Agenda Item: 650-1132

Rev 0 - 05/05/2026

Title: **650-1132: Annex F.8.3 Anchorage Proof Test**

Date: 05/05/2026

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Purpose: The **2nd API 650 Annex F.8.3 fully pneumatic test** is often avoided in industry due to its high risk (especially inside of plants) and the required clear distance for personnel during pneumatic tests. This clear distance is often determined using the equivalent "amount of TNT" as energy. This ballot is aiming to offer a much lower risk alternative for this 2nd test (empty tank full of air).

Source: **RFI 10607** – SGF resulted in form letter on suggestion for a change. **Passed to SGD**.

Impact: This could reduce potential industry risk to personnel and surrounding equipment due to very large amount of stored energy during pneumatic tests of a large empty tank. This could also reduce the requirement for vast amounts of compressed air for large diameter tanks.

Rationale: Provide an option to check anchor bolt pullout (or shear) by performing a mechanical pull test (or shear test for anchor straps) of all anchor bolts and multiply an additional 1.1 factor to foundation uplift design.

Revision: 0

Background:

API 650 F.8.3 calls for **(2) two** applications of air pressure:

1st) 1.25 x Design Pressure with tank **full** of water and then,
2nd) Fully Pneumatic test at 1.0 x Design Pressure (DP) after tank is **completely empty**.

What is the 2nd (empty) test proving?

- The **only** additional benefits of this 2nd empty pneumatic test is to check the **anchorage strength** (anchor bolts, anchor chairs and welds to shell) and **foundation uplift and pullout**.
- API 650 F.8.3 states this test is needed for a final check of "anchorage tightness".
- The roof and shell have already been tested to a **higher** pressure of 1.25 x DP for 1st test.
- Tank "**annular plate uplift**" will not be appreciable until the anchor bolt stretches / yields. This is not credible during an F.8.3 empty pneumatic test. Therefore, testing of the annular ring / floor (double hinge potential during seismic events) is not a valid purpose of this 2nd "empty" pneumatic test.
- Foundation anchor bolts, anchor chairs and foundation design are not required to be strength tested for any other equipment in our industry (skirts, towers, columns, structures, poles or any other equipment attached with anchor bolts). **Foundation Uplift** is unique to flat bottom tanks.
- Probability of tanks experiencing **full** Design Pressure when "**empty**" is extremely low for tanks designated to operate in liquid service.

Note: API 620 does **not** require this "empty" fully pneumatic test:
API 620 7.18.3.2 (Hydro / Pneumatic Combo) and 7.18.4.3 (Hydrotest) requires 1.25 x DP above the liquid level **only**.
7.18.3.3 recognizes the risk of pneumatic testing (pneumatic testing is **only** for vapor space above liquid).

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API 650 Current language:

F.8 Mechanically anchored Tanks with Design Pressures up to 18 kPa (2.5 psi) Gauge
F.8.3 After the tank is filled with water, the shell and the anchorage shall be visually inspected for tightness. Air pressure of 1.25 times the design pressure shall be applied to the tank filled with water to the design liquid height. The air pressure shall be reduced to the design pressure, and the tank shall be checked for tightness. In addition, all seams above the water level shall be tested using a soap film or another material suitable for the detection of leaks. After the test water has been emptied from the tank (and the tank is at atmospheric pressure), the anchorage shall be checked for tightness. The design air pressure shall then be applied to the tank for a final check of the anchorage.

Proposed Change (Rev 0 in red):

F.8 Mechanically anchored Tanks with Design Pressures up to 18 kPa (2.5 psi) Gauge
F.8.3 After the tank is filled with water, the shell and the anchorage shall be visually inspected for tightness. Air pressure of 1.25 times the design pressure shall be applied to the tank filled with water to the design liquid height. The air pressure shall be reduced to the design pressure, and the tank shall be checked for tightness. In addition, all seams above the water level shall be tested using a soap film or another material suitable for the detection of leaks. After the test water has been emptied from the tank (and the tank is at atmospheric pressure), the anchorage shall be checked for tightness. This can be accomplished by either (a) or (b) below:

a) The design air pressure shall then be applied to the empty tank for a final check of the anchorage.
b) A mechanical pull test (or shear test for anchor strap bolts) per ASTM E3121/E3121M using a force equivalent to the maximum anchor design uplift load (Tb) from 5.12.2 shall be applied to each anchor bolts. Option (b) is not recommended for tanks designated to operate in full vapor service. In addition to the mechanical pull test (or shear test for anchor strap bolts), the following shall be required:
    i. Anchor bolts, chairs (or straps), repads and attachments to shell shall be designed to meet 5.12 using an industry standard design (RAGAGEP).
    ii. VT and (MT or PT) testing shall be successfully applied to all welds for anchor chairs (or straps), repads and shell attachments per Section 8.

