.					
Density of contents	D_L	=	1004.9	kg./m^3			
Specific gravity of contents	G	=	1.0049				
Material's yield strength	d_y	=	260	MPa			API 650 Table-3.2
Design Temperature	T	=	71	^{o}C			
Internal Pressure	Pi	=	0.747	Kpa	=	3.0	inch of water
External Pressure	Pe	=	0.245	Kpa	=	1.0	inch of water
High Liquid Level	H_l	=	8.560	m			
Design Liquid Level	H_L	=	9.000	m			
Allowable Design Stress at Design Temp.	Sd	=	173.00	MPa			API 650 Table-3.2
Allowable Test Stress for Hydrostatic Test Condition	St	=	195.00	MPa			API 650 Table-3.2
Corrosion allowance							
Bottom		=	3.20	mm			
Shell		=	3.20	mm			
Roof		=	3.20	mm			
Roof Supporting Structure		=	3.20	mm			
Slope of Tank Roof	θ	=	9.46	^{0}		1 : 6	
Outside dia. of tank	D_o	=	13.516	m			
Inside dia of tank	D_i	=	13.500	m			
Nominal dia. of tank	D	=	13.508	m	=	44.32	ft
Height of Shell	H	=	9.000	m			
Weight of roof attachments							
(platform, handrail, nozzles, etc.)	Wr	=	30.00	KN			
Weight of attachments (pipe clips, nozzles, etc.)	Ws	=	5.00	KN			
Weight of curb Angle	Wc	=	6.85	KN			
Design Wind Velocity	V	=	154	Km/hr			
Yield Strength of Steel Structure	Fy	=	250	M Pa	=	36.26	Ksi
Live Load on roof	L_r	=	1.2	Kpa			API 650 Sec. 3.2.1d

4- CALCULATION FOR TANK FOUNDATION

-	Item No.	TK-1601
-	Service	Oily Water Retention Tanks
-	Type	Concrete Ring Wall Foundation

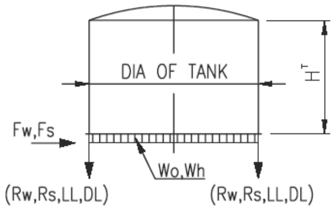
Document

-	Refer to Dwg.No.	8474L-015-DW-1743-626
-	Refer to G.A Dwg No.	RGX-D-87-1354-001

4.1- LOADING DATA

◉ FOUNDATION LOADING
○ WEIGHT SUMMARY

-	Dead Load, Shell, Roof, & Ext.Structure Loads	: D_L	14.37	kN/m
-	Live Load	: L_L	2.89	kN/m
-	Uniform Load, Operating Condition	: W_O	112.89	kN/m^2
-	Uniform Load, Hydrotest Load	: W_h	123.93	kN/m^2
-	Base Shear due to Wind	: F_W	80.71	kN
-	Reaction due to Wind	: R_W	2.09	kN/m
-	Moment Due to Wind	: M_W	533.15	kN-m
-	Base Shear due to Seismic Load	: F_S	807.26	kN
-	Reaction due to Seismic Load	: R_S	17.16	kN/m
-	Moment Due to Seismic Load	: M_S	4492.39	kN-m



4.2- TANK DATA

-	Diameter of Tank = D =	9.000	m
-	Bolt Center Dia = BCD =	9.174	m
-	Height of Tank = H^T =	12.000	m

4.3- MATERIAL SPECIFICATIONS

fy	420	MPa
fc'	28	MPa
$\gamma_{Concrete}$	24.00	kN/m^3
γ_{Steel}	78.40	kN/m^3
γ_{Soil}	18.00	kN/m^3
γ_{Water}	10.00	kN/m^3

4.4- SOIL CONDITION

Net Soil Bearing Capacity of Area

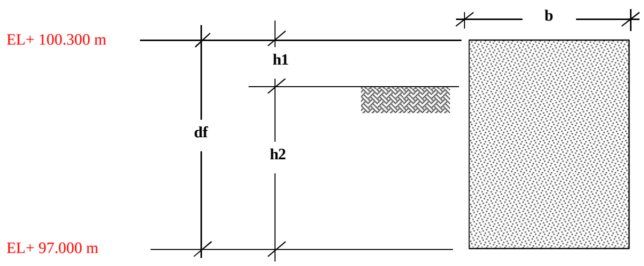
In normal operations: 250 kPa

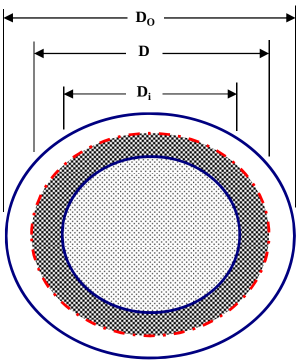
Coefficient of Lateral Soil Pressure

Angle of Internal Friction	ϕ =	30
Active soil pressure coefficient	Ka = tan² (45 - ϕ/2)	0.33
At rest soil pressure coefficient	Ko = 1 - sinϕ	0.50
Passive soil pressure coefficient	Kp = tan² (45 + ϕ/2)	3.00
Coefficient of friction	μ =	0.50

