

## ASME UG 37 Nozzles

$d := 600 - 24 \text{Hole Diameter}$

$t := 10$  Actual Shell Thickness, Corroded

$t_r := 0.522$  Required Shell Thickness From Calculations

$t_n := 12$  Nozzle Wall Thickness, Corroded

$t_{rn} := 0.343$  Required Nozzle Thickness From Calculations

$f_{r1} := 1$   $S_n/S_v$  For Set In Nozzle Only, Maximum = 1

$f_{r2} := \frac{105}{115}$   $S_n/S_v$  Maximum = 1

$f_{r3} := 1$  The Lesser Of  $S_n$  or  $S_p/S_v$  Maximum = 1

$f_{r4} := 1$   $S_p/S_v$

$E_1 := 1$  1 if in solid plate or cat B Joint

**Note:- Design Stress Notation**  
 **$S_v = \text{Vessel Shell}$**   
 **$S_n = \text{Nozzle Design Stress}$**   
 **$S_p = \text{Pad design stress}$**

**Limits** Nozzles less than 1/2 D AND 508mm, in cylindrical shells  $< = 1520\text{mm Dia}$   
Nozzles less than 1/3 D AND 1000mm, in cylindrical shells  $> 1524\text{mm Dia}$   
No restriction on Formed Heads (UG 36)

### Set Through Nozzles

$h := 0$  Distance nozzle extends below shell; must not exceed the smaller of  $2.5 \times t$  or  $2.5 \times t_j$

$t_j := t_n$  Wall thickness of nozzle below shell

### Reinforcing Elements (Pads)

$D_p := 0$  Diameter Of Reinforcing Pad, must not extend beyond reinforcement limit

$t_e := 0$  Thickness of Reinforcing Pad

### Correction Factor F Fig UG37

$\theta := 0$  Plane of Interest Relative to Longitudinal axis, Always = 0 except when considering Ligaments between adjacent openings. Entered in degrees (Converted to Radians For calculating cos)

$$F := \frac{1 + \cos\left(\frac{\theta}{180} \cdot \pi\right)^2}{2} \quad F = 1$$

### Required Area A

$$A := d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \quad A = 300.67$$

The second term of the above equation is to compensate for the portion of a set in nozzle adjacent to  $t_r$  that has a lower allowable design stress than the shell. If the nozzle is set on, or if set in has the same design stress as the shell, and  $F = 1$ : this equation reduces to  $A = d \times t_r$ .

### Area Available In Shell, Larger Of

$$A_{11} := d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \quad A_{11} = 5459.33$$

$$A_{12} := 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \quad A_{12} = 417.032$$

The compensation area extends the larger of d or  $R_n+t+t_n$ . A11 calculates the compensation area based on it extending d, A12 calculates it based on it extending  $R_n+t+t_n$ . The second term of the above equations is discussed in the note above concerning A.

$$A_1 := \text{if}(A_{11} > A_{12}, A_{11}, A_{12}) \quad A_1 = 5459.33$$

### Area Available In Nozzle, Smaller Value

$$A_{21} := 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \quad A_{21} = 532.167$$

$$A_{22} := 2 \cdot (t_n - t_m) \cdot (2.5 \cdot t_n + t_e) \cdot f_{r2} \quad A_{22} = 638.601$$

Nozzle compensation extends a distance from the surface of the shell to the smaller of :-  $2.5 \times t$  (Considered in equation A21) or  $2.5 \times t_n + t_e$  (Considered in equation A22).

$$A_2 := \text{if}(A_{21} < A_{22}, A_{21}, A_{22}) \quad A_2 = 532.167$$

### Reinforcement Area Below Shell (Set Through)

$$A_3 := 5 \cdot h \cdot t_j \quad A_3 = 0$$

### Fillet Welds $leg := 0$

$$A_4 := leg^2$$

All fillet welds within the reinforcement limit can be considered as contributing to compensation, and as there is a fillet weld on either side of the joint, the area for each joint is equal to the leg length of the weld squared. This area may have to be factored by fr2, fr3, or fr4 depending on weld location and design stresses.

