Agenda Item 620-1023

Title: SSE Stress Limits and Seismic Clarifications for Secondary Containers & Membrane Outer Containers

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Revision: 2

Handled By:
Eric Gnade
CB&I Storage Solutions
14105 S. Route 59
Plainfield, IL 60544-8984
Telephone: 815-439-6476
Eric.Gnade@mcdermott.com

Doug Miller
CB&I Storage Solutions
14105 S. Route 59
Plainfield, IL 60544-8984
Telephone: 620-809-9801
Doug.Miller@mcdermott.com

Purpose: 1) Complete missing coverage for membrane containment tanks in Tables L-1Q and L-1R

2) Complete missing coverage of std allowable stresses for membrane tank outer containers

3) Provide specifics on stress limits to be used in conjunction with the R=1.0/no-damage approach outlined in API 625 via agenda item 625-1008.

Source: Purpose 3 is from Rama Challa request during discussion of item 625-1008.

Impact: Safer product containment. Especially during seismic aftershocks

Rationale: As ACI 376 and NFPA 59A have observed, in SSE events it is generally allowed that structures sustain damage as they absorb energy. But, it is logical that designs preclude that damage unless the damaged condition is considered following SSE.

Revisions:
2 – Reformat of Table L-1Q and L-1R to provide more clear guidance on the proper reduction factors to use for CLE and ALE. This guidance considers that most secondary liquid containers and Type M-CC will be designed with an R=1 for the CLE event. Also, clarifies that Membrane Tank Outer Container Type M-1 with CS can use Table L-1R.

Proposed Changes:

Table L-1Q—Force Reduction Factors for Strength Design Methods, Annex Q Tanks (See Notes)

~~Anchorage System~~ Containment Type	R_i, (impulsive)		R_c, (convective)	
~~Inner Tank:~~ Primary Liquid Container and Membrane Tank Outer Container Type M-1 (See Note 2):	CLE	ALE	CLE	ALE
Steel (nickel, or stainless)				
Self-anchored	1.5	n/a	1.0	n/a
Mechanically-anchored	1.75	n/a	1.0	n/a
Aluminum				
Self-anchored	1.25	n/a	1.0	n/a
Mechanically-anchored	1.5	n/a	1.0	n/a
Secondary Liquid Container (See Note 3):				
Steel (nickel, or stainless)	1.0	1.75	n/a	1.0
Aluminum	1.0	1.5	n/a	1.0
Membrane Tank Outer Container Type M-CC (See Note 4):				
Steel (nickel, or stainless)	1.0	1.75	1.0	1.0
Aluminum	1.0	1.5	1.0	1.0
Warm Product Vapor or Purge Gas Container	2.0	n/a	n/a	n/a
~~Outer Tank (Empty):~~				
~~Self-anchored~~	~~2.0~~		~~n/a~~	
~~Mechanically-anchored~~	~~2.0~~		~~n/a~~	
NOTE 1: ~~The above R factors are applied for CLE (or SSE) event and ALE as noted.~~ For OLE (or OBE), the elastic design ~~(R = 1.0) is used~~ shall use R_i and R_c equal to 1.0. NOTE 2: A Membrane Tank Outer Container Type M-1 composed of carbon steel may use Force Reduction Factors from Table L-1R. NOTE 3: R_i = 2.0 may be used for the CLE (or SSE) event if prior damage from the CLE event is accounted for in the ALE design. Refer to API 625. NOTE 4: R_i and R_c for the CLE (or SSE) event may be equivalent to the values used for Primary Liquid Container if prior damage from the CLE event is accounted for in the ALE design. Refer to API 625.				

Table L-1R—Force Reduction Factors for Strength Design Methods, Annex R Tanks (See Note 1)

~~Anchorage System~~ Containment Type	R_i, (impulsive)		R_c, (convective)	
~~Inner Tank:~~				
Primary Liquid Container and Membrane Tank Outer Container Type M-1:	CLE	ALE	CLE	ALE
Self-anchored	2.25	n/a	1.5	n/a
Mechanically-anchored	2.5	n/a	1.5	n/a
Secondary Liquid Container (See Note 2):	1.0	2.5	n/a	1.5
Membrane Tank Outer Container Type M-CC (See Note 3):	1.0	2.5	1.0	1.5
Warm Product Vapor or Purge Gas Container:	2.0	n/a	n/a	n/a
~~Mechanically-anchored~~	~~2.0~~		~~n/a~~	

