



S V E U Č I L I Š T E   U   Z A G R E B U  
FAKULTET STROJARSTVA I BRODOGRADNJE  
Katedra za elemente strojeva i konstrukcija



# ELEMENTI KONSTRUKCIJA III

## REDUKTOR

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Uzmi podaci: 5e

List 1/35

Potrebna snaga rodnog  
stroja  $P [kW]$  33

Broj okretja elektro-  
motora  $n, [\text{min}^{-1}]$  1420

Standardni prijenosni omjer: 2,8

Zagonski moment mase  
rodnog stroja  $G D^2 [\text{Nm}^2]$  71

Vrijeme uključivanja  
elektromotora  $t_u [s]$  3,3

Torzijsko opterećenje NAIZMJEНИЧНО

$K_A$  1

Pogon uključen TAKO (TP=100%)

#### ZUPČANIK

Broj zubi manjeg  
zupčanika  $z_1$  17

Materijal manjeg zupčanika  $z_1$  18CrNi8 (č5421)  
kaljen

Materijal većeg zupčanika  $z_2$  ODREDITI

Kvaliteta tolerancija ODABRATI

Kut zahvata  $\alpha [{}^\circ]$  20°

Pomak profila ODREDITI

Izvedba Kućišta ZAVARENO

#### VRATILO

Materijal S275 (č0461)

Obada vratila  $R_a < 1,6 \mu\text{m}$

Oboda rulavaca FINO BROŠENO  $R_a < 1,6 \mu\text{m}$

Potrebna sigurnost Spri 1,5

## 1. Zupčanici

## 1.1. Orijentacijski modul

$$m \geq \sqrt[3]{\frac{2 \cdot T_{max}}{z_1 \cdot z_2 \cdot \sigma_{FP}}} \cdot Y_F \cdot Y_S \cdot K_{FL}$$

$$T_{max} = T_{NAZ} + T_E'$$

$$J_{RED} = G D_{es}^2 \cdot \left( \frac{\omega_{RS}}{\omega_{EM}} \right)^2 = 71 \left( \frac{1}{i} \right)^2 = 71 \left( \frac{1}{2,8} \right)^2 = 9,056 \text{ Nm}^2$$

$$T_E' = \frac{J_{RED} \cdot m_1}{375 \cdot f_U} = \frac{9,056 \cdot 1420}{375 \cdot 3,3} = 10,39 \text{ Nm}$$

$$T_{NAZ} = \frac{P}{\omega_1 \cdot \eta_{uk}} = \frac{P}{m_1 \cdot \frac{\pi}{30} \cdot \eta_{uk}} = \frac{33000}{1420 \cdot \frac{\pi}{30} \cdot 0,93} = 238,62 \text{ Nm}$$

$$J_{RED} = 9,056 \text{ Nm}^2$$

$$T_E' = 10,39 \text{ Nm}$$

$$T_{NAZ} = 238,62 \text{ Nm}$$

$\eta_{uk} = 0,93$  (odabrano, Redaktor str. 9.)

$$T_{max} = 238,62 + 10,39 = 249,02 \text{ Nm}$$

$z = 25$  (odabrano, Redaktor str. 70, Tablica 35.)

$$Y_F = 2,2$$

$$\sigma_{FP} = \frac{\sigma_{Flim} \cdot 0,7}{S_F} = \frac{500}{2,5} \cdot 0,7 = 140 \frac{N}{mm^2}$$

$$Y_S = 1$$

$$K_{FL} = 1 \quad \sigma_{Flim} = 500 \frac{N}{mm^2} \text{ (odabrano, Redaktor str. 67, Tab. 20)}$$

$$m \geq \sqrt[3]{\frac{2 \cdot 249,02}{17 \cdot 25 \cdot 140}} \cdot 2,2 \cdot 1 \cdot 1 = 2,956 \text{ mm}$$

$$\text{ODABRANO : } m = 3 \text{ mm}$$

$$m = 3 \text{ mm}$$

1.1.1. Dimenzije zupčnika u odnosu na orijentacijski modul

$$d_1 = m \cdot z_1 = 51 \text{ mm}$$

$$d_1 = 51 \text{ mm}$$

$$z_2 = i \cdot z_1 = 2,8 \cdot 17 = 47,6 \rightarrow \text{odabrano } z_2 = 48$$