4.5- FOUNDATION OUTLINE

-	Top of Ringwall	EL +	100.300	m
-	Bottom of Ringwall	EL +	97.000	m
-	Unit Elevation	EL +	100.000	m





-	Width of Ring wall	b =	1.00	m
-	Height of Ringwall	df =	3.30	m
-	Soil Cover	h2 =	3.00	m
-	Projection	h1 =	0.30	m
-	Footing Outer Dia	Do = BCD + b	10.17	m
-	Footing Inner Dia	Di = BCD - b	8.17	m

SEISMIC BASE SHEAR AND OVERTURNING MOMENT

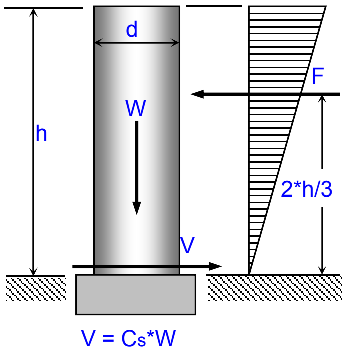
Per IBC 2006 and ASCE 7-05 Specifications

For Ground Supported Vertical Cylindrical Tanks, Vessels, and Stacks

Job Name:		Subject:			
Job Number:		Originator:		Checker:	

Input Data:

Occupancy Category =	IV		IBC 2006, Table 1604.5, page 281
Importance Factor, I =	1.50		ASCE 7-05 Table 11.5-1, page 116
Soil Site Class =	D		IBC 2006 Table 1613.5.2, page 303
Location Zip Code =	29607		
Spectral Accel., S_S =	0.352		ASCE 7-05 Figures 22-1 to 22-14
Spectral Accel., S_1 =	0.106		ASCE 7-05 Figures 22-2 to 22-14
Long, Trans. Period, T_L =	8.000	sec.	ASCE 7 Fig's. 22-15 to 22-20
Tank/Vessel Height, h =	30.000	ft.	
Tank/Vessel Diameter, d =	30.000	ft.	
Wall Thickness, t =	0.3750	in.	
Tank Mat'l. Unit Wt., ρ_t =	490	pcf	
Tank Elastic Modulus, E =	29000	ksi	
Roof Weight, W_r =	15.00	kips	
Shell Weight, W_s =	43.25	kips	
Bottom Weight, W_b =	10.82	kips	
Contents Unit Weight, ρ_c =	62.40	pcf	
Height of Contents, hp =	25.000	ft.	
Contents Weight, W_p =	1098.11	kips	
Liquid Contents?	Yes		
Structural System =	7a		Flat bottom, ground supported tanks - steel or fiber-reinforced - mechanically anchored (ASCE 7-05 Table 15.4-2)



Seismic Base Shear

Results:

Site Coefficients:

F_a =	1.518	IBC 2006 Table 1613.5.3(1), page 304
F_v =	2.375	IBC 2006 Table 1613.5.3(2), page 304

Maximum Spectral Response Accelerations for Short and 1-Second Periods:

S_{MS} =	0.535	$S_{MS} = F_a*S_S$, IBC 2006 Eqn. 16-37, page 303
S_{M1} =	0.252	$S_{M1} = F_v*S_1$, IBC 2006 Eqn. 16-38, page 303

Design Spectral Response Accelerations for Short and 1-Second Periods :

S_{DS} =	0.357	$S_{DS} = 2*S_{MS}/3$, IBC 2006 Eqn. 16-39, page 304
S_{D1} =	0.168	$S_{D1} = 2*S_{M1}/3$, IBC 2006 Eqn. 16-40, page 304

Seismic Design Category:

Category(for S_{DS}) =	D	IBC 2006 Table 1613.5.6(1), page 306
Category(for S_{D1}) =	D	IBC 2006 Table 1613.5.6(2), page 306
Use Category =	D	Most critical of either category case above controls

Fundamental Period:

T =	0.047	sec., T = 0.00000765*(h/d)^2*(W*1000/h*d/(t/12))^(1/2)
Rigid or Flexible?	Rigid	Criteria: If T < 0.06, then Rigid, else if T >= 0.06, then Flexible

Seismic Design Coefficients and Factors:

Response Mod. Coef., R =	3	ASCE 7-05 Table 15.4-2, page 163
Overstrength Factor, Ω_o =	2	ASCE 7-05 Table 15.4-2, page 163
Defl. Amplif. Factor, C_d =	2.5	ASCE 7-05 Table 15.4-2, page 163

(continued:)

Tank and Dike Work Book

Instructions and Notes

1 **Purpose:** This Excel Work Book was created to assist the Plant Layout Designer with a task that can be complicated, filled with potential error and take a lot of time. The goal is to reduce costs by reducing time and improving quality.

