

**TRIAL WITH WELDOLET**

Date: Wo 28-Jan-2015

Time: 18:39:20

Project: Virtueel

Jobnr: PV2021



**Scope of calculation**

Calculation according to the Dutch Rules for Pressure Vessels (RToD)

**Actual dimensions of calculated pipes and pipelines**

114.300 mm x 13.487 mm Seamless pipe ANSI B16.10

168.275 mm x 18.263 mm Seamless pipe ANSI B16.10

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CALCULATION OF PIPES UNDER INTERNAL PRESSURE ACC. TO STW D0201

110.500 bar - 515.00 C

Flange-rating according to ANSI B16.5 material group 1.9 - 2500#

431.0 bar -	-29 C	431.0 bar -	38 C	426.2 bar -	50 C
406.4 bar -	100 C	386.4 bar -	150 C	379.0 bar -	200 C
370.6 bar -	250 C	353.5 bar -	300 C	335.3 bar -	350 C
323.4 bar -	375 C	304.9 bar -	400 C	292.5 bar -	425 C
281.7 bar -	450 C	263.8 bar -	475 C	231.6 bar -	500 C
168.9 bar -	525 C	131.4 bar -	540 C	106.4 bar -	550 C
70.8 bar -	575 C	49.0 bar -	600 C	28.2 bar -	625 C
19.3 bar -	650 C	0.0 bar -	675 C	0.0 bar -	700 C
0.0 bar -	725 C	0.0 bar -	750 C	0.0 bar -	775 C
0.0 bar -	800 C				

=====  
 Design Pressure : 11.0500 Mpa  
 Test pressure : 145.65 bar See T0240 par.3.1.2  
 Test pressure according the Eurocode: 263.52 bar PED annex 1 par 7.4  
 Temperature : 515.000 degr. C  
 Corrosion : 1.00 mm

DIMENSIONS  
 Diameter : 114.30 mm  
 Nominal wallthickness : 11.125 mm SCHED 120  
 Tolerance : 1.391 mm See D0101 par.3.4

MATERIAL : ASTM A 335 Gr.P22+ A 520 2Cr-1Mo  
 Ansi B16.10 Seamless

Re Yieldstress at 20 degr. C : 207.00 N/mm<sup>2</sup>  
 Rm Tensile strength : 414.00 N/mm<sup>2</sup>  
 Re(Tm) Yieldstress at 515.00 degr. C: 108.50 N/mm<sup>2</sup>  
 f Design Stress : 72.69 N/mm<sup>2</sup>  
 z weld : 1.00

Min. d req'd for internal pressure : 8.073 mm  
 d = dd-tol-corr : 8.735 mm  
 z min : 0.9186

According D0201 par.4 -> z min < z weld <= 1  
 Maximum allowable pressure : 12.0297 N/mm<sup>2</sup>

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CALCULATION OF PIPES UNDER INTERNAL PRESSURE ACC. TO STW D0201

Design Pressure : 11.0500 Mpa  
 Test pressure : 145.65 bar See T0240 par.3.1.2  
 Test pressure according the Eurocode: 263.52 bar PED annex 1 par 7.4  
 Temperature : 515.000 degr. C  
 Corrosion : 1.00 mm

DIMENSIONS

Diameter : 168.27 mm  
 Nominal wallthickness : 18.263 mm SCHED\_160  
 Tolerance : 2.283 mm See D0101 par.3.4

MATERIAL : ASTM A 335 Gr.P22+ A 520 2Cr-1Mo  
 Ansi B16.10 Seamless

Re Yieldstress at 20 degr. C : 207.00 N/mm<sup>2</sup>  
 Rm Tensile strength : 414.00 N/mm<sup>2</sup>  
 Re(Tm) Yieldstress at 515.00 degr. C: 108.50 N/mm<sup>2</sup>  
 f Design Stress : 72.69 N/mm<sup>2</sup>  
 z weld : 1.00

Min. d req'd for internal pressure : 11.886 mm  
 d = dd-tol-corr : 14.980 mm  
 z min : 0.7778

According D0201 par.4 -> z min < z weld <= 1  
 Maximum allowable pressure : 14.2073 N/mm<sup>2</sup>

**BRANCHED CONNECTIONS  
 COMPUTER RESULTS**

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CALCULATION OF WELDED TEE UNDER INTERNAL PRESSURE ACC. TO RTOD D0501.

