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1. Contents

2. Review of access methods, how to observance the regulation UL-2

In following part is mentioned what were the methods to the meet the particular articles of regulation.

Subparagraph 1. General:
proved with flying tests, aerodynamic calculations and with weighing

Subparagraph 2. Flying performances and characteristic:
proved with flying tests, aerodynamic calculations

Subparagraph 3. Strength of structure:
proved with strength calculation and load tests

Subparagraph 4. Design and structure:
- proved with the technical inspection and checking of drawing documentation

Subparagraph 5. Power unit:
proved with technical inspection

Subparagraph 6. Flying instruments and equipment:
proved with technical inspection

Subparagraph 7. Operating limitation:
proved with checking of flying manual

Subparagraph 8. Engines:
- It isn't proved - the engines, which are used are standard engines ROTAX only

Subparagraph 9. Propellers:
- It isn't proved – they are used standard propellers only

3. Proof test of strength

For the whole plane was realised the design calculation all of the basic strength parts of plane, because they are mostly complicated three-dimensional shells is necessary to check the calculation through the load tests and proof test is emphatic for the load tests provided . The strength calculations were indicated there only, where was possible to accept the proof calculation only. They are especially the control lines calculations and checking of some hinges on bearing stress. Strength calculations was if necessary replaced by load tests.

3.1 Loads

Load of plane was processed under UL-2 regulations. For some parts of plane was used the methods of higher regulations JAR-VLA. In the concrete it is so with delimitation of loads from gust according gust envelope UFM-13. JAR-VLA 423© give more realistic values of load then the calculation on sudden deflection of rudder. Access method according The Appendix JAR-VLA was also used for delimitation the loads of aileron and flap. The simplify was the reason because the load especially on flaps come out on safe side.

Conjoint reports: Calculation of load of the aircraft UFM - 11

3.2 Proof test of wing

Proof test of wing was executed with the tests under report " Strength test of wing UFM-13 " from Air department of Technical University Brno. By flange is critical break-down of material and this is why were implicated the influences from temperature and scatter of manufacturing. This is why the safety coefficient f = 2.25.

With performance of bending test was not check the safe of wing skin, root rib and hinges of wing. Therefore was checked the maximal torsion case, which those parts proved. The strength of aileron, flap and flapperon and their hinges was proved by separate load tests.

Conjoint reports: Strength tests of wing UFM-13
Strength tests of UFM-11,13
Comparison of wings UFM

3.3 Proof test of fuselage

Proof test of fuselage, except some details which had extra compute-proof test (hinge), was realised with a lot of load tests, vide report " Strength tests of UFM-11,13". In this case of load are critical stability break-downs and therefore was selected safety coefficient f = 1.5.

Conjoint reports: Strength tests of UFM-11,13
Proof test of UFM-11,13

3.4 Proof test of landing gear

Proof test of landing gear including its hinges (landing gear mountings) on fuselage was realised by crash-down test. There were supplemented load cases for nose leg by separate proof test. Safety coefficient f = 1.5.

Conjoint reports: Strength tests of UFM-11,13

3.5 Proof test of horizontal tail-plane.

The proof test was realised by device which simulates the some hinge of tail-plane as the fuselage has. By reason of proof test of the spar, skin and hinge were the tests provided not only for case with maximal force on tail-plane, but for case of maximal torsion (gust case) too. For hinge was critical the eccentric case of tail-plane. Supplement is the calculate-proof of hinge. Safety coefficient f = 1.5.

Conjoint reports: Strength tests of UFM-11,13
Proof tests of UFM-11,13

3.6 Proof test of fin (vertical tail) and its hinges.

The proof test was provided by fuselage load test. Once again were tested all of cases by reason of proof of skin, spar and hinges. The rudder was tested on separate device. Supplement is calculation of hinges. Safety coefficient f = 1,5.

Conjoint reports: Strength tests of UFM-11,13
Proof tests of UFM-11,13

3.7 Proof test of control lines.

Whole control lines are integral part of plane. The compute-proof was provided. As a supplement were load tests only. Safety coefficient f = 1.5.

Conjoint reports: Strength tests of UFM-11,13
Calculation of control lines UFM-11,13

3.8 Proof test of engine mounting.

The proof test was realised together with the test of fuselage. Separate was provided the test on the side load. Safety coefficient f = 1.5.

