HOW ONGUARD IS DESIGNED

CASING

Is welded to the tank and provides buckling restraint to the yielding fuse.

FUSE

Ductile mild steel, designed to yield at a predetermined load.

OG PRO ANCHOR COMPONENTS ARE OFTEN EXPOSED TO THE ELEMENTS AND ARE MANUFACTURED FROM CORROSION-RESISTANT STAINLESS STEEL. THE ANCHORS ARE FACTORY ASSEMBLED AND HERMETICALLY SEALED, PROTECTING INTERNAL MILD STEEL ELEMENTS.

COUPLER

Attaches the fuse to an epoxy-anchored stud in the foundation.

CAP

Locks the fuse in position and can be removed to inspect the fuse.

DESIGN APPROACH

FOR TANKS SUPPORTED ON A CONCRETE SLAB, PEDESTAL OR STAND

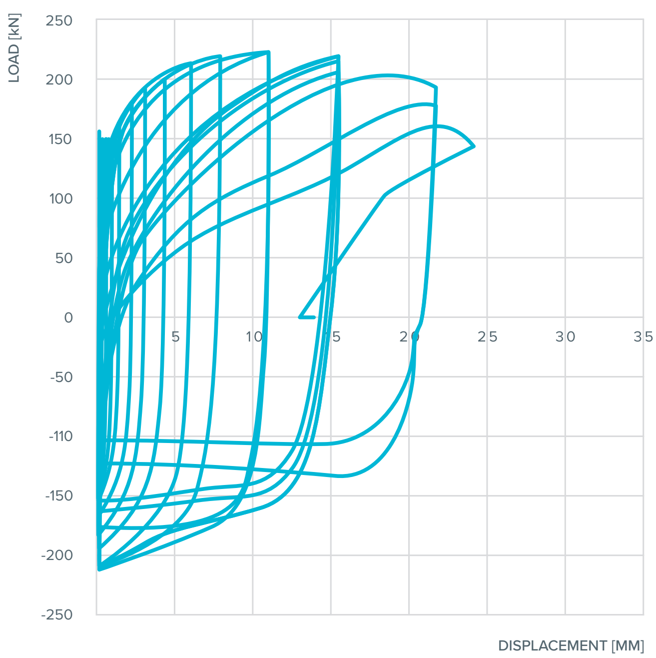
Seismic action produces loadings on tanks that are potentially damaging. To maximize asset protection, it is critical that the correct design approach is utilized as this will underpin the performance of the entire seismic tank system.

The traditional approach, designing purely to API 650, assumes ductility within the tank walls, which means tank walls will be subject to damage in a seismic event. ONGUARD considers this approach to be unacceptable for tanks for which damage leading to loss of contents would have significant health and safety, environmental or economic consequences. The ONGUARD system therefore employs a capacity design approach, where ductile anchors are used, concentrating damage from seismic loading in one small replaceable component and providing protection to the tank walls.

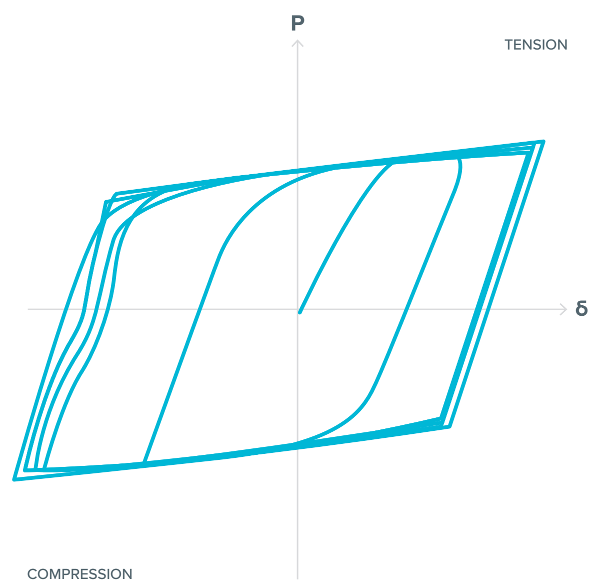
This is “Earthquake Engineering 101” for building structures, applied to liquid storage tanks.