$$z_2 = 48$$

$$i_N = \frac{z_2}{z_1} = \frac{48}{17} = 2,824$$

$$i_N = 2,824$$

$$\Delta i = \frac{i_N}{i} = \frac{2,824}{2,8} \approx 1,0084$$

$$\Delta i = 0,84\% \leq 3\%$$

ZADOVOLJIVA

$$d_2 = m \cdot z_2 = 3 \cdot 48 = 144 \text{ mm}$$

$$d_2 = 144 \text{ mm}$$

1.1.2. Novi zagonski momenti:

ZUPČANIK 1:  $J_{z_1} = G_{z_1} \cdot D_{z_1}^2$

$$G_{z_1} = 60,2 \cdot d_1^2 \cdot b = 60,2 \cdot 51^2 \cdot 0,75 = 11,74 \text{ N}$$

$$G_{z_1} = 11,74 \text{ N}$$

$$b = \pi \cdot m = 25 \cdot 0,003 = 0,75$$

$$D_{z_1} = \sqrt{\frac{d_1^2}{2}} = \sqrt{\frac{0,051^2}{2}} = 0,0361 \text{ m}$$

$$J_{z_1} = 11,74 \cdot 0,0361^2 = 0,0153 \text{ Nm}^2$$

$$J_{z_1} = 0,0153 \text{ Nm}^2$$

ZUPČANIK 2:  $J_{z_2} = G_{z_2} \cdot D_{z_2}^2$

$$G_{z_2} = 60,2 \cdot d_2^2 \cdot b = 60,2 \cdot 144^2 \cdot 0,75 = 93,62 \text{ N}$$

$$D_{z_2} = \sqrt{\frac{d_2^2}{2}} = \sqrt{\frac{0,144^2}{2}} = 0,1018 \text{ m}$$

$$J_{z_2} = 93,62 \cdot 0,1018^2 = 0,971 \text{ Nm}^2$$

$$J_{z_2} = 0,971 \text{ Nm}^2$$

SPOŠTA 2:  $T_{S_2} = (T_{N42} \cdot i_N \cdot \eta_{ul}) =$

$$T_{S_2} = 238,62 \cdot 2,824 \cdot 0,93 = 626,7 \text{ Nm}$$

$$T_{S_2} = 626,7 \text{ Nm}$$

ODABRANA: ES4 (Dedektor s1,47, Tb, 10.)

$$J_{S_2} = 1,85 \text{ Nm}^2$$

$$G = 140 \text{ N}$$

$$\begin{aligned} J_{RED} &= J_{Z_1} + (J_{Z_2} + J_{S_1} + J_{S_2}) \cdot \left(\frac{m_2}{m_1}\right)^2 = \\ &= 0,0153 + (0,971 + 1,85 + 71) \left(\frac{1}{2,824}\right)^2 = 9,36 \text{ Nm}^2 \\ T_S &= \frac{J_{RED} \cdot m_1}{375 \cdot t_0} = \frac{9,36 \cdot 1420}{375 \cdot 3,3} = 10,74 \text{ Nm} \end{aligned}$$

$$T_{uk} = T_{UAZ} + T_S = 238,624 + 10,74 =$$

$$T_{uk} = 249,37 \text{ Nm}$$

$$T_{uk} = 249,37 \text{ Nm}$$

$$m = 2,954 \rightarrow \text{osirajem } m = 3 \text{ mm}$$

$$m = 3 \text{ mm}$$

1.2. Standardni osni razmak

$$a = \frac{d_1 + d_2}{2} = \frac{m}{2} (z_1 + z_2) = \frac{3}{2} (17 + 48) \\ = 97,5 \text{ mm}$$

$$\text{ODABRANO } d_w = 100 \text{ mm}$$

$$a = 97,5 \text{ mm}$$

$$|d_w - a| \leq m$$

$$100 - 97,5 \leq 3$$

$$2,5 \leq 3$$

Zadovoljivo

$$d_w = 100 \text{ mm}$$

1.2.1. Orientacijski uvjet vrstocene vratila 1.

$$d_{z_1} \geq 2 d_{v_1} \text{ za spoj perom}$$

$$d_{z_1} \geq 1,2 d_w \text{ za izvedbu 12 jednog komoda}$$

$$d_{v_1} \geq \sqrt[3]{\frac{5 \cdot T_{uk}}{\bar{c}_{dop}^2}}$$

$$\bar{c}_{dop} = \frac{\bar{c}_{DN}}{10} = \frac{110}{10} = 11 \frac{N}{mm^2}$$

$$\bar{c}_{DN} = 110 \frac{N}{mm^2} (\text{odabran Redukt str. 67, 75, 28., 00461})$$