Conjoint reports: Load tests of UFM - 11

3.9 Proof test of seats and hinge of safety belts.

The proof test of seats was realised together with fuselage test. The hinge of safety belts was checked by separate proof test.

Conjoint reports: Strength tests of UFM-11,13
Proof test of safety belts hinge of plane UFM-11,13

3.10 Strength test.

Common extend of tests under LAA covers following points:
wing load on maximal arithmetical multiple
crash test with down speed under area loading
test of engine mountings
test of control stiffness and maximal forces to the stops
By reason mentioned at the beginning of report was proof test preferential built to the strength tests, therefore we modify standard schedule.

The new schedule is in following:
- Wing test of maximal positive multiple
- Wing test on maximal case of torsion
- Test of tail-plane - manoeuvre
- Test of tail-plane - gust
- Test of tail-plane - eccentric gust

Test of fin - manoeuvre
Test of fin - gust
Test of rudder – manoeuvre
Manoeuvre on tail-plane and positive multiple a = 4g on front of fuselage
Combination of 100% manoeuvre on fin and maximal balancing force on tail-plane, which is important for torsion of fuselage tail.
Maximal load on fuselage front and seats by positive multiple from gust
Crash test for down speed (vertical speed) v = 2.23 m/sec
Supplementary test of nose leg – front-back force
Supplementary test of nose leg – back force
Supplementary test of nose leg – side force
Test of engine mounting on maximal torsion and multiply
Test of engine mounting on side load
Test of control stops
Test of stiffness of control lines
Test of aileron
Test of flap
Test of flapperon

Scheme of all tests is possible to see on prints, where are visible the methods of loading too. Evident are the holding devices in which were tested the components of plane.
The critical point of the fuselage appears the place above engine bed (joint point of engine bed to the firewall) which had maximal deformation.
In whole range of loading don't offered any ruffle of skin and there aren't any problems of stability.

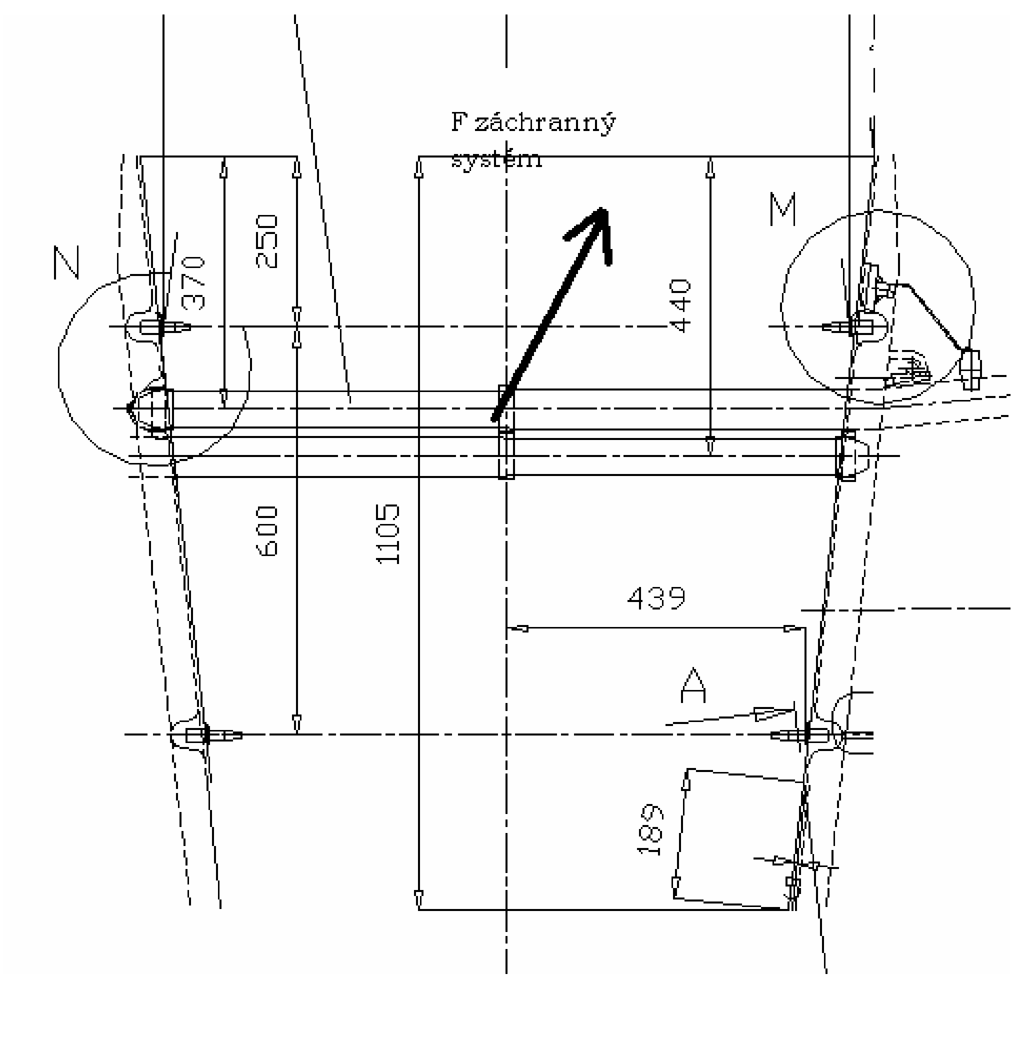
Appreciation of the tests is in following:
It was proofed ample strength and stiffness following parts of plane: tail plane, fin, front and tail of fuselage, landing gear wing and engine mounting. After dismantling of loading there were not any residual deformations to find.

