

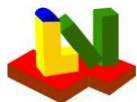
ASME BPVC VIII-1 2023
PTB-4-2021 / E4.6.1; E4.6.2

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Layout

Input values:	1.234	or	1.234
Calculated values:	1.234	or	1.234
Critical values:	1.234	or	1.234
Estimated values:	1.234	or	1.234



ASME BPVC VIII-1 2023
PTB-4-2021 / E4.6.1; E4.6.2

Strength Calculation Software	Program System ATLAS --- version : 11.0.7.161
Developed by Lauterbach Verfahrenstechnik GmbH	
Certified per DIN EN ISO 9001:2008	Certificate Number 01 100 044763

	LV Soft	ASME	Diff [%]
E 4.6.1 - Flat Unstayed Circular heads Attached by Bolts			
Required plate thickness t	41,95 mm 1,65 in	1,65 in	0,05%
E 4.6.2 - Flat Unstayed Non Circular heads Attached by Welding			
Required plate thickness t	17,88 mm 0,70 in	0,70 in	0,09%



ASME BPVC VIII-1 2023
PTB-4-2021 / E4.6.1; E4.6.2

E 4.6.1 - Unstayed flat heads and covers - ASME BPVC VIII-1 UG-34 & UG-39: 2023

Select Header

Circular flat heads and plates with flange moment

Circular flat heads and plates with flange moment

Design data

Design pressure	p_D	135 psi
Hydrostatic head	D_p	0 psi
Calculation pressure	p_0	135 psi
Calculation temperature	T_0	650 °F
Design type (Fig. UG-34)	Type	1

Gasket

Gasket diameter	G	29.5 in
Effective gasket width	b	0.2031 in
Gasket factor	m	3.7
Gasket seating load	y	7600 psi

Bolt forces

Gasket seating force W acc. 2-5(e) Eq.(5), AFL	W_{E1}	237101 lbf
Lever arm	h_g	0.875 in

Flat head or plate

Final wall thickness	t_h	1.437 in
Wall thickness allowance	c_1	0 in
Allowance (corrosion)	c_2	0.125 in
Wall thickness without allowances	t_0	1.312 in
Design diameter	d	29.5 in
Joint efficiency (or Cast Quality Factor)	E	1

Material data

Material	K03504-SA-105--Class:-Size:	
Allowable stress installation	S_E	20015 psi
Allowable stress operation	S_B	17811 psi

Results

Gasket force for min. pressure	W_{m2}	142982 lbf
Bolting force for installation	W_E	237101 lbf
Bolt force for operation	W_{m1}	111020 lbf
Design factor	C	0.3
Required thickness	t	1.526 in
Required thickness incl. allowances	$t + c_1 + c_{2 < 7 \text{sub} >}$	1.651 in
Minimum required thickness in a groove	t_m	0.8171 in

Remark

Openings according to UG-39

Nozzle material		
Opening diameter, corroded ($\leq d/2$)	d_i	in
Nozzle wall thickness without allowances	t_n	in
Allowable nozzle stress	S_n	psi
Wall thickness reserve	t'	-0.2145 in
Available reinforcement area (plate)	A_1	in ²
Required reinforcement area	A	in ²
Alternative plate thickness acc. UG-39(d) corroded	t_A	in
Remark		

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

$d \leq 89 \text{ mm for } t \leq 10 \text{ mm}$	or	$d \leq 3 \frac{1}{2} \text{ in for } t \leq \frac{3}{8} \text{ in}$
$d \leq 60 \text{ mm for } t > 10 \text{ mm}$	or	$d \leq 2 \frac{3}{8} \text{ in for } t > \frac{3}{8} \text{ in}$



Equations

$$t_E = d \cdot \sqrt{1.9 \cdot W_E \cdot \frac{h_g}{(S_E \cdot E \cdot d^3)}} = 749.3 \text{ mm} \cdot \sqrt{1.9 \cdot 1054673 \text{ N} \cdot \frac{22.23 \text{ mm}}{(138 \text{ MPa} \cdot 1 \cdot (749.3 \text{ mm})^3)}} = 20.75 \text{ mm}$$

$$t_B = d \cdot \sqrt{C \cdot \frac{P_0}{(S_B \cdot E)} + 1.9 \cdot W_{m1} \cdot \frac{h_g}{(S_B \cdot E \cdot d^3)}} =$$