NOTE 1: The above R factors are applied for CLE (or SSE) event and ALE as noted. For OLE (or OBE), the elastic design (R = 1.0) is used.
NOTE 2:R_i = 2.0 may be used for the CLE (or SSE) event if prior damage from the CLE event is accounted for in the ALE design. Refer to API 625.
NOTE 3: R_i and R_c for the CLE (or SSE) event may be equivalent to the values used for Primary Liquid Container if prior damage from the CLE event is accounted for in the ALE design. Refer to API 625.

L.4.5.2 Modification Factors

~~The secondary containment~~ Secondary liquid containers and membrane tank outer containers Type M-CC shall be designed for ALE while containing liquid using an importance factor equal to 1.0 and response modification values in Table L-1Q or Table L-1R. ~~as applicable for the inner tank.~~

Q.3.3 Allowable Design Stresses

Q.3.3.1 For the primary liquid container and membrane tank outer container Type M-CC, the maximum allowable design stresses for the materials outlined in Q.2.2 shall be in accordance with Table Q-3

Q.3.3.2 The maximum allowable tensile stress for the membrane tank outer container Type M-1, shall be taken from Table 5-1 or Table Q-3.

~~Q.3.3.2~~ Q.3.3.3 For the primary liquid container and membrane tank outer container Type M-CC, the values for the allowable design tensile stress given in Table Q-3 for materials other than bolting steel are the lesser of (a) 33 1/3 % of the specified minimum ultimate tensile strength for the material or (b) 66 2/3 % of the specified minimum yield strength, but they are 75 % of the specified minimum yield strength for the stainless steel, nickel alloy, and aluminum materials.

Q.3.3.4 The maximum allowable design tensile stress for the secondary liquid container may be higher, but shall not exceed the smaller of the following:
— 150 % of the allowable tensile stress from Table Q-3 for the secondary liquid container material;
— maximum tensile stress permitted in Q.6.2.2 for hydrotest of primary liquid containers.

Q.3.3.5 For secondary liquid containers and membrane tank outer containers Type M-CC to be considered undamaged from the contingency level earthquake (CLE or SSE), the general tensile and compressive membrane stresses determined in accordance with API 620 while using R=1.0 shall not exceed the material's specified minimum yield strength or the critical buckling stress including imperfection and material knockdown factors, respectively.

Publishing to renumber existing Q.3.3.3 through Q.3.3.7 accordingly

Agenda Item 620-1010 has a reference to the current Q.3.3.6 in Q.3.3.4. Publishing to change reference to Q.3.3.9.

R.3.3 ~~Design~~ Allowable Design Stresses

R.3.3.1 The maximum allowable tensile stress for the primary liquid container and membrane tank outer container (Type M-1 and M-CC), shall be taken from Table 5-1 or Table Q-3. For the maximum allowable stresses for design loadings combined with wind or earthquake loads, see 5.5.6 for carbon steel and ~~Q.3.3.6~~ Q.3.3.9 for stainless steel and aluminum.

R.3.3.2 The maximum allowable design tensile stress for the secondary liquid container may be higher, but shall not exceed the smaller of the following:
— 150 % of the allowable tensile stress from Table 5-1 or Table Q-3 for the secondary liquid container material;
— maximum tensile stress permitted in R.6.2 for hydrotest of primary liquid containers.

R.3.3.3 For secondary liquid containers and membrane tank outer containers Type M-CC to be considered undamaged from the contingency level earthquake (CLE or SSE), the general tensile and compressive membrane stresses determined in accordance with API 620 while using R=1.0 shall not exceed the material's specified minimum yield strength or the critical buckling stress including imperfection and material knockdown factors, respectively.

5.5.6 Maximum Allowable Stresses for Wind or Earthquake Loadings
The maximum allowable stresses for design loadings combined with wind or earthquake loadings shall not exceed 133 % of the stress permitted for the design loading condition; except as allowed in Annex L, this stress shall not exceed 80 % of the specified minimum yield strength for carbon steel. For stainless steel and aluminum, see ~~Q.3.3.6~~ Q.3.3.9.