Project Eveler

Coastal Pacific Food Distributors
322 Valley Avenue Northwest, Puyallup, Washington, US, 98371

PRCA20240398 - Revision (Water Tank)

Calculations required to be provided by the Permittee on site for all Inspections

To 1 reviewer

From

Magnus Neil
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CST Fire Water Tank Calcs

Jul 9, 2024

Awaiting review - 0/1 reviews complete

Submittal no.	Version	Spec section	Due date
000-02	1	-	Jul 23, 2024

Included items

No items

Reviewers

0/1 complete

Reviewer	Review response	Date Reviewed
Magnus Neil	Awaiting review	-

City of Puyallup
Building
REVIEWED FOR COMPLIANCE
BSnowden
09/13/2024
8:33:21 AM

CONFORMANCE WITH THE DESIGN CONCEPT AND GENERAL COMPLIANCE WITH THE CONTRACT DOCUMENTS. THIS REVIEW IN NO WAY RELEASES THE SUBCONTRACTOR/SUPPLIER FROM THEIR RESPONSIBILITY TO ADHERE TO THE REQUIREMENTS OF THE CONTRACT DRAWINGS. INCLUDING ALL DIMENSIONS & QUANTITIES.

REVIEWED

REVIEWED AS NOTED

NOT APPROVED

CORRECT & RESUBMIT

WHITING-TURNER

W-T SUBMITTAL NO. 000-02
THE WHITING-TURNER CONTRACTING COMPANY

BY Magnus Neil DATE 7/9/2024

City of Puyallup
Development & Permitting Services
ISSUED PERMIT
Building | Planning
Engineering | Public Works
Fire | Traffic

APPROVED
Khiem Huynh , 5/20/2024 ,3:22:53 PM

Design Calculations For a Bolted Liquid Storage Tank

Customer	: Coastal Pacific Food Distributers
Sales Order	: 100068_001
Project	: Puyallup, WA
Tank Diameter	: 29.709 Ft (9.055 m)
Tank Height	: 22.000 Ft (6.706 m)
Freeboard	: 4.540 Ft (1.384 m)
Liquid Height	: 17.460 Ft (5.322 m)
Liquid Stored	: Fire Protection Water
Specific Gravity	: 1.00
Tank Capacity	: 90546 Gallons (342754 Liters)
Design Standard	: AWWA D103-2019/NFPA 22-2023
Wind Design	: IBC 2018/2021 w ASCE 7-16
Wind Velocity	: 120 Mph (193 Kph)
Exposure	: C
Risk Cat. Wind	: 4.00
Deck Live Load	: 25 Psf (1.20 kPa)
Seismic Design	: IBC 2018/2021/AWWA D103-19
Ss	: 127.00 %
S1	: 43.70 %
Seismic Design Category	: D
Site Class	: Ddef
Importance Factor Ie	: 1.50
Design Method	: Allowable Stress Design

Wind Design Note:

Tank is designed in strict accordance with AWWA D103-09 or AWWA D103-19. ASCE7-16 and IBC 2018/2021 environmental values are utilized in determining the dynamic loads. Specific exceptions are incorporated in providing the submittal in accordance with AWWA D103

Vertical Seam Bolt Loadings

Liquid Pressure (Psf) = Liquid Depth (Ft.) x Specific Gravity x 62.428 (Pcf)
Hoop Force (#/Ft.) = Liquid Pressure x Tank Radius (Ft.)
Bolt Load (lbs) = Hoop Force / 6 Bolts per Ft.

Ring	Liquid Depth	Bolt Load
1	17.46	2699
2	9.40	1453
3	1.34	207

WIND LOAD (At Tank Base)

Ref. ASCE 7-16

Tank Dia. (D)	= 29.709 Ft	qz	= Pv*Kz
Tank Ht. (h)	= 22.000 Ft	Pv	= LF * 0.00256 * Kd * Kzt * Ke *(V^2)
Velocity	= 120 Mph	F'	= (Pv * Kz) * G * Cf >= 18 psf **Where F' is the applied wind pressure.
Risk Cat. Wind	= 4	Af	= Ht * D
Exposure	= C	F	= F' * Af
ASD Load Factor (LF)	= 0.6	OTM	= F * h
Structure Ht.	= 0.00 Ft		
G	= 0.85		
Kzt	= 1.00		
Kd	= 1.00		
Ke	= 1.00		
Pv	= 22.12 Psf		
h/D	= 0.74		
Cf	= 0.63		