Design Pressure : 11.050 Mpa  
 Test pressure according the RTOD : 145.650 bar  
 Test pressure according Eurocode PED : 263.52 bar  
 Temperature : 515.000 degr. C  
 Corrosion : 1.000 mm

DIMENSIONS OF RUN PIPE

Outside Diameter : 114.300 mm  
 Nominal wallthickness : 13.487 mm SCHED\_160  
 Tolerance : 1.686 mm  
 Netto thickness of the run pipe : 10.801 mm  
 z weld : 1.000  
 z min required : 0.728

DIMENSIONS OF BRANCH PIPE

Outside Diameter : 114.300 mm  
 Nominal wallthickness : 13.487 mm SCHED\_160  
 Tolerance : 1.686 mm  
 Netto thickness of the branch pipe : 10.801 mm  
 z weld : 1.000

DIMENSIONS TEE

Diameter header : 114.300 mm  
 Nominal wallthickness : 17.120 mm XXS  
 Tolerance : 2.140 mm  
 Netto thickness of the header pipe : 13.980 mm  
 z min required : 0.545

Diameter outlet : 114.300 mm  
 Nominal wallthickness : 17.120 mm XXS  
 Tolerance : 2.140 mm  
 Netto thickness of the outlet pipe : 13.980 mm

Max. external radius of curvature ro : 32.000 mm  
 Crotch thickness : 25.679 mm  
 Dimension centerline to end : 104.648 mm  
 Dimension centerline to top : 104.648 mm

Half width of reinforcement zone : 37.541 mm  
 Local Inside diameter at boundary : 86.835 mm  
 Local Wall thickness at boundary : 13.980 mm

Altitude of reinforcement zone : 42.199 mm  
 Local Inside diameter at boundary : 92.297 mm  
 Local Wall thickness at boundary : 11.030 mm

MATERIAL : ASTM A 335 Gr.P22+ A 520 2Cr-1Mo  
 Re Yieldstress at 20 degr. C : 207.000 N/mm<sup>2</sup>  
 Rm Tensile strength : 414.000 N/mm<sup>2</sup>  
 Re(Tm) Yieldstress at 515.00 degr. C : 108.500 N/mm<sup>2</sup>  
 f2 Design Stress : 72.695 N/mm<sup>2</sup>

CALCULATED AREAS

A0 Cross sectional area in header : 1343.178 mm<sup>2</sup>  
 A1\*(f1/f) Additional Cross sectional area: 0.000 mm<sup>2</sup>  
 ----- +  
 A Load carrying cross-sectional area : 1343.178 mm<sup>2</sup>  
 Ap Pressurized area : 6937.399 mm<sup>2</sup>

CONCLUSION

z3 Strength reduction coefficient : 0.633 mm  
 z3 to be >= z min  
 0.633 >= 0.545 Criterium is fullfilled Ratio = 0.861

