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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

Comparison - Form for equations

Equation form

Comment

Results for example E4.3.7-8 acc. ASME and Lauterbach Verfahrenstechnik GmbH (LV)
The LV-program uses formulas for Flat Heads acc. VIII-1,UG-34/39 and App.2

Equations		Value
Conversion factor	mm2in = 0.03937	0.03937
'Results Ex. E4.6.1 LV and ASME		0
Required thickness t acc. LV	t1 = mm2in*#30(3)	1.651
Required thickness t ASME	t1Asme = 1.6532	1.653
Difference in %	Diff1 = (t1-t1Asme)/t1Asme*100	-0.1035
'Results Ex. E4.6.2 LV and ASME		0
Required thickness t acc. LV	t2 = mm2in*#30(5)	0.7039
Required thickness t ASME	t2Asme = 0.7032	0.7032
Difference in %	Diff1 = (t2-t2Asme)/t2Asme*100	0.09357
'Maximum difference between LV and ASME		0
Dmax = Max(|Diff1|;|Diff2|;|Diff3|;|Diff4|)		1.438

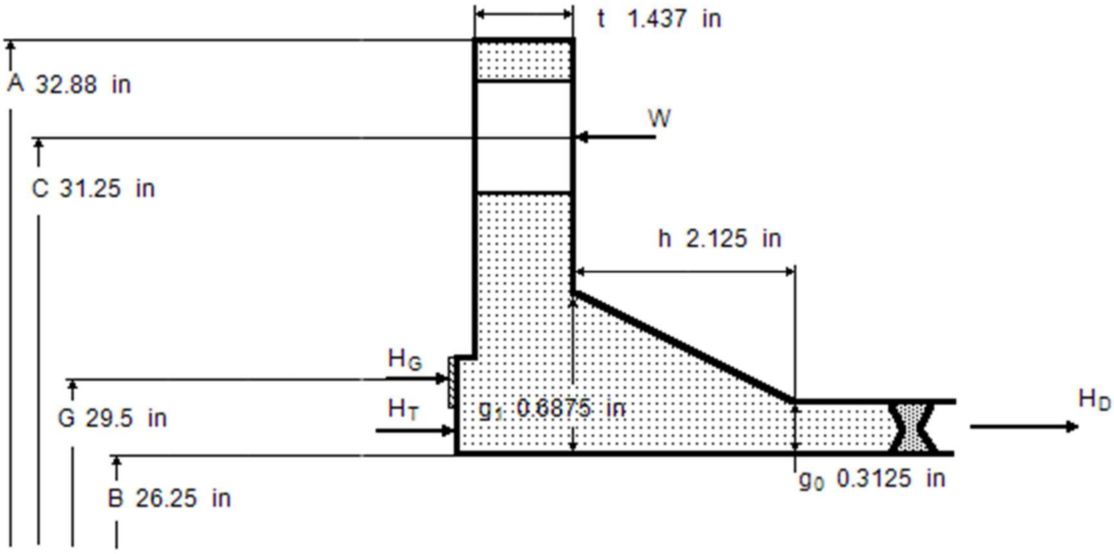
E 4.16.1 - Bolted flanges ASME BPVC VIII DIVISION 1 APP. 2, 2017 Edition

Integral Type Flange

Design data

Design pressure	P_D	**135** psi	$= p_D$	135 psi
Hydrostatic head	D_P	**0** psi	$= D_p$	0 psi
Calculation pressure	P_0	**135** psi	$= p_0$	**135** psi
Calculation temperature			T_0	650 °F

Flange



Outside diameter	A	32.88 in	Inside diameter	B	26.25 in
Bolt circle diameter	C	31.25 in	Pipe size	B_n	**26.25** in
Hub length	h	2.125 in	Flange thickness	t	1.437 in
Large hub thickness	g_1	0.6875 in	Small hub thick.	g_0	0.3125 in

Material K03504-SA-105--Class:-Size:

Allowable operating stress	S_{fb}	17811 psi
Allowable installation stress	S_{fa}	20015 psi
Corrosion allowance	c_2	0 in
Modulus of elasticity at operation	E_T	2.591e+7 psi
Modulus of elasticity at test (20°C)	E_{20}	2.915e+7 psi

Gasket

Gasket diameter		G	29.5 in
Effective gasket width	[Table: 2-5.2]	b	0.2031 in
Gasket factor	[Table: 2-5.1]	m	*3.75*
Gasket seating load	[Table: 2-5.1]	y	7600 psi

Bolts

Number	n	44	
Root diameter	d_K	0.62	in
Nominal diameter	a	0.75	in
Material G41400-SA-193-B7-Class:-Size:<=64			
Allowable operating stress	S_b	24946	psi
Allowable installation stress	S_a	24946	psi
Consider bolt spacing correction factor B_{SC} 2-6(7)?	(N=No)	Y	(Y/N)

Required operation bolt load	Eq.(1)	W_{m1}	**111274**	lbf	
Minimum initial bolt load	Eq.(2)	W_{m2}	***142982***	lbf	
Available cross section of bolts		A_b	**13.28**	in²	
Required cross section	W_{m1}/S_b	A_{m1}	**4.46**	in²	
Required cross section	W_{m2}/S_a	A_{m2}	**5.732**	in²	
Req. bolt load for gasket seating	$(A_m+A_b)\cdot S_a/2$	W	***237101***	lbf	(5)
Allowable bolt load	$A_b \cdot S_a$	W_{all}	**331221**	lbf	
Design (gasket seating =1; max. allowable=2)			1	(1,2)	

Moment

		Force		·	Lever arm		=	Result	
$M_D = H_D \cdot h_D$	=	**73024**	lbf	·	**2.156**	in	=	**13122**	lbf·ft
$M_G = H_G \cdot h_G$	=	**19049**	lbf	·	**0.875**	in	=	**16667**	lbf·in
$M_T = H_T \cdot h_T$	=	**19202**	lbf	·	**1.688**	in	=	**32403**	lbf·in

Total operating moment	M_{01}	=	$M_D + M_G + M_T$	=	**206529**	lbf·in
Total gasket seating moment, Eq. (6)	M_{02}	=	$W \cdot (C-G)/2$	=	**207464**	lbf·in

Stress

			Operation			Installation		≤ Allowable	
Longitudinal	S_H		**17786**	psi		**17866**	psi	≤ $1.5 \cdot S_f$	(8)
Ratio	S_H/S_f		**0.9986**			**0.8926**		≤ 1.5	
Allowable stress	S_f		17811	psi		20015	psi		
Radial	S_R		**6157**	psi		**6184**	psi	≤ S_f	(9)
Tangential	S_T		**5548**	psi		**5573**	psi	≤ S_f	(10)
Combination	$(S_H+S_R)/2$	=	**11971**	psi		**12025**	psi	≤ S_f	
Combination	$(S_H+S_T)/2$	=	**11667**	psi		**11719**	psi	≤ S_f	
Bolt pitch	B_S		**2.231**	in	≤	**3.529**	in	= B_{Smax}	(3)

Remark

Auxiliary values

$K=\frac{A}{B}=1.252$

$T=1.817$ (Fig. 2-7.1)

$U=9.623$ (Fig. 2-7.1)

$Y=8.757$ (Fig. 2-7.1)

$Z=4.518$ (Fig. 2-7.1)

$h_0=\sqrt{B \cdot g_0}=72.75$ mm

$F=0.7677$ (Fig. 2-7.2)

$V=0.1576$ (Fig. 2-7.3)

$f=1$ (Fig. 2-7.6)