2 **Application:** This Work Book can be used for single tank within a single containment area or can be used for multiple tanks within a single containment area.

3 **Contents:** There are five (5) sheets included. Sheet "1 (this sheet) is the instructions and Notes. Sheet #2 is a list of some of the most common API Storage Tank sizes. Space is included so the user can record other sizes consistent with project specific requirements. Sheet #3 is the work sheet for the Single Tank application. Sheet #4 is the work Sheet for the multiple tank application. Sheet #5 is a two page work sheet: Page 1 is for the Dike Detail and page 2 is for the Tank Pad Detail.

4 **Tank Data:** A) Collect a list of Tanks for the Project. This list must include the sizes (in Barrels), the Tank Types and the Commodities. B) Determine if there is a Local or Client imposed Code that defines Grouping or separation of Tank types or Commodities. If there are Tanks on the project list that are not included on Sheet #2 then add them in the "Yellow" spaces provided and in this case only hit "Save".

5 **Civil/Structural Data:** Meet with the appropriate Civil/Structural Group and have them define preliminary guidelines for A) the Angle of Repose of the material to be used for the Dikes (Berms, Bungs, etc.), the recommended maximum height of the Dikes and for B) The proposed approach to Tank Pad profiles (Height and configuration).

6 **The Task:** Add the Dike Height and Angle of Repose data into Page 1 of Sheet #5. Add the Tank Pad height Data to Page 2 of Sheet #5

7 **For Single Tank Installation:** Use Sheet #3. Enter all the data required (and Optional) Data in the "Yellow" user entry boxes. The Form and the built-in formulas will do the work for you.

8 **For Multiple Tank Installation:** Use Sheet #4. Enter all the data required (and Optional) Data in the "Yellow" user entry boxes. The Form and the built-in formulas will do most of the work for you. With this grouping you must select and enter a choice for the "Width" of the Containment Area. This is a "Trial and Error" method until you get the shape that fits the project needs.

9 **Quitting and Closing:** It is recommended that before closing the program that Copies of all Sheets be printed out for all Tank configurations completed. When closing the program do not save the data. This will allow you to start with a clean Work Book for the next Tank configuration.

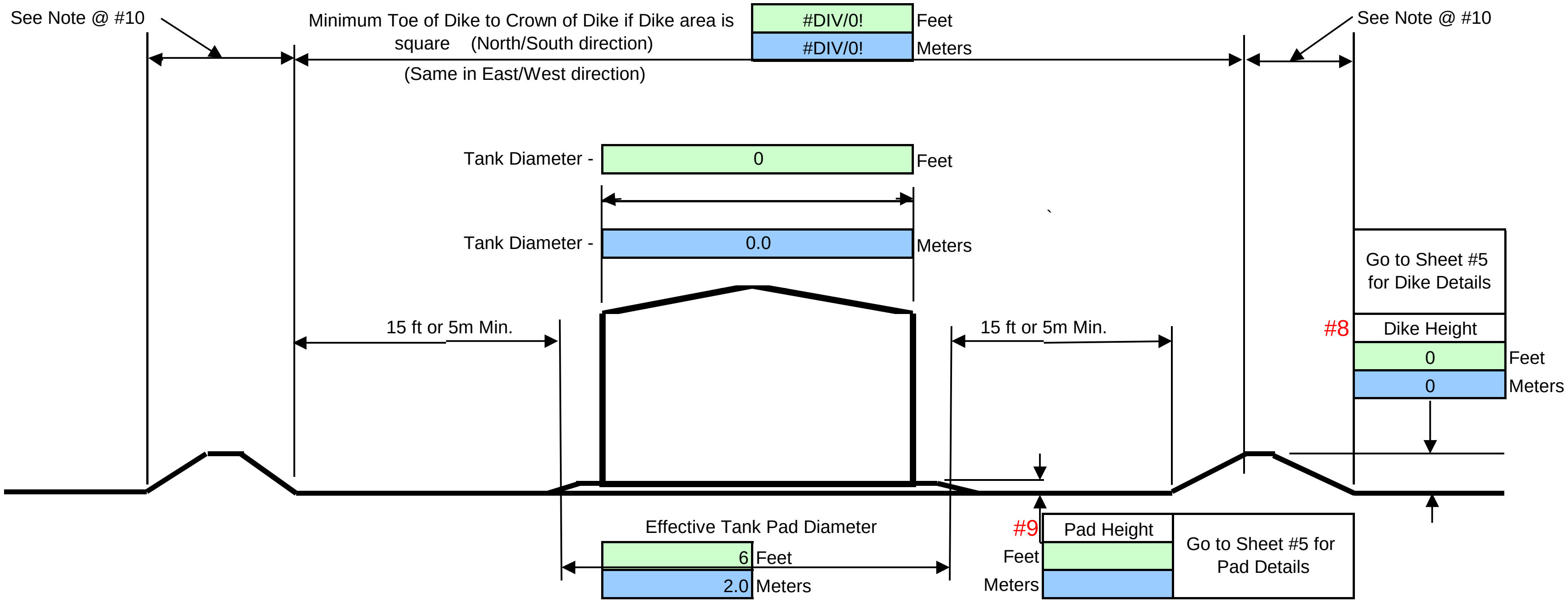
Note: Each Sheet of this Work Book is Password protected. In order to make a change to a "cell" that is not "Yellow" the Sheet must be "unprotected" using the password. This Password will be furnished on request.