UG-34 (c-2) (2)

$$749.3 \text{ mm} \cdot \sqrt{0.3 \cdot \frac{0.9308 \text{ MPa}}{(122.8 \text{ MPa} \cdot 1)} + 1.9 \cdot 493841 \text{ N} \cdot \frac{22.23 \text{ mm}}{(122.8 \text{ MPa} \cdot 1 \cdot (749.3 \text{ mm})^3)}} = 38.77 \text{ mm}$$

$$38.77 \text{ mm} = \text{Max} \begin{cases} t_E \\ t_B \end{cases}$$

$$t_m = d \cdot \sqrt{1.9 \cdot \max \left(\frac{W_E}{S_E}, \frac{W_{m1}}{S_B} \right) \cdot \frac{h_g}{(E \cdot d^3)}} = 749.3 \text{ mm} \cdot \sqrt{1.9 \cdot 7643 \text{ mm}^2 \cdot \frac{22.23 \text{ mm}}{(1 \cdot (749.3 \text{ mm})^3)}} = 20.75 \text{ mm}$$

$$t' = E_1 \cdot (t_h - c_1 - c_2) - t_{(E=1)} = 1 \cdot (36.5 \text{ mm} - 0 \text{ mm} - 3.175 \text{ mm}) - 38.77 \text{ mm} = -5.448 \text{ mm}$$

Available reinforcement area analogously to Fig. UG-37.1

If

$$d_i > 2 \cdot (t_0 + t_n) \Leftrightarrow d_i > 2 \cdot (33.32 \text{ mm} + t_n)$$

Fig. UG-37.1

then

$$A_1 = \left(d_i - 2 \cdot t_n \cdot \left(1 - \frac{S_n}{S_B} \right) \right) \cdot t' = \left(d_i - 2 \cdot t_n \cdot \left(1 - \frac{S_n}{122.8 \text{ MPa}} \right) \right) \cdot -5.448 \text{ mm} = A_1$$

Fig. UG-37.1

else

$$A_1 = 2 \cdot \left[t_0 + t_n - t_n \cdot \left(1 - \frac{S_n}{S_B} \right) \right] \cdot t' =$$

Fig. UG-37.1

$$2 \cdot \left[33.32 \text{ mm} + t_n - t_n \cdot \left(1 - \frac{S_n}{122.8 \text{ MPa}} \right) \right] \cdot -5.448 \text{ mm} = A_1$$



ASME BPVC VIII-1 2023
PTB-4-2021 / E4.6.1; E4.6.2

Required reinforcement area acc. UG-39(b)(1)

UG-39 (b) (1)

$$A = 0.5 \cdot t \cdot d_i + t \cdot t_n \cdot \left(1 - \frac{S_n}{S_B} \right) =$$

$$0.5 \cdot 38.77 \text{ mm} \cdot d_i + 38.77 \text{ mm} \cdot t_n \cdot \left(1 - \frac{S_n}{122.8 \text{ MPa}} \right) = A$$

If $A_1 > A$ in² > in² is not met, the available reinforcement area can better be calculated acc. UG-37 analogously to openings in cylinders (Longitudinal plane, F=1)

A_{avl} in² acc. UG-37 ($\geq A$ in²)
Alternatively the plate thickness without allowances can be increased
 t in acc. UG-39(d) ($\leq t_0$ **1.312** in)



ASME BPVC VIII-1 2023
PTB-4-2021 / E4.6.1; E4.6.2

E.4.6.2 - Unstayed flat heads and covers - ASME BPVC VIII-1 UG-34 & UG-39: 2023

Select Header

Non-circular flat heads and plates without flange moment

Non-circular flat heads and plates without flange moment

Design data

Design pressure	P_D	400	psi
Hydrostatic head	D_p	0	psi
Calculation pressure	p_0	400	psi
Calculation temperature	T_0	500	°F
Design type (Fig. UG-34)	Type	c	

Cylinder

Outside diameter	D_0	in
Final thickness without allowance	t_s	in
Required thickness without allowance	t_r	in
Final thickness for type b1 ($\geq 2 \cdot t_s$)	t_f	in

Flat head or plate

Final wall thickness	t_h	0.8	in
Wall thickness allowance	c_1	0	in
Allowance (corrosion)	c_2	0.125	in
Wall thickness without allowances	t_0	0.675	in
Short span	d	7.375	in
Long span	D	9.5	in
Joint efficiency (or Cast Quality Factor)	E	1	