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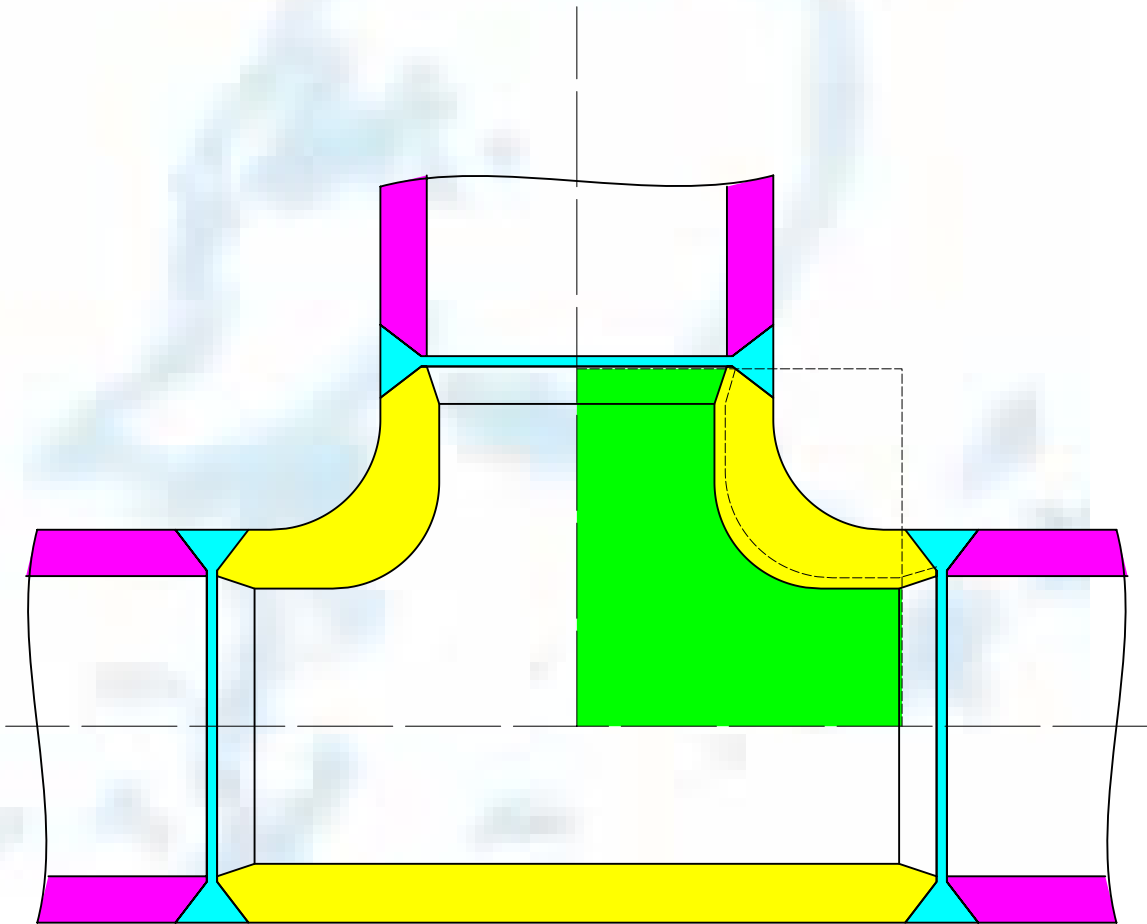
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**Welding Tee 114.300 mm x 114.300 mm 17.120 mm x 17.120 mm**