Revision History:
2026 Spring – Presented in SGD as "Proposal for New Ballot" - Rev 0 in red

End of Ballot

Backup: *How does "water weight" or lack thereof affect anchor bolt forces?*

Although a free body diagram could be used, the percentage of water weight attributed to the anchor bolts offers a complicated determination of resultant anchor bolt forces.
Therefore, two (2) Test Cases were performed using FEA w/ 1.25 X Design Pressure:

Test Case #1: Test the effect of water weight *alone*

1st test was **full** of water
2nd test was **empty**
The **only difference** in the 2nd test was the **removal of water weight** and the subsequent liquid pressure on the floor and shell.
The **air pressure remained constant** to demonstrate the differential amount of force on anchorage **due to water weight alone**.

1st test: Liquid **Full** w/ **1.25** X Design Pressure applied above liquid. Bolt Force = **6,193 Lbs**
2nd test: Empty with **1.25** X Design Pressure (same air test pressure). Bolt Force = **12,020 Lbs**.
It quickly becomes obvious (even w/o FEA) that **removal of the water weight significantly increases the anchor bolt forces**.

Test Case #2: Test 1st F.8.3 Hydro w/ 1.25 DP vs 2nd Empty w/ 1.0 DP

Two (2) additional tests were performed **per F.8.3 requirements (Hydro w/ 1.25 DP vs Empty w/ 1.0 DP)** using FEA**:**

1st test: Liquid **Full** w/ **1.25** X Design Pressure applied above liquid. Bolt Force = **6,193 Lbs**
2nd test: Empty with **1.0** X Design Pressure (same air test pressure). Bolt Force = **9,365 Lbs**.

Here, although the air **pressure** was **lower** in the 2nd test (1 vs 1.25), the **anchor bolt forces** are still significantly **increased** once water weight is removed for 2nd empty test.

Tank parameters used for these test cases:

20' Diameter x 24' Tall x ¼" Th shells w/ 2:12 5/16" Th Cone Roof
(8) 1" diameter anchor bolts were used w/ NO Seismic or Wind applied.
Design Pressure was 2.5 psig, therefore 1.25 x DP = 3.125 psig.
The focus of this example was regarding the **difference water weight makes in anchor bolt forces** and **not** the specific values used or derived during this test.

Note: The weight of the water (full) in this example would be ~470,500 Lbs. (470,500 Lbs / 8 = 58,812 Lbs). Therefore, the entire **full** water weight **cannot** be subtracted from the anchor bolt forces since water weight is supported evenly by entire foundation inside the anchor bolts / annular ring. Although the full water weight cannot be attributed entirely to the anchor bolt forces, the anchor bolt forces are still reduced by a "portion" of the water weight, which was the **purpose of these tests**. Therefore, **removal of water significantly increases the anchor bolt forces**. Although this seems obvious, this test was demonstrated to eliminate any proposals that water weight does not have a significant effect on anchor bolt uplift forces since this was brought up during seismic discussions (different topic).

Conclusion: The 2nd test in F.8.3 is indeed a check of the "anchorage strength design" and "tightness" per language in F.8.3.

This ballot is proposing to prove the same "anchorage" testing with an **anchor bolt mechanical pull test.** Although this mechanical pull test will **not test foundation uplift**, foundation failure is more probable to be a financial risk than an EH&S risk and should be an owner decision. An added factor could be applied to foundation **uplift** design to account for the lack of testing for uplift. This could be similar to the 1.1 x SG listed in 650 7.3.6.2.2 (Hydrotest exemption provisions) for foundation **settlement**.
Since the anchor chair design will also not be tested at this higher anchor bolt force (empty test), the anchor chair **shall be** designed per 5.12 and industry standards (RAGAGEP) and the anchor chair to shell welds **shall be** fully tested (VT **and** PT or MT) for weld defects.

What is the ASTM E3121 Anchor Bolt Pull Test?

Note: ASTM E488 and ASTM E3121 are both anchor testing standards, but they serve different purposes. **ASTM E488** is used for laboratory testing to determine the maximum strength of anchor bolts, while **ASTM E3121** is used for **field** testing to verify that installed anchors meet design requirements in concrete or masonry. E448 testing standards are referenced within E3121, as necessary.

