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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 |

## Summary

| | |
|---|---|
| Strength Calculation Software | Program System ATLAS --- version : 11.0.8.24 |
| 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% |

## E 4.6.1 - Unstayed flat heads and covers - ASME BPVC VIII-1 UG-34 & UG-39: 2025

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 | MAX($W_{E1}$, $W_{m2}$) | $W_E$ | **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 | | $t+c_1+c_{2<7sub>}$ | **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 (≤ 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) | $A_1$ | | in² |
| Required reinforcement area | A | | in² |
| 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 ≤ 89 mm for t ≤10 mm | or | d ≤ 3 1/2 in for t ≤3/8 in |
| d ≤ 60 mm for t > 10 mm | or | d ≤ 2 3/8 in for t > 3/8 in |

**Equations**

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

UG-34 (c-2) (2)

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

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

$$38.77\ \text{mm} = Max\left\{\begin{matrix} t_E \\ t_B \end{matrix}\right.$$

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

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

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

Fig. UG-37.1

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

else

Fig. UG-37.1

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

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

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 A1 > 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 ( ≥ A in² )

Alternatively the plate thickness without allowances can be increased

t in acc. UG-39(d) ( ≤ $t_0$ **1.312** in )

## E.4.6.2 - Unstayed flat heads and covers - ASME BPVC VIII-1 UG-34 & UG-39: 2025

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 | $t+c_1+c_{2<7sub>}$ | **0.7039** | in | |
| Required bend radius | rmin | | in | |

Remark

**Openings according to UG-39**

| | | | | |
|---|---|---|---|---|
| Nozzle material | | | | |
| Opening diameter, corroded | $d_i$ | | in | ≤ 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) | $A_1$ | | in² | |
| Required reinforcement area | A | | in² | |
| 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 ≤ 89 mm for t ≤10 mm | or | d ≤ 3 1/2 in for t ≤3/8 in |
| d ≤ 60 mm for t > 10 mm | or | d ≤ 2 3/8 in for t > 3/8 in |

**Equations**

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

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

$1.537\leq 2.5$

UG-34 (b-2) (3)

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

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

Available reinforcement area analogously to Fig. UG-37.1
If

Fig. UG-37.1

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

then

Fig. UG-37.1

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

else

Fig. UG-37.1

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

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

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 A1 > 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 | ( ≥ A | | in² | ) |

Alternatively the plate thickness without allowances can be increased

| | | | | | | |
|---|---|---|---|---|---|---|
| t | in | acc. UG-39(d) | ( ≤ $t_0$ | **0.675** | in | ) |