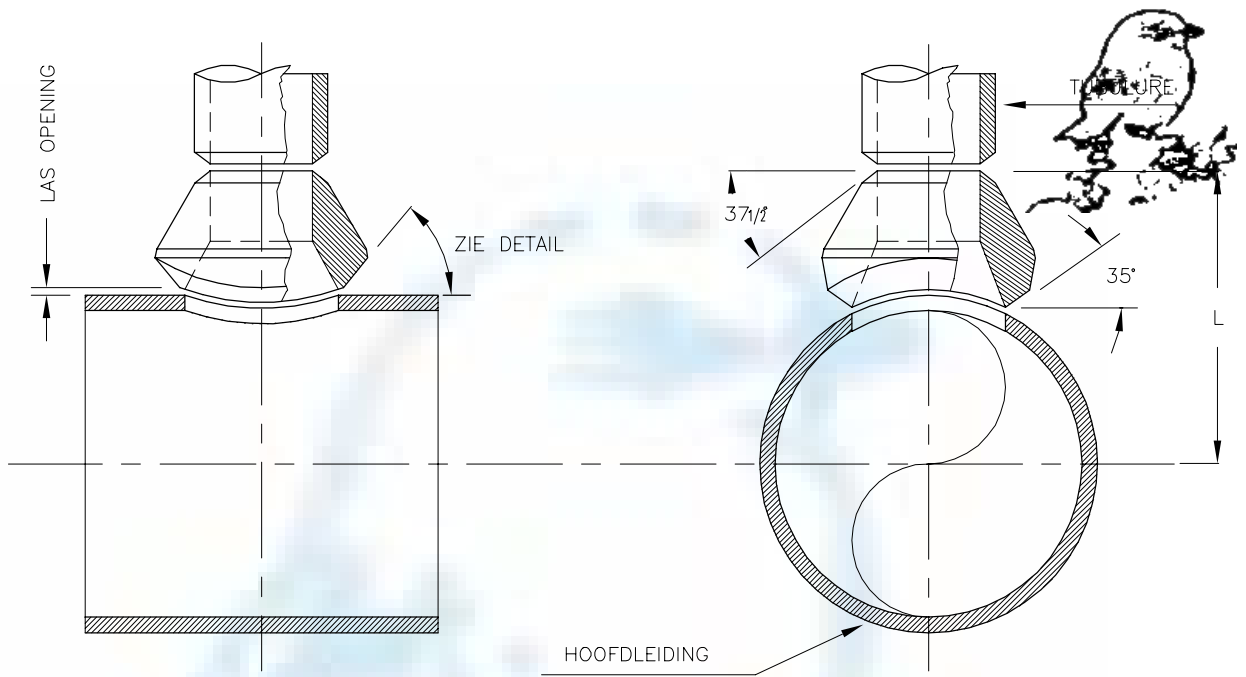
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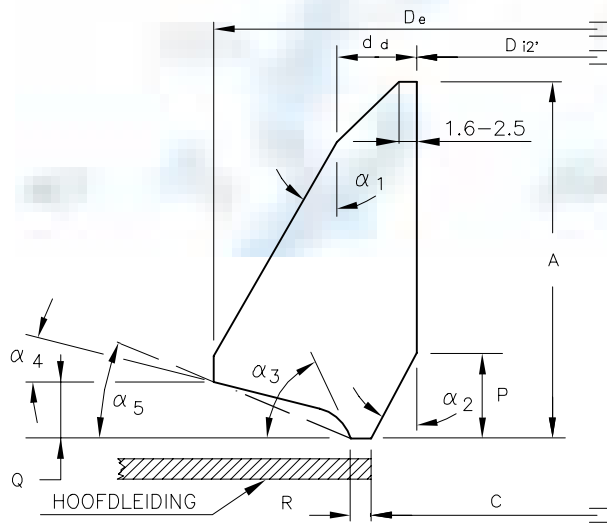
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INVOER GEGEVENS

		HOOFDLEIDING		TUBULURE		WELDOLET	
BEREKENINGSDRUK	$P_d$	11.050	MPa	11.050	MPa		
UITWENDIGE MIDDELIJN	$D_e$	168.275	mm	114.300	mm	152.400	mm
NOMINALE WANDDIKTE	$d_d$	18.263	mm	13.487	mm	13.487	mm
CORROSIE TOESLAG	$d_c$	1.000	mm	1.000	mm	1.000	mm
TOLERANTIE	$d_t$	2.283	mm	1.686	mm	0.500	mm
FORMULE WANDDIKTE	$d$	14.980	mm	10.801	mm	11.987	mm
MATERIAAL		ASTM A 335 Gr.P22+ A 520	2Cr-1Mo	ASTM A 335 Gr.P22+ A 520	2Cr-1Mo	ASTM A 335 Gr.P22+ A 520	2Cr-1Mo
METAALTEMPERatuur	$\vartheta_m$	515.000	°C	515.000	°C	515.000	°C
TREKSTERKTE	$R_m$	414.000	N/mm <sup>2</sup>	414.000	N/mm <sup>2</sup>	414.000	N/mm <sup>2</sup>
WARMREKGRENS	$R_e(\vartheta_m)$	108.500	N/mm <sup>2</sup>	108.500	N/mm <sup>2</sup>	108.500	N/mm <sup>2</sup>
ONTWERPSPANNING	$f$	72.695	N/mm <sup>2</sup>	72.695	N/mm <sup>2</sup>	72.695	N/mm <sup>2</sup>
VERZWAKKINGSFACTOR	$z$	1.000		1.000		0.000	