$$d_{v_1} \geq \sqrt[3]{\frac{5 \cdot 249,37}{1,1}} = 48,39 \text{ mm}$$

$$\frac{d_{z_1}}{d_{v_1}} = \frac{51}{48,39} = 1,05$$

$$1,05 \geq 2$$

NEZADOVOLJSTVA

$$d_{v_1} \geq \sqrt[3]{\frac{5 \cdot 249,37}{37}}$$

$$z_{dp} = \frac{\tilde{c}_{DN}}{10} = \frac{370}{10} = 37 \frac{N}{mm^2}$$

$\tilde{c}_{DN} = 370 \frac{N}{mm^2}$  (odobreno, Reduktor dr. 67, Tb. 28.,  $\bar{c}_{5421}$ )

$$d_{v_1} \geq 32,3 \rightarrow \text{odobreno } 35 \text{ mm}$$

$$\frac{d_{z_1}}{d_{v_1}} = \frac{51}{35} = 1,46$$

$$1,46 \geq 1,2$$

ZADOVOLJSTVA,  $z_1$  će biti izadjen 12 jednog komoda sa vratilom 1.

### 1.2.2. Faktori pomaka profila

$$x_1 + x_2 = (z_1 + z_2) \frac{evd_{ew} - evd}{2 \cdot \operatorname{tg} \alpha}$$

$$\cos d_{ew} = a \cdot \frac{\cos \alpha}{\operatorname{tg} \alpha} = 97,5 \frac{\cos 20^\circ}{100} =$$

$$d_{ew} = 23^\circ 37'$$

$$d_{ew} = 23^\circ 37'$$

$evd = 0,014904$  (ocitano Reduktor dr. GP, Tb. 30.)

$evd_{ew} = 0,025048$  (INTERPOLACIJA Tb. 30.)

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$$X_1 + X_2 = (17 + 48) \frac{0,025648 - 0,014904}{2 \cdot \tan 20^\circ} = 0,906$$

$$\Sigma X = 0,906$$

$$X_1 = \frac{i \cdot \Sigma X}{1+i} = \frac{2,824 \cdot 0,906}{1+2,824} = 0,6689$$

$$X_1 = 0,575$$

$$X_2 = 0,331$$

$$X_{1,MAX} = 0,575 \quad (\text{Dij. 3., granica zaštitljivosti } z=17)$$

$$X_1 = 0,575 \quad \text{OBRANJENO}$$

$$X_2 = \Sigma X - X_1 = 0,906 - 0,575 = 0,331$$

1, 2, 3. Dimenzije zupčanika makom  
pomaka profila

$$\text{ZUPČANIK 1: } d_1 = m \cdot z_1 = 3 \cdot 17 = 51 \text{ mm}$$

$$d_1 = 51 \text{ mm}$$

$$da_1 = d_1 + 2m + 2mx_1 = 51 + 2 \cdot 3 + 2 \cdot 3 \cdot 0,575$$

$$da_1 = 60,45 \text{ mm}$$

$$da_1 = 60,45 \text{ mm}$$

$$dw_1 = d_1 \frac{\cos \alpha}{\cos \omega_w} = 51 \frac{\cos 20^\circ}{\cos 23^\circ 37'} = 52,31 \text{ mm}$$

$$dw_1 = 52,31 \text{ mm}$$

$$db_1 = dw_1 \cos \omega_w = 52,31 \cos(23^\circ 37') \\ = 47,92 \text{ mm}$$

$$db_1 = 47,92 \text{ mm}$$

$$df_1 = d_1 - 2c + 2mx_1 = 46,95 \text{ mm}$$

$$df_1 = 46,95 \text{ mm}$$

$$\text{ZUPČANIK 2: } d_2 = z_2 \cdot m = 48 \cdot 3 = 144 \text{ mm}$$

$$d_2 = 144 \text{ mm}$$

$$da_2 = d_2 + 2m(1+x_2) = 144 + 2 \cdot 3(1+0,331)$$

$$da_2 = 151,99 \text{ mm}$$

$$da_2 = 151,99 \text{ mm}$$

$$da_2 = 147,69 \text{ mm}$$

$$dw_2 = d_2 \frac{\cos \alpha}{\cos \omega_w} = 144 \frac{\cos 20^\circ}{\cos 23^\circ 37'} = 147,69 \text{ mm}$$

