

Agenda Item: 650-1113

Title: Dynamic Hoop Stress Analysis Point

Date: May 13, 2022

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Purpose: To clarify the analysis point to be used in calculating dynamic hoop stress.
Correct example problem #6 in Annex EC.

Source: Justin Kline

Revision: 0 – Presented Spring 2022

Impact: None

Rationale:

API 650 Annex E.6.1.4 requires that the dynamic hoop tensile stress be combined with the hydrostatic design stress. The location of the dynamic hoop tensile stress in Annex E is given as the variable, Y . Y is defined as the distance from the liquid surface to the analysis point. The analysis point for determination of the dynamic hoop tensile stress is the same location as the maximum hydrostatic design stress. For a tank with a diameter more than 200 feet, API 650 (5.6.3) prohibits the use of the 1-Foot Method, therefore the Variable-Design-Point Method is used to determine the maximum stress in each shell ring.

Proposal:

E.2.2 Notations

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Y Distance from liquid surface to analysis point, (positive down), **which is the location of the maximum hydrostatic design stress (see 5.6.3 for shells designed using the 1-Foot Method and 5.6.4 for shells designed using the Variable-Design-Point Method, m (ft)**

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EC.9.6 Example Problem #6

EC.9.6.1 Calculating Hydrodynamic Hoop Stresses
See E.6.1.4

Consider both lateral and vertical accelerations.

The owner has specified a vertical acceleration of 12.5%g.

Know information about the tank:

$$H = 40 \text{ ft}$$

$$D = 100 \text{ ft}$$

$$G = 0.7$$

$$t_s = 0.5625 \text{ in.}, \text{ thickness of the bottom shell course}$$

$$F_y = 30,000 \text{ psi for ASTM A283, Grade C material for the bottom plate welded to the shell}$$

$$S_d = 20,000 \text{ psi for ASTM A283, Grade C material for the lowest shell course}$$

$$E = 1.0 \text{ weld joint efficiency}$$

$$A_i = 0.210 \text{ g}$$

$$A_c = 0.054 \text{ g}$$

$$A_v = 0.125 \text{ g}$$

The product hydrostatic membrane hoop load at the base of the tank is:

$$N_h = 2.6(H - 1)DG$$

$$= 7098 \text{ lb/in.}$$

The impulsive hoop membrane hoop force at the base of the tank is calculated by Equation (E.6.1.4-1b):

$$D/H = 2.5 \quad Y = H = 40 \text{ ft} \quad Y = 40 - 1 = 39 \text{ ft}$$

$$N_i = 4.5A_iGDH \left[\frac{Y}{H} - 0.5 \left(\frac{Y}{H} \right)^2 \right] \tanh \left(0.866 \frac{D}{H} \right) \quad (\text{E.6.1.4-1b})$$

$$= 43421288 \text{ lb/in.}$$

The convective hoop membrane hoop load at the base of the tank is Equation (E.6.1.4-4b):

$$D/H = 2.5 \quad Y = H = 40 \text{ ft} \quad Y = 40 - 1 = 39 \text{ ft}$$

$$N_c = \frac{0.98 A_c G D^2 \cosh\left[\frac{3.68(H-Y)}{D}\right]}{\cosh\left[\frac{3.68H}{D}\right]}$$

$$= 163162 \text{ lb/in.}$$

The total hoop stress, including lateral and vertical seismic accelerations per Equation (E.6.1.4-b):

$$\sigma_T = \sigma_h \pm \sigma_s = \frac{N_h \pm \sqrt{N_f^2 + N_c^2 + (A_v N_h)^2}}{t_s}$$

$$= 15,44915,414 \text{ psi (max)}$$

The allowable seismic hoop stress is the lesser of:

$$1.333 \times S_d = 26,660 \text{ psi (GOVERNS)} < 22,92415,414 \text{ psi} = \text{OK}$$

$$0.9F_y = 27,000 \text{ psi}$$