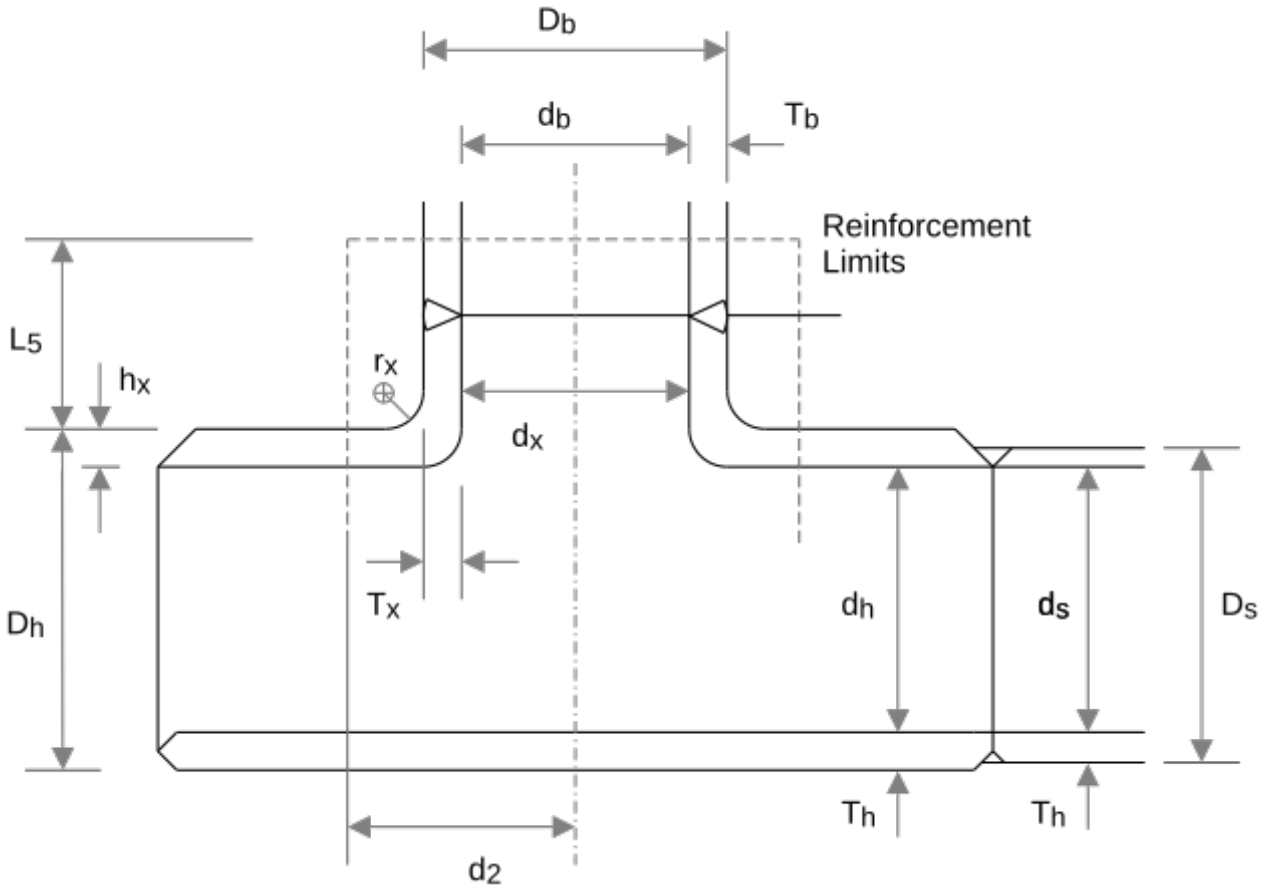
Reinforcement of Extruded Outlet Header or Fitting ASME 31.5-2019

Fabricated per ASME B31.5 -2019 Refrigeration Piping and Heat Transfer Components



Design temperature	T := 37.8 **degC**
Design pressure	P := 740 **psi**
Thickness allowances (corrosion, erosion, mechanical)	c := 0 **mm**
Fabricated from	ASTM A312 TP304L Seamless Austenitic SS 18-8 Pipe

Run Connecting Pipe

Allowable stress $SE_s := 115.1\ \text{MPa}$

$y_s := 0.4$

Long weld joint quality $E_s := 1.000$

Pipe size NPS 10 (DN 250) - 40 Std 40S thk = 0.365 inch

$D_s := 273.050\ \text{mm}$

Nominal wall thickness $T_{hs} := 9.271\ \text{mm}$

Inside diameter $d_s := 254.508\ \text{mm}$

Thickness tolerance $Mill_s := 0.125$

Minimum required thickness of connecting run pipe $t_s := \frac{P \cdot D_s}{2 \cdot \left(SE_s + P \cdot y_s\right)} = 5.946\ \text{mm}$