Analyzed Height (Ft)	Ht. From Grade (Ft)	Kz	F' (psf)	Af (Sq.Ft)	F (LBs.)	h (Ft)	OTM (Ft-Lbs)
15.00	15.00	0.85	18.00	446	8021	7.50	60161
5.00	20.00	0.90	18.00	149	2674	17.50	46792
2.00	22.00	0.92	18.00	59	1070	21.00	22460

Total Base Shear = Sum of the Forces (F) >= 11765 Lbs

Total Overturning Moment At Tank Base = Sum of the OTMs >= 129412 Ft-Lbs

WIND LOAD PER RING

Ref. ASCE 7-16

Tank Dia. (D)	= 29.709 Ft	qz	= Pv*Kz
Tank Ht. (h)	= 22.000 Ft	Pv	= LF * 0.00256 * Kd * Kzt * Ke *(V^2)
Velocity	= 120 Mph	F'	= (Pv * Kz) * G * Cf >= 18 psf **Where F' is the applied wind pressure.
Risk Cat. Wind	= 4	Af	= Ht * D
Exposure	= C	F	= F' * Af
ASD Load Factor (LF)	= 0.6	OTM	= F * h
Structure Ht.	= 0.00 Ft	EVL	= 4 * OTM / D
G	= 0.85		
Kzt	= 1.00		
Ke	= 1.0		
Pv	= 22.12 Psf		
h/D	= 0.74		
Cf	= 0.63		

Individual Ring Ht. (Ft)	Total Height (Ft)	Base Shear (Lbs)	OTM (Ft-Lbs)	EVL (Lbs)
8.06	22.00	11765	129412	17424
8.06	13.94	7455	51958	6996
5.88	5.88	3144	9245	1245

Seismic Design
IBC 2018/2021 / AWWA D103-19
General Procedure

Ss = mapped maximum considered earthquake spectral response acceleration at 0.2 sec period
S1 = mapped maximum considered earthquake spectral response acceleration at 1 sec period
Sms = maximum considered earthquake spectral reponse acceleration at 0.2 sec period
Sm1 = maximum considered earthquake spectral reponse acceleration at 1 sec period
Fa = short period site coefficient
Fv = long period site coefficient
g = acceleration of gravity
Sds = design earthquake spectral response accleration at 0.2 sec period
Sds = design earthquake spectral response accleration at 1 sec period
U = scaling factor = 2/3
Sai = design spectral response acceleration for impulsive components at the natural period of the structure Ti
Sac = design spectral response acceleration for convective the component at the first sloshing wave period Tc
= sloshing wave period Tc
Ti = natural period of the structure
TL = region dependent transition period for longer period ground motion
Ts = Sdi / Sds
K = damping scaling factor = 1.5
Tc = first mode sloshing wave
Ai = impulsive deign acceleration
Ac = convective design acceleration
AvLow = non-buckling vertical design acceleration
AvHigh = buckling stress vertical design acceleration
Ri = response modification factor for the impulsive component
Rc = response modification factor for the convective component

$$Ms = \{[Ai (Ws Xs + Wr Ht + Wi Xi)]^2 + [Ac Wc Xc]^2\}^{0.5}$$

$$Vf = \{[Ai (Ws + Wr + Wf + Wi]^2 + [Ac Wc]^2\}^{0.5}$$

Ms = design overturning moment at the bottom of the shell caused by horizontal
= design acceleration
Ws = total weight of the tank shell
Wr = total weight of tank roof
Wi = weight of effective mass of the tank comtents that moves in unison with the tank shell
Wc = weight of effective mass of the first mode sloshing contents of the tank
Xs = height from the bottom of the shell to the center of gravity of the shell
Ht = total height of the shell
Xi = total height from the bottom of the shell to the centroid of the effective
= impulsive weight
Xc = total height from the bottom of the shell to the centroid of the effective
= compulsive weight
Vf = design shear at the bottom of the tank shell due to horizontal design acceleration
Wf = total weight of the tank bottom
J = overturning ratio = Ms / (D^2 [wt (1 - 0.4AvLow) + wL])
= If J < 0.785 there is no uplift
= If 0.785<=J<=1.54 there is uplift but the tank is stable
= If J > 1.54 the tank is not stable
wt = weight of the tank shell and portion of the roof reacting on the shell = (Ws/Pi D)+Wrs
Wrs = total weight of the tank roof acting on the shell
wL = maximum resisting weight of tank contents = 7.9 tb (Fy H G)^0.5 <= 1.25 H D G
tb = tank bottom thickness
Fy = bottom yield stress
ts = tank shell thickness
sigma c = maximum longitudinal shell compression stress
sigma c = [wt(1 + 0.4AvHigh) + (1.273 Ms / D^2)] (1 / 12ts) If J < 0.785 or Anchored Tank
sigma c = [((wt(1 + 0.4AvHigh) + wL) / (0.607 - 0.18667 J^2.3)) - wL] (1/12ts) If 0.785<=J<= 1.54