4. Strength calculations.

In this paragraph are the calculation checks provided especially joint fittings in reference to bearing stress, which can created permanent deformation during longer operating time. Itself strength was proof at strength test.

4.1 Main connecting of wing - fuselage.

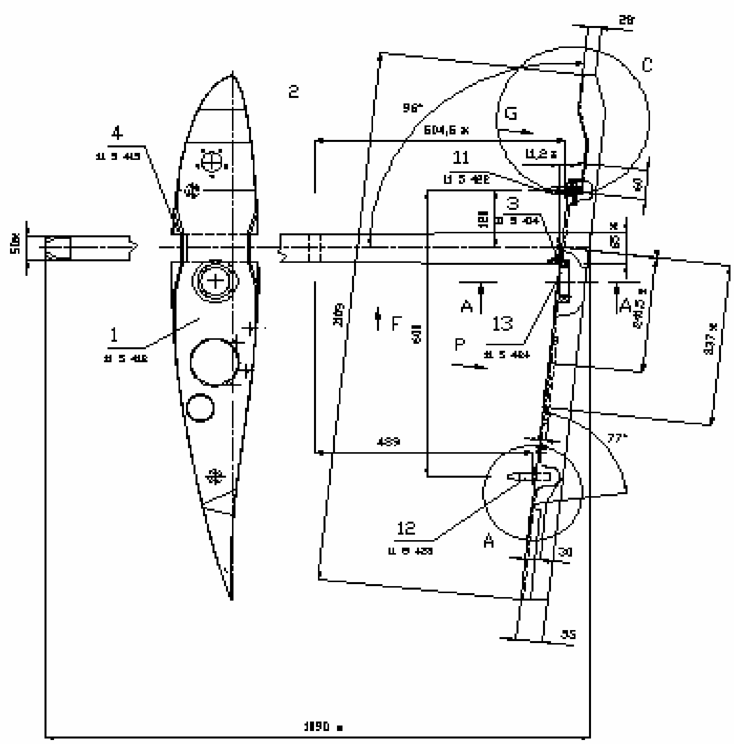
The wing with fuselage is connected double sided with two joints, which transfer only perpendicular (normal) forces and couple of forces from torsion moment. The scheme of this connecting see on fig.