Purchase spec min or measured thickness of connecting run pipe $T_s := T_{hs} - T_{hs} \cdot Mill_s = 8.112\ \text{mm}$

Corroded thickness of connecting run pipe $T_s - c = 8.112\ \text{mm}$

$$check\_1 := \begin{cases} \text{"Thickness of connected header pipe is not sufficient at design pressure"} & T_s < t_s \\ \text{"Thickness of connected header pipe is sufficient at design pressure"} & \text{otherwise} \end{cases}$$

check_1 = "Thickness of connected header pipe is sufficient at design pressure"

Branch (1) Connecting Pipe

ASTM A312 TP304L Welded Austenitic SS 18-8 Pipe

Allowable stress $SE_b := 97.9\ \text{MPa}$

$y_b := 0.4$

Long weld joint quality $E_b := 0.85$

Pipe size

NPS 10 (DN 75) - 40 Std 40S thk = 0.216 inch

$D_b := 88.9\ \text{mm}$

Nominal wall thickness

$T_{nb} := 5.486\ \text{mm}$

Inside diameter

$d_b := 77.927\ \text{mm}$

Thickness tolerance

$Mill_b := 0.125$

Minimum required thickness of connecting run pipe

$$t_b := \frac{P \cdot D_b}{2 \cdot \left(SE_b + P \cdot y_b\right)} = 2.269\ \text{mm}$$

Purchase spec min or measured thickness of connecting run pipe

$T_b := T_{nb} - T_{nb} \cdot Mill_b = 4.800\ \text{mm}$

Corroded thickness of connecting run pipe

$T_b - c = 4.800\ \text{mm}$

$$check\_2 := \begin{cases} \text{"Thickness of connected branch pipe is not sufficient at design pressure"} & T_s < t_s \\ \text{"Thickness of connected branch pipe is sufficient at design pressure"} & \text{otherwise} \end{cases}$$

check_2 = "Thickness of connected branch pipe is sufficient at design pressure"

Extruded Tee or Header

Long. weld joint quality

$E_h := 1$

Allowable stress

$SE_h := 115.1\ \text{MPa}$

$y_h := 0.4$

Ensure sure the connecting header pipe thickness is adequate. dh is usually same as ds dimension below.

Sometimes the design calls for the I.D. to be same for the both the extruded part and the run connecting pipe, thus the manifold or tee might need to be of non-standard dimensions.

Inside diameter of run

$d_h := 10.020\ \text{mm}$

Wall thickness of run

$T_{nh} := 0.375\ \text{mm}$

Required thickness will probably be greater than that of the connecting header.

Outside diameter of run $D_h := d_h + 2 \cdot T_{nh} = 10.770\ \text{mm}$

Thickness tolerance of run $Mill_h := 0$

Minimum required thickness of run portion of extruded tee $t_h := \frac{P \cdot (d_h + 2 \cdot c)}{2 \cdot (SE_h - P \cdot y_h - P)} = 0.237\ \text{mm}$

Purchase spec. min. or measured thickness of extruded tee $T_h := T_{nh} - T_{nh} \cdot Mill_h = 0.375\ \text{mm}$

Corroded thickness of run portion of tee $T_h - c = 0.375\ \text{mm}$

$$check\_3 := \begin{cases} \text{"STOP! Add thickness to run portion of extruded tee, or change design conditions"} & T_h - c \le t_h \\ \text{"PASS. Thickness of run portion of extruded tee is enough at design conditions"} & \text{otherwise} \end{cases}$$

check_3 = "PASS. Thickness of run portion of extruded tee is enough at design conditions"

Check if diameter and thickness ratios are valid. Refer to ASME B31.3 para 304.3.1(b)(1) & (2)

$$check\_4 := \begin{cases} \text{"STOP. Branch OD exceeds run OD. Re-enter branch size"} & D_b > D_h \\ \text{"PASS. Branch OD does not exceed run"} & \text{otherwise} \end{cases}$$

check_4 = "STOP. Branch OD exceeds run OD. Re-enter branch size"

$$check\_5 := \begin{cases} \text{"PASS"} & \frac{D_h}{T_h} < 100 \ \textbf{and} \ \frac{D_b}{D_h} < 1 \\ \text{"STOP"} & \text{otherwise} \end{cases} = \text{"STOP"}$$

check_5 = "STOP"

Corroded inside diameter of branch pipe or flange hub connection $d_b + 2 \cdot c = 77.927\ \text{mm}$