Key Aspects of ASTM E3121 Anchor Pull Testing:

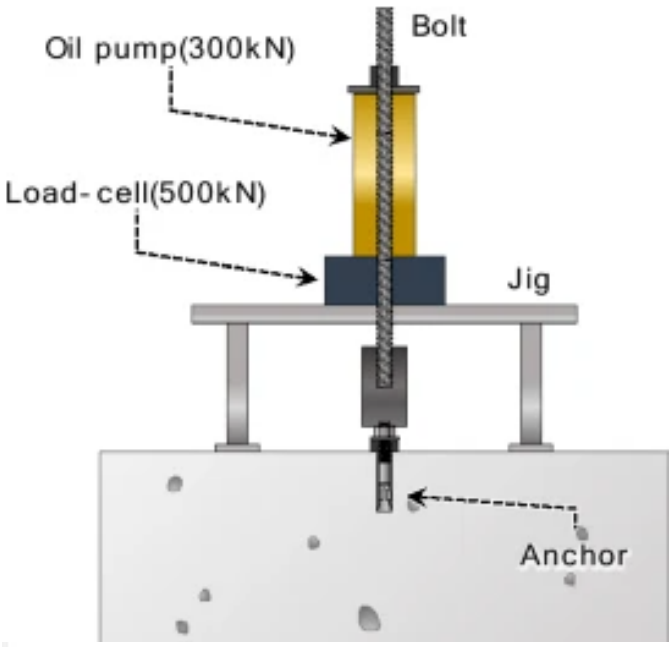
- Objective: To verify the performance of anchors, including tension tests to evaluate load-carrying capacity and displacement.
- Procedure: A hydraulic ram or load cell applies a tensile load to the anchor.
- Equipment: The setup requires a loading device, a tripod or bearing ring to transfer loads, and a calibrated load indicator.
- Safety/Proof Loads: Proof tests typically measure the deflection or confirm the anchorage sustains a specified load.

Highlights:

5. Apparatus 5.1 *Equipment* - Calibrated electronic load cells or hydraulic ram and pressure gauge systems calibrated together as a system shall be used. This equipment shall be capable of measuring the forces to an accuracy within 62 % of the calibrated capacity, when calibrated in accordance with Practices E4.

5.1.3.1 Tension Test: (1) Single Anchor—The displacement measuring device(s) shall be positioned to measure the vertical movement of the anchors with respect to points on the member in such a way that the device is not influenced during the test by deflection or failure of the anchor

Examples of Anchor Bolt Testing Equipment:

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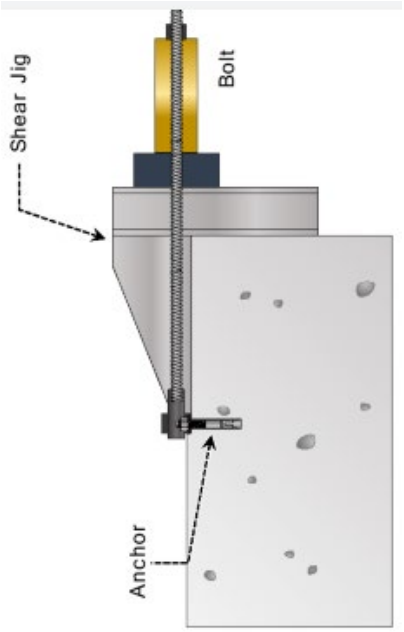
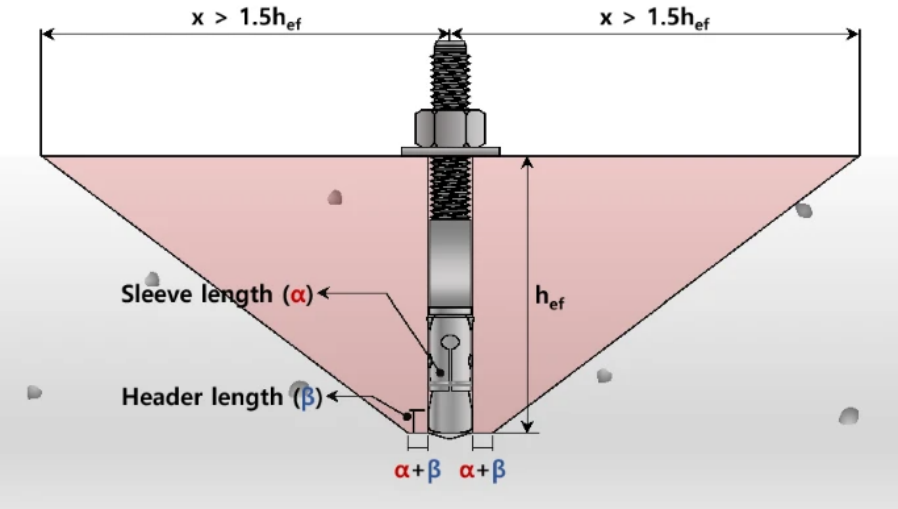
Anchor Tester 28





NOTES:

- The testing apparatus may push against foundation within the foundation “shear cone” and therefore only testing anchor bolt pullout and **not** foundation cone shear.
- This foundation failure is not typically required to be tested on any other equipment in industry (skirts, towers, columns, structures, supports, poles or any other equipment attached with anchor bolts).
- It will also be designed with a 1.1 multiplication factor for additional safety.
- This type of foundation failure is more probable to be a financial consequence rather than an EH&S consequence and therefore should be at the owner’s discretion.
- The intent is not to be overly prescriptive regarding how the owner agrees to test the anchor bolts