Seismic Design
IBC 2018/2021 / AWWA D103-19

Ss	= 127.00 %g	ASCE 7-16 Fig 22-1	S1	= 43.70 %g	ASCE 7-16 Fig 22-1
Sms	= Fa * Ss = 1.524	AWWA Eq 14-1	Sm1	= Fv * S1 = 0.814	AWWA Eq 14-2
Fa	= 1.20	ASCE 7-16 Tab 11.4-1	Fv	= 1.86	ASCE 7-16 Tab 11.4-2
Sds	= U * Sms = 1.016	AWWA Eq 14-3	Sd1	= U * Sm1 = 0.543	AWWA Eq 14-4
U	= 2/3	AWWA Sec 14.2.6.3	U	= 2/3	AWWA Sec 14.2.6.3

Risk Cat. Seismic	= 4	ASCE 7-16 Table 1.5-1
Ie	= 1.50	(Table 2)
Site Class	= Ddef	ASCE 7-16 CH. 20
Ri	= 3.00	AWWA Table 5
Rc	= 1.50	AWWA Table 5

14.2.7.3.1 Design Response Spectrum For Impulsive Components

For 0<= Ti <= Ts	Sai = Sds	= 1.016 g	AWWA Eq 14-5
For Ts <= Ti <= TL	Sai = Sd1 / Ti <= Sds	= N/A g	AWWA Eq 14-6
For Ti > TL	Sai = TL Sd1 / Ti^2	= N/A g	AWWA Eq 14-7
	Ti = Natural Period of Structure	= 0.00 sec	AWWA Sec 14.3.1
	(Ti is very small and is assumed to be zero for the general procedure (AWWA Sec 14.2.8.1))		
	TL	= 6.00	ASCE 7-16 Fig 22-12 to 22-16
	Ts = Sd1 / Sds	= 0.53 sec	
	Sai	= 1.016 g	

14.2.7.3.2 Design Response Spectrum For Convective The Component

For Tc <= TL	Sac = K Sd1 / Tc <= Sds	= 0.255 g	AWWA Eq 14-8
For Tc > TL	Sac = K TL Sd1 / Tc^2	= 0.478 g	AWWA Eq 14-9
	K	= 1.50	
	TC	= 2 pi (D / 3.68g tanh(3.68H / D))^0.5	AWWA Eq 14-14
	g = Acceleration Due To Gravity	= 32 ft/sec^2	
	H = Maximum Operating Level	= 17.46 ft	
	D = Tank Diameter	= 29.709 Ft	
	TC	= 3.20 sec	
	TL	= 6.00 sec	ASCE 7-16 Fig 22-12 to 22-16
	Sac	= 0.255 g	

14.2.9 Horizontal Design Accelerations

14.2.9.1 Ground-Supported Flat-Bottom Tanks

Ai = (LambdaE Sai Ie /Ri) >= (0.36 S1 Ie /Ri)	= 0.356 g	AWWA Eq 14-12
Ac = LambdaE Sac Ie / Rc	= 0.178 g	AWWA Eq 14-13
Where LambdaE	= 0.7	AWWA Sec 14.2.8.1

14.3.4.3 Vertical Design Accelerations

AvLow = 0.19 Sds =	= 0.193 g	AWWA Sec 14.3.4.3
AvHigh = 0.48 Sds =	= 0.488 g	AWWA Sec 14.3.4.3

Hoop Tension

IBC 2018/2021 / AWWA D103-19

Tank Diameter (D)	= 29.709 Ft	Ai	= 0.356 g
Maximum Operating Depth = MOL = H	= 17.460 Ft	Ac	= 0.178 g
Specific Gravity (G	= 1.000 Ft	AvLow	= 0.193 g

