NB-3512.2 Alternative Design Rules. A valve design may not satisfy all of the requirements of NB-3512.1. A design may be accepted provided it meets one of the alternatives listed in (a), (b), (c), or (d) below.

(a) When the valve design satisfies the rules of NB-3530 through NB-3546.2 with thermal stresses neglected, the rules of NB-3200 relative to accounting for thermal secondary stresses and fatigue analysis [NB-3222.2, NB-3222.3, and NB-3222.4] shall also be satisfied.

(b) When a valve is exempted from fatigue analysis by the rules of NB-3222.4(d), the design is acceptable, provided that the requirements of (1) or (2) below are met.

1. The rules of NB-3530 through NB-3546 shall be met. The rules of NB-3200 may be substituted for those of NB-3545.2 for evaluating secondary stresses, and NB-3545.3 need not be considered.

2. The rules of NB-3530 and NB-3541 shall be met. An experimental stress analysis is performed in accordance with Appendix II, and the rules of NB-3200 with respect to primary and secondary stresses resulting from pressure and mechanical loads shall be met. Unless otherwise specified in the Design Specifications, the pipe reactions shall be taken as those loads which produce a stress (NB-3545.2(b)) of 0.5 times the yield strength of the piping in tension for the direct or axial load and a stress of 1.0 times the yield strength of the piping in bending and torsion. Thermal secondary stresses shall be accounted for by either the rules of NB-3200 or NB-3545.

(c) When a valve design satisfies the rules of NB-3530 and NB-3541, and when an experimental stress analysis has been performed upon a similar valve in accordance with Appendix II, and an acceptable analytic method has been established, the results may be used in conjunction with the requirements of NB-3200 for pressure and mechanical loads to establish design acceptability. Accommodation of thermal secondary stresses and pipe reactions shall be as given in NB-3545(c) Requirements for fatigue analysis of either NB-3200 or NB-3550 shall be met.

(d) When permitted by the Design Specification, a weld end valve that does not meet all of the requirements of NB-3540 may be designed so that it meets the requirements of NB-3200 for all pressure-retaining parts and those parts defined by NB-3546.3(a), and shall also meet all of the following requirements.

1. Pressure, thermal, and mechanical effects, such as those resulting from earthquake, maximum stem force, closure force, assembly forces, and others that may be defined in the Design Specification, shall be included in the design analysis. For Level A Service Limits, the pipe reaction effects are to be determined by considering that the maximum fiber stress in the connected pipe is at one-half of its yield strength in direct tension and at its yield strength in torsion and in bending in the plane of the neck and run, and also in the plane of the run perpendicular to the neck, each considered separately. The individual pipe reaction effects that result in the maximum stress intensity at all points, including all other effects, shall be used for the analysis to satisfy the rules of NB-3200. The valve Design Specification shall provide the loadings and operating requirements to be considered under Level B, C, and D Service Limits [NB-3252(a)(5)] for which a design analysis is to be included in the Design Report.

2. In place of using the values of \( S_m \) to satisfy the rules of NB-3200, the allowable stress intensity values for ferritic valve body and bonnet materials shall be those allowable stress values given in Section II, Part D, Subpart 1, Table 1A. For materials in Section II, Part D, Subpart 1, Tables 2A and 2B, a reduced allowable stress intensity based on applying a factor of 0.67 to the yield strengths listed in Section II, Part D, Subpart 1, Table Y-1 shall be used.

3. The adequacy of the stress analysis of the body and bonnet shall be verified by experimental stress analysis conducted in accordance with the requirements of II-1100 through II-1400. Individual tests shall be made to verify the adequacy of the stress analysis of internal pressure effects and pipe reaction effects. Tests shall be made on at least one valve model of a given configuration, but a verified analytical procedure may then be applied to other valves of the same configuration, although they may be of different size or pressure rating. The geometrical differences shall be accounted for in the extrapolation stress analysis. The analytical procedure shall have verified capability of providing this extrapolation.

4. A Design Report shall be prepared in sufficient detail to show that the valve satisfies all applicable requirements.

5. Prior to installation, the valve shall be hydrostatically tested in accordance with NB-3531.2. For this purpose, the primary pressure rating shall be determined by interpolation in accordance with NB-3543(c).

NB-3513 Acceptability of Small Valves

Valves having an inlet piping connection NPS 4 (DN 100) or less are acceptable when they satisfy either the standard design rules or the alternative design rules.