$d=\left(\frac{U}{V}\right) \cdot h_0 \cdot g_0^2=279869$ mm³

$e=\frac{F}{h_0}=0.01055$ 1/mm

$L=\frac{(t \cdot e+1)}{T}+\frac{t^3}{d}=0.9359$

$H=0.785 \cdot G^2 \cdot P \cdot 0.1=410239$ N

$H_D=0.785 \cdot B^2 \cdot P \cdot 0.1=324826$ N

$H_P=2 \cdot b \cdot \pi \cdot G \cdot m \cdot P \cdot 0.1=84732$ N

$H_T=H-H_D=85412$ N

$W_{m1}=H+H_P=494970$ N Eq.(1)

$W_{m2}=\pi \cdot b \cdot g \cdot y=636011$ N Eq.(2)

$H_G=W_{m1}-H=84732$ N

$R=\frac{(C-B)}{2}-g_1=46.04$ mm

$h_D=R+0.5 \cdot g_1=54.77$ mm

$h_G=\frac{(C-G)}{2}=22.23$ mm

$h_T=\frac{(R+g_1+h_G)}{2}=42.86$ mm

Bolt pitch $B_S=\pi \cdot \frac{C}{n}=56.67$ mm

$$B_{Smax}=2\cdot a+6\cdot\frac{t}{(m+0.5)}=89.63\text{ mm}\qquad(3)$$

For $B_S>2\cdot a+t$

$$B_{SC}=\sqrt{\frac{B_S}{(2\cdot a+t)}}=1\qquad(7)$$

KI (=0.3 acc. Table 2-14) = **0.3**

J = 52.14·V·[M_{01} or M_{02}]/L/[E or E_{20C}]/(g_0-c_2)²/K_L/h_0
= 52.14 · **0.1576** · [**2.333e+7** or **2.344e+7**]/ **0.9359**

/[178667 or 201000]/(7.938 0)²/ **0.3** / **72.75**

Rigidity criterion: J **0.8339** ≤ 1.0

E 4.6.1 - Unstayed flat heads and covers ASME BPVC VIII UG-34 & UG-39, 2017 Edition

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	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
Altern. plate thickness acc. UG-39(d) corroded	t_A		in
Remark			

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

d_A ≤ 89 mm for t ≤10 mm	or	d_A ≤ 3 1/2 in for t ≤3/8 in
d_A ≤ 60 mm for t > 10 mm	or	d_A ≤ 2 3/8 in for t > 3/8 in

Equations

$$t_E = d \cdot \sqrt{1.9 \cdot W_E \cdot \frac{h_g}{\left(S_E \cdot E \cdot d^3\right)}} = 749.3\ \text{mm} \cdot \sqrt{1.9 \cdot 1054673\ \text{N} \cdot \frac{22.23\ \text{mm}}{(138\ \text{N/mm}^2 \cdot 1 \cdot (749.3\ \text{mm})^3)}} = 20.75\ \text{mm}$$

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

$$749.3\ \text{mm} \cdot \sqrt{0.3 \cdot \frac{9.308\ \text{bar}}{(122.8\ \text{N/mm}^2 \cdot 1)} + 1.9 \cdot 493841\ \text{N} \cdot \frac{22.23\ \text{mm}}{(122.8\ \text{N/mm}^2 \cdot 1 \cdot (749.3\ \text{mm})^3)}} = 38.77\ \text{mm}$$

UG-34 (c-2) (2)

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

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

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

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

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

Fig. UG-37.1

else

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

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

Fig. UG-37.1

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

$$A = 0.5 \cdot t \cdot d_i + t \cdot t_n \cdot \left(1 - \frac{S_n}{S_B}\right) = 0.5 \cdot 38.77\ \text{mm} \cdot d_i + 38.77\ \text{mm} \cdot t_n \cdot \left(1 - \frac{S_n}{122.8\ \text{N/mm}^2}\right) = A$$

UG-39 (b) (1)

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 UG-34 & UG-39, 2017 Edition

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 (≥ 2·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
Design diameter	d	7.375	in
Large diameter	D	9.5	in
Joint efficiency	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
Allowable pressure without hydrostatic head	MAWP	**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	
Altern. plate thickness acc. UG-39(d) corroded	t_A		in	
Remark				

