Area of reinforcement required (see PG-33.3 and Figure PG-33.1)

\[ A = (d + 2t_n) \cdot t \cdot f \]
\[ = (3.5 + 2 \cdot 0.375) \cdot 0.521 \cdot 1.0 \]
\[ = 2.214 \text{ in.}^2 \]

Area of reinforcement available in vessel wall (see PG-33.3, PG-36.4.1, and Figure PG-33.1) with \( w_d = 0 \)

\[ A_1 = (d - 2t_n)(t - Ft) \]
\[ = (3.5 - 2 \cdot 0.375)(0.625 - 1.0 \cdot 0.521) \]
\[ = 0.286 \text{ in.}^2 \]

Area of reinforcement available in the nozzle wall external of the vessel (see PG-33.3, PG-36.4.2, and Figure PG-33.1)

In that the actual nozzle projection is less than that permitted within the limits of reinforcement, modification of the equation provided in PG-33.1 will be required to reflect the actual area available for reinforcement.

\[ A_2 = 2(t_n - t_m)(\text{actual projection})(S_n / S_v) \]
\[ = 2 \times (0.375 - 0.044) \times 0.625 \times (15,000 / 17,500) \]
\[ = 0.354 \text{ in.}^2 \]

Area of reinforcement available in the nozzle and nozzle lip internal of the vessel (see PG-33.3, PG-36.4.2, and Figure PG-33.1). Due to the nozzle lip, modification of the equation provided in Figure PG-33.1 will be required to reflect the actual area present.

\[ A_3 = 2t_m F t_1 \cdot h + \text{area present in lip} \]
\[ = 2 \times 0.375 \times 15,000 / 17,500 \times 1.375 \]
\[ + 2 \times 0.5 \times 0.75 \]
\[ = 1.634 \text{ in.}^2 \]

Area of reinforcement available in attachment welds (see PG-36.4.3 and Figure PG-33.1)

\[ A_{41} + A_{43} = \left[ W_{L_1}^2 + W_{L_3}^2 \right] (S_n / S_v) \]
\[ = (0.375^2 + 0.375^2)(15,000 / 17,500) \]
\[ = 0.241 \text{ in.}^2 \]
Figure PG-33.1
Nomenclature and Equations for Reinforced Openings

Area required
\[ A = (d - 2t_r)F \]
Area available in shell: use larger value
\[ A_1 = \left( d - 2t_n \right) \left( t - F_{tr1} \right) - 2\left( d - 2t_n \right) \left( 1 - F_{tr1} \right) \]
Area available in nozzle projecting outward; use smaller value
\[ A_2 = 2\left( t_n - t_{r_n} \right) \left( 2^{1/2} F_{tr1} \right) \]
Area available in nozzle projecting inward
\[ A_3 = 2t_n f_{r1} \]
Area available in outward nozzle weld
\[ A_{41} = (WL1)^2 f_{r2} \]
Area available in inward nozzle weld
\[ A_{43} = (WL3)^2 f_{r1} \]

If \( A_1 + A_2 + A_3 > A \)
Opening is adequately reinforced

If \( A_1 + A_2 + A_3 < A \)
Opening is not adequately reinforced so reinforcing elements must be added and/or thickness must be increased

With reinforcing element added:
Area available in outer element weld
\[ A_{42} = (WL2)^2 f_{r3} \]
Area available in element [Note (2)]
\[ A_5 = (D_p - d - 2t_n) f_{r3} \]

If \( A_1 + A_2 + A_3 + A_4 + A_5 > A \)
Opening is adequately reinforced

GENERAL NOTES:
(a) This figure illustrates common nozzle configurations and is not intended to prohibit other configurations permitted by the Code.
(b) See PG-33.3 and PG-36 for definitions of nomenclature.

NOTES:
(1) For the left-hand side of the illustration, \( w_d = 0 \).
(2) This formula is applicable for a rectangular cross-sectional element that falls within the limits of reinforcement.