NB-3513.1 Standard Design Rules. The design shall be such that the requirements of NB-3530 and NB-3541 shall be met for wall thicknesses corresponding to the applicable pressure-temperature rating. When the Special Class Ratings of ASME B16.34 apply, the NDE exemptions of NB-2510 shall not be used.

NB-3513.2 Alternative Design Rules. A valve design shall satisfy the requirements of NB-3512.2.

NB-3515 Acceptability of Metal Bellows and Metal Diaphragm Stem Sealed Valves

Valves using metal bellows or metal diaphragm stem seals shall be constructed in accordance with the rules of this Subarticle, based on the assumption that the bellows or diaphragms do not retain pressure, and Design
\[ P_m = \text{general primary membrane stress intensity at crotch region, calculated according to NB-3545.1(a), psi (MPa)} \]
\[ p_r = \text{Design Pressure, psi (MPa)} \]
\[ p_i = \text{Pressure Rating Class Index, psi (MPa)} \]
\[ p_t = \text{standard calculation pressure from NB-3545.1, psi (MPa)} \]
\[ p_1, p_2 = \text{rated pressures from tables of ASME B16.34 corresponding to Pressure Rating Class Indices}\]
\[ Q_p = \text{sum of primary plus secondary stresses at crotch resulting from internal pressure [NB-3545.2(a)], psi (MPa)} \]
\[ Q_{TT} = \text{maximum thermal stress component caused by through-wall temperature gradient associated with 100°F/hr (56°C/hr) fluid temperature change rate [NB-3545.2(c)], psi (MPa)} \]
\[ Q_{TT} = \text{maximum thermal secondary membrane plus bending stress resulting from structural discontinuity and 100°F/hr (56°C/hr) fluid temperature change rate, psi (MPa)} \]
\[ r = \text{mean radius of body wall at crotch region [Fig. NB-3545.2(c)-1], in. (mm)} \]
\[ r_1 = \text{inside radius of body at crotch region for calculating } Q_p [\text{NB-3545.2(a)], in. (mm)} \]
\[ r_2 = \text{fillet radius of external surface at crotch [NB-3545.1(a)], in. (mm)} \]
\[ S = \text{assumed maximum stress in connected pipe for calculating the secondary stress due to pipe reaction [NB-3545.2(b)], psi (MPa)} \]
\[ S_1 = \text{fatigue stress intensity range at crotch region resulting from step change in fluid temperature } \Delta T_p \text{ and pressure } \Delta P_p [\text{NB-3550}], psi (MPa) \]
\[ S_m = \text{design stress intensity (NB-3532), psi (MPa)} \]
\[ S_{n(max)} = \text{maximum range of sum of primary plus secondary stress, psi (MPa)} \]
\[ S_{p1} = \text{fatigue stress intensity at inside surface in crotch region resulting from 100°F/hr (56°C/hr) fluid temperature change rate [NB-3545.3], psi (MPa)} \]
\[ S_{p2} = \text{fatigue stress intensity at outside surface in crotch region resulting from 100°F/hr (56°C/hr) fluid temperature change rate [NB-3545.3], psi (MPa)} \]
\[ T_b = \text{thickness of valve wall adjacent to crotch region for calculating } L_3 \text{ and } L_6 \text{ [Fig. NB-3545.1(a)-1], in. (mm)} \]
\[ T_e = \text{maximum effective metal thickness in crotch region for calculating } L_3 \text{ and } L_6 \text{ [Fig. NB-3545.2(c)-1], in. (mm)} \]
\[ T_r = \text{thickness of body (run) wall adjacent to crotch for calculating } L_3 \text{ and } L_6 \text{ [Fig. NB-3545.1(a)-1], in. (mm)} \]
\[ t_e = \text{minimum body wall thickness adjacent to crotch for calculating thermal stresses [Fig. NB-3545.2(c)-1], in. (mm)} \]
\[ t_m = \text{minimum body wall thickness as determined by NB-3541, in. (mm)} \]
\[ t_{b_1}, t_{b_2} = \text{minimum wall thicknesses from ASME B16.34 corresponding to Listed Pressure Class Indices } p_r \text{ and } p_2 \text{ and inside diameter } d_{in}, \text{ in. (mm)} \]
\[ \Delta P_p = \text{full range of pressure fluctuation associated with } \Delta T_p \text{ psi (MPa)} \]
\[ \Delta P_i = \text{specified range of pressure fluctuation associated with } \Delta T_i \text{ psi (MPa)} \]
\[ \Delta T_p = \text{a specified step change in fluid temperature, °F (°C), where } i = 1, 2, 3, ..., n; \text{ used to determine the fatigue acceptability of a valve body (NB-3554)} \]
\[ \Delta T_i = \text{specified range of fluid temperature, °F (°C), where } i = 1, 2, 3, ..., n; \text{ used to evaluate normal valve usage (NB-3553)} \]
\[ \Delta T = \text{maximum magnitude of the difference in average wall temperatures for walls of thicknesses } t_e \text{ and } T_e \text{ resulting from 100°F/hr (56°C/hr) fluid temperature change rate, °F (°C)} \]

