Report No.: 5ML_2017_059

APLEG SYSTEMS, S.R.O.

ASSESMENT OF STRENGHT CAPACITY OF THE EXTENSION FLANGE 60X1200-240

Abstract:
This report contains stress check of the EXTENSION FLANGE 60X1200-240, Article No. 076029.

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RECORD OF REVISIONS

Rev.	Date of Issue	Description of Changes	Affected Pages
-	20/09/2017	Initial issue	All

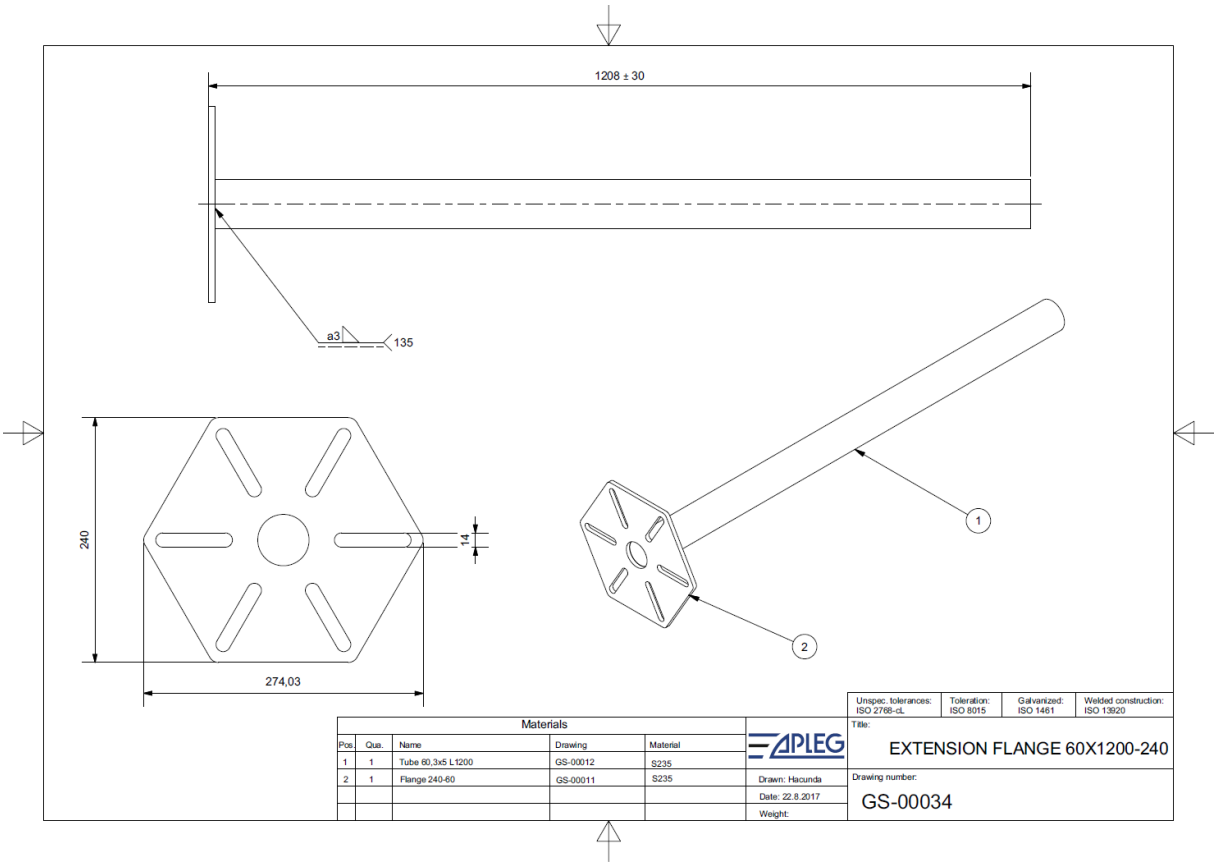
CONTENT

1 ÚVOD

This report was worked out on the basis of APLEG SYSTEM company order, delivered by e-mail on 24.08.2017.

The aim is to set strength capacity of screw extension.

Drawing:



Extensions can be used in combination with screw:

- SCREW PIPE 76X1500-8M16
- SCREW PIPE 76X1800-8M16

The strength capacity of installed screw is given by:

- tube dimensions,
- bolted joints,
- capacity of weld between flange and tube.