Tank & Dike Calculation Sheet #1

Single Tank in Single Dike Area

The user only fills in data in the approprate "Yellow" boxes. No. 1, 2, 3, 4, 5 are optional, 6, 7, 8, 9 are required. The Answer is at #10

					#2 Tank Number		#3 By		#4 Date	
A		#1 Project -								
	Capacity						#7 Diameter		#5 Height (Information only)	
	Barrels	Gallons (US)	Gallons (UK)	Cubic Feet	Cubic Yards	Cubic Meters	Feet	Meters	Feet	Meters
B		0	0	0	0	0				
	#6		Volume (110%)	0		0				



Tank Pad		Dike Containment Area			
Pad Volume		Total Volume Required (*)	Minimum Dike surface area	**Min. Req'd Length/Width**	**#10**
0.00	Cubic Feet	0	#DIV/0!	**#DIV/0!**	Feet
0.00	Cubic Meters	0	#DIV/0!	**#DIV/0!**	Meters

(*) Total Volume required includes Tank contents plus Pad displacement volume.

Note: For Total Outside Toe to Outside Toe Dimension add dim "Y" & "Z" from Sheet #5

Design For Obove-Ground Fuel Tank

MOGAS Tank For Fuel Point		
Data		
Physical Dimensions		
Length	4	13.12
Hight	1.5	4.92
Width	2.25	7.38
Diameter		0
Structure Specs		
material Type	Steel	
Shape	Rectangular Prism	
Elyctrolyte		Soil
Electrolyte Resistivity	5000 ohm-centimeter	
Current		
Current Requirement	1	milli Amp
Total Current Requirment	**0.3953712**	**Amp**
Coating Resistance		
Resistance	2500 ohm per square foot	
Life Time		
Years	20	
Efficiency		
Percentage	80	
Anode Type	magnisium Alloy Anode	
Tank Surface Area	**36.75**	m^2
Tank Surface Area	**395.3712**	m^2

Design Steps
Soil Resistivity
Selecting Anode
Number of Anodes meets Groundbed resistance Limitations
Number of Anodes for Sys life expectancy
Number of Anodes to be used
Select Groundbed layout

Number of Anode

$$w = \frac{Y \times S \times I}{E}$$

w =	Waight		lb
Y =	Years		20
I =	Current Requirement		0.3953712
S =	pound per Ampere-year		8.8
E =	years		20
W=	**86.981664**		
No of Anodes	**5.1165685**	**6**	

Anode Specification			
Dimensions	3.75x3.75 x26		Inch
Weight	17 lb		
Package Weight	45 lb		
Package Size	6.5 x 29		

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Baseplate Design per API 650

A. Introduction

API 650 requires that the baseplates be designed per AISC or other approved standard. These baseplates are designed using the latest edition of AISC with temperature modification factors per API 650, Appendix M.

B. Geometry

Column diameter	Corrosion allowance		Baseplate thickness	
$d_c := 18 \cdot in$	$CA_b := 0 \cdot in$	$t_b := .25 \cdot in$	$t_{bp1} := 1.75 \cdot in$	$D_{bp} := 75 \cdot in$

C. Material Properties

Design temperature	Yield stength	Allowable Soil bearing pressure
$T_d := 350 \cdot °F$	$F_{ybp} := 36 \cdot ksi$	$Q_{sbc} := 3000 \cdot psf$

$$RF_{ys} := \begin{cases} RY1\left(\frac{T_d}{°F}\right) & \text{if } F_{ybp} \le 45 \cdot ksi = 0.87 \\ RY3\left(\frac{T_d}{°F}\right) & \text{if } F_{ybp} > 55 \cdot ksi \\ RY2\left(\frac{T_d}{°F}\right) & \text{otherwise} \end{cases}$$

Yield strength reduction factor for baseplate design per **API 650, Appendix M**

$RF_{ys} = 0.87$

Poisson's ratio

$v := 0.3$

☑ Bottom Participation Allowed

D. Loading

$P_c := 100000 \cdot lbs$ Total load at base of column

$\Omega_{bp} := 1.67$ Safety factor for baseplate design

Pipe Column Design per API 650

A. Introduction

API 650 requires that the columns be designed per AISC or other approved standard. These columns are designed using the latest edition of AISC with temperature modification factors per API 650, Appendix M.