**NB-3540** **DESIGN OF PRESSURE-RETAINING PARTS**

**NB-3541** **General Requirements for Body Wall Thickness**

The minimum wall thickness of a valve body is to be determined by the rules of NB-3542 or NB-3543.

**NB-3542** **Minimum Wall Thickness of Listed Pressure Rated Valves**

The wall thickness requirements for listed pressure rated valves apply also to integral body venturi valves. For a valve designed to a listed pressure rating of ASME B16.34, the minimum thickness of its body wall, including the neck, is to be determined from ASME B16.34, except that the inside diameter \( d_{in} \) shall be the larger of the basic valve body inside diameters in the region near the welding ends. Highly localized variations of inside diameter associated with weld preparation [NB-3544.8(a) and NB-3544.9(b)] need not be considered for establishing minimum wall thickness \( t_m \). In all such cases, however, the requirements of NB-3545.2(b)(6) shall be satisfied.

**NB-3543** **Minimum Wall Thickness of Valves of Nonlisted Pressure Rating**

To design a valve for Design Pressure and Design Temperature corresponding to other than one of the pressure ratings listed in the tables of ASME B16.34, the procedure is the same as that of NB-3542 except that interpolation is required as follows.

(a) Based on the Design Temperature, linear interpolation between the tabulated temperature intervals shall be used to determine the listed pressure rating \( p_r \), next
(e) For socket welding ends, valves NPS 2 (DN 50) and smaller for which the body cavity consists of cylindrically bored sections shall meet all of the following:

(1) \( d_b \) shall be the port drill diameter;

(2) the requirements of NB-3542 shall be satisfied; and

(3) socket welding end valves greater than NPS 2 (DN 50) shall not be used.

**NB-3544.9 Openings for Auxiliary Connections.** Openings for auxiliary connections, such as for drains, bypasses, and vents, shall meet the requirements of ASME B16.34 and the applicable reinforcement requirements of NB-3330.

**NB-3545 Body Primary and Secondary Stress Limits.**

The limits of primary and secondary stresses are established in the following subparagraphs.

**NB-3545.1 Primary Membrane Stress Due to Internal Pressure.** For valves meeting all requirements of this Subarticle, the most highly stressed portion of the body under internal pressure is at the neck to flow passage junction and is characterized by circumferential tension normal to the plane of center lines, with the maximum value at the inside surface. The rules of this paragraph are intended to control the general primary membrane stress in this crotch region. The Standard Calculation Pressure \( p_s \) to be used for satisfying the requirements of NB-3545 is found either directly or by interpolation from the tables in ASME B16.34 as the pressure at 500°F (260°C) for the given Pressure Rating Class Index \( P_r \).

(a) In the crotch region, the maximum primary membrane stress is to be determined by the pressure area method in accordance with the rules of (1) through (6) below using Fig. NB-3545.1(a)-1.

(1) From an accurately drawn layout of the valve body, depicting the finished section of the crotch region in the principal plane of the bonnet and flow passage center lines, determine the fluid area \( A_f \) and metal area \( A_m \). \( A_f \) and \( A_m \) are to be based on the internal surface after complete loss of metal assigned to corrosion allowance.

(2) Calculate the crotch general primary membrane stress intensity:

\[ P_m = \left( \frac{A_f}{A_m} + 0.5 \right) p_s \]

The allowable value of this stress intensity is \( S_m \) for the valve body material at 500°F (260°C) as given in Section II, Part D, Subpart 1, Tables 2A and 2B.