VOLGENS WO301 BIJLAGE 1

L	171.275	mm
D <sub>12'</sub>	90.325	mm
A	84.138	mm
C	98.425	mm
P	16.118	mm
Q	31.700	mm
R	1.600	mm
LASOPENING	3.000	mm
α <sub>1</sub>	24.000	°
α <sub>2</sub>	19.000	°
α <sub>3</sub>	0.000	°
α <sub>4</sub>	0.000	°
α <sub>5</sub>	50.000	°

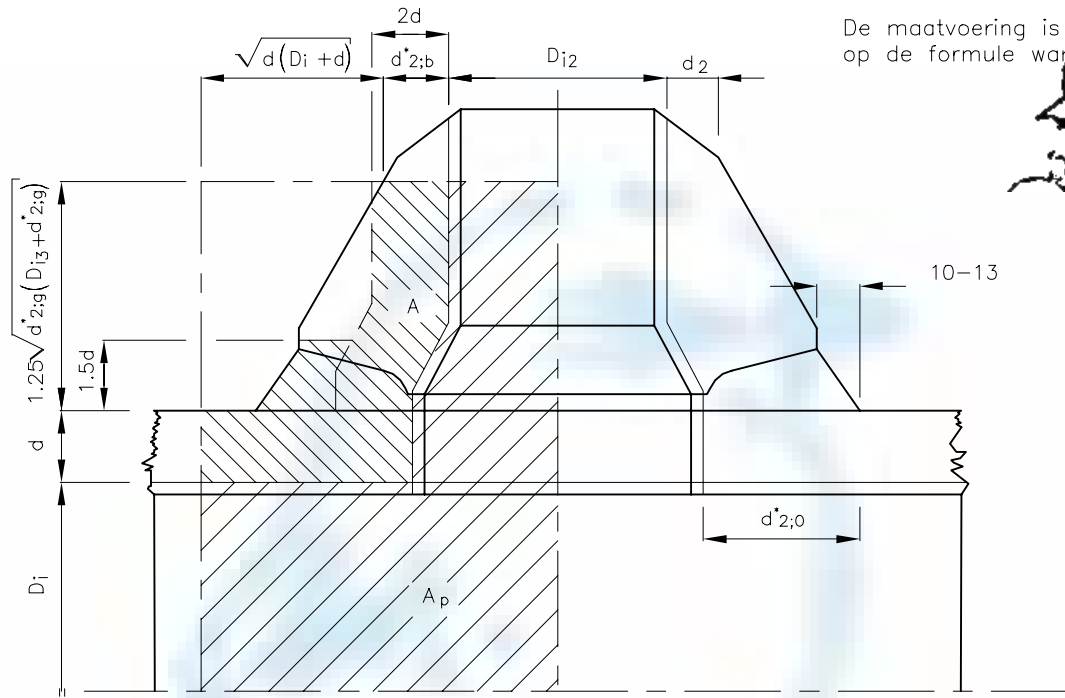
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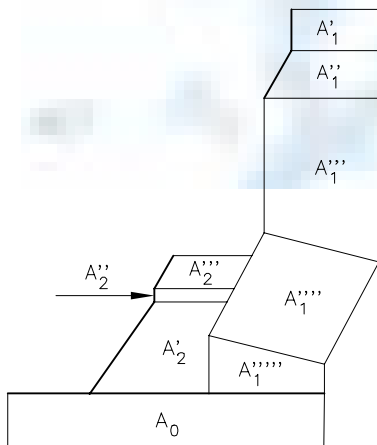