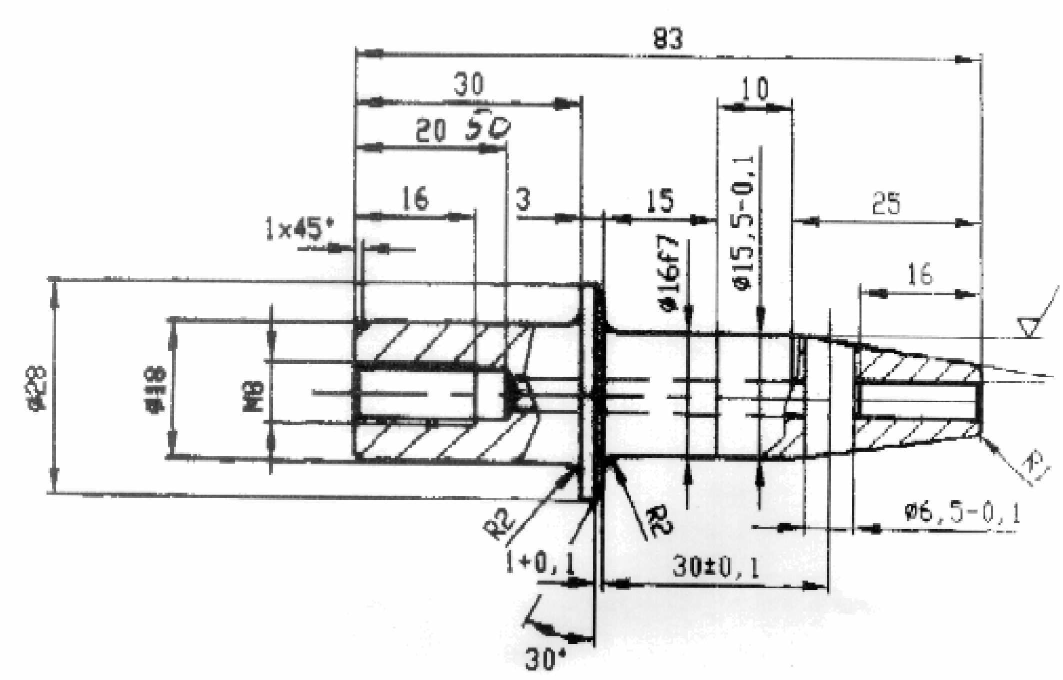


Maximal load on one plug by safety coefficient f = 1 is R1c = 9811 N, this load makes reaction of fuselage's holding device for loading case Nr.1, so positive multiply of gust. This reaction comes out from concept of fuselage static loading, when the fuselage presents a spar with two holds. It was not absorbing calculated, so the loading is on the safety side.

Own hinge is designed as a bushing which is sealed in laminate (fibre glass). Scheme is on following fig.

Opposite - parts on the root rib is the plug sealed in cantilever (fibre glass) see fig.





We check the deposition in the wing and fuselage in laminate on stress

The bushing is set in fuselage in epoxy laminate of thickness t= 4.05 mm , $\sigma_{Dov.}$ = 140 MPa at operating load. The force is to the laminate load on bushing's diameter d = 23.5 mm, see drawing. The value of stress in laminate is following:

$$\sigma_{otlačení} = \frac{R1c}{t \cdot d} = \frac{9811}{4.05 \cdot 23.5} = 103 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa}$$, comply

In the root rib is a plug d = 18 mm set in laminate t = 4.5 mm

$$\sigma_{otlačení} = \frac{R1c}{t \cdot d} = \frac{9811}{4.5 \cdot 18} = 121 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa}$$, comply

Next place which is necessary to check from this point of view is connection of cantilever's end in the root rib. There transfers the reaction's force which is created from bend moment. Its value is $R = \frac{Mo\max}{r}$ where

Momax is maximal bend moment there in the place of root rib. In this case at gust 15 m/sec Momax = 20 726 Nm and r = 1.3 m as distance both of root ribs

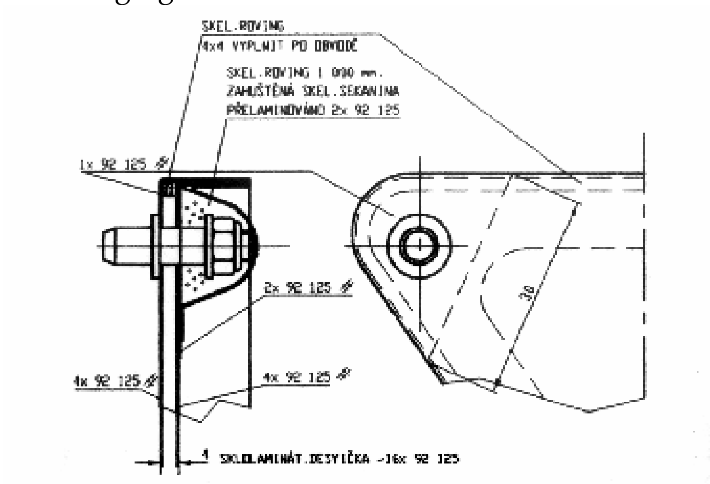
$$R = \frac{20726}{1.1} = 18842 \text{ N}$$