$$dw_2 = 135,32 \text{ mm}$$

$$db_2 = dw_2 \cos \omega_w = 147,69 \cos 23^\circ 37' = \\ = 135,32 \text{ mm}$$

$$df_2 = d_2 - 2(m + c - mx_2) = 138,49 \text{ mm}$$

$$df_2 = 138,49 \text{ mm}$$

# 1.2.4. Kontrola výšnosti

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$$C > C_{\min}$$

$$\alpha_w = \frac{d\omega_1 + d\omega_2}{2} \geq 0,12 \cdot m$$

$$100 - \frac{60,45 + 138,49}{2} \geq 0,12 \cdot 3$$

$$0,53 \geq 0,36$$

Zároveň je

$$C = 0,53 \text{ mm}$$

## 1.3. KONTROLA ČVRSTOCÉ

### 1.3.1. Kontrola napravky u krajiny zuba

$$\sigma_{F_1} = \frac{F_{tw}}{b \cdot m} \cdot Y_{F_1} \cdot Y_S \cdot K_{F_{dl}} \leq \sigma_{F_{Pl}}$$

$$F_{tw} = \frac{2 \cdot T_{max}}{d\omega_1} = \frac{2 \cdot 249,37 \cdot 1000}{52,31} = 9534,32 \text{ N}$$

$$F_{tw} = 9534,32 \text{ N}$$

$$Y_{F_1} = 2,175 \quad (\text{odkaz Díj. 5.}, z_1=17, x_1=0,575, \beta=0^\circ)$$

$$Y_S = \frac{2 \cdot d\omega_1}{d\omega_1 - d\omega_2} = \frac{2 \cdot 52,31}{60,45 - 52,31} = 12,85$$

$$\epsilon_{k_1} = 0,66 \quad (\alpha_w = 23,62^\circ, z_{k_1} = 12,85, D_g = 4)$$

$$z_{k_2} = \frac{2 \cdot d\omega_2}{d\omega_2 - d\omega_1} = \frac{2 \cdot 147,69}{151,99 - 147,69} = 68,69$$

$$\epsilon_{k_2} = 0,79 \quad (\alpha_w = 23,62^\circ, z_{k_2} = 68,69, D_g = 4)$$

$$Y_S = \frac{1}{\epsilon_{k_1} \cdot \frac{z_1}{z_{k_1}} + \epsilon_{k_2} \cdot \frac{z_2}{z_{k_2}}} = 0,702$$

$U =$

$K_{Fd}$ 

$$v = \omega_1 \cdot r_1 = 3,9 \text{ m/s}$$

 $IT = 8 (\text{odabrono, tb. 32, st. 69.})$ 

$$g_L = 0,91 (IT = 8, d_{2w} = 147,69 \text{ mm}, m = 3 \text{ mm}, \frac{F_{tw}}{b} = 127 \frac{N}{mm})$$

$$g_L > Z_S$$

$$0,91 > 0,702$$

$$K_{Fd1} = g_L \cdot \xi_d = 1,3$$

$$\frac{9534,32}{75 \cdot 3} \cdot 2,175 \cdot 0,702 \cdot 1,3 \leq 140$$

$$84,11 \leq 140$$

ZADOVOLJIVA

1.3.2. Kontrola naprezanja na Hertzov  
pritisak

$$\sigma_H \leq \sigma_{H_P} = \frac{\sigma_{H_{lim}}}{S_H}$$

$$Z_H \cdot Z_M \cdot Z_S \sqrt{\frac{i_{n+1}}{i_N} \cdot \frac{F_{tw}}{b \cdot d_{w1}}} \cdot K_{Hd} \leq \frac{\sigma_{H_{lim}}}{S_H}$$