(3) The distances \( L_A \) and \( L_N \) which provide bounds on the fluid and metal areas are determined as follows. Use the larger value of:

\[ L_A = 0.5d + \tau_b \]

or

\[ L_A = \tau_f \]

and use

\[ L_N = 0.5r_2 + 0.354 \sqrt{\tau_b (d + \tau_b)} \]

where the dimensions are as shown in Fig. NB-3545.1(a)-1.

In establishing appropriate values for the above parameters, some judgment may be required if the valve body is irregular as it is for globe valves and others with nonsymmetric shapes. In such cases, the internal boundaries of \( A_f \) shall be the lines that trace the greatest width of internal wetted surfaces perpendicular to the plane of the stem and pipe ends [Fig. NB-3545.1(a)-1 sketches (b), (d), and (e)].

(4) If the calculated boundaries for \( A_f \) and \( A_m \), as defined by \( L_A \) and \( L_N \), fall beyond the valve body [Fig. NB-3545.1(a)-1 sketch (b)], the body surface becomes the proper boundary for establishing \( A_f \) and \( A_m \). No credit is to be taken for any area of connected piping which may be included within the limits of \( L_A \) and \( L_N \). If the flange is included with \( A_m \), the area of one bolt hole is to be subtracted for determining the net value of \( A_m \).

(5) Except as modified below, web or fin-like extensions of the valve body are to be credited to \( A_m \) only to an effective length from the wall equal to the average thickness of the credited portion. The remaining web area is to be added to \( A_f \) [Fig. NB-3545.1(a)-1 sketch (b)]. However, to the extent that additional area will pass the following test, it may also be included in \( A_m \). A line perpendicular to the plane of the stem and pipe ends from any point in \( A_m \) does not break out of the wetted surface but passes through a continuum of metal until it breaks through the outer surface of the body.

(6) In most cases, it is expected that the portions defined by \( A_m \) in the several illustrations of Fig. NB-3545.1(a)-1 will be most highly stressed. However, in the case of highly irregular valve bodies, it is recommended that all sections of the crotch be checked to ensure that the largest value of \( P_m \) has been established considering both open and fully closed conditions.

(b) In regions other than the crotch, while the value of \( P_m \), calculated by (a), will be the highest value of body general primary membrane stress for all normal valve types with typical wall proportioning, the designer is cautioned to review unusual body configurations for possible higher stress regions. Suspected regions are to be checked by the pressure area method applied to the particular local body contours. The allowable value of this stress intensity is \( S_m \) for the valve body material at 500°F (260°C) as given in Section II, Part D, Subpart 1, Tables 2A and 2B.

**NB-3545.2 Secondary Stresses.** In addition to satisfying the criteria of NB-3541 through NB-3545.1, a valve body shall also satisfy the criterion that the range of
19 These requirements for the acceptability of a valve design are not intended to ensure the functional adequacy of the valve. However, for pressure relief valves the Designer is cautioned that the requirements of NB-7000 relative to set pressure, lift, blowdown, and closure shall be met.

20 **CAUTION:** Certain types of double seated valves have the capability of trapping liquid in the body or bonnet cavity in the closed position. If such a cavity accumulates liquid and is in the closed position at a time when adjacent system piping is increasing in temperature, a substantial and uncontrolled increase in pressure in the body or bonnet cavity may result. Where such a condition is possible, it is the responsibility of the Owner or the Owner's designee to provide, or require to be provided, protection against harmful overpressure in such valves.

21 The severity and frequency of specified fluid temperature variations may be such that the period of calculated pressure integrity is less than plant design life. In such cases it is the responsibility of the Certificate Holder to state these conditions in the Design Report (NB-3560).

22 Special features such as wear surfaces or seating surfaces may demand special alloys or proprietary treatments. The absence of such materials from Section II, Part D, Subpart 1, Tables 2A and 2B shall not be construed to prohibit their use and such materials do not require approval under Appendix IV (NB-2121).

23 A listed pressure rated valve is one listed in the tables of ASME B16.34. A nonlisted pressure rated valve is one whose Design Pressure and Temperature do not specifically appear in those tables (NB-3543).

24 For all listed pressure ratings except Class 150, the Pressure Rating Class Index is the same as the pressure rating class designation. For Class 150 use 115 for the Pressure Rating Class Index.

25 *Adjacent points* are defined as points which are spaced less than the distance \(2\sqrt{Rt}\) from each other, where \(R\) and \(t\) are the mean radius and thickness, respectively, of the vessel, nozzle, flange, or other component in which the points are located.

