(d) for vessels with welds between materials having different coefficients of expansion, is the number of temperature cycles which causes the value of \((a_1 - a_2) \Delta T\) to exceed 0.00034, where \(a_1\) and \(a_2\) are the mean coefficients of thermal expansion, 1/°F (1/°C) (Section II, Part D, Subpart 2, Tables TE), and \(\Delta T\) is the service temperature range, °F (°C). This does not apply to cladding.

NC-3219.3.2 Condition BP. All of the requirements of NC-3219.2.2, Condition B, are met using the adjusted values in (a) through (c) below.

(a) Use a value of 4 instead of 3 in NC-3219.2.2(a).
(b) Use a value of one-quarter instead of one-third in NC-3219.2.2(b).
(c) Use a value of 2.7 instead of 2 in the denominator of NC-3219.2.2(c), NC-3219.2.2(d), and NC-3219.2.2(e).

NC-3220 DESIGN CONSIDERATIONS
NC-3221 Design Loadings
The provisions of NC-3210 apply.

NC-3222 Special Considerations
The provisions of NC-3121 and NC-3214 apply.

NC-3223 General Design Rules
NC-3223.1 General Requirements. The design shall be such that the design rules of NC-3200 are satisfied for all configurations and loadings, using the stress intensity values \(S_m\) of Section II, Part D, Subpart I, Tables 2A, 2B, and 4 in the various equations.

NC-3223.2 Design Reports. The Certificate Holder shall provide a Design Report conforming to the requirements of NC-3211.1(e).

NC-3224 Vessels and Parts Under Internal Pressure
NC-3224.1 General Requirements. The thickness of vessels and parts under internal pressure shall be not less than that computed by the equations in the following paragraphs. In addition, provision shall be made for the applicable load combinations listed in NC-3218 in establishing the value of \(F\) as defined below.

NC-3224.2 Nomenclature. The symbols used are defined below. Except for test conditions, dimensions used or calculated shall be in the corroded condition.

\[
\begin{align*}
D & = \text{inside diameter of a head skirt or inside length of the major axis of an ellipsoidal head or inside diameter of a conical head at the point under consideration measured perpendicular to the axis of revolution.} \\
F & = \text{meridional membrane force in the shell wall at the point under consideration resulting from primary loadings other than internal pressure, lb/in. (N/mm) length of circumference. If this force is not uniform, as when resulting from wind or earthquake moment loading, the loading requiring the greatest shell thickness shall be used where the tensile load is positive.} \\
h & = \text{one-half the length of the minor axis of an ellipsoidal head or the inside depth of an ellipsoidal head, measured from the tangent line} \\
k & = \text{stress intensity factor for design, service, and test load combination from Table NC-3217-1} \\
L & = \text{inside spherical or crown radius of torispherical and hemispherical heads} \\
P & = \text{internal pressure at the top of vessel plus any pressure due to the static head of the fluid, at any point under consideration, psi (MPa)} \\
Q & = \text{a factor in the equations for cone to cylinder junctions depending on } P/S \text{ and } \alpha \\
R & = \text{inside radius of the shell under consideration. This radius is measured normal to the surface from the of revolution} \\
R_L & = \text{radius of a cylinder at the large end of a cone to cylinder junction} \\
R_S & = \text{radius of a cylinder at the small end of a cone to cylinder junction} \\
r & = \text{inside knuckle radius of torispherical and toriconical heads} \\
S & = \text{membrane stress intensity limit from Section II, Part D, Subpart I, Tables 2A, 2B, and 4 multiplied by the stress intensity factor in Table NC-3217-1} = k S_m, \text{psi (MPa)} \\
t & = \text{minimum required thickness of shell} \\
t_r & = Q \times \text{the required thickness of a cylinder calculated in accordance with NC-3224.13(b)(6)(b)} \\
\alpha & = \text{one-half of the apex angle of a cone to cylinder junction}
\end{align*}
\]

NC-3224.3 Minimum Thickness of Cylindrical Shells. The minimum thickness of cylindrical shells shall be the greatest of the thicknesses determined by (a), (b), and (c) below.

(a) \[
\begin{align*}
t & = \frac{PR}{S - 0.5P}
\end{align*}
\]

If \(P > 0.4S\), the following equation must be used:

\[
\ln \left( \frac{R + t}{R} \right) = \frac{P}{S}
\]

where \(\ln\) is the natural log.

(b) If \(F\) is positive and exceeds \(0.5PR\),

\[
t = \frac{0.5PR + F}{S - 0.5P}
\]

(c) If \(F\) is negative, the condition of axial structural instability or buckling shall be considered separately (see NC-3245).