$$Z_M = 189,5 (\text{Tab. 37, st. 71., čelik-čelik})$$

$$Z_M = 189,5$$

$$Z_H = 2,275 (\text{Dij. 7., } \frac{x_1+x_2}{z_1+z_2} = 0,014, \beta = 0)$$

$$Z_H = 2,275$$

$$Z_S = \sqrt{\frac{4 - \xi_d}{3}} = \sqrt{\frac{4 - 1,425}{3}} = 0,927$$

$$Z_S = 0,927$$

$$K_{Hd} = 1,15 (\text{Dij. 6., } g_L = 0,91, Z_S = 0,927)$$

$$\sigma_{H_{lim}} = 1630 \frac{N}{mm^2} (\text{očitno, Tb. 28, st. 67.})$$

$$\sigma_H = 2,275 \cdot 189,5 \cdot 0,927 \sqrt{\frac{2,824+1}{2,824} \cdot \frac{9534,32}{75 \cdot 52,31} \cdot 1,15} = \\ = 777,44 \frac{N}{mm^2}$$

$$\sigma_H = 777,44 \frac{N}{mm^2}$$

$$1,3 < S_H < 3,5$$

$$1,3 < \frac{\sigma_{H_{lim}}}{\sigma_H} < 3,5$$

$$1,3 < \frac{1630}{777,44} < 3,5$$

$$1,3 < \sigma_{2,1} < 3,5$$

ZAPOMENUTA

$$S_H = 2,1$$

1. 3. 2. 1. Kontrola Hertzovog pritiska u  
točkama C i D

$$P_E = P \cos \alpha = \pi \cdot m \cdot \cos \alpha = 3\pi \cos 20^\circ = 8,8564 \text{ mm}$$

$$\varphi_{1B} = 9,5683 \text{ mm}$$

$$\varphi_{2B} = 30,5038 \text{ mm}$$

$$\varphi_{1C} = 10,4809 \text{ mm}$$

$$\varphi_{2C} = 29,5913 \text{ mm}$$

$$\varphi_{1D} = 14,3256 \text{ mm}$$

$$\varphi_{2D} = 25,7466 \text{ mm}$$

$$Z_B = \sqrt{\frac{\varphi_{1C} \cdot \varphi_{2C}}{\varphi_{1B} \cdot \varphi_{2B}}} = 1,031$$

$$Z_D = \sqrt{\frac{\varphi_{1C} \cdot \varphi_{2C}}{\varphi_{1D} \cdot \varphi_{2D}}} = 0,917$$

$$Z_B = 1,031$$

$$Z_D = 0,917$$

$$\sigma_{HB} = \sigma_H \cdot Z_B = 777,44 \cdot 1,031 = 801,54 \frac{N}{mm^2} \quad \text{ZAPOMENUTA}$$

$$\sigma_{HD} = \sigma_H \cdot Z_D = 777,44 \cdot 0,917 = 712,91 \frac{N}{mm^2} \quad \text{ZAPOMENUTA}$$

$$\sigma_{HB} = 801,54 \frac{N}{mm^2}$$

$$\sigma_{HD} = 712,91 \frac{N}{mm^2}$$

$$\sigma_{HB}, \sigma_{HD} < \frac{\sigma_{Hcm}}{S_u}$$

$$801,54, 712,91 < \frac{1630}{1,3}$$

$$801,54, 712,91 < 1253,85$$

ZAPOMENUTA

- mekačjen:  $\sigma_{H\text{lim}} \geq \sigma_H \cdot S_H = 777,44 \cdot 1,3 =$

$$\sigma_{H\text{lim}} \geq 1010,67 \frac{N}{mm^2}$$

NE POSTOJI NEKALJENI MATERIJAL S  
TAKVOM ČUĐSTOĆOM  $\sigma_{H\text{lim}}$

- kalsjen:  $\sigma_{F\text{lim}} \geq \sigma_F \cdot S_F$

$$\sigma_{F\text{lim}} \geq \frac{F_w}{b \cdot m} \cdot Y_{F_2} \cdot Y_\varepsilon \cdot K_F \cdot S_F$$

$$Y_{F_2} = 2,1625 \quad (\text{Dj. 5.}, z_2 = 48, x_2 = 0,331, \beta = 0^\circ)$$

$$\sigma_{F\text{lim}} \geq \frac{9534,32}{3,75} \cdot 2,1625 \cdot 0,702 \cdot 1,3 \cdot 1,5$$

