Step 3. From the intersection obtained in Step 2, move horizontally to the right and read the value of factor $B$. This is the maximum allowable compressive stress for the values of $T$ and $R$ used in Step 1.

Step 4. For values of $A$ falling to the left of the applicable material/temperature line, the value of $B$ shall be calculated using the following equation:

$$B = \frac{AE}{2}$$

Step 5. Compare the value of $B$ determined in Step 3 or 4 with the computed longitudinal compressive stress in the cylindrical shell or tube, using the selected values of $T$ and $R$. If the value of $B$ is smaller than the computed compressive stress, a greater value of $T$ must be selected and the design procedure repeated until a value of $B$ is obtained which is greater than the compressive stress computed for the loading on the cylindrical shell or tube.

**NC-3133.7 Conical Heads.** The required thickness of a conical head under external pressure shall not be less than that determined by the rules of (a), (b), and (c) below.

(a) When one-half of the included apex angle of the cone is equal to or less than $22\frac{1}{2}$ deg, the thickness of the cone shall be the same as the required thickness of a cylindrical shell, the length of which equals the axial length of the cone or the axial distance center to center of stiffening rings, if used, and the outside diameter of which is equal to the outside diameter at the large end of the cone or section between stiffening rings.

(b) When one-half of the included apex angle of the cone is greater than $22\frac{1}{2}$ deg and not more than 60 deg, the thickness of the cone shall be the same as the required thickness of a cylindrical shell, the outside diameter of which equals the largest inside diameter of the cone measured perpendicularly to the cone axis, and the length of which equals an axial length that is the lesser of either the distance center to center of stiffening rings, if used, or the largest inside diameter of the section of the cone considered.

(c) When one-half of the included apex angle of the cone is greater than 60 deg, the thickness of the cone shall be the same as the required thickness for a flat head under external pressure, the diameter of which equals the largest inside diameter of the cone (NC-3325).

(b) The design of the component shall include consideration of the interaction effects and loads transmitted through the attachment to and from the pressure-retaining portion of the component. For vessels designed to NC-3200, thermal stresses, stress concentrations, and restraint of the pressure-retaining portion of the component shall be considered.

(c) Beyond $2t$ from the pressure-retaining portion of the component, where $t$ is the nominal thickness of the pressure-retaining material, the appropriate design rules of Article NF-3000 may be used as a substitute for the design rules of Article NC-3000 for portions of attachments which are in the component support load path.

(d) Nonstructural attachments shall meet the requirements of NC-4435.

**NC-3133.8 Internal Tubes and Pipes When Used as Tubes in Shell and Tube Heat Exchangers**

As an alternative to NC-3133.3, for internal tubes in shell and tube heat exchangers, the required wall thickness for tubes and pipes under external pressure may be determined in accordance with Figure NC-3133.8-1.

**NC-3135 Attachments**

(a) Except as in (c) and (d) below, attachments and connecting welds within the jurisdictional boundary of the component as defined in NC-1130 shall meet the stress limits of the component.
Figure NC-3133.8-1
Chart for Determining Wall Thickness of Tubes Under External Pressure

Design Stress, ksi (MPa)

Design Pressure, psi (MPa)

Revise to:
Allowable Stress, S as defined in NC-3321, ksi (MPa)
Step 2. Using the value of $A$ calculated in Step 1, enter the applicable material chart in Section II, Part D, Subpart 3 for the material under consideration. Move vertically to an intersection with the material/temperature line for the Design Temperature. Interpolation may be made between lines for intermediate temperatures. In cases where the value at $A$ falls to the right of the end of the material/temperature line, assume an intersection with the horizontal projection of the upper end of the material/temperature line. For values of $A$ falling to the left of the material/temperature line, see Step 4.

Step 3. From the intersection obtained in Step 2, move horizontally to the right and read the value of factor $B$. This is the maximum allowable compressive stress for the values of $T$ and $R$ used in Step 1.

Step 4. For values of $A$ falling to the left of the applicable material/temperature line, the value of $B$ shall be calculated using the following equation:

$$B = \frac{AE}{2}$$

Step 5. Compare the value of $B$ determined in Steps 3 or 4 with the computed longitudinal compressive stress in the cylindrical shell or tube, using the selected values of $T$ and $R$. If the value of $B$ is smaller than the computed compressive stress, a greater value of $T$ must be selected and the design procedure repeated until a value of $B$ is obtained that is greater than the compressive stress computed for the loading on the cylindrical shell or tube. The joint efficiency for butt-welded joints may be taken as unity.