2 ABBREVISATIONS

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3 REFERENCE

Standards

[1] ČSN EN 1993-1-1 (materiál)
[2] ČSN EN 1993-1-8 ed 2. (svary)

Literature

[3] Airframe - Stress analysis and sizing, Michael Chun-Young Niu, 1999
[4] VDI 2230 - Systematic calculation of high duty bolted joints, 2003-10
[5] 5ML_2017_048 SCREW PIPE 76X1500-8M16
[6] 5ML_2017_045 SCREW PIPE 76X1800-8M16

Drawings

[7] GS-00033 EXTENSION FLANGE 60X750-240

Models

[8] -

Software:

[9] -

4 USED MATERIALS

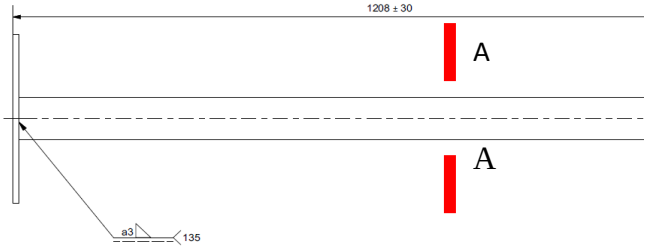
4.1 Metallic materials

Part	Material	Semi product	Yield stress	Tension strength	Reference
			$f_y = R_{p0,2}$	$f_u = R_m$	
			[MPa]	[MPa]	
Tube	S235	TR 76,1x3,6	235	360	Tab 3.1 lit. [1]
Šroub 16x30	8.8	--	640	880	DIN 914

5 STRENGHT CAPACITY ANALYSIS

5.1 Tube

Tension capacity was determined according to procedure described below in critical cross section showed in the picture bellow.



5.1.1 Tension (Compression)

Tension capacity in the cross-section A-A is calculated according to following formula:

$F_{tr\_tah} = \frac{f_y * A}{\gamma_{M0}}$; according to (6.6) [1]

where A tube cross section area $A = \frac{\pi(D^2 - d^2)}{4}$

γ_{M0} partial safety factor (=1,0 according 6.1, [1])

Tube cross section area:

$$A = \frac{\pi(D^2 - d^2)}{4} = \frac{\pi(60{,}3^2 - 50{,}3^2)}{4} = 868\ mm^2$$

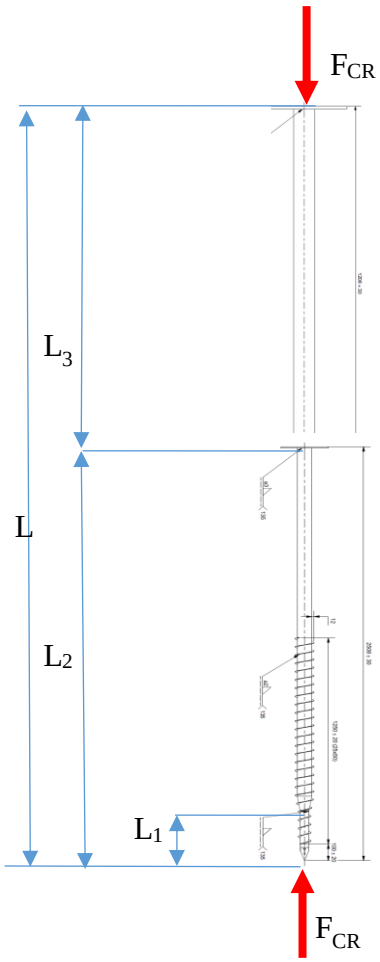
Tension capacity:

$$F_{tr\_tah} = \frac{f_y * A}{\gamma_{M0}} = \frac{235 * 868}{1{,}0} = 203\ 900N$$

Tension capacity of the extension tube is higher than tension capacity of screw tube. Extension don't limit screw capacity in tension.

5.1.2 Compression and Buckling capacity

Compression capacity was calculated for not-installed screw with extension according to methodology [1], Chapter 6.3.1.2. and [3] , Chapter 10.3. The length of insert part is considered 100mm and maximal extension is considered L_3=1100mm.