$$\sigma_{F\text{lim}} \geq 125,44 \frac{N}{mm^2}$$

odabralo: Č1531 (18CrNi8,  $\sigma_{F\text{lim}} = 270 \frac{N}{mm^2}$ ,  
 $\sigma_{H\text{lim}} = 1100 \frac{N}{mm^2}$ )

$$S_H = \frac{\sigma_{H\text{lim}}}{\sigma_H} = \frac{1100}{777,44} = 1,42 \quad , \quad 1,3 < 1,42 < 3$$

$$S_H = 1,42$$

ZADOVOLJIVA

$$S_F = \frac{\sigma_{F\text{lim}}}{\sigma_F} = \frac{270}{83,63} = 3,23 \quad , \quad 1,5 < 3,23 < 3,5$$

$$S_F = 3,23$$

ZADOVOLJIVA

1.5. Izvedbe hladjenja reduktora

List 11/35

$$P_{geE} = 2\%$$

$$t_z = 20^\circ C$$

$$P_{geE} = P_{0,02} = 33 \cdot 0,02 = 0,66 kW$$

$$P_{geE} = 0,66 kW$$

$$A_L = 2(H \cdot L + H \cdot W + L \cdot W)$$

$$H = 284 \text{ mm} - \text{visina reduktora}$$

$$L = 380 \text{ mm} - \text{dužina reduktora}$$

$$W = 180 \text{ mm} - \text{širina reduktora}$$

$$A_L = 2(284 \cdot 380 + 284 \cdot 180 + 180 \cdot 380) = 454880 \text{ mm}^2$$

$$A_L = 0,45488 \text{ m}^2$$

$$\lambda_s = 92 \frac{kJ}{m^2 K h}$$

$$\phi = \lambda_s \cdot A_L (t_u - t_z)$$

$$t_u = \frac{\phi}{\lambda_s \cdot A_L} + t_z = \frac{2376}{92 \cdot 0,45488} + 20 = 76,78^\circ C$$

$$t_u = 76,78^\circ C$$

$$\phi = P_{geE} \cdot 3,6 \cdot 10^3 = 2376 \frac{kJ}{h}$$

$$\phi = 2376 \frac{kJ}{h}$$

$$76,78^\circ > 60^\circ$$

POTREBNO DOBAVLJENO HLAĐENJE

$$\phi_{adv} = \lambda_s \cdot A_L (t_u - t_z) = 92 \cdot 0,45488 (45 - 20) \\ = 1023,48 \frac{kJ}{h}$$

$$\phi_{adv} = 1023,48 \frac{kJ}{h}$$

$$t_u = 45^\circ C (\text{pretpostavka})$$

$$\phi_{cu} = \phi - \phi_{adv} = 2376 - 1023,48 = 1352,52 \frac{kJ}{h}$$

$$A_{cij} = \frac{\phi_{cu}}{(t_u - t_{rv}) \cdot L} = \frac{1352,52}{(45 - 20) \cdot 1600} = 0,033813 \text{ m}^2$$

$$A_{cij} = 0,033813 \text{ m}^2$$

$$L = 1600 \frac{kJ}{m^2 K h}$$

$$t_{rv} = \frac{12 + (12 + 10)}{2} = 17^\circ C$$

$$t_{rv} = 17^\circ C$$

$$L_{ej} = \frac{A_{cijev}}{\pi \cdot d} = \frac{0,033813}{\pi \cdot 0,008} = 1,35 \text{ m}$$

$d = 8 \text{ mm}$  (pretp.)