Material data

Material	K02700-SA-516-70-Class:-Size:		
Allowable stress	S	19957	psi

Results

Ratio	m		
Design factor	Z	1.537	
Design factor	C	0.2	
Required thickness	t	0.5789	in
Allowable excess pressure	P	543.9	psi
Required thickness incl. allowances	$t + c_1 + c_2 < 7_{sub>$	0.7039	in
Required bend radius	r_{min}		in

Remark

Openings according to UG-39

Nozzle material			
Opening diameter, corroded	d_i	in	$\leq d/2$
Nozzle wall thickness without allowances	t_n	in	
Allowable nozzle stress	S_n	psi	
Wall thickness reserve	t'	0.09614	in
Available reinforcement area (plate)	A_1	in ²	
Required reinforcement area	A	in ²	
Alternative plate thickness acc. UG-39(d) corroded	t_A	in	
Remark			

Allowable unreinforced opening diameter d for welded, brazed, and flued connections acc. UG 36(c)3

$d \leq 89 \text{ mm for } t \leq 10 \text{ mm}$	or	$d \leq 3 \frac{1}{2} \text{ in for } t \leq 3/8 \text{ in}$
$d \leq 60 \text{ mm for } t > 10 \text{ mm}$	or	$d \leq 2 \frac{3}{8} \text{ in for } t > 3/8 \text{ in}$



Equations

$$m = \frac{t_r}{t_s}$$

$$Z = 3.4 - 2.4 \cdot \frac{d}{D} = 3.4 - 2.4 \cdot \frac{187.3 \text{ mm}}{241.3 \text{ mm}} = 1.537$$

$$1.537 \leq 2.5$$

$$t = d \cdot \sqrt{Z \cdot C \cdot \frac{P_0}{(S \cdot E)}} = 187.3 \text{ mm} \cdot \sqrt{1.537 \cdot 0.2 \cdot \frac{2.758 \text{ MPa}}{(137.6 \text{ MPa} \cdot 1)}} = 14.7 \text{ mm}$$

UG-34 (b-2) (3)

$$t' = E_1 \cdot (t_h - c_1 - c_2) - t_{(E=1)} = 1 \cdot (20.32 \text{ mm} - 0 \text{ mm} - 3.175 \text{ mm}) - 14.7 \text{ mm} = 2.442 \text{ mm}$$

Available reinforcement area analogously to Fig. UG-37.1

If

$$d_i > 2 \cdot (t_0 + t_n) \Leftrightarrow d_i > 2 \cdot (17.15 \text{ mm} + t_n)$$

Fig. UG-37.1

then

$$A_1 = \left[D_i - 2 \cdot t_n \cdot \left(1 - \frac{S_n}{S_B} \right) \right] \cdot t' = \left[D_i - 2 \cdot t_n \cdot \left(1 - \frac{S_n}{137.6 \text{ MPa}} \right) \right] \cdot 2.442 \text{ mm} = A_1$$

Fig. UG-37.1

else

$$A_1 = 2 \cdot \left[t_0 + t_n - t_n \cdot \left(1 - \frac{S_n}{S_B} \right) \right] \cdot t' =$$

$$2 \cdot \left[17.15 \text{ mm} + t_n - t_n \cdot \left(1 - \frac{S_n}{137.6 \text{ MPa}} \right) \right] \cdot 2.442 \text{ mm} = A_1$$

Fig. UG-37.1

Required reinforcement area acc. UG-39(b)(1)

UG-39 (b) (1)

$$A = 0.5 \cdot t \cdot d_i + t \cdot t_n \cdot \left(1 - \frac{S_n}{S_B} \right) =$$

$$0.5 \cdot 14.7 \text{ mm} \cdot d_i + 14.7 \text{ mm} \cdot t_n \cdot \left(1 - \frac{S_n}{137.6 \text{ MPa}} \right) = A$$

If $A_1 > A$ in² > in² is not met, the available reinforcement area can better be calculated acc. UG-37 analogously to openings in cylinders (Longitudinal plane, F=1)

A_{avl} in² acc. UG-37 ($\geq A$) in²)

Alternatively the plate thickness without allowances can be increased

t in acc. UG- ($\leq t_0$) **0.675** in)

39(d)