This force is transferred to the root rib with the metallic ring (coil) ř 65 mm in to laminate of thickness t = 3 mm.

$$\sigma_{otlačení} = \frac{R}{t \cdot d} = \frac{18842}{3.0 \cdot 65} = 96.6 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa}$$, comply

4.2 Hinge of tail-plane.

Tail-plane is mounted with a couple of plugs ř d – 10 mm. Scheme of assembly see following fig.



For load of this connecting on critical the induced moment on tail-plane, from gust on the fin, its value is Mt = 447 Nm.

The load from moment on the plug is $R = \frac{Mt}{r}$ where distance both plugs r = 100 mm.

$$R = \frac{447000}{100} = 4470N$$

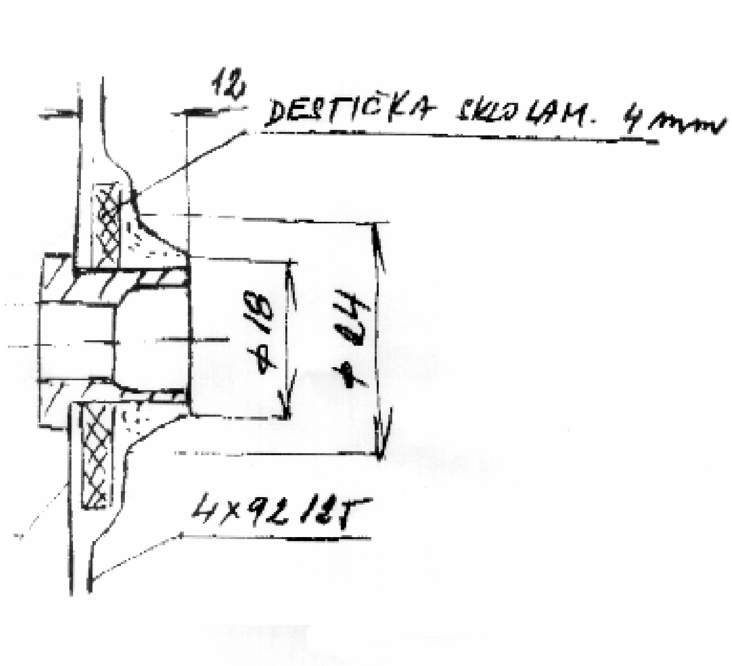
Maximal load of connection is thus R = 4 470 Nm.

In tail-plane's hinge is the force set up through a sealed plug ø10 mm in to laminate of thickness t = 5.5 mm.

$$\sigma_{otlačení} = \frac{R}{t \cdot d} = \frac{4470}{5.5 \cdot 10} = 81.2\ MPa\ <,\ \sigma_{Dov.} = 140\ MPa\ ,comply$$

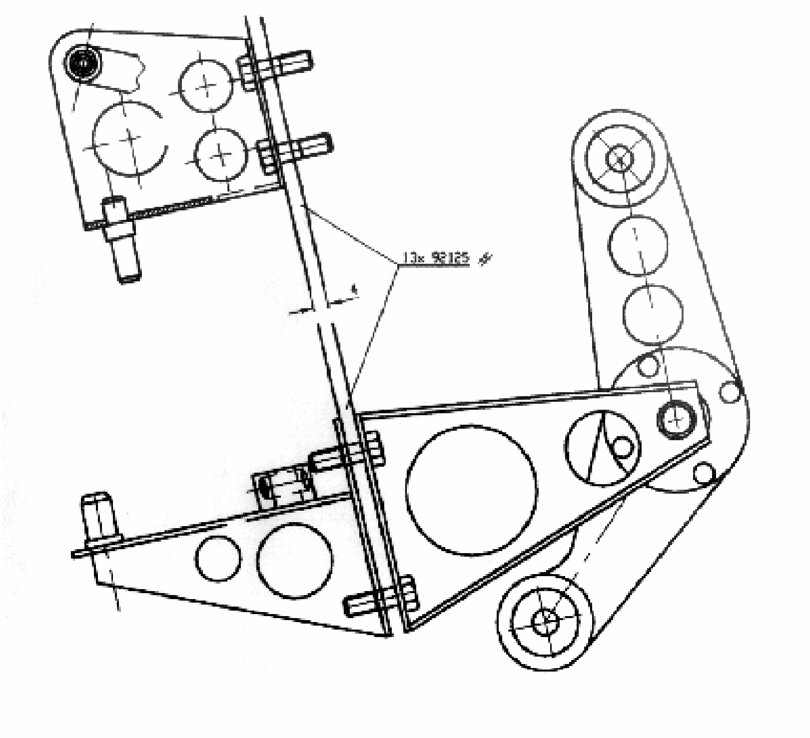
There in tail-plane structure is the force transferred through a bushing ø18 mm in to laminate of thickness t = 4.2 mm.