$$z = \frac{L}{\ell} = \frac{1,35}{0,220} = 6,12 \rightarrow z = 8$$

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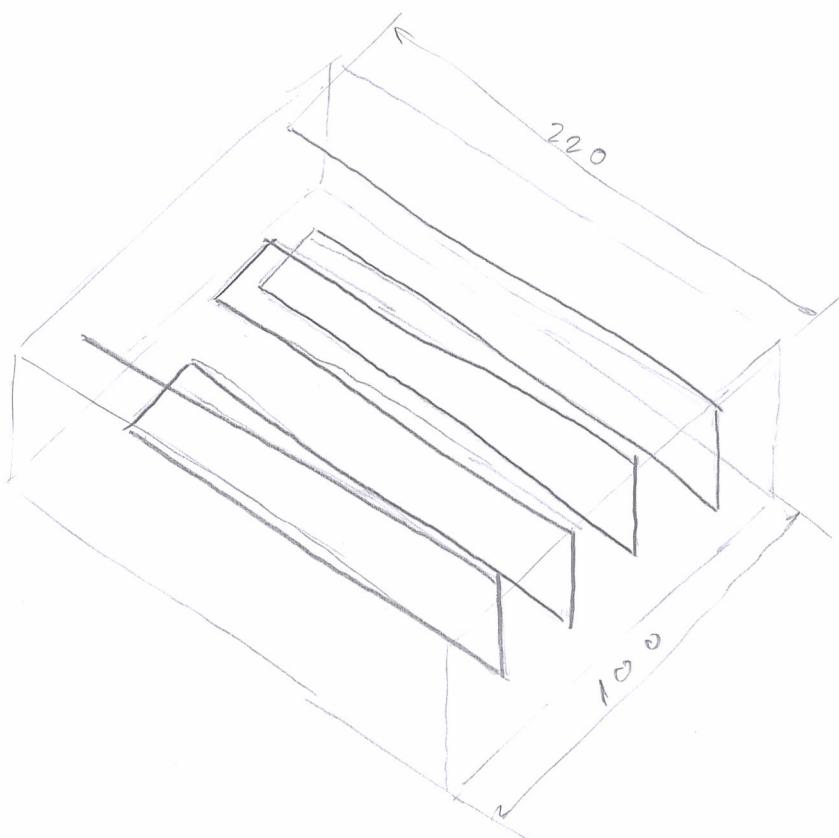
$$L_{ej} = 1,35 \text{ m}$$

$$z = 8$$

$\ell$  - dužina cijevi u reduktoru = 220mm

$z$  - broj cijevi u reduktoru

$\varnothing 8$  cijev CuCr1Zr



## 2. Vratila

List 13/35

### 2. 1. Proračun ; dimenzioniranje vratila 1.

Izbor spojke 1.

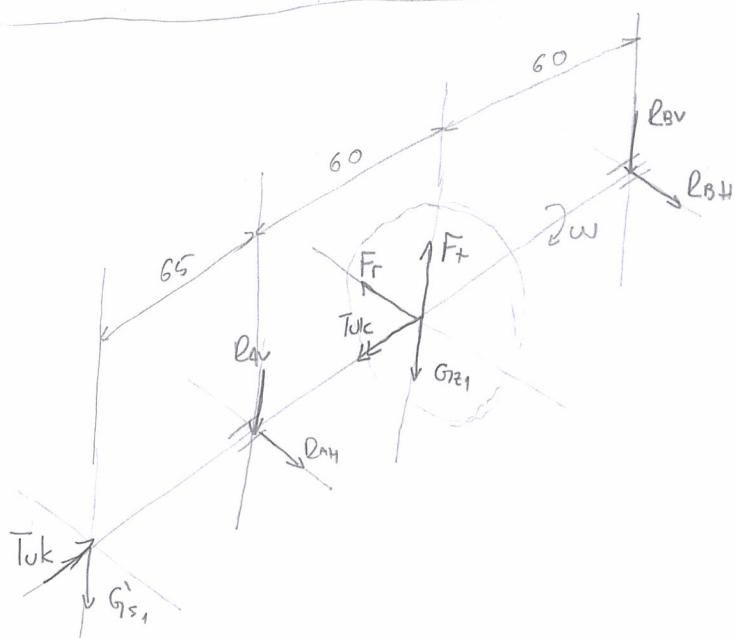
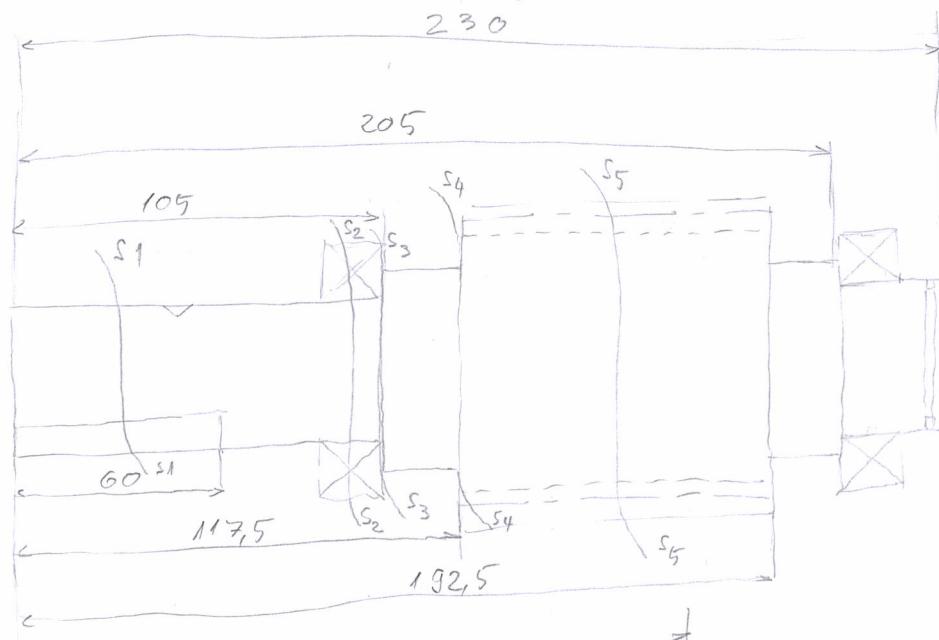
$$T_{S1} = \frac{T_{uk}}{\gamma_{S1} \cdot \gamma_{U1}} = \frac{249,37}{0,975 \cdot 0,995} = 257,05 \text{ Nm}$$