B. Geometry

Column diameter

$d_c := 18 \cdot in$

Column thickness

$t_c := .375 \cdot in$

Corrosion allowance

$CA_{rc} := 0 \cdot in$

Length of column

$L_c := 50 \cdot ft$

Effective length factor

$K := 1.0$

C. Material Properties

Design temperature

$T_d := 350 \cdot °F$

Yield stength

$F_{yc} := 35 \cdot ksi$

$$RF_{ys} := \begin{cases} RY1\left(\frac{T_d}{°F}\right) & \text{if } F_{yc} \le 45 \cdot ksi = 0.87 \\ RY3\left(\frac{T_d}{°F}\right) & \text{if } F_{yc} > 55 \cdot ksi \\ RY2\left(\frac{T_d}{°F}\right) & \text{otherwise} \end{cases}$$

Yield strength reduction factor for column design per **API 650, Appendix M**

$RF_{ys} = 0.87$

$$E_c := EST\left(\frac{T_d}{°F}\right) = 28000000.00\,psi$$

Modulus of elasticity with temperature modification per **API 650, Appendix M**

D. Loading

$P_c := 30000 \cdot lbs$ — Total load at base of column

$M_c := 10000 \cdot ft \cdot lbs$ — Moment on column

$\Omega_c := 1.67$ — Safety factor for column design

Rafter Design per API 650

A. Introduction

API 650 requires that the structural rafters be designed per AISC or other approved standard. These rafters are designed using the latest edition of AISC with temperature modification factors per API 650, Appendix M. API 650 requires that rafters not use roof plate for lateral support when considering the roof plate loads only. When considering the total load with live load and other dead loads included, the roof plate may be considered as effective in bracing the compression flange of the rafter (per API 650).

B. Geometry

Beam Selection (W or C shapes)

W12X16 / W310X23.8
W5X16 / W130X23.8
W6X16 / W150X24
W10X17 / W250X25.3

(•) Internal Rafter
( ) External Rafter

Radius to outside rafter connection: $R_o := 50 \cdot ft$

Radius to inside rafter connection: $R_I := 4 \cdot ft$

Number of rafters in bay: $N_{rb} := 50$

Number of lateral braces: $N_{bt} := 4$

Roof slope: $RS := .75 \cdot \frac{in}{ft}$

Thickness of roof: $t_r := .1875 \cdot in$

Effective Span of rafter: $L_B := R_o - R_I = 46.00\,ft$

C. Material Properties

Yield Strength: $F_{yB} := 50 \cdot ksi$

Safety factor required per AISC 360: $\Omega_b := 1.67$

Rafter Design (AISC 360-05)

D. Rafter Loadings

Ground snow load: $SL_g := 25 \cdot psf$

Balanced snow load on roof: $SL_b := 0.84 \cdot SL_g = 21.00 \cdot psf$

Roof live load: $LL_r := 20 \cdot psf$

Additional roof dead load: $DL_{misc} := 1.5 \cdot psf$

External pressure: $P_{ext} := 5.2 \cdot psf$

Design temperature: $T_d := 350 \cdot °F$

Venting Inputs

Venting Capacity

A. Introduction

This program designs bleeder vents for steel internal or external floating roofs for above ground storage tanks.

B. Tank Information

Fill rate

$Q_{in} := 7500 \cdot bph$

Suction rate

$Q_{out} := 7500 \cdot bph$

Floating roof deck thickness

$t_d := .1875 \cdot in$

Number of bleeder vents

$N_{vent} := 1$

Inside diameter of bleeder vent

$d_v := 8 \cdot in$

Outside diameter of sleeve

$d_{slv} := 3.5 \cdot in$

Opening height of bleeder vent

$H_{open} := 5 \cdot in$

Percentage of open area

$RF := 95\%$

Flow coefficient

$C_{OF} := .55$

$P_P := t_d \cdot \gamma_s$ $\quad P_P = 1.47 \cdot inH2O$ Driving pressure when filling

$P_V := 12.5 \cdot psf$ $\quad P_V = 2.40 \cdot inH2O$ Driving pressure when withdrawing

$$A_{vent} := \min\left(\begin{bmatrix} \frac{\pi}{4} \cdot \left(d_v^{\,2} - d_{slv}^{\,2}\right) \cdot RF \cdot N_{vent} \\ \pi \cdot d_v \cdot H_{open} \cdot N_{vent} \end{bmatrix}\right)$$