Sigma s	= hydrodynamic hoop tensile stress
	Sigma s = (Ni^2 + Nc^2 + (Nh AvLow)^2)^0.5 / ts
Ni	= impulsive hoop tensile force
	For D/H >= 1.333
	Ni = 4.5 Ai G D H (Y / H - 0.5 (Y / H)^2) tanh (0.866 D / H)
	Ni For D/H < 1.333 and Y < 0.75D
	Ni = 2.77 Ai G D^2 (Y / 0.75 D - 0.5 (Y / 0.75 D)^2)
	For D/H < 1.33 and Y >= 0.75D
	Ni = 1.39 Ai G D^2
Nc	= convective hoop tensile force
	For all proportions of D/H
	Nc = (0.98 Ac G D^2 (cosh (3.68 (H - Y) / D)) / cosh(3.68 H / D))
Nh	= hydrostatic hoop tensile force
	Nh= 2.6 G Y D

Ring	Y Liquid Depth (ft)	ts Stave Thickness (in)	Ni (lb/in)	Nc (lb/in)	Nh (lb/in)	Sigma s PSI	Total Hoop Tensile Force = Nh + (Sigma s x ts) (lb/in)
1	17.46	10 GA	373.63	34.99	1348.67	3395.77	1805.40
2	9.40	10 GA	294.01	53.93	726.09	2454.61	1056.23
3	1.34	12 GA	55.15	131.24	103.51	1374.30	247.26

Seismic Design Overturning Moment And Shear
AWWA D103-19 / IBC 2018/2021

Ms = {[Ai (Ws Xs + Wr Ht + Wi Xi)]^2 + [Ac Wc Xc}^2}^0.5 (Eq 14-19)

Height	= 22.00 ft	ts	= 0.1345 in		
Ai	= 0.356 g	tb	= 0.1046 in		
Ac	= 0.178 g	Fy	= 40000 PSI		
AvLow	= 0.193 g	AvHigh	= 0.488 g	H	= 17.46 Ft
Ws	= 12198 Lbs	Xs	= 11.00 Ft		
Wr	= 3383 Lbs	Ht	= 22.00 Ft		
Wf	= 3410 Lbs	Xi	= 6.55 Ft		
Wi	= 461420 Lbs	Xc	= 11.04 Ft		
Wc	= 287767 Lbs	wt	= 167 Lbs / Ft		
Wt	= 755256 Lbs	wL	= 664 Lbs		
J	= 1.774	sigma c	= 1268 PSI		
Ms = Overturning Moment		= 1280540 Ft-Lbs			
Vf = Base Shear		= 178365 Lbs			
EVL = sigma c * D * PI * ts * 12		= 190998 Lbs			

Height	= 13.94 ft	ts	= 0.1345 in		
Ai	= 0.356 g	tb	= 0.1046 in		
Ac	= 0.178 g	Fy	= 40000 PSI		
AvLow	= 0.193 g	AvHigh	= 0.488 g	H	= 9.40 Ft
Ws	= 7447 Lbs	Xs	= 6.97 Ft		
Wr	= 3383 Lbs	Ht	= 13.94 Ft		
Wf	= 3410 Lbs	Xi	= 3.52 Ft		
Wi	= 147318 Lbs	Xc	= 5.17 Ft		
Wc	= 242793 Lbs	wt	= 116 Lbs / Ft		
Wt	= 406610 Lbs				
J	= 0.765	sigma c	= 366 PSI		
Ms = Overturning Moment		= 313529 Ft-Lbs			
Vf = Base Shear		= 71920 Lbs			
EVL = sigma c * D * PI * ts * 12		= 55147 Lbs			

Height	= 5.88 ft	ts	= 0.1046 in		
Ai	= 0.356 g	tb	= 0.1046 in		
Ac	= 0.178 g	Fy	= 40000 PSI		
AvLow	= 0.193 g	AvHigh	= 0.488 g	H	= 1.34 Ft
Ws	= 2696 Lbs	Xs	= 2.94 Ft		
Wr	= 3383 Lbs	Ht	= 5.88 Ft		
Wf	= 3410 Lbs	Xi	= 0.50 Ft		
Wi	= 3019 Lbs	Xc	= 0.67 Ft		
Wc	= 48485 Lbs	wt	= 65 Lbs / Ft		
Wt	= 57964 Lbs				
J	= 0.122	sigma c	= 76 PSI		
Ms = Overturning Moment		= 11936 Ft-Lbs			
Vf = Base Shear		= 9718 Lbs			
EVL = sigma c * D * PI * ts * 12		= 8871 Lbs			