BEREKENING

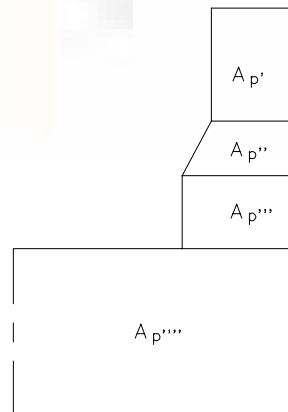
MAATVOERING

$d = d_d - d_c - d_t$	14.980 mm	$D_{i3} = D_{i2}$	90.325 mm	$\sqrt{d(D_i + d)}$	47.920 mm
1.5d	22.470 mm	$d'_{2;0} \geq 2d$	35.487 mm	$1.25\sqrt{d'_{2;g}(D_{i3} + d'_{2;g})}$	68.833 mm
$d_2 = d_{d2} - d_{c2} - d_{t2}$	11.987 mm	$d'_{2;b} \leq 2d$	16.623 mm		
$D_i = D_e - 2d$	138.315 mm	$d'_{2;g} = 0.5(d'_{2;b} + d'_{2;0})$	26.055 mm		

BEPALING OPPERVLAK A



$$\begin{aligned}
 A_0 &= 901.465 \\
 A_1' &= 0.000 \\
 A_1'' &= 697.684 \\
 A_1''' &= 509.380 \\
 A_1'''' &= 510.715 \\
 A_1''''' &= 172.500 + \\
 A_1 &= 1890.279 \\
 A_2' &= 86.201 \\
 A_2'' &= 0.000 \\
 A_2''' &= 0.000 + \\
 A_2 &= 86.201
 \end{aligned}$$



$$\begin{aligned}
 A_{p'} &= 2233.917 \\
 A_{p''} &= 772.661 \\
 A_{p'''} &= 924.529 \\
 A_{p''''} &= 7668.991 + \\
 A_p &= 11600.099
 \end{aligned}$$

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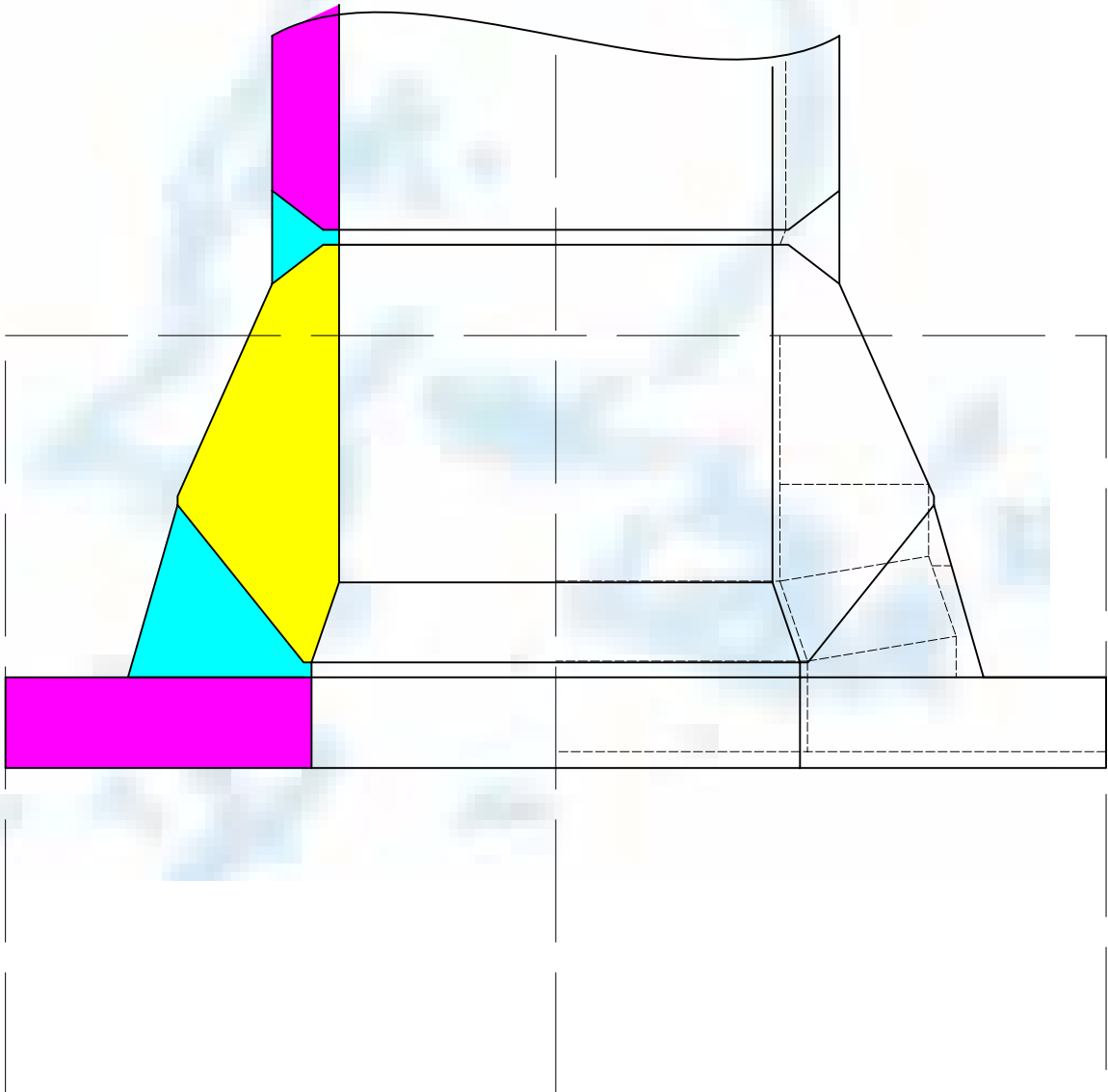
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**Weldolet Bonney Forge 6.00" x 4.00" Schedule: SCHED\_160**