ONGUARD’s ductile anchors have been designed and tested to yield repetitively in tension and compression, and exhibit the same elasto-plastic hysteresis response as Buckling-Restrained Braces (BRBs) that are a common and accepted feature of building structures globally.

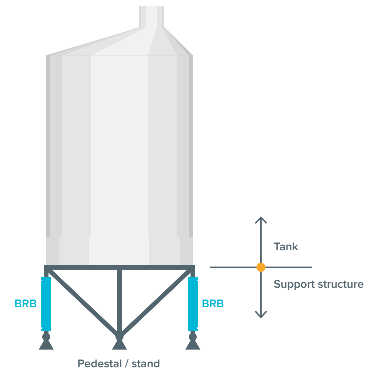
ONGUARD’s design approach is one that considers the anchorage and foundation (pedestal or stand) to be an independent structure, similar to a BRB-equipped building, which supports the tank.



ONGUARD test response



Typical BRB response



Equivalent tank system

For new tanks, the tank designer calculates the seismic demand on the equivalent BRB system using appropriate Allowable Stress Design (ASD) Response Modification Factors, R_{wi}, R_{wc} (API 650 / ASCE 7-16) or Structural Ductility Factors, μ (NZSEE) and adopts the most efficient combination of anchor fuse yield load and quantity to resist this overturning moment demand. Using a capacity design approach, every other element in the tank system (tank walls, connections, anchorage to the base slab) is designed to resist the overstrength of the ductile anchors. The minimum overstrength factor used is typically 1.4 and ensures protection of the entire system.

In adopting values for R_{wi}, R_{wc} and μ the following should be noted:

Adopting factors from ASCE 7-16:

1. Table 12.2-1 allows a Response Modification Factor R^a of up to 8 for steel BRB frames.
2. Notwithstanding the above, Table 15.4-2 limits the Impulsive Response Modification Factor R_i of a ground-supported tank to 3 or less (Load and Resistance Factor Design (LRFD)), equivalent to R_{wi} = 4.2 (ASD).
3. API 650 limits the Convective Response Modification Factor R_{wc} of a ground-supported tank to 2 or less.

ONGUARD typically adopts values of R_{wi} = 6 and R_{wc} = 2 for the design of the yielding elements within the ductile anchors. When overstrength is applied, this equates to R_{wi} = 4.2 (R^a = 3) for the design of every other component of the tank system, thus meeting the requirements above and providing protection to the tank.

Designing to NZSEE and NZS1170.5:

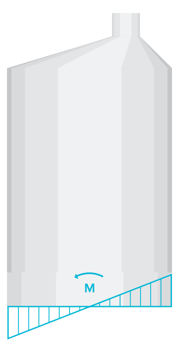
ONGUARD typically adopts a value of μ = 3 for the design of the yielding pins within the ductile anchors (a value of up to 6 is allowed for steel BRB frames). When overstrength is applied, this equates to μ = 2.1 for the design of every other component of the tank system.

The tank designer can also specify which anchor load distribution is assumed. Ductile elastic distribution requires fewer or smaller anchors.

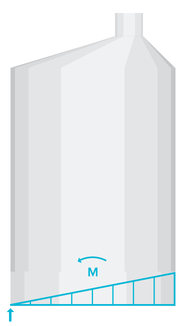
Although this distribution is not included in the elastic-based API 650, it is a more accurate load distribution where ductile anchors are used and is included in international tank guidance (e.g. Figure C5.2 of the NZSEE guidelines). The antisymmetric anchor force distribution will tend to underestimate the tank over-strength moment.

The ductile elastic anchor force distribution, as well as reducing the number of anchors, also provides superior protection to tank walls.

API 650 1.1.12 Annex E states that it “provides minimum requirements for tanks subject to seismic loading. An alternative or supplemental design may be mutually agreed upon by the Manufacturer and the Purchaser”. To meet this requirement and therefore ensure compliance with API 650, ONGUARD consults with its clients on each project to ensure that they endorse this proven approach.



Antisymmetric anchor force distribution



Ductile elastic anchor force distribution