Total venting area provided

$A_{vent} = 38.61 \cdot in^2$

Venting Inputs

Vent Results

Internal Pontoon Floating Design

A. Introduction

This program designs pontoon floating roofs to the requirements of API 650, Appendix H (internal roofs)

Design methodologies are as follows:

1. Pontoon ring is designed using section properties determined in accordance with the AISI Cold-Formed Steel Design Manual (accounts for local buckling of plates with large width to thickness ratios)
2. Floating roof legs are designed in accordance with AISC 360, Latest Edition for loads listed in API 650, Appendix H.
3. Deck stresses and deflections are determined in accordance with the paper: "Stresses in Ruptured Floating Roofs", H.I. Epstein and J.R. Buzek, *1978 ASME Journal of Pressure Vessel Technology*.
4. Pontoon ring is modeled as a ring on elastic foundation.
5. Ponton ring strength is evaluated in accordance with AISI Cold-Formed Steel Design Manual.

B. Pontoon Geometry

Diameter
$D := 220 \cdot ft$

Rim space
$S_{rim} := 8 \cdot in$

Pontoon width
$W_{pon} := 12 \cdot ft$

Height of inner rim
$H_{ir} := 30 \cdot in$

Height of outer rim
$H_{or} := 30 \cdot in$

Width of inner rim extension
$W_{iExt} := 0 \cdot in$

Width of outer rim extension
$W_{oExt} := 0 \cdot in$

Height of outer rim extension
$H_{oExt} := 3 \cdot in$

Backslope
$BS := 0 \cdot in$

Cover slope
$CS_{min} := -.1875 \cdot \frac{in}{ft}$

Deck thickness
$t_d := .1875 \cdot in$

Cover thickness
$t_c := .1875 \cdot in$

Bulkhead thickness
$t_{bh} := .1875 \cdot in$

Inner rim thickness
$t_{ir} := .75 \cdot in$

Outer rim thickness
$t_{or} := .75 \cdot in$

Suggested number of bulkheads
$$\frac{(D - 2 \cdot S_{rim}) \cdot \pi}{17.75 \cdot ft} = 38.70$$

Suggested number of posts per rafter
$$\mathrm{floor}\left(\frac{W_{pon}}{6 \cdot ft}\right) = 2.00$$

Rafters per Pontoon
$N_{rp} := 2$

Number of bulkheads
$N_{bh} := 40$

Posts per Rafter
$N_{pp} := 2$

Spacing of weld to rafter
$S_{wr} := 12 \cdot in$

Length of weld per spacing
$L_{wr} := 2 \cdot in$

Weld size for cover to rafter connection
$t_{wr} := .1875 \cdot in$

○ Angle Rafters
◉ Channel Rafters

Angle Rafter
- L2X2X3/16 / L51X51X4.8
- L2-1/2X2X3/16 / L64X51X4.8
- L2-1/2X2-1/2X3/16 / L64X64X4.8
- L3X2X3/16 / L76X51X4.8

Channel Rafter
- C3X4.1 / C75X6.1
- C4X4.5 / C100X6.7
- C3X5 / C75X7.4
- C4X5.4 / C100X8

BASIS FOR TANK NOZZLE LOAD CHECK AS PER API650-P3

AT NOZZLE OF D-002	
LOAD CASE	OPER. AT MAX. DESIGN TEMP.

INPUT

1) GEOMETRICAL INPUT

TANK DIAMETER, D =	32020	mm
TANK SHEEL THICKNESS, ts =	10	mm
NOZZLE OUTSIDE DIAMETER, d =	168.275	mm
NOZZLE NECK THICKNESS, tn =	12.7	mm
REINFORCEMENT PAD THICKNES, tr =	12.7	mm
NOZZLE LOCATION FROM BOTTOM, l =	275	mm
MATERIAL =	A36	
ALLOWABLE DESIGN STRESS, Sd =	160	MPa

2) LOAD INPUT

2a) SUSTAINED LOAD

RADIAL THRUST, F_R =	44	N
TRANSVERSE SHEAR FORCE, V_C =	-30	N
LONGITUDINAL SHEAR FORCE, V_L =	-958	N
TORSIONAL MOMENT, M_T =	5.30E+04	N-mm
CIRCUMFERENTIAL MOMENT, M_C=	1.00E+03	N-mm
LONGITUDINAL MOMENT, M_L =	-1.10E+04	N-mm