FAILURE MODE	DESCRIPTION	
1	HOLE TEAR OUT	P=L x .6 Fy x t
2	NET SECTION	P=ft x t x An
3	BEARING	P=1.35 Fy x d x t
4	BOLT SHEAR	P= .25 Fu x Ats

NOMENCLATURE:

P = Allowable Bolt Load (lbs.)
L = Edge Distance = .875 in.
t = Steel Thickness (in.)
Fy = Steel Yield Strength (ksi)
Fu = Steel Ultimate Tensile Strength (ksi)
Fu' = Bolt Ultimate Tensile Strength (ksi)

s = Hole Spacing = 2 in.
h = Hole Size = 0.53125 in
An = Net Distance = S - h = 1.46875 in.
d = Bolt Diameter = .5 in.
r = 1 (1 Row)
r = 1/2 (2 Row)
r = 1/3 (3 Row)

Allowable Bolt Loads for Grade 5 Bolts with Fu' = 120 ksi and Ats = 0.142 sq.in.

ASTM	Gage	t	1 Row	Mode	2 Row	Mode	3 Row	Mode
Fy= 40 ksi	12	.1046	2197	-1-	3380	-2-		
Fu= 55 ksi	10	.1345	2824	-1-	4346	-2-		
	9	.1495	3140	-1-	4831	-2-		
	8	.1644	3452	-1-	5312	-2-		
Fy= 40 ksi	3/16	.1875	3938	-1-	6114	-2-	6279	-2-
Fu= 58 ksi	7/32	.2188	4260	-4-	7133	-2-	7325	-2-
	1/4	.25	4260	-4-	8152	-2-	8372	-2-
	5/16	.3125	4260	-4-	8520	-4-	10465	-2-

Gage	t (in.)	fs (psi)	A (sq. in.)	Allowable Load (lbs.)
5/16	0.3125	3301	350	1155470
1/4	0.2500	2674	280	748680
7/32	0.2188	2354	245	576722
3/16	0.1875	2030	210	426296
8 Ga	0.1644	1788	184	329194
9 Ga	0.1495	1630	167	273009
10 Ga	0.1345	1471	151	221611
12 Ga	0.1046	1151	117	134801

SEISMIC ALLOWABLE COMPRESSION STRESS
AWWA D103-19 / IBC 2018/2021
For Mechanically Anchored Tank

Tank Dia	= 29.709 Ft	R = Tank Radius	= 178.25 in	Specific Gravity	= 1.00

P	= Hydrostatic Pressure at Point Under Consideration (psi) = Liq. Depth x SpG x 62.4 /144
E	= Modulus of Elasticity = 29000000 psi
t	= Thickness of the Plate Under Consideration, (in)
Sigma a	= fs = Allow. Compressive Stress
Delta cc	= Pressure Stabilizing Buckling Coefficient
	If (P / E) x (R / t)^2 <= 0.064
	Delta cc = 0.72 [(P / E) x (R / t)^2]^0.84
	If (P / E) x (R / t)^2 > 0.064
	Delta cc = 0.045 log [(P / E) x (R / t)^2 + 0.0018] + 0.194 <= .22
Delta cr	= Critical Buckling Stress Increase Due to Pressure, (psi) = Delta cc x E x t / R
Sigma e	= Seismic allowable stress
	For Self-Anchored Tanks
	Sigma e = 1.333 (Sigma a + (Delta cr / 2))
	For Mechanically Anchored Tanks
	Sigma e = 1.333 Sigma a

Ring	Liquid Depth (ft)	p (psi)	t (in)	fs (psi)	(P/E)x (R/t)^2	Delta cc	Delta cr (psi)	Sigma e (psi)	Area (in^2)	Allowable Load @ S.F. 2.0 (lbs)
1	17.46	7.57	0.1345	1471	0.46	0.16	3481	1961	151	295519
2	9.40	4.07	0.1345	1471	0.25	0.13	2874	1961	151	295519
3	1.34	0.58	0.1046	1151	0.06	0.07	1123	1534	117	179743