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

d_A ≤ 89 mm for t ≤10 mm	or	d_A ≤ 3 1/2 in for t ≤3/8 in
d_A ≤ 60 mm for t > 10 mm	or	d_A ≤ 2 3/8 in for t > 3/8 in

Equations

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

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

$1.537\leq 2.5$

$$t=d\cdot\sqrt{Z\cdot C\cdot\frac{P_0}{(S\cdot E)}}=187.3\text{ mm}\cdot\sqrt{1.537\cdot 0.2\cdot\frac{27.58\text{ bar}}{(137.6\text{ N/mm}^2\cdot 1)}}=14.7\text{ mm}$$ 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

$$A_1=\left[D_i-2\cdot t_n\cdot\left(1-\frac{S_n}{S_B}\right)\right]\cdot t'=\left[D_i-2\cdot t_n\cdot\left(1-\frac{S_n}{137.6\text{ N/mm}^2}\right)\right]\cdot 2.442\text{ mm}=A_1$$ Fig. UG-37.1

else

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

$$2\cdot\left[17.15\text{ mm}+t_n-t_n\cdot\left(1-\frac{S_n}{137.6\text{ N/mm}^2}\right)\right]\cdot 2.442\text{ mm}=A_1$$ Fig. UG-37.1

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

$$A=0.5\cdot t\cdot d_i+t\cdot t_n\cdot\left(1-\frac{S_n}{S_B}\right)=0.5\cdot 14.7\text{ mm}\cdot d_i+14.7\text{ mm}\cdot t_n\cdot\left(1-\frac{S_n}{137.6\text{ N/mm}^2}\right)=A$$ UG-39 (b)(1)

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)

Appendix: Material documentation

Section 2: Flansch/AFL

Material specification:

Regulation:	ASMET1A:2017Spec. No.: SA-105	Product:	Forgings
Material code:	K03504-SA-105--Class:-Size:	Short name:	Carbon steel

Design conditions and dimensions:

Temperature [°C]:	343,33	Pressure [bar]:	9,31
Thickness [mm]:	2	Outside diameter [mm]:	0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	138,00	122,80
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	138,00	122,80
Modulus of elasticity [kN/mm²]:	201	178,667

Notes:
G10 General Requirements
Upon prolonged exposure to temperatures above 425°C, the carbide phase of carbon steel may be converted to graphite. See Nonmandatory Appendix A, A–201 and A–202.

S1 Size Requirements
For Section I applications, stress values at temperatures of 450°C and above are permissible but, except for tubular products 75 mm O.D. or less enclosed within the boiler setting, use of these materials at these temperatures is not current practice.

T2 Time-Dependent Properties
Allowable stresses for temperatures of 400°C and above are values obtained from time–dependent properties.

--
Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm		50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
			138	138	138	136	129	122	101

K-values as function of the temperature

Diam./ Thickn. <= mm		450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	67.0	33.6	12.9					

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550	600
207	215	211	201	197	194	191	188	183	178	170	161	149	136	121

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4					

—

Section 2: Schraube/AFL

Material specification:

Regulation:	ASMET3:2010Spec. No.: SA-193	Product:	Bolting
Material code:	G41400-SA-193-B7-Class:-Size:<=64	Short name:	1Cr-0.2Mo

Design conditions and dimensions:

Temperature [°C]:	343,3333	Pressure [bar]:	9,30798
Thickness [mm]:	2	Outside diameter [mm]:	0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	172,00	172,00
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	172,00	172,00
Modulus of elasticity [kN/mm²]:	204	183,4

Notes:

--
Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm	50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
		172	172	172	172	172	172	162

K-values as function of the temperature

Diam./ Thickn. <= mm	450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	118	68.8	18.9				

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

650	-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550
150	210	218	213	204	200	197	193	190	186	183	179	174	169	164

Static modulus of elasticity in [kN/mm²] at the temperature of

600	700			
157	142			

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4	-	-	-		

—

Section 3: Boden/Platte/UG34

Material specification:

Regulation:	ASMET1A:2017Spec. No.: SA-105	Product:	Forgings
Material code:	K03504-SA-105--Class:-Size:	Short name:	Carbon steel

Design conditions and dimensions:

Temperature [°C]:	343,3333	Pressure [bar]:	9,30798
Thickness [mm]:	2	Outside diameter [mm]:	0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	138,00	122,80
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	138,00	122,80
Modulus of elasticity [kN/mm²]:	201	178,6667

Notes:
G10 General Requirements
Upon prolonged exposure to temperatures above 425°C, the carbide phase of carbon steel may be converted to graphite. See Nonmandatory Appendix A, A–201 and A–202.

S1 Size Requirements
For Section I applications, stress values at temperatures of 450°C and above are permissible but, except for tubular products 75 mm O.D. or less enclosed within the boiler setting, use of these materials at these temperatures is not current practice.

T2 Time-Dependent Properties
Allowable stresses for temperatures of 400°C and above are values obtained from time–dependent properties.

--
Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm	MPa	50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
		138	138	138	136	129	122	101	

K-values as function of the temperature

Diam./ Thickn. <= mm	450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	67.0	33.6	12.9				

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550	600
207	215	211	201	197	194	191	188	183	178	170	161	149	136	121

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4					

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Section 4: Boden/Platte/UG34

Material specification:

Regulation: ASMET1A:2017Spec. No.: SA-516 Product: Plate
Material code: K02700-SA-516-70-Class:-Size: Short name: Carbon steel

Design conditions and dimensions:

Temperature [°C]: 260 Pressure [bar]: 27,58
Thickness [mm]: 2 Outside diameter [mm]: 0

Material values for test and design conditions:

	Test condition	Operating condition
Nominal design strength [N/mm²]:	138,00	137,60
Safety factor:	1,00	1,00
Allowable stress [N/mm²]:	138,00	137,60
Modulus of elasticity [kN/mm²]:	202	188,2

Notes:
G10 General Requirements
Upon prolonged exposure to temperatures above 425°C, the carbide phase of carbon steel may be converted to graphite. See Nonmandatory Appendix A, A–201 and A–202.

S1 Size Requirements
For Section I applications, stress values at temperatures of 450°C and above are permissible but, except for tubular products 75 mm O.D. or less enclosed within the boiler setting, use of these materials at these temperatures is not current practice.

T2 Time-Dependent Properties
Allowable stresses for temperatures of 400°C and above are values obtained from time–dependent properties.

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Creep rupture strength for 100000 h [MPa]:

Tensile strength and yield stress at ambient temperature:

Diam./ Thick. <= mm	Tensile str. Rm min MPa	Rm max MPa	ReH MPa	Rupture elong. längs %	Rupture elong quer %

K-values as function of the temperature

Diam./ Thickn. <= mm	50°C MPa	100°C MPa	150°C MPa	200°C MPa	250°C MPa	300°C MPa	350°C MPa	400°C MPa
		138	138	138	138	136	128	101

K-values as function of the temperature

Diam./ Thickn. <= mm	450°C MPa	500°C MPa	550°C MPa	600°C MPa	650°C MPa	700°C MPa	800°C MPa
	67.1	33.6	12.9				

Modulus of elasticity in dependence of the temperature:

Static modulus of elasticity in [kN/mm²] at the temperature of

-75	-200	-125	25	100	150	200	250	300	350	400	450	500	550
209	216	212	202	198	195	192	189	185	179	171	162	151	137

Coefficient of linear expansion:

Thermal coefficient of expansion between 20°C and

Density (20 °C) kg/dm³	100°C 10E-6/K	200°C 10E-6/K	300°C 10E-6/K	400°C 10E-6/K	500°C 10E-6/K	600°C 10E-6/K	700°C 10E-6/K	800°C 10E-6/K	Heat cond. W/Km	Heat capac. J/kgK
7,85	12,1	12,7	13,3	13,8	14,4	-	-	-		