MANDATORY APPENDIX XXII

ARTICLE XXII-1000
RULES FOR REINFORCEMENT OF CONE-TO-CYLINDER JUNCTION UNDER EXTERNAL PRESSURE

XXII-1100 INTRODUCTION

XXII-1110 SCOPE

(a) The equations of this Appendix provide for the design of reinforcement, if needed, at the cone-to-cylinder junctions for reducer sections and conical heads where all the elements have a common axis and the half-apex angle $\alpha \leq 60$ deg. Subparagraph XXII-1300(d) provides for special analysis in the design of cone-to-cylinder intersections with or without reinforcing rings where $\alpha$ is greater than 60 deg.

(b) In the design of reinforcement for a cone-to-cylinder juncture, the requirements of ND-3336 shall be met.

XXII-1200 NOMENCLATURE

The nomenclature given below is used in the equations of the following subparagraphs:

$A$ = factor determined from the applicable chart in Section II, Part D, Subpart 3 for the material used in the stiffening ring, corresponding to the factor $B$, below, and the design temperature for the shell under consideration

$A_e$ = effective area of reinforcement due to excess metal thickness

$A_{RL}$ = required area of reinforcement at large end

$A_{RS}$ = required area of reinforcement at small end

$A_s$ = cross-sectional area of the stiffening ring

$A_T$ = equivalent area of cylinder, cone, and stiffening ring

where

\[ A_{T_L} = \frac{L_{1/2}}{2} + \frac{L_{t_c}}{2} + A_p \text{ for large end} \]

\[ A_{T_S} = \frac{L_{t_s}}{2} + \frac{L_{t_c}}{2} + A_p \text{ for small end} \]

$B$ = factor determined from the applicable chart in Section II, Part D, Subpart 3 for the material used for the stiffening

$D_L$ = outside diameter of large end of conical section under consideration

$D_o$ = outside diameter of cylindrical shell (In conical shell calculations, the value of $D_o$ and $D_L$ should be used in calculations in place of $D_o$ depending on whether the small end $D_s$, or large end $D_L$, is being examined.)

$D_s$ = outside diameter at small end of conical section under consideration

$E$ = lowest efficiency of the longitudinal joint in the shell or head or of the joint in the reducer; $E = 1$ for butt welds in compression

$E_c$ = modulus of elasticity of cone material

$E_R$ = modulus of elasticity of reinforcing material

$E_s$ = modulus of elasticity of shell material

$E_x = E_o E_R$ or $E_s$

$f_1$ = axial load at large end (excluding pressure $P$), lb/in. (N/mm)

$f_2$ = axial load at small end (excluding pressure $P$), lb/in. (N/mm)

$I_x$ = required moment of inertia of the stiffening ring cross section about its neutral axis parallel to the axis of the shell

$I_x'$ = required moment of inertia of the combined ring-shell-cone cross section about its neutral axis parallel to the axis of the shell, in.$^4$ (mm$^4$). The width of shell which is taken as contributing to the moment of inertia of the combined section shall not be greater than $1.10 D_o T$ and shall be taken as lying one-half on each side of the centroid of the ring. Portions of the shell plate shall not be considered as contributing area to more than one stiffening ring. If the stiffeners should be so located that the maximum permissible effective shell sections overlap on either or both sides of a stiffener, the effective shell section for that stiffener shall be shortened by one-half of each overlap.

$k = \frac{S_p E_s}{S_p E_R}$ but not less than 1.0

$L$ = axial length of cone
ARTICLE XXII-1000
RULES FOR REINFORCEMENT OF
CONE-TO-CYLINDER JUNCTION
UNDER EXTERNAL PRESSURE

XXII-1100 INTRODUCTION

XXII-1110 SCOPE

(a) The formulas of this Appendix provide for the design of reinforcement, if needed, at the cone-to-cylinder junctions for reducer sections and conical heads where all the elements have a common axis and the half-apex angle \( \alpha \leq 60 \text{ deg} \). Subparagraph XXII-1300(d) provides for special analysis in the design of cone-to-cylinder intersections with or without reinforcing rings where \( \alpha \) is greater than 60 deg.

(b) In the design of reinforcement for a cone-to-cylinder juncture, the requirements of ND-3336 shall be met.

XXII-1200 NOMENCLATURE

The nomenclature given below is used in the formulas of the following subparagraphs:

- \( A \) = factor determined from the applicable chart in Section II, Part D, Subpart 3 for the material used in the stiffening ring, corresponding to the factor \( B \), below, and the design temperature for the shell under consideration.
- \( A_e \) = effective area of reinforcement due to excess metal thickness, sq in.
- \( A_{HL} \) = required area of reinforcement at large end, sq in.
- \( A_{HS} \) = required area of reinforcement at small end, sq in.
- \( A_r \) = cross-sectional area of the stiffening ring, sq in.
- \( A_T \) = equivalent area of cylinder, cone, and stiffening ring, sq in.

where

\[
A_{TL} = \frac{L_1 L_2}{2} + \frac{L_1 L_3}{2} + A_r, \text{ for large end}
\]

\[
A_{TS} = \frac{L_2 L_3}{2} + \frac{L_1 L_3}{2} + A_r, \text{ for small end}
\]

\( B \) = factor determined from the applicable chart in Section II, Part D, Subpart 3 for the material used for the stiffening (see ND-3112.2)

\( D_L \) = outside diameter of large end of conical section under consideration, in.

\( D_B \) = outside diameter of cylindrical shell, in. (In conical shell calculations, the value of \( D_s \) and \( D_L \) should be used in calculations in place of \( D_B \) depending on whether the small end \( D_s \) or large end \( D_L \), is being examined.)

\( D_s \) = outside diameter at small end of conical section under consideration, in.

\( E \) = lowest efficiency of the longitudinal joint in the shell or head or of the joint in the reducer; \( E = 1 \) for butt welds in compression

\( E_c \) = modulus of elasticity of cone material, psi

\( E_B \) = modulus of elasticity of reinforcing material, psi

\( E_s \) = modulus of elasticity of shell material, psi

\( f_1 \) = axial load at large end (excluding pressure \( P \)), lb/in.

\( f_2 \) = axial load at small end (excluding pressure \( P \)), lb/in.

\( I_s \) = required moment of inertia of the stiffening ring cross section about its neutral axis parallel to the axis of the shell, in.\(^4\)

\( I' \) = required moment of inertia of the combined ring-shell-cone cross section about its neutral