**ND-3133.7 Tubes and Pipes When Used as Tubes.**

The required wall thickness for tubes and pipe under external pressure shall be determined in accordance with Figure ND-3133.7-1.

**ND-3135 Attachments**

(a) Except as in (c) and (d) below, attachments and connecting welds within the jurisdictional boundary of the component as defined in ND-1130 shall meet the stress limits of the component.

(b) The design of the component shall include consideration of the interaction effects and loads transmitted through the attachment to and from the pressure-retaining portion of the component.

(c) Beyond 2t from the pressure-retaining portion of the component, where $t$ is the nominal thickness of the pressure-retaining material, the appropriate design rules of Article NF-3000 may be used as a substitute for the design rules of Article ND-3000 for portions of attachments that are in the component support load path.

(d) Nonstructural attachments shall meet the requirements of ND-4435.

**ND-3300 VESSEL DESIGN**

**ND-3310 GENERAL REQUIREMENTS**

Class 3 vessel requirements as stipulated in the Design Specifications (NCA-3250) shall conform to the design requirements of this Article.

**ND-3320 DESIGN CONSIDERATIONS**

**ND-3321 Stress Limits for Design and Service Loadings**

Stress limits for Design and Service Loadings are specified in Table ND-3321-1. The symbols used in Table ND-3321-1 are defined as follows:

- $S = \text{allowable stress value given in Section II, Part D, Subpart 1, Tables 1A and 1B. The allowable stress shall correspond to the highest metal temperature at the section under consideration during the condition under consideration.}$
- $\sigma_b = \text{bending stress. This stress is equal to the linear varying portion of the stress across the solid section under consideration. It excludes discontinuities and concentrations, and is produced only by pressure and other mechanical loads.}$
- $\sigma_L = \text{local membrane stress. This stress is the same as } \sigma_m, \text{ except that it includes the effect of discontinuities and concentrations.}$

**ND-3133.7 Internal Tubes and Pipes When Used as Tubes in Shell and Tube Heat Exchangers**

As an alternative to ND-3133.3, for internal tubes in shell and tube heat exchangers, the required wall thickness for tubes and pipes under external pressure may be determined in accordance with Figure ND-3133.7-1.
Figure ND-3133.7-1
Chart for Determining Wall Thickness of Tubes Under External Pressure

GENERAL NOTE: For welded tubes or pipes, use the design stress for seamless material.

Revise "design" to "allowable"

Revise to:
Allowable Stress, S as defined in ND-3321, psi (MPa)
Step 4. The smaller of the values of $P_{\alpha_1}$ calculated in Step 2, or $P_{\alpha_2}$ calculated in Step 3 shall be used for the maximum allowable external pressure $P_{\alpha}$. Compare the calculated value of $P_{\alpha}$ with $P$. If $P_{\alpha}$ is smaller than $P$, select a larger value for $T$ and repeat the design procedure until a value of $P_{\alpha}$ is obtained that is equal to or greater than $P$.

Step 5. Provide adequate reinforcement of the cone-to-cylinder juncture according to Section III Appendices, Mandatory Appendix XXII.

NCD-3133.8 Tubes and Pipes When Used as Tubes.
The required wall thickness for tubes and pipes under external pressure shall be determined in accordance with Figure NCD-3133.8-1.

(2) When $\alpha$ of the cone is greater than 60 deg, the thickness of the cone shall be the same as the required thickness for a flat head under external pressure, the diameter of which equals the largest diameter of the cone (see NCD-3325).

(3) The thickness of an eccentric cone shall be taken as the greater of two thicknesses obtained using both the smallest and largest $\alpha$ in the calculations.
Note to Editors: Markups are based on 2019 Edition of NC-3000. Changes are shown in red. Cross references to paragraphs within this sub-article shall be updated based on this proposal’s markups.

**Figure NCD-3133.8-1 — Chart for Determining Wall Thickness of Tubes Under External Pressure**

FOR INFORMATION ONLY: THIS IS A PROPOSED CONSOLIDATION OF THE 18-212 MARKUP WITH THE PREVIOUSLY APPROVED NCD SECTION PREVIOUSLY APPROVED IN RECORD 19-1991

GENERAL NOTE: For welded tubes or pipes, use the design stress for seamless material.

**NCD-3135 Attachments**

(a) Except as in (c) and (d) below, attachments and connecting welds within the jurisdictional boundary of the component as defined in NCD-1130 shall meet the stress limits of the component.

Revise "design" to "allowable"