$$\sigma_{otlačení} = \frac{R}{t \cdot d} = \frac{4470}{4.2 \cdot 18} = 59\ MPa\ <,\ \sigma_{Dov.} = 140\ MPa\ ,comply.$$



4.3 Connection of rudder

Rudder is hinged on fin with a couple of hinges , scheme in following.



The maximal load of the rudder hinges is at manoeuvre case when on upper hinge acts force R1 = 116 N and bottom hinge R2 = 141 N. The bottom hinge of rudder transfers hinge moment Mz = 23 866 Nmm.
For load of bottom hinge is necessary to consider also load from simultaneous act on both pedals from one pilot, which creates reaction R = 1 200 N.

Upper and bottom are mounted on the spar with 4 screws d = 5 mm on laminate of thickness t = 3.9 mm.

$$\sigma_{otlačení} = \frac{R}{n \cdot t \cdot d} = \frac{141}{4 \cdot 3.9 \cdot 5} = 1.8 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa ,comply.}$$

Bottom hinge in the rudder is fixed with 2 screws d = 5 mm on laminate T = 4 mm.
The load of one screw of this connection we obtain under following way:

$$Ršroub = \frac{R1}{2} + \frac{Mzávěz}{\cdot r} = \frac{141}{2} + \frac{23866}{74} = 393 \text{ N}$$

R = 74 mm distance of screws.

$$\sigma_{otlačení} = \frac{Ršroub}{t \cdot d} = \frac{393}{4 \cdot 5} = 19.65 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa ,comply}$$

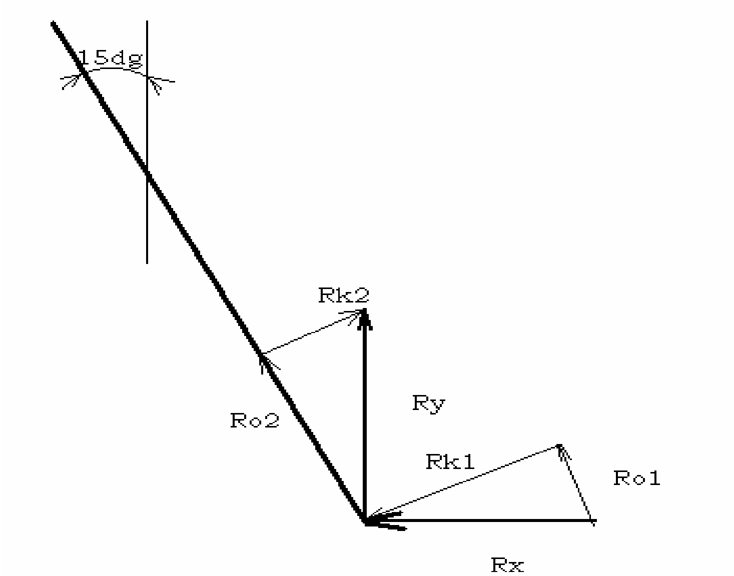
For simultaneous act on rudder's pedals is Rs = 600 N

$$\sigma_{otlačení} = \frac{Ršroub}{t \cdot d} = \frac{600}{4 \cdot 5} = 30 \text{ MPa} <, \sigma_{Dov.} = 140 \text{ MPa ,comply}$$

4.4 Nose leg of landing gear.

Nose leg is designed as steel weld part. Its basic proportion are on following fig. With marking of critical cross-sections k1, k2. Whole nose leg is declined with angle 15° forward.

