§ 178.338-3   Structural integrity.

(a) *General requirements and acceptance criteria.* (1) Except as permitted in paragraph (d) of this section, the maximum calculated design stress at any point in the tank may not exceed the lesser of the maximum allowable stress value prescribed in section VIII of the ASME Code, or 25 percent of the tensile strength of the material used.

(2) The relevant physical properties of the materials used in each tank may be established either by a certified test report from the material manufacturer or by testing in conformance with a recognized national standard. In either case, the ultimate tensile strength of the material used in the design may not exceed 120 percent of the minimum ultimate tensile strength specified in either the ASME Code or the ASTM standard to which the material is manufactured.

(3) The maximum design stress at any point in the tank must be calculated separately for the loading conditions described in paragraphs (b), (c), and (d) of this section. Alternate test or analytical methods, or a combination thereof, may be used in lieu of the procedures described in paragraphs (b), (c), and (d) of this section, if the methods are accurate and verifiable.

(4) Corrosion allowance material may not be included to satisfy any of the design calculation requirements of this section.

(b) *Static design and construction.* (1) The static design and construction of each tank must be in accordance with appendix G in Section VIII of the ASME Code (IBR, see §171.7 of this subchapter). The tank design must include calculation of stress due to the design pressure, the weight of lading, the weight of structures supported by the tank wall, and the effect of temperature gradients resulting from lading and ambient temperature extremes. When dissimilar materials are used, their thermal coefficients must be used in calculation of the thermal stresses.

(2) Stress concentrations in tension, bending, and torsion which occur at pads, cradles, or other supports must be considered in accordance with appendix G in Section VIII of the ASME Code.

(c) Stresses resulting from static and dynamic loadings, or a combination thereof, are not uniform throughout the cargo tank motor vehicle. The following is a simplified procedure for calculating the effective stress in the tank resulting from static and dynamic loadings. The effective stress (the maximum principal stress at any point) must be determined by the following formula:

$$S = 0.5 (S_y + S_x) \pm (0.25(S_y - S_x)^2 + S_s2)^{0.5}$$

Where:

(1) S = effective stress at any given point under the most severe combination of static and dynamic loadings that can occur at the same time, in psi.

(2) S_y = circumferential stress generated by internal and external pressure when applicable, in psi.

(3) S_x = the net longitudinal stress, in psi, generated by the following loading conditions:

(i) The longitudinal tensile stress generated by internal pressure;

(ii) The tensile or compressive stress generated by the axial load resulting from a decelerative force applied independently to each suspension assembly at the road surface using applicable static loadings specified in §178.338–13 (b);

(iii) The tensile or compressive stress generated by the bending moment resulting from a decelerative force applied independently to each suspension assembly at the road surface using applicable static loadings specified in §178.338–13 (b);

(iv) The tensile or compressive stress generated by the axial load resulting from an accelerative force applied to the horizontal pivot of the fifth wheel supporting the vehicle using applicable static loadings specified in §178.338–13 (b);

(v) The tensile or compressive stress generated by the bending moment resulting from an accelerative force applied to the

horizontal pivot of the fifth wheel supporting the vehicle using applicable static loadings specified in §178.338–13 (b); and

(vi) The tensile or compressive stress generated by a bending moment produced by a vertical force using applicable static loadings specified in §178.338–13 (b).

(4) S_s= The following shear stresses that apply, in psi,: The vectorial sum of the applicable shear stresses in the plane under consideration, including direct shear generated by the static vertical loading; direct lateral and torsional shear generated by a lateral accelerative force applied at the road surface, using applicable static loads specified in §178.338–13 (b)

(d) In order to account for stresses due to impact in an accident, the design calculations for the tank shell and heads must include the load resulting from the design pressure in combination with the dynamic pressure resulting from a longitudinal deceleration of "2g". For this loading condition the stress value used may not exceed the lesser of the yield strength or 75 percent of the ultimate tensile strength of the material of construction. For a cargo tank constructed of stainless steel, the maximum design stress may not exceed 75 percent of the ultimate tensile strength of the type steel used.

(e) The minimum thickness of the shell or heads of the tank must be 0.187 inch for steel and 0.270 inch for aluminum. However, the minimum thickness for steel may be 0.110 inches provided the cargo tank is:

(1) Vacuum insulated, or

(2) Double walled with a load bearing jacket designed to carry a proportionate amount of structural loads prescribed in this section.

(f) Where a tank support is attached to any part of the tank wall, the stresses imposed on the tank wall must meet the requirements in paragraph (a) of this section.

(g) The design, construction and installation of an attachment, appurtenance to the cargo tank or structural support member between the cargo tank and the vehicle or suspension component or accident protection device must conform to the following requirements:

(1) Structural members, the suspension subframe, accident protection structures and external circumferential reinforcement devices must be used as sites for attachment of appurtenances and other accessories to the cargo tank, when practicable.

(2) A lightweight attachment to the cargo tank wall such as a conduit clip, brakeline clip, skirting structure, lamp mounting bracket, or placard holder must be of a construction having lesser strength than the cargo tank wall materials and may not be more than 72 percent of the thickness of the material to which it is attached. The lightweight attachment may be secured directly to the cargo tank wall if the device is designed and installed in such a manner that, if damaged, it will not affect the lading retention integrity of the tank. A lightweight attachment must be secured to the cargo tank shell or head by a continuous weld or in such a manner as to preclude formation of pockets that may become sites for corrosion. Attachments meeting the requirements of this paragraph are not authorized for cargo tanks constructed under part UHT in Section VIII of the ASME Code.

(3) Except as prescribed in paragraphs (g)(1) and (g)(2) of this section, the welding of any appurtenance the cargo tank wall must be made by attachment of a mounting pad so that there will be no adverse effect upon the lading retention integrity of the cargo tank if any force less than that prescribed in paragraph (b)(1) of this section is applied from any direction. The thickness of the mounting pad may not be less than that of the shell or head to which it is attached, and not more than 1.5 times the shell or head thickness. However, a pad with a minimum thickness of 0.187 inch may be used when the shell or head thickness is over 0.187 inch. If weep holes or tell-tale holes are used, the pad must be drilled or punched at the lowest point before it is welded to the tank. Each pad must:

(i) Be fabricated from material determined to be suitable for welding to both the cargo tank material and the material of the appurtenance or structural support member; a Design Certifying Engineer must make this determination considering chemical and physical properties of the materials and must specify filler material conforming to the requirements in Section IX of the ASME Code (IBR, see §171.7 of this subchapter).

(ii) Be preformed to an inside radius no greater than the outside radius of the cargo tank at the attachment location.

(iii) Extend at least 2 inches in each direction from any point of attachment of an appurtenance or structural support member. This dimension may be measured from the center of the attached structural member.

(iv) Have rounded corners, or otherwise be shaped in a manner to minimize stress concentrations on the shell or head.

(v) Be attached by continuous fillet welding. Any fillet weld discontinuity may only be for the purpose of preventing an intersection between the fillet weld and a tank or jacket seam weld.