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From Rules for Pressure Vessels RToD sheet D0501 par.6 we derive the following formula for the load-carrying cross-sectional area of the branch connection:

$$A = A_0 + \frac{f_1}{f} \cdot A_1 + k \cdot \frac{f_2}{f} \cdot A_2$$

The following auxiliary values are calculated:

A<sub>0</sub> This is the cross-sectional area of the material present around the opening in the wall and nozzle to be introduced, in so far as the design stress thereof is at least equal to that of the wall.

$$A_0 = 901.465 \text{ mm}^2$$

A<sub>1</sub> This is the cross-sectional area of the material present around the opening in the wall and nozzle to be introduced, in so far as the design stress thereof is less equal than the design stress f of the wall.

$$A_1 = 1890.279 \text{ mm}^2$$

A<sub>2</sub> This is the cross-sectional area of the additional reinforcing material with a reinforcement efficiency k and a design stress f<sub>2</sub> to be introduced, in so far as that the material is effectively connected to the wall.

Factor  $\frac{f_2}{f}$  shall not be introduced higher than 1.

$$A_2 = 86.201 \text{ mm}^2$$

A<sub>p</sub> This is the area on which the pressure acts. The so called pressurized area. In the previous figures this is indicated by coarse hatching.

$$A_p = 11600.099 \text{ mm}^2$$

The design stresses f<sub>1</sub> and f<sub>2</sub> are established in the same way as f.

For this, therefore, the RToD sheet applicable to the wall has been used.

$$f = 72.695 \text{ MPa} \quad f_1 = 72.695 \text{ MPa}$$

$$k = 0.75 \quad f_2 = 72.695 \text{ MPa}$$

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The load-carrying cross-sectional area of the branch connection 'A' is derived according:

$$A = A_0 + \frac{f_1}{f} \cdot A_1 + k \cdot \frac{f_2}{f} \cdot A_2 \quad A = 2857.395 \text{ mm}^2$$

The auxiliary value  $z_3$  is calculated according RTOD sheet D0501 par. 6:

$$D_i = 138.315 \text{ mm} \quad d = 14.980 \text{ mm} \quad p_d = 11.050 \text{ MPa}$$

$$z_3 = \frac{D_i + d}{d} \cdot \frac{A}{2 \cdot A + A} \quad z_3 = 1.122$$

This  $z_3$  is also known as the strength reduction coefficient and should be greater than a required minimum. This minimum is calculated according the following:

$$z_{\min} = \frac{p_d \cdot [D_i + d]}{2 \cdot d \cdot z \cdot f} \quad z_{\min} = 0.778$$

The criterium  $z_3 \geq z_{\min}$  is fulfilled.