Methodology:

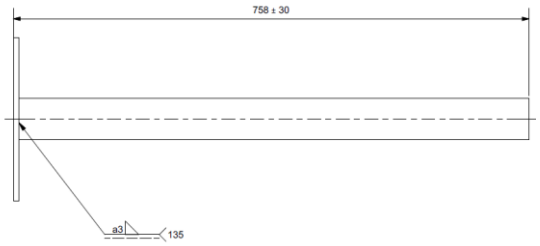
- A reduced moment of inertia will be calculated for screw euler critical force and screw length L_2: $J_{Red} = \frac{F_{kr} * L_2^2}{\pi^2 * E}$, where E is young material modulus 210 000MPa
- A geometric ratio will be calculated: L_3/L and $\sqrt{\frac{J_3}{J_{\mathrm{Red}}}}$.
- Constant C_1 will be set from Fig. 10.3.2 lit. [3]
- Euler critical force: $F_{cr} = C_1 * \pi^2 \frac{E J_{Red}}{L^2}$
- Euler ratio: $\lambda' = \sqrt{\frac{A f_y}{F_{cr}}}$, where A is screw tube cross section area 820mm^2 and fy is yield stress 235MPa
- Buckling coefficient will be set from diagram χ
- Buckling force will be calculated: $N_{b,Rd} = \chi \frac{A f_y}{\gamma_{M0}}$

Calculatuion:

Length of screw L_2	[mm]	1500	1800
Critical force	[N]	422 800	300 500
Reduced moment of inertia of screw J_{red} at lenght L_2	[mm^4]	458984	469753
Moment of inertia of extension J_3 at lenght L_3	[mm^4]	334700	334700
Ratio L_3/L	[-]	0,42	0,38
Ratio $\sqrt{\frac{J_3}{J_{\mathrm{Red}}}}$.	[-]	0,85	0,84
C_1 from Figure 10.3.2 lit. [3]	[-]	0,9	0,9
Critical Euler force for extended screw F_{cr}	[N]	126652	104192
Euler ratio $\lambda' = \sqrt{\frac{Af_y}{F_{cr}}}$	[-]	1,23	1,36
Buckling coefficient χ	[-]	0,47	0,4
Buckling force	[N]	**90 500**	**77 000**

5.2 Anchoring through flange

The strength capacity of flange is limited by weld between flange and tube. There is prescribed fillet weld size 3mm.



Allowable weld strength according to (4.4) lit [2]:

$$f_{w,d} = \frac{f_u/\sqrt{3}}{\beta_w * \gamma_{M2}},$$

where β_w weld correction factor; for fillet weld and S235 $\beta_w = 0{,}80$

γ_{M2} joint partial factor – fillet weld (=1,25 acc. to 2.2 [2])

$$f_{w,d} = \frac{f_u/\sqrt{3}}{\beta_w * \gamma_{M2}} = \frac{360/\sqrt{3}}{0{,}8*1{,}25} = 208 Nmm^{-1}$$

Strength capacity of 1 mm weld length:

$$F_{w,d} = f_{w,d} * a = 208 * 3 = 624 Nmm^{-1}$$

where a is weld thickness

The length of weld corresponding to tube circumference:

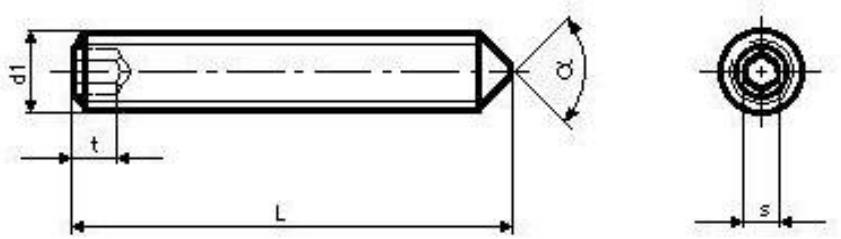
$$L = \pi D = \pi * 76{,}1 = 239 mm$$

The weld is able to transfer force:

$$F_{sv} = L * F_{w,d} = 239 * 624 = 149\,000 N$$

5.3 Capacity of the connection between screw and extension

For the connection between basic screw and extension are designed 8 items of screw according to specification in Chapter 4.1



The load is transferring by friction and by screw top pressed into inner tube. The capacity is calculated for screw preload at 50% of yield stress. The preloaded is set according to VDI 2230 [4] , Tab. A1:

- for tightening moment at 90% of yield stress and thread friction coefficient 0,10 the preloaded force is 82,9kN and tightening moment 180Nm
- with respect of tightening condition only 55% of tightening moment is recommended, it means 99Nm, preload force will be 45,5kN
- friction coefficient was considered f=0,1; Tab. A6 VDI, lit.[4],
- for friction force calculation, a higher safety factor of $\gamma_{M2} = 1{,}5$ was considered.