### Reinforcing Pads

$$A_5 := (D_p - d - 2 \cdot t_n) \cdot t_e \cdot f_{r4} \quad A_5 = 0$$

### Reinforcement Limit For Shell, Measured from Bore of Nozzle

$$\text{Limit\_shell} := \text{if}\left(\frac{d}{2} > t_n + t, \frac{d}{2}, t_n + t\right) \quad \text{Limit\_shell} = 288$$

### Reinforcement Limit For Nozzle, Measured from Shell Surface below any Reinforcing Pad

$$\text{Limit\_Nozzle} := \text{if}(2.5 \cdot t < 2.5 \cdot t_n + t_e, 2.5 \cdot t, 2.5 \cdot t_n + t_e) \quad \text{Limit\_Nozzle} = 25$$

Therefore Area Required  $A \geq A_1 + A_2 + A_3 + A_4 + A_5$

$$A = 300.672 \leq A_1 + A_2 + A_3 + A_4 + A_5 = 5991.5$$

### External Pressure Compensation, UG37 d) 1.

$$A = 300.672 \leq 2 \cdot (A_1 + A_2 + A_3 + A_4 + A_5) = 11982.99$$

Note:- F is always equal to 1 and tr and tn are calculated using external pressure rules

### Large Opening Check

**1-7a)** For all nozzles outside the limits in UG36 (See Above) two thirds of the required reinforcement must fit in :- half the limit along the shell measured from the nozzle bore or 3/4 d measured from the centre (assuming limit is based on d) plus the full limit along the branch.

**1-7b)** For Radial Nozzles with no internal projection, In Cylinders.

Nozzles greater than :- 1016mm AND  $3.4 \sqrt{R \cdot t}$  Diameter, in cylindrical shells  $> 1524\text{mm}$  Dia  
 $R_n / R < 0.7$  (Inside Nozzle Radius / Inside Shell Radius)

$$P := 0.125 \quad \text{Design Pressure}$$

$$R := 480 \quad \text{Inside Radius Of Shell}$$

$$R_m := R + \frac{t}{2} \quad \text{Mean Radius Of Shell}$$

$$R_n := \frac{d}{2} \quad \text{Inside Radius Of Nozzle}$$

$$R_{nm} := R_n + \frac{t_n}{2} \quad \text{Mean Radius Of Nozzle}$$

### Shaded Area $A_s$ , Fig 1-7-1

$$l_s := \sqrt{R_m \cdot t} \quad l_s = 69.642 \quad \text{Length Of Shell Considered}$$

$$l_n := t_e + t + \sqrt{R_{nm} \cdot t_n} \quad l_n = 69.397 \quad \text{Length Of Nozzle Considered}$$

$$l_p := \text{if}[(D_p - d - 2 \cdot t_n) > l_s, (D_p - d - 2 \cdot t_n), l_s] \quad l_p = 69.642 \quad \text{Length Of Pad Considered}$$

$$A_s := (t \cdot l_s) + l_p \cdot t_e + (t_n \cdot l_n) \quad A_s = 1529.18$$

### Membrane Stress, must not exceed S

$$S_m := P \cdot \left[ \frac{R \cdot (R_n + t_n + \sqrt{R_m \cdot t}) + R_n \cdot (t + t_e + \sqrt{R_{nm} \cdot t_n})}{A_s} \right] \quad S_m = 16.14$$

### Bending Stress

$$l_s := \text{if} \left[ \left( \sqrt{R_m \cdot t} \right) > (16 \cdot t), \sqrt{R_m \cdot t}, 16 \cdot t \right] \quad l_s = 160$$

$$l_n := \text{if} \left[ \left( t_e + t + \sqrt{R_{nm} \cdot t_n} \right) > (t_e + t + 16 \cdot t_n), t_e + t + \sqrt{R_{nm} \cdot t_n}, t_e + t + 16 \cdot t_n \right] \quad l_n = 202$$

$$l_p := \text{if} \left[ (D_p - d - 2 \cdot t_n) > l_s, (D_p - d - 2 \cdot t_n), l_s \right] \quad l_p = 160 \quad \text{Length Of Pad Considered}$$

Note: The value for  $l_s$  and  $l_n$  is the greatest value from Fig 1-7-1 and 1-7-2

$$a := 62.8 \quad \text{Distance To Neutral Axis}$$

$$I := 17138280 \quad \text{Second Moment Of Area I, for greatest shaded area in Fig 1-7-1 and 1-7-2}$$

$$e := a - \frac{t}{2}$$

$$M := \left( \frac{R_n^3}{6} + R \cdot R_n \cdot e \right) \cdot P \quad M = 1.5 \cdot 10^6 \quad \text{Section Bending Moment}$$

$$S_b := \frac{M \cdot a}{I} \quad S_b = 5.483 \quad \text{Bending Stress}$$

$$S_c := S_m + S_b \quad S_c = 21.621 \quad \text{Combined Bending and Membrane Stress. Must Not Exceed } S_v \times 1.5$$

Note: Nozzle design stress divided by shell design stress,  $S_n / S_v < 0.8$  For above large opening analysis. If necessary reduce  $S_v$  to maintain ratio.