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1	CALCULATION OF PIPE TO PIPE CONN. UNDER INTERNAL PRESSURE ACC. TO RToD D0501.		
2			
3	Design Pressure	: 11.050	Mpa
4	Test pressure according the RToD	: 145.650	bar
5	Test pressure according Eurocode PED	: 263.52	bar
6	Temperature	: 515.000	degr. C
7	Corrosion	: 1.000	mm
8			
9	DIMENSIONS OF RUN PIPE		
10	Outside Diameter	: 168.275	mm
11	Inside Diameter	: 138.315	mm
12	Nominal wallthickness	: 18.263	mm
13	Tolerance	: 2.283	mm
14	Netto thickness of the run pipe	: 14.980	mm
15	Min. req. thickness of the run pipe	: 11.886	mm
16	z weld	: 1.000	
17	z min required	: 0.778	
18	MATERIAL	: ASTM A 335 Gr.P22+ A 520	2Cr-1Mo
19	Re Yieldstress at 20 degr. C	: 207.000	N/mm <sup>2</sup>
20	Rm Tensile strength	: 414.000	N/mm <sup>2</sup>
21	Re(Tm) Yieldstress at 515.00 degr. C	: 108.500	N/mm <sup>2</sup>
22	f Design Stress	: 72.695	N/mm <sup>2</sup>
23			
24	DIMENSIONS OF BRANCH PIPE		
25	Outside Diameter	: 168.275	mm
26	Inside Diameter	: 138.315	mm
27	Nominal wallthickness	: 18.263	mm
28	Tolerance	: 2.283	mm
29	Netto thickness of the branch pipe	: 14.980	mm
30	z weld	: 1.000	
31	MATERIAL	: ASTM A 335 Gr.P22+ A 520	2Cr-1Mo
32	Re Yieldstress at 20 degr. C	: 207.000	N/mm <sup>2</sup>
33	Rm Tensile strength	: 414.000	N/mm <sup>2</sup>
34	Re(Tm) Yieldstress at 515.00 degr. C	: 108.500	N/mm <sup>2</sup>
35	f1 Design Stress	: 72.695	N/mm <sup>2</sup>
36			
37	DIMENSIONS OF SET-ON NOZZLE		
38	Half width of reinforcement zone	: 48.878	mm
39	Altitude of reinforcement zone	: 59.900	mm
40			
41	DIMENSIONS OF ADDITIONAL REINFORCEMENT RING		
42	Outside Diameter	: 264.000	mm
43	Nominal thickness	: 18.263	mm
44	Tolerance	: 2.283	mm
45	Effective thickness	: 15.980	mm
46	k reinforcement efficiency factor	: 0.750	
47	MATERIAL	: ASTM A 335 Gr.P22+ A 520	2Cr-1Mo
48	Re Yieldstress at 20 degr. C	: 207.000	N/mm <sup>2</sup>
49	Rm Tensile strength	: 414.000	N/mm <sup>2</sup>
50	Re(Tm) Yieldstress at 515.00 degr. C	: 108.500	N/mm <sup>2</sup>
51	f2 Design Stress	: 72.695	N/mm <sup>2</sup>
52			
53	CALCULATED AREAS		
54	A0 Cross sectional area in header	: 942.225	mm <sup>2</sup>
55	A1 Cross sectional area in branch	: 897.289	mm <sup>2</sup>
56	A2 Cross sectional area in reinforcing	: 765.751	mm <sup>2</sup> x 0.75
57			----- +
58	A Load carrying cross-sectional area	: 2413.827	mm <sup>2</sup>
59	Ap Pressurized area	: 14311.314	mm <sup>2</sup>
60			
61	CONCLUSION		
62	z3 Strength reduction coefficient	: 0.796	mm
63	z3 to be >= z min		
64	0.796 >= 0.778 Criterium is fulfilled		Ratio = 0.977
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