Stave Ring 1

Thickness = 10 Ga		Rows of Bolts	= 1 Grade 5 Bolts
Vertical Loads	(1) Tank Weight		= 15581 Lbs.
	(2) Deck Live Load on Shell @ 25 PSF		= 11554 Lbs.
	(3) Evl Wind		= 17424 Lbs.
	(4) Evl Seismic		= 190998 Lbs.
	Total Static Load (1 + 2)		= 27134 Lbs.
	Static Allowable Vertical Load = fs x A		= 221695 Lbs.
	Total Wind Dynamic Load (1 + 3)		= 33005 Lbs.
	Wind Allowable Vertical Load = (fs x A) x 1.333		= 295519 Lbs.
	Total Seismic Dynamic Load (1 + 4)		= 206579 Lbs.
	Seismic Allowable Vertical Load = sigma e x A		= 295519 Lbs.
Hoop Tension Loads			
	Hydrostatic Bolt Load = Nh x 2 in. bolt spacing		= 2697 Lbs.
	Hydrostatic Allowable Bolt Load		= 2824 Lbs.
	Total Bolt Load = Total Hoop Tensile Force x 2 in. bolt spacing		= 3611 Lbs.
	Total Allowable Bolt Load = Hydrostatic Allowable Bolt Load x 1.333		= 3765 Lbs.

Stave Ring 2

Thickness = 10 Ga		Rows of Bolts	= 1 Grade 5 Bolts
Vertical Loads	(1) Tank Weight		= 10829 Lbs.
	(2) Deck Live Load on Shell @ 25 PSF		= 11554 Lbs.
	(3) Evl Wind		= 6996 Lbs.
	(4) Evl Seismic		= 55147 Lbs.
	Total Static Load (1 + 2)		= 22383 Lbs.
	Static Allowable Vertical Load = fs x A		= 221695 Lbs.
	Total Wind Dynamic Load (1 + 3)		= 17825 Lbs.
	Wind Allowable Vertical Load = (fs x A) x 1.333		= 295519 Lbs.
	Total Seismic Dynamic Load (1 + 4)		= 65977 Lbs.
	Seismic Allowable Vertical Load = sigma e x A		= 295519 Lbs.
Hoop Tension Loads			
	Hydrostatic Bolt Load = Nh x 2 in. bolt spacing		= 1452 Lbs.
	Hydrostatic Allowable Bolt Load		= 2824 Lbs.
	Total Bolt Load = Total Hoop Tensile Force x 2 in. bolt spacing		= 2112 Lbs.
	Total Allowable Bolt Load = Hydrostatic Allowable Bolt Load x 1.333		= 3765 Lbs.

Stave Ring 3

Thickness = 12 Ga		Rows of Bolts	= 1 Grade 5 Bolts
Vertical Loads	(1) Tank Weight		= 6078 Lbs.
	(2) Deck Live Load on Shell @ 25 PSF		= 11554 Lbs.
	(3) Evl Wind		= 1245 Lbs.
	(4) Evl Seismic		= 8871 Lbs.
	Total Static Load (1 + 2)		= 17632 Lbs.
	Static Allowable Vertical Load = fs x A		= 134841 Lbs.
	Total Wind Dynamic Load (1 + 3)		= 7323 Lbs.
	Wind Allowable Vertical Load = (fs x A) x 1.333		= 179743 Lbs.
	Total Seismic Dynamic Load (1 + 4)		= 14949 Lbs.
	Seismic Allowable Vertical Load = sigma e x A		= 179743 Lbs.
Hoop Tension Loads			
	Hydrostatic Bolt Load = Nh x 2 in. bolt spacing		= 207 Lbs.
	Hydrostatic Allowable Bolt Load		= 2197 Lbs.

Total Bolt Load = Total Hoop Tensile Force x 2 in. bolt spacing	= 495 Lbs.
Total Allowable Bolt Load = Hydrostatic Allowable Bolt Load x 1.333	= 2928 Lbs.

