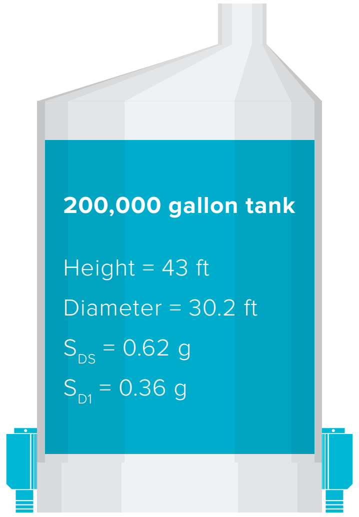
CASE STUDY: CALIFORNIA

200,000 GALLON TANK ANCHORED DIRECTLY TO A CONCRETE SLAB

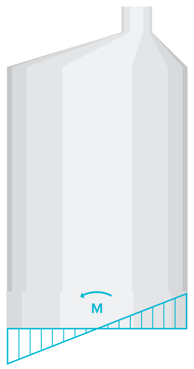
1. **Tank walls designed by tank designer to API 650:**
   $R_{wc} = 2$ $R_{wi} = 4$
2. **Tank designer provides the following information to ONGUARD Engineers:**
   Tank wall design moment M* = 5487 ft - kips

   Initial anchor load assumption which tank wall design is based on:
   Number of anchors n = 24
   Design tension per anchor P* = 30.3 kips/bolt
3. **Tank designer discusses assumptions with ONGUARD.**
4. **ONGUARD design anchors using one of two options:**



OPTION 1:

Antisymmetric anchor force distribution.



Option 1

Impulsive response modification factor	R_{wi} = 6.9
Impulsive acceleration	A_i = 0.089 g
Convective response modification factor	R_{wc} = 2
Convective acceleration	A_c = 0.083 g (no change)
Overturning moment	M = 3290 ft-kips
Number of anchors	n = 24
Design force per anchor	P = 18.2 kips
→ 24 OG PRO 81 anchors	
Design capacity	$\varnothing T_n$ = 18.2 kips
Anchor over-strength*	$\varnothing_{OMS}$ = 1.4
Over-strength overturning moment	M_{OS} = 4500 ft-kips

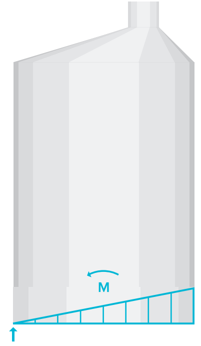
This over-strength moment is less than the tank wall design moment, so tank walls are protected.

OPTION 2:

Ductile elastic anchor force distribution.

Impulsive response modification factor	R_{wi} = 6.1
Impulsive acceleration	A_i = 0.10 g
Convective response modification factor	R_{wc} = 2
Convective acceleration	A_c = 0.083 g (no change)
Overturning moment	M = 3660 ft-kips
Number of anchors	n = 18
Design force per anchor	P = 18.0 kips
→ 18 OG PRO 81 anchors	
Design capacity	$\varnothing T_n$ = 18.2 kips
Anchor over-strength*	$\varnothing_{OMS}$ = 1.4
Over-strength overturning moment	M_{OS} = 5030 ft-kips

This over-strength moment is less than the tank wall design moment, so tank walls are protected.



Option 2

SUMMARY

Option 1 aligns more closely with the design approach used in API650. Option 2 uses principals and assumptions described in other international tank guidelines. **Option 2** is the preferred design approach of ONGUARD, as it uses a more accurate anchor force distribution for a tank with ductile anchors, and it provides a higher degree of protection to the tank walls.

In both cases above, the over-strength anchor force T_o = 25.5 kips. This is less than the anchor force used to design the tank walls, so the local tension load applied by ONGUARD anchors is consistent with the tank wall design.

Maximum local compression in the tank wall is equal to the over-strength anchor force, T_o = 25.5 kips.

This compressive force can be provided to the tank designer, or ONGUARD can engineer the wall or doubler plate thickness required. In this case, a 1/4" wall or doubler plate at each anchor is required to resist local buckling.

Similarly, the global compression point reaction from the ductile elastic anchor force distribution can be provided to the tank designer, or ONGUARD can advise the tank wall thickness required to resist this compression. In this case, the overstrength compression reaction is 225 kips, and is assumed to be distributed over 1/6 of the tank circumference, so requires a 3/16" wall thickness at the bottom of the tank.

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