2b) THERMAL LOAD

RADIAL THRUST, F_R =	-8761	N
TRANSVERSE SHEAR FORCE, V_C =	1479	N
LONGITUDINAL SHEAR FORCE, V_L =	3793	N
TORSIONAL MOMENT, M_T =	-1.98E+06	N-mm
CIRCUMFERENTIAL MOMENT, M_C=	2.77E+05	N-mm
LONGITUDINAL MOMENT, M_L =	8.61E+06	N-mm

CALCULATION FOR GEOMETRIC

u =	$(d/D) \times (D/t)^{0.5}$	
	0.20	
d/tn =	13	
B =	$2(Dxt)^{0.5}$	
	1705	
h =	L/B	
	0.16	
t/tn =	1.787401575	
z =	(h+0.5)/1.5	from Fig. P-11
	0.66	

STRESS FACTOR

Based on d/tn & t/tn user need to do interpolation as per the appropriate table attached

LOAD	STRESS FACTOR	VALUE
FR	f_r	2.24293374
FR	f_θ	1.304759646
MC	f_r	1.649571821
MC	f_θ	1.171710421
ML	f_r	1.63916237

Product Form

- (•) Plate
- ( ) Forgings
- ( ) Pipe
- ( ) Tube
- ( ) Bar
- ( ) Fitting
- ( ) Cast

Select first the Product Form before looking for the material specification.

Plate

SA-204	316H
SA-225	316H
SA-240	316L
SA-283	316L
SA-285	316LN

TABLE 1A
MAXIMUM ALLOWABLE STRESS VALUES *S* FOR FERROUS MATERIALS AT DESIGN TEMPERATURE
(Materials Permitted on ASME Sec. VIII-1 Only)

Remarks:

Heat-Resisting Stainless Steel..Low Carbon

REMARKS;
*1) Rimmed Steel
ASME SEC.II SA-6/SA-6M
para.3.6-Steel containing
oxygen to give a continous
evolution of carbon monoxide
while the ingot is solidifying,
resulting in a case or rim of
of metal virtually free of voids.

ASME 2001

Design Temperature			
90	°C	194	°F

Allowable Stress at Design Temp.			
Stress	16.7	115.14	1174.1
	ksi	Mpa	kg/cm^2

Nominal Composition
16Cr - 12Ni - 2Mo

Mi. Strength			
Tensile	70	482.63	4,922
Yield	25	172.37	1,758

Spec No	Type/Grade
SA-240	316L

Alloy Design / UNS
S31603

Applic. & Max. Temp.(deg.F / NP)	
Limits on Section I	850
Limits on Section II	800
Limits on Sec.VIII-1	850

ASME Locator

Addenda	Page	Line
01	66	11

Class / Cond / Tempe

Applicable Notes									
G5	G42								

Ext.Chart.No.	Tick(in)	P-No.	G-No.
HA-4	0	8	1

SCROLL DOWN to view Notes or use "FIND" {Ctrl.+F} command in "EDIT" menu.

General Notes

(a) The following abbreviations are used: Applic., Applicability; Cond., Condition; Desig., Designation; Smls., Seamless; and Wld., Welded.

(b) The stress values in this Table may be interpolated to determine values for intermediate temperatures.

(c) When used for Section III Class MC design, the stress values listed herein shall be multiplied by a factor of 1.1 (NE-3112.4); these values shall be considered as design stress intensities or allowable stress values as required by NE-3200 or NE-3300, resp

(d) For Section VIII applications, stress values in restricted shear such as dowel bolts or similar construction in which the shearing member is so restricted that the section under consideration would fail without reduction of area shall be 0.80 times the va

(e) For Section VIII applications, stress values in bearing shall be 1.60 times the values in the above Table.

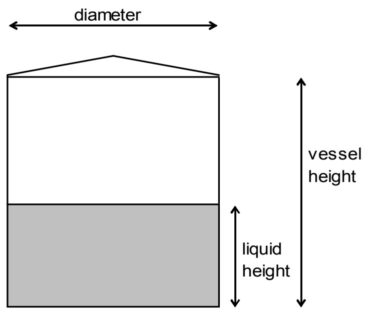
(f) Stress values for -20 to 100oF are applicable for colder temperatures when toughness requirements of Section III or Section VIII are met.

G5 Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The

G42 For Section I, use is limited to PEB-5.3. See PG-5.5 for cautionary note.

Ambient Heat Loss from a Vessel

This tool calculates the ambient heat losses from a vertical vessel.