TENSION LOADS ON CHIMES (AWWA D103-97)

TANK DIA = 29.709 FT

TENSION ON CHIME = ((EVL-DL)/CIRCUMFERENCE)

ALLOWABLE TENSION IN CHIME = (YIELD/36) X (9600 X t^2)

IF ALLOW TEN. > TEN. ON CHIME THEN A TENSION STRAP IS NOT REQUIRED

LOAD ON TENSION STRAP = 2 X TENSION ON CHIME

RING	t (IN)	YIELD (KSI)	WIND/SEIS EVL (LBS)	TANK DL (LBS)	TENSION ON CHIME (LBS/IN)	TENSION ALLOW (LBS/IN)	LOAD ON TEN STRAP (LBS/2IN)	TENSION (STRAP)
1	0.1345	40	190998	15581	157	193	----	N/R
2	0.1345	40	55147	10829	40	193	0	N/R
3	0.1046	40	8871	6078	2	117	0	N/R

Intermediate Girder Check
AWWA D103-97

D = Tank I.D. (ft.) = 29.709

Paw = Average Wind Pressure (psf) = 18

h = 10.625 * (10^6) * t)/ Paw * (D/t)^1.5 (Eq 15-5)

t = Average stave thickness (in)

h = Vertical distance between the top of the tank and the bottom of the stave being checked (ft)

Stave Gage	Row Vert	F' (psf)	Stave Avg Thickness (in)	Stv Ht. (in)	h Total Stv. Ht. (ft)	Avg Thick (in)	Req Thick (in)
12 Ga	1	18.00	0.1130	70.56	5.88	0.1130	0.076
10 Ga	1	18.00	0.1460	96.50	13.92	0.1321	0.108
10 Ga	1	18.00	0.1460	96.50	21.96	0.1372	0.129

Intermediate Girder is not required

Minimum Freeboard Requirements
AWWA D103-19

Section 14.4 Freeboard

(Table 6)

Minimum Freeboard		= 0 ft	(For Risk Cat I and II)
Minimum Freeboard		= 0 ft	(For Risk Cat III and Sds < 0.33g
Minimum Freeboard		= 0.7 d ft	(For Risk Cat III and Sds >= 0.33g
Minimum Freeboard		= d ft	(For Risk Cat IV
	Sds	= 1.016 g	(Eq. 14-3)
	d = 0.42 D Af	= 3.18 Ft	Eq 14-45
	Tank Diameter = D	= 29.709 Ft	

For Risk Cat I, II, and III

When Tc <= 4	Af = K Sd1 Ie / Tc	= 0.382 g	Eq 14-46
When Tc > 4	Af = 4 K Sd1 Ie / Tc^2	= 0.478 g	Eq 14-47

For Seismic Use Group 3

When Tc <= TL	Af = K Sd1 / Tc	= 0.255 g	Eq 14-48
When Tc > TL	Af = K Sd1 TL / Tc^2	= 0.478 g	Eq 14-49
	K	= 1.500	
	Sd1	= 0.543 g	AWWA Eq 14-4
	Ie	= 1.500	
	Tc	= 3.198 sec	AWWA Eq 14-14
	TL	= 6.000 sec	ASCE 7-16 Fig 22-12 to 22-16
Minimum Freeboard		= 3.18 Ft	

Uplift
Ref. AWWA D103-19

Wind Uplift Force = Pw	= (4 Mw / N Dac) - (W' / N)	(Eq. 5-13)
Seismic Uplift Force = Ps	= (4 Ms / N Dac) - ((1 - 0.4AvLow) * (W' / N))	(Eq. 5-14)

Wind Overturning Moment = Mw	= 129412 Ft-Lbs
Seismic Overturning Moment = Ms	= 1280540 Ft-Lbs
Number Of Anchors = N	= 20
Diameter Of Bolt Circle = Dac	= 30.23 Ft
Dead Weight Of Tank = W' = Ws + Wr	= 15581 Lbs
Pw	= 137 Lbs / Anchor Bolt
Ps	= 7753 Lbs / Anchor Bolt

Use (20) 7/8 Dia. Anchor Bolts, ASTM F1554 Grade 36

Center Support

Tank Diameter	= 29.709 Ft.
Center Rafter Bearing Plate O.D.	= 36 in
Number of Deck Segments = n	= 20
Deck Slope (1:12 = 4.7636)	= 4.764 deg
Equipment Load	= 0 lbs
Total Load = DL + LL	= 31.4 psf
Live Load = LL	= 25 psf
Dead Load (Deck Sheet + Rafters) = DL	= 6.366 psf
Total Deck Weight	= 5075 lbs