The critical case of load is combination of front-back force Rx = 1 833 N and vertical force Ry = 2 292 N.



We provide the resolution of the forces in to plane of leg.

Ro1=Rx sin15 = 474 N

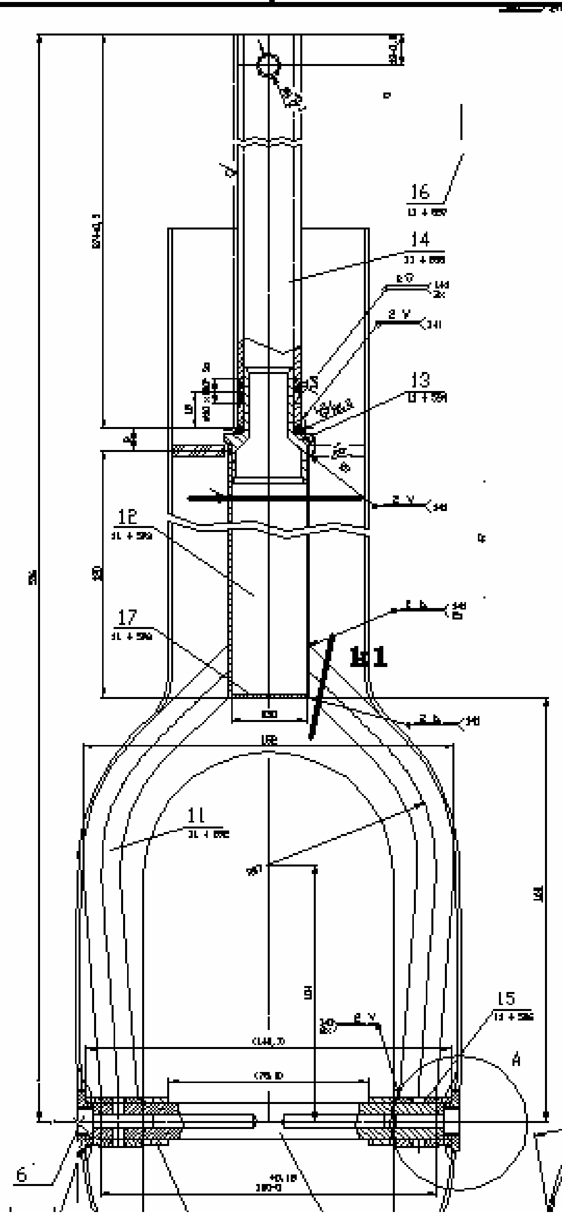
Ro2= Ry cos15 =2213N

Rk1= Rx cos15 =1770N

Rk2= Ry sin15 = 593 N

Ro= RO1+Ro2 =1067 N

Rk =Rk1-Rk2 =1177N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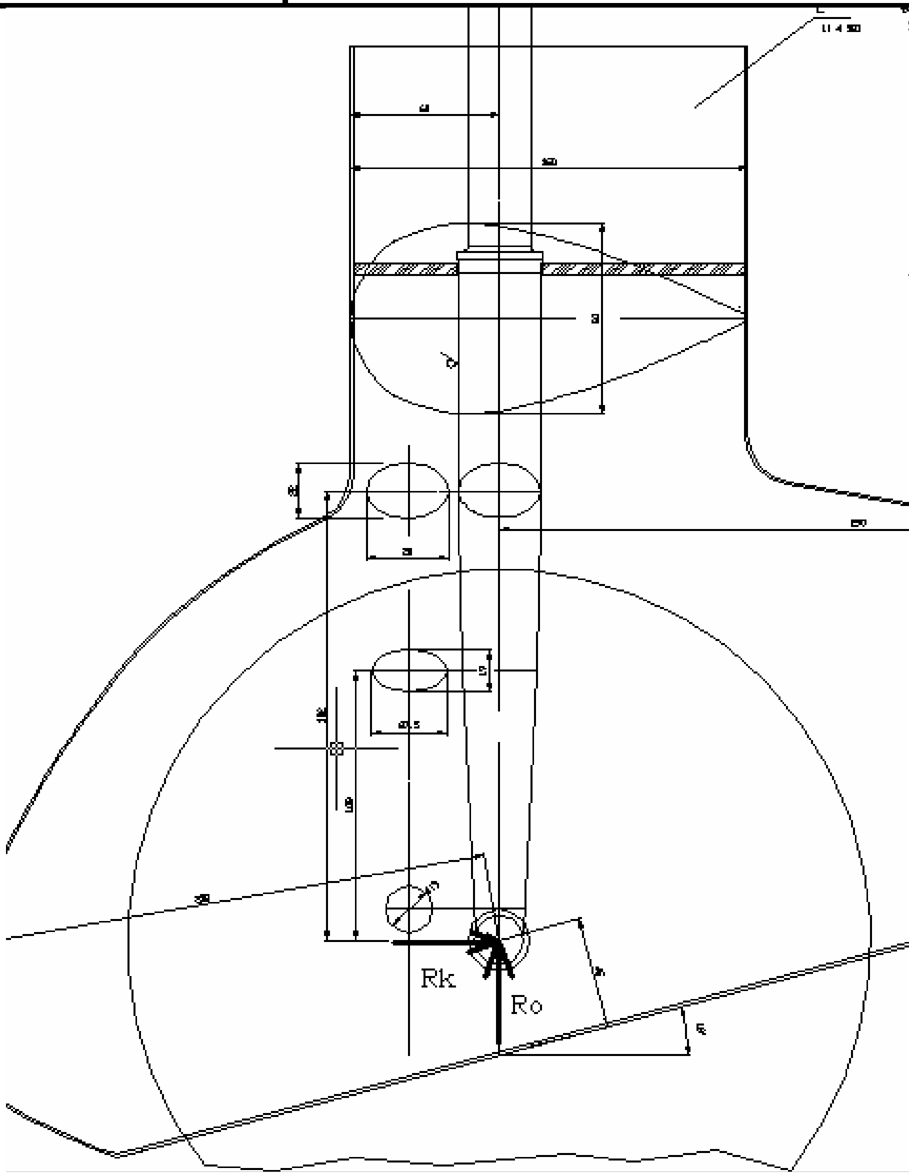

Cross-section k1 is loaded with a combination of torsion, moved force and bend in two planes.

M1=Ro/2 . 44= 23474 Nmm

M2=Rk/2 . 44 =25894 Nmm

Mk= Rk/2 .165 =96937 Nmm

Check of cross-section is in following tab

Check of cross-section Description check of cross-section k1					
Load		geometry of cross-section		*stress*	
M1=	23474 [Nmm]	W1=	402 [mm^3]	Sigo1=	58.39303 [MPa]
M2=	25894 [Nmm]	W2=	460 [mm^3]	Sigo2=	56.2913 [MPa]
T1=	533.5 [N]	Wk=	871 [mm^3]	Sig Fo=	0 [MPa]