Vessel Dimensions

Tank diameter	(ft)	**50**
Vessel height	(ft)	**48**
Liquid height	(ft)	**30**
Sidewall insulation thickness	(inches)	**1.5**
Roof insulation thickness	(inches)	**0**

Ambient Conditions

Ambient temperature	(°F)	**35**
Wind speed	(mph)	**10**

Liquid Properties

Temperature	(°F)	**55**
Liquid specific heat	(BTU/lb/°F)	**0.6**
Liquid viscosity	(Centipoise)	**40**
Liquid thermal conductivity	(BTU/hr/ft/°F)	**0.12**
Liquid density	(lb/ft^3)	**46.8**
Liquid coeff of thermal expansion	(/°F)	**1.00E-06**

Vapor Properties

Vapor specific heat	(BTU/lb/°F)	**0.25**
Vapor viscosity	(Centipoise)	**0.0175**
Vapor thermal conductivity	(BTU/hr/ft/°F)	**0.015**
Vapor density	(lb/ft^3)	**0.08**
Vapour coeff of thermal expansion	(/°F)	**0.002**

RESULTS

Location	**Area (ft^2)**	**Heat Loss (BTU/hr)**
Dry Wall	2,827	6,320
Wet wall	4,712	18,130
Roof	1,967	2,717
Bottom	1,963	1,157
Total	11,471	**28,324**

Yellow fields are input
Red fields are results
*** These calculations are provided for educational use only - USE AT YOUR OWN RISK.**

Assumptions
1. Roof slope = 0.75 inch/ft
2. Thickness of metal sidewalls and roof = 0.1875 inches
3. Thermal conductivity of metal sidewalls and roof = 26 BTU/Hr-ft-°F
4. Insulation Type = cellular glass
5. External surface has white paint with emmissivity = 0.9
6. Dirt factor for dry sidewall = 0.001 ft^2.hr.°F/BTU
7. Dirt factor for wet sidewall = 0.00125 ft^2.hr.°F/BTU
8. Dirt factor for bottom = 0.002 ft^2.hr.°F/BTU
9. Dirt factor for bottom = 0.002 ft^2.hr.°F/BTU
10. Dirt factor for roof = 0.001 ft^2.hr.°F/BTU
11. Atmospheric pressure = 14.7 psia
12. Ground Temperature = 5°F above ambient temperature
13. Thermal Conductivity of ground = 0.8 BTU/Hr/ft/°F
14. Specific heat of air = 0.25 BTU/lb/°F
15. Viscosity of air = 0.0175 Centipoise

Tank Pressure & Vacuum Protection

Design Sheet

Stored Material	Crude Oil		
Flash Point	^oF	350	(Estim.)
Boiling Point	^oF	360	(Estim.)
Latent Heat Vap.	Btu/lb	144	(Hexane)
Molecular Wt.		274	

Tank

MAWP
Max Vacuum
Diameter
Max fill Height
Max fill Volume
Wetted Area

Inflows, SCFH

Normal Operation	12,861
Relief Scenario	**20,578**

Fire

Therm. Conductivity
Required Capacity

Outflows, SCFH 40,104

Blow Through

From Upstream
From Hose
Relief, Hose +unload

Breathing, Note 1

Out	SCFH	6,295
In	SCFH	10,491

Vent Valve set at 4 **in WC** Consider this when using emission vapor contro

Required	SCFH	NA	Normal max inflow + out breathing + Blowoff (no
selected	SCFH	NA	With vent system Pressure Drop of 9 in WC
Fail Open	SCFH	0	Consider this only if the tank vents to a vacuum

Blanket Gas Valve set at 2" WC

Required	SCFH	**50,595**	sum of outflows + in Breathing + fail open vent v
Selected	SCFH	**75,893**	Fisher Model ___ Regulator with ___" trim.
Valve Fail Open	SCFH	**0**	This flowrate assumes the valve's Cv determine:

Pressure Relief Cases

Inflow	SCFH	**102,766**	Relief Inflow + Out Breathing + Blanket Gas Valv
Fire	SCFH	**877,654**	Fire + Blanket Gas valve
Outflow	SCFH	**50,595**	sum of outflows + in Breathing + fail-open vent v

Conservation Vent

Pressure side set at		5	in WC, Rated at	**20**	in WC
Required	SCFH	**0**	zero (if have Vent Valve and Emergency vent) o		
Selected Size	SCFH	44,000	each from catalog; total number	1	
Vacuum Side set at 0.5 oz/in^2 Vacuum, rated at			**2 1/2**	oz/in^2	
Required	SCFH	**50,595**	Outflow Case		
Selected Capacity	SCFH	**15,000**	each from catalog; total number	1	

Emergency Relief, Note 2

Set at	**10**	in WC, Rated at	**20**	in WC	
Required	SCFH	**833,654**	zero (if Con vent has capacity) or Worst case - C		
Selected Size	SCFH	**680,000**	each from catalog; total number	1	

Selected Equipment:

	Tag	Manufacturer	Model
Blanket Gas Regulator	PCV 400B	Fisher	1190
Conservation Vent	PVSV 400		
Emergency Vent			

Notes:

1) For Tanks larger than 840,000 gal (20,000 Bbls), refer to API-2000 for breathing requirem