Deck Sheets

Deck Sheet Thickness	= 0.1046 in
W = LL + Deck Sheet DL	= 29.3 psf
Deck Sheet Fy	= 40000 psi
Maximum Rafter Spacing (L)	= 56 in
Minimum Deck Thickness Required	= (L^2 W / 300 Fy)^0.5
0.087 in	< 0.1046 in

Rafters

Distance Between Rafters At Shell	= 4.667 ft
Distance Between Raftes At Center Ring	= 0.471 ft
Rafter Load At Ceter Ring = q2	= 15 lb/ft
Horizontally Projected Length of Rafter = a	= 13.354 ft
W	= 879 lbs
w	= 15 lb/ft
Reaction At Shell = V1 = ((a / 6) x (2q1 + q2))	= 684 lbs
Reaction At Center Ring = V2 = (a / 6) x (q1 + 2q2)	= 392 lbs
Maximum Moment Location = x = 0.5774 L	= 7.738 ft
Maximum Moment = (0.1283 W L) + (wx / 2 (L - x))	= 1835 ft-lbs
Rafter Type	= C4 x 5.4
Plastic Section Modulus (Zx)	= 2.290 in^3
Rafter Length	= 13.401 ft
Moment of Inertia (Ix)	= 3.850 in^4
Fy	= 50000 psi
Modulus of Elasticity (E)	= 29000 ksi

omega b	= 1.670
Nominal Flexural Strength = Mn = Mp = Fy Zx	= 114500 in-lbs = 9542 ft-lbs
Mn / omega b	= 5714 ft-lbs > 1835 ft-lbs
Maximum Deflection Location = x' = 0.5193 L	= 6.959 ft
Actual Deflection = (0.01304 (W L^3 / E I) + ((w x' / 24 E I) x (L^3 - 2 L x'^2 + x'^3))	= 0.478 in
Allowable Deflection = L / 120 =	= 1.340 in

Center Support Column

Sum of the Reactions from Main Rafters	= 7832 lbs
Equipment Load at Rafter Ring	= 0 lbs
Center Cover Load	= 222 lbs
Total Load on Center Support Column	= 8053 lbs
Center Support Column Height = L	= 23.237 ft
K	= 1.000
Column Size	= 6" Sch 40
Liquid Depth	= 17.460 ft
A	= 5.220 in^2
Product Specific Gravity	= 1.000
r	= 2.250 in
Fy	= 35000 psi
Modulus of Elasticity (E)	= 29000 ksi
Base Plate Area	= 1.969 ft^2
KL / r	= 124 < 175
Cc	= 128
If KL / r <= Cc Then Fa	= 9688 psi
If KL / r > Cc Then Fa	= 9723 psi
Allowable Compressive Stress	= 9688 psi
Actual Compressive Stress = P / A	= 1543 psi
Pressure Under the Ctr. Pole Base Pl. (Deck Loads Only)	= 4090 psf
Pressure Under the Ctr. Pole Base Pl. (Deck Loads+Liq.Pressure of the Product)	= 5180 psf

Tank Loadings on Foundation

Customer	: Coastal Pacific Food Distributers
Sales Order	: 100068_001
Engineer	: Khiem Huynh
Project	: Puyallup, WA
Date	: 20-May-2024

Tank Diameter	: 29.709 Ft (9.055 m)	Weight Of Shell	: 12198 Lb (5533 Kg)
Tank Height	: 22.000 Ft (6.706 m)	Weight Of Roof	: 5075 Lb (2302 Kg)
Specific Gravity	: 1.00	Weight Of Roof On Shell	: 3383 Lb (1534 Kg)
Deck Live Load	: 25 Psf (1.20 kPa)	Weight Of Floor	: 3418 Lb (1551 Kg)
Total Deck Live	: 11554 Lb (5241 Kg)	J (Self Anchored)	: 1.77
Tank Dead Load	: 20691 Lb (9385 Kg)	Seismic Design Category	: D

Base Shear (Wind)	: 11.765 Kips	(52332 N)
Overturning Moment (Wind)	: 129.412 Kip-Ft	(175460 N-m)
Base Shear (Seismic)	: 178.365 Kips	(793407 N)
Overturning Moment (Seismic)	: 1280.540 Kip-Ft	(1736180 N-m)
Bottom Pressure from contents	: 1090 Psf	(52.19 kPa)
Center Support Axial Load DL + LL	: 8.053 Kips	(3653 kg)