T2=	588.5 [N]	S=	75.4 [mm^2]	Tau1=	9.433893 [MPa]
Fo=	0 [N]	k1 smyk=	1.3333 [ ]	Tau2=	10.40646 [MPa]
Mk=	96937 [Nmm]	k2 smyk=	1.3333 [ ]	Taukrut=	111.2939 [MPa]
		Sig red =	263.4747 [MPa]	K plastic =	1.27 [ ]
		Sig krit =	800 [MPa]		
		f=	3.036344 [ ]	**f=**	3.856157

Cross-section k2 is loaded with bend and axle's force.

M1 = Rk .365 = 429605 Nmm

Fo=Ro=1067 N

Check of cross-section k2 is in following tab.

Check of cross-section Description check of cross-section k2					
Load		geometry of cross-section		*stress*	
M1=	429605 [Nmm]	W1=	1046 [mm^3]	Sigo1=	410.7122 [MPa]
M2=	0 [Nmm]	W2=	1046 [mm^3]	Sigo2=	0 [MPa]
T1=	1177 [N]	Wk=	2092 [mm^3]	Sig Fo=	7.420028 [MPa]
T2=	0 [N]	S=	143.8 [mm^2]	Tau1=	10.91303 [MPa]
Fo=	1067 [N]	k1 smyk=	1.3333 [ ]	Tau2=	0 [MPa]
Mk=	0 [Nmm]	k2 smyk=	1.3333 [ ]	Taukrut=	0 [MPa]
		Sig red =	418.7015 [MPa]	K plastic =	1.27 [ ]
		Sig krit =	600 [MPa]		
		f=	1.433002 [ ]	**f=**	1.819912