NC-3324.5 Formed Heads, General Requirements.
Formed heads shall meet the requirements of (a) through (g) below.

(a) All formed heads, thicker than the shell and concave to pressure, for butt welded attachment, shall have a skirt length sufficient to meet the requirements of Figure NC-3358.1(a)-1 when a tapered transition is required.

(b) Any taper at a welded joint within a formed head shall be in accordance with NC-3361. The taper at a circumferential welded joint connecting a formed head to a main shell shall meet the requirements of NC-3358 for the respective type of joint shown therein.

(c) All formed heads concave to pressure and for butt welded attachment need not have an integral skirt when the thickness of the head is equal to or less than the thickness of the shell. When a skirt is provided, its thickness shall be at least that required for a seamless shell of the same diameter.

(d) The inside crown radius to which an unstayed head is dished shall be not greater than the outside diameter of the skirt of the head. The inside knuckle radius of a torispherical head shall be at least 6% of the outside diameter of the skirt of the head but in no case less than three times the head thickness.

(e) When an ellipsoidal, torispherical, hemispherical, conical, or toriconical head is of a lesser thickness than required by the rules of this paragraph, it shall be stayed as a flat surface according to the rules of NC-3329.

(f) If a torispherical, ellipsoidal, or hemispherical head is formed with a flattened spot or surface, the diameter of the flat spot shall not exceed that permitted for flat heads as given by eqs. NC-3325.2(b)(5) or NC-3325.2(b)(6) using \( C = 0.25 \).

(g) Openings in formed heads under internal pressure shall comply with the requirements of NC-3330.

NC-3324.6 Ellipsoidal Heads.

(a) Ellipsoidal Heads. The required thickness of a dished head of semiellipsoidal form, in which one-half the minor axis, inside depth of the head minus the skirt, equals one-fourth the inside diameter of the head skirt, shall be determined by:

\[
t = \frac{PD}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{D + 0.2t}
\]

(b) Ellipsoidal Heads of Other Ratios. The minimum required thickness of an ellipsoidal head of other than a 2:1 ratio shall be determined by:

\[
t = \frac{PDK}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{KD + 0.2t}
\]

\[
t = \frac{PDK}{2S + 2P(K - 0.1)}
\]

or

\[
P = \frac{2St}{KD_0 - 2t(K - 0.1)}
\]

where

\[
K = \frac{1}{6} \left[ 2 + \left( \frac{D}{2h} \right)^2 \right]
\]

Numerical values of the factor \( K \) are given in Table NC-3324.2-1.

NC-3324.7 Hemispherical Heads.

(a) When the thickness of a hemispherical head does not exceed 0.356\( L \) or \( P \) does not exceed 0.665\( S \), the following equations shall apply:

\[
t = \frac{PL}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{L + 0.2t}
\]

(b) When the thickness of the hemispherical head under internal pressure exceeds 0.356\( L \), or when \( P \) exceeds 0.665\( S \), the following equations shall apply:

\[
t = L \left( \frac{Y^{1/3} - 1}{\frac{Y^{1/3}}{Y^{1/3}}} \right) = L_0 \left( \frac{Y^{1/3} - 1}{\frac{Y^{1/3}}{Y^{1/3}}} \right)
\]

where

\[
Y = \frac{2(S + P)}{2S - P}
\]

or

\[
P = \frac{2S(Y - 1)}{Y + 2}
\]

where

\[
Y = \left( \frac{L + t}{L} \right)^3 = \left( \frac{L_0}{L_0 - t} \right)^3
\]

NC-3324.8 Torispherical Heads.

(a) Torispherical Heads With a 6% Knuckle Radius. The required thickness of a torispherical head in which the knuckle radius is 6% of the inside crown radius shall be determined by:

\[
t = \frac{0.885PL}{S - 0.1P} \quad \text{or} \quad P = \frac{St}{0.885L + 0.1t}
\]

(b) Torispherical Heads of Other Proportions. The required thickness of a torispherical head in which the knuckle radius is other than 6% of the crown radius shall be determined by:

\[
t = \frac{PLM}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{LM + 0.2t}
\]
(b) Ellipsoidal Heads of Other Ratios. The minimum required thickness of an ellipsoidal head of other than a 2:1 ratio shall be determined by:

\[ t = \frac{PD}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{KD + 0.2t} \]

or

\[ t = \frac{PDK}{2S + 2P(K - 0.1)} \]

where

\[ K = \frac{1}{6} \left[ 2 + \left( \frac{D}{2L} \right)^2 \right] \]

Numerical values of the factor \( K \) are given in Table NC-3324.2-1.

NC-3324.7 Hemispherical Heads

(a) When the thickness of a hemispherical head does not exceed 0.356\( L \) or \( P \) does not exceed 0.665\( S \), the following equations shall apply:

\[ t = \frac{PL}{2S - 0.2P} \quad \text{or} \quad P = \frac{2St}{L + 0.2t} \]

(b) When the thickness of the hemispherical head under internal pressure exceeds 0.356\( L \), or when \( P \) exceeds 0.665\( S \), the following equations shall apply:

\[ t = L \left( \frac{Y^2}{Y} - 1 \right) = L_0 \left( \frac{Y^2}{Y} - 1 \right) \]

where

\[ Y = \frac{2(S + P)}{2S - P} \]

or

\[ P = 2S \left( \frac{Y - 1}{Y + 2} \right) \]

where

\[ Y = \left( \frac{L + t}{L} \right)^2 = \left( \frac{L_0}{L_0 - t} \right)^3 \]

NC-3324.8 Torispherical Heads

(a) Torispherical Heads With a 6% Knuckle Radius. The required thickness of a torispherical head in which the knuckle radius is 6% of the inside crown radius shall be determined by:

\[ t = \frac{0.885PL}{S - 0.1P} \quad \text{or} \quad P = \frac{St}{0.885L + 0.1t} \]

(b) Torispherical Heads of Other Proportions. The required thickness of a torispherical head in which the knuckle radius is other than 6% of the crown radius shall be determined by:

\[ t = \frac{PLM}{2S + P(M - 0.2)} \quad \text{or} \quad P = \frac{2St}{LM + 0.2t} \]

where

\[ M = \frac{1}{4} \left( 3 + \sqrt{\frac{L}{r}} \right) \]

Numerical values of the factor \( M \) are given in Table NC-3324.8(b)-1.

(c) Torispherical heads made of materials having a specified minimum tensile strength exceeding 80 ksi (550 MPa) shall be designed using a value of \( S \) equal to 20 ksi (140 MPa) at room temperature and reduced in proportion to the reduction in maximum allowable stress values at temperature for the material as shown in Tables 1A, 1B, and 3, Section II, Part D, Subpart 1.

NC-3324.10 Toriconical Heads. Toriconical heads in which the inside knuckle radius is neither less than 6% of the outside diameter of the head skirt nor less than three times the knuckle thickness shall be used when the angle \( \alpha \) exceeds 30 deg, except when the design complies with NC-3324.11. The required thickness of the knuckle shall be determined by the first equation of NC-3324.8(b) in which

\[ L = \frac{D_1}{2 \cos \alpha} \]

The required thickness of the conical portion shall be determined by the equation in NC-3324.9, using \( D_1 \) in place of \( D \).