Design ID of extruded outlet, measured at level of outside of surface. This is after removal of mechanical, corrosion and thickness tolerances. dx must be less than or equal to db $d_x := 3.068\ \text{mm}$

$$check\_5 := \begin{cases} cat("Input a smaller dx. Maximum dx = ", d_b + 2\cdot c) & d_x > d_b + 2\cdot c \\ cat("OK. Maximum dx = ", d_b + 2\cdot c) & otherwise \end{cases}$$

check_5 = "OK. Maximum dx = 77.927*Unit(mm)"

Half width of reinforcement zone (equal to dx)

$d_2 := 3.068\ mm$

End of header-to-center of branch

$minU := d_2 + 2\ inch = 53.868\ mm$

Minimum rx

$min\_r_x := \min(0.05\cdot D_b, 1.5\ inch) = 4.445\ mm$

Maximum rx
(a) for Db < DN 200 (NPS 8), Rx = 32 mm (or 1.25 in)
(b) for Db >= DN 200, rx= 0.1*Db+13 mm (or 0.5 in)

$$max\_r_x := \begin{cases} 1.25\ inch & D_b < 8.625\ inch \\ 0.1\cdot D_b + 0.5\ inch & otherwise \end{cases}$$

$max\_r_x = 31.750\ mm$

Radius of curvature of external contoured portion of outlet, measured in the plane containing the axes of the header and branch. Changing rx and Tx changes the reinforcement provided

$r_x := 0.375\ mm$

Corroded fin thk of extruded outlet, measured at a height equal or rx above the outside surface of the header

$T_x := 0.3\ mm$

Height of reinforcement zone outside of header pipe

$L_5 := 0.7\cdot(D_b\cdot T_x)^{\frac{1}{2}} = 3.615\ mm$

Height of extrudeed outlet. Must be equal to or greater than rx

$h_x := 0.770\ mm$

$$check\_1 := \begin{cases} "OK.\ hx\ is\ equal\ to\ or\ greater\ than\ rx" & h_x \geq r_x \\ "Increase\ hx\ to\ at\ least\ rx" & otherwise \end{cases}$$

check_1 = "OK. hx is equal to or greater than rx"

Factor for Strength Connection

Factor for strength correction of branch area

$$F_b := \begin{cases} 1 & \frac{SE_b}{E_b} > SE_h \\ \frac{\frac{SE_b}{E_b}}{\frac{SE_h}{E_h}} & \text{otherwise} \end{cases}$$

$F_b = 1$

Factor K

$$K := \begin{cases} 1 & \frac{D_b}{D_h} > 0.6 \\ 0.6 + \frac{2}{3} \cdot \frac{D_b}{D_h} & \frac{D_b}{D_h} \\ 0.7 & \text{otherwise} \end{cases}$$

$K = 1$

Areas

Required area of reinforcement

$$A_1 := K \cdot t_h \cdot d_x = 0.726\ mm^2$$

Area of excess wall thickness in run portion of extruded tee

$$A_2 := d_x \cdot (T_h - t_h - c) = 4.241 \times 10^{-7}\ m^2$$

Area of excess wall thickness of branch pipe or fig hub

$$A_3 := \begin{cases} 0 & L_5 < h_x \\ 2 \cdot (L_5 - h_x) \cdot (T_b - t_b - c) & \text{otherwise} \end{cases}$$

$A_3 = 1.440 \times 10^{-5}\ m^2$

Area of excess thickness in 1st portion of extruded outlet lip

$$A_{3a} := \begin{cases} 2 \cdot h_x \cdot (T_b - t_b - c) & h_x < L_5 \\ 2 \cdot L_5 \cdot (T_b - t_b - c) & \text{otherwise} \end{cases}$$

$A_{3a} = 3.898 \times 10^{-6}\ m^2$

Area resulting from excess thickness in 2nd portion of extruded outlet lip

$$A_4 := \max(2 \cdot r_x \cdot (T_x - (T_b - c)), 0) = 0$$

Area available for reinforcement (w/strength correction for different materials in zone)

$$A_5 := A_2 + A_3 \cdot F_b + A_{3a} + A_4$$

$$A_5 = 1.872 \times 10^{-5}\ \mathrm{m}^2$$

Perecent of area replaced

$$\text{area\_replaced} := \frac{A_5}{A_1} \cdot 100 = 2.577 \times 10^{3}$$

$$\text{check\_2} := \begin{cases} \text{"OK. This branch has sufficient reinforcement"} & A_5 > A_1 \\ \text{"FAIL. Change input"} & \text{otherwise} \end{cases}$$

check_2 = "OK. This branch has sufficient reinforcement"