$$T_{S1} = 257,05 \text{ Nm}$$

$\gamma_{S1} = 0,975$  (korisnost spojke 1., protp.)

$\gamma_{U1} = 0,995$  (korisnost valjnih ležajeva, protp.)

ODABRANO: ES2 ( $M_n = 300 \text{ Nm}$ ,  $M_{int} = 450 \text{ Nm}$ ,  $G_{S1} = 4,2 \text{ kg}$ , (Reduktivni faktori 0,7, Tabela 10.)  $J_{S1} = 0,18 \text{ Nm}^2$ )



Sile ma vratio 1:

$$G_{S1} = \frac{G_{S1}}{2} = \frac{42}{2} = 21 \text{ N}$$

$$G_{S1} = 21 \text{ N}$$

$$G_{Z1} = m_{Z1} \cdot g = V_{Z1} \cdot \rho_c \cdot g$$

$$G_{Z1} = 11,72 \text{ N}$$

$$V_{Z1} = \frac{d_1^2 \pi}{4} \cdot b = \frac{0,051^2 \pi}{4} \cdot 0,075 = 1,53 \cdot 10^{-4} \text{ m}^3$$

$$G_{Z1} = 1,53 \cdot 10^{-4} \cdot 7800 \cdot 9,81 = 11,72 \text{ N}$$

$$\rho_c = 7800 \text{ kg/m}^3 \text{ (gustoča čelika)}$$

$$F_{T1} = \frac{T_{uk}}{\frac{dw_1}{2}} = \frac{2 \cdot T_{uk}}{dw_1} = \frac{2 \cdot 249,37}{0,05231} = 9534,32 \text{ N}$$

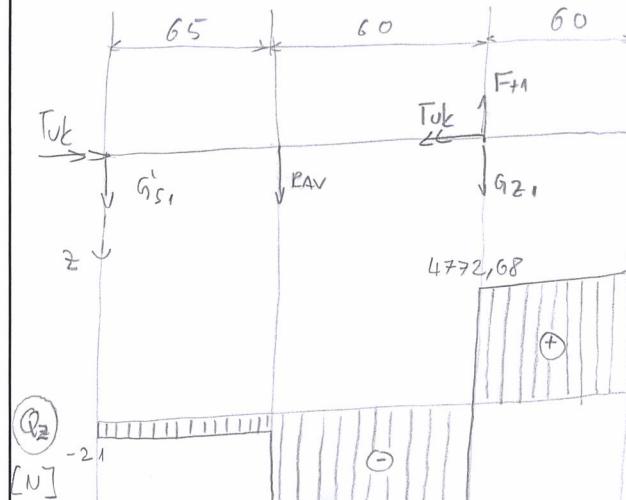
$$F_{T1} = 9534,32 \text{ N}$$

$$\operatorname{tg} \alpha_{dw} = \frac{F_{r1}}{F_{T1}} \rightarrow F_{r1} = F_{T1} \cdot \operatorname{tg} \alpha_{dw} = 9534,32 \cdot \operatorname{tg} 23,62^\circ$$

$$F_{r1} = 4169,9