The force transferred by friction at 1 screw:

$$F_{1fr} = \frac{F_{Q}*f}{\gamma_{M2}} = \frac{45000*0{,}1}{1{,}5} = 3000N$$

The force transferred by bearing after pressed 2mm of screw top into inner tube:

- bearing area, A=2*4=8mm^2
- allowable bearing stress p=1,5Rm=540MPa
- safety factor $\gamma_{M2} = 1{,}25$
- maximal force transferred by bearing

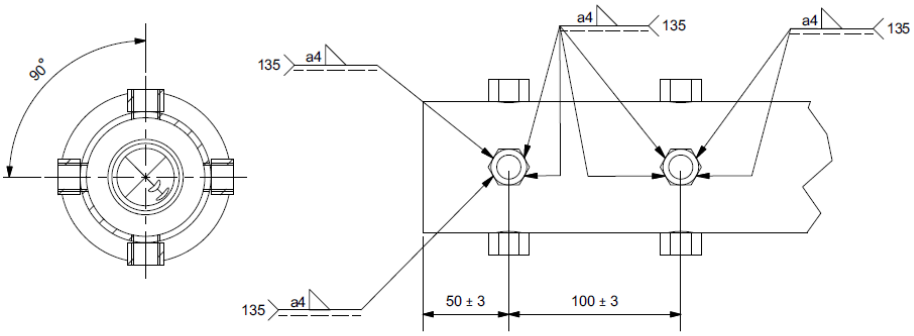
$$\mathrm{F_{1br}} = \frac{\mathrm{p} * \mathrm{A}}{\gamma_{M2}} = \frac{540 * 8}{1{,}25} = 3450\mathrm{N}$$

Total force transferred by 8 screws:

$F_{SCR8} = n(F_{1fr} + \mathrm{F_{1br}})$=8(3000+3450)=51 600N

The joint capacity limits push or pull force in the screw by 51 000N.

A stress check of welded joint between nut and tube was done for preload force 45 000N and transferred force 3660N+3450N = 7110N.



Total transferred force:

$$F = \sqrt{F_Q^2 + F_{SCR8}^2} = \sqrt{45\ 000^2\ + 7\ 110^2}$$ =45 500N

The nut will be transfer proportional force given by high of nut 16mm and thickness of whole joint (nut high 16mm and tube thickness 3,6mm):

$$F_{NUT} = \frac{16}{16+3,6} * 45500 = 37140N$$

Load capacity of 8 nuts are determined in [5] a [6] to 319 400N, one nut 39 925N > F_{NUT}=37 140N. COMPLY.

6 CONCLUSION

The report contains stress check of the EXTENSION FLANGE 60X750-240. Extended screw is not proper for horizontal force loading.

Extended screws are limited by capacity of the screw joint.

Load capacity of SCREW PIPE 76X1500-8M16 + EXTENSION FLANGE 60X1200-240:

SCREW PIPE 76X1500-8M16 + EXTENSION FLANGE 60X1200-240				
Soil capacity level		1	2	3
Description	-	Weakly coherent small-grained soil	**Moderately coherent gravel soil**	Strong coherent soil
Ultimate strength in compression $R_{d,t}$	[MPa]	0,08-0,15	**0,15-0,4**	0,4-0,5
Strength capacity in pull direction	[N]	15 000	**26 600**	51 000
Strength capacity in push direction	[N]	25 100	**45 600**	51 000
Strength capacity in horizontal direction	[N]	Don't apply	Don't apply	Don't apply

Source: 5ML_2017_045.

Load capacity of SCREW PIPE 76X1800-8M16 + EXTENSION FLANGE 60X1200-240:

SCREW PIPE 76X1800-8M16 + EXTENSION FLANGE 60X1200-240				
Soil capacity level		1	2	3
Description	-	Weakly coherent small-grained soil	**Moderately coherent gravel soil**	Strong coherent soil
Ultimate strength in compression $R_{d,t}$	[MPa]	0,08-0,15	**0,15-0,4**	0,4-0,5
Strength capacity in pull direction	[N]	16 900	**29 300**	51 000
Strength capacity in push direction	[N]	27 500	**49 300**	51 000
Strength capacity in horizontal direction	[N]	Don't apply	Don't apply	Don't apply

Source: 5ML_2017_048.