26 For piping products, such as tees and branch connections, the second term of eqs. NB-3652(9), NB-3653.1(a)(10), and NB-3653.2(a)(11), namely that containing \(M_s\) is to be calculated as referred to in NB-3683.1(d).

27 Socket welds shall not be used where the existence of crevices could accelerate corrosion.

28 The flexibility of a curved pipe or welding elbow is reduced by *end effects*, provided either by the adjacent straight pipe or by the proximity of other relatively stiff members which inhibit ovalization of the cross section. In certain cases, these end effects may also reduce the stress.

29 \(t\) equals nominal wall thickness.

30 Welds that are exposed to corrosive action should have a resistance to corrosion that is not substantially less than that of the cladding. The use of filler metal that will deposit weld metal which is similar to the composition of the cladding material is recommended. If weld metal of different composition is used, it should have properties compatible with the application.

31 An *intermediate postweld heat treatment* for this purpose is defined as a postweld heat treatment performed on a weld within a temperature range not lower than the minimum holding temperature range to which the weld shall be subjected during the final postweld heat treatment.

32 A radiographic examination [NB-5111(a)] is required; a preservice examination [NB-5111(b)] may or may not be required for compliance to the Design Specification [NCA-3252(c)].

33 SNT-TC-1A is a Recommended Practice for Nondestructive Testing Personnel Qualification and Certification published by the American Society for Nondestructive Testing, 1711 Arlingate Lane, P.O. Box 28518, Columbus, OH 43228-0518.

34 Personnel qualified by examination and certified to the previous editions of SNT-TC-1A are considered to be qualified to the edition referenced in Table NCA-7100-2 when the recertification is based on continuing satisfactory performance. All reexaminations and new examinations shall be in accordance with the edition referenced in Table NCA-7100-2.

35 *Employer* as used in this Article shall include: N Certificate Holders; Quality System Certificate Holders; Material Organizations who are qualified in accordance with NCA-3842; and organizations who provide subcontracted nondestructive examination services to organizations described above.
14 Adjacent points are defined as points that are spaced less than the distance $2\sqrt{R_R}$ from each other, where $R$ and $r$ are the mean radius and thickness, respectively, of the vessel, nozzle, flange, or other part in which the points are located.

15 The head design curves have been developed considering membrane stress requirements, plastic collapse, cyclic load conditions, and the effects of maximum allowable tolerances in accordance with NC-4222. See A-4000 of Appendix A for the design formulas for the curves of Fig. NC-3224.6-1.

16 Heads having $D/2h = 2$ have equivalent torispherical properties of a torisphere of $L/D = 0.90$ and $r/D = 0.17$.

17 The minimum thickness for all pipe materials is the nominal thickness listed in Table 2 of ASME B36.10M less $12\frac{1}{2}\%$. For diameters other than those listed in the table, the minimum thickness shall be that of the next larger pipe size.

18 The formulas provide safe construction as far as stress is concerned. Greater thicknesses may be necessary if deflection would cause leakage at threaded or gasketed joints.

19 When axial compressive loadings occur in addition to the external pressure, the combined axial loading shall meet the requirements of NC-3245.

20 Stress means the maximum normal stress.

21 Since $H$, $h$, in some cases will subtract from the total moment, the moment in the flange ring when the internal pressure is zero may be the determining loading for the flange design.

22 The rules in NC-3329(f) apply to ligaments between tube holes and not to single openings. They may give lower efficiencies in some cases than those for symmetrical groups that extend a distance greater than the inside diameter of the shell as covered in NC-3329(c). When this occurs, the efficiencies computed by the rules under NC-3329(b) shall govern.

23 Communicating chambers are defined as appurtenances to the vessel that intersect the shell or heads of a vessel and form an integral part of the pressure retaining enclosure, such as sumps.

24 Side plates of a flat-sided vessel are defined as any of the flat plates forming an integral part of the pressure retaining enclosure.

25 Written for fittings with internal threads but also applicable to externally threaded and socket- or butt-welded fittings.

26 All dimensions given are nominal.

27 It is recognized that other acceptable procedures may exist which also constitute adequate design methods, and it is not the intention to rule out these alternative methods, provided they can be shown to have been satisfactory by actual service experience.

28 CAUTION: Certain types of double-seated valves have the capability of trapping liquid in the body or bonnet cavity in the closed position. If such a cavity accumulates liquid and is in the closed position at a time when adjacent system piping is increasing in temperature, a substantial and uncontrolled increase in pressure in the body or bonnet cavity may result. Where such a condition is possible, it is the responsibility of the Owner or his designee to provide, or require to be provided, protection against harmful overpressure in such valves.

29 The minimum thicknesses of straight pipe shown in Table NC-3642.1(c)-1 should be sufficient to allow the pipe to meet the minimum wall thickness requirements of NC-3641 after having been bent on the radii shown.

30 Expansion Joint Manufacturers Association, 25 North Broadway, Tarrytown, NY 10591.

31 See Appendix II, I-1520(g).

32 The pressure term in eqs. NC-3652(8), NC-3653.1(a)(9a), NC-3653.1(b)(9b)and NC-3653.2(c)(11) may not apply for bellows and expansion joints.

33 Design Pressure may be used if the Design Specification states that peak pressure and earthquake need not be taken as acting concurrently.

34 Socket welds should not be used where the existence of crevices could accelerate corrosion.

35 Fillet and partial penetration welds should not be used where severe vibration is expected.
18 Side plates of a flat sided vessel are defined as any of the flat plates forming an integral part of the pressure retaining enclosure.

19 Written for fittings with internal threads but also applicable to externally threaded and socket or butt welded fittings.

20 $t_D$ is defined in XI-3130.

21 All dimensions given, for size of vessel on which inspection openings are required, are nominal.

22 It is recognized that other acceptable procedures may exist that also constitute adequate design methods, and it is not the intention to rule out these alternative methods provided they can be shown to have been satisfactory by actual service experience.

23 **CAUTION:** Certain types of double seated valves have the capability of trapping liquid in the body or bonnet cavity in the closed position. If such a cavity accumulates liquid and is in the closed position at a time when adjacent system piping is increasing in temperature, a substantial and uncontrolled increase in pressure in the body or bonnet cavity may result. Where such a condition is possible, it is the responsibility of the Owner or his designee to provide, or require to be provided, protection against harmful overpressure in such valves.

24 The minimum thicknesses of straight pipe shown in Table ND-3642.1(c)-1 should be sufficient to allow the pipe to meet the minimum wall thickness requirements of ND-3641 after having been bent on the radii shown.


26 See Appendix II, II-1520(g).

27 The pressure term in eqs. ND-3652(8), ND-3653.1(a)(9a), ND-3653.1(b)(9b) and ND-3653.2(c)(11) may not apply for bellows and expansion joints.

28 Design Pressure may be used if the Design Specification states that peak pressure and earthquake need not be taken as acting concurrently.

29 Socket welded joints should not be used where the existence of crevices could result in accelerated corrosion.

30 Fillet and partial penetration welds should not be used where severe vibration is expected.

31 These rules do not limit storage tanks from being installed below grade or below ground, provided the tanks are not subject to external pressure resulting from earth or fill.

32 The limitation of the Design Pressure to atmospheric is not intended to preclude the use of these tanks at vapor pressure slightly above or below atmospheric within the range normally required to operate vent valves. If these pressures or vacuums exceed $\frac{1}{2}$ oz/in.$^2$, especially in combination with large diameter tanks, the forces involved may require special consideration in the design.

33 Any specified corrosion allowance for the shell plates shall be added to the calculated thickness.

34 The nominal thickness of shell plates refers to the tank shell as constructed. The thicknesses specified are based on erection requirements.


36 The decrease in yield stress at Design Temperature shall be taken into account.

37 The formulas applying to self-supporting roofs provide for a uniform live load of 25 lb/ft.$^2$ (1.2 kPa).

38 Whenever a tank is to be operated with liquid levels that at no time reach the top of the roof, but is to be filled to the very top of the roof during the hydrostatic test, it shall be designed for both of these maximum liquid level conditions, using in each case the density of the liquid employed. If a tank is not designed to be filled to the very top of the roof, overfill protection is required.

39 A suitable margin shall be allowed between the pressure normally existing in the gas or vapor space and the pressure at which the relief valves are set, so as to allow for the increases in pressure caused by variations in the temperature or gravity of the liquid contents of the tank and other factors affecting the pressure in the gas or vapor space.

40 The partial vacuum shall be greater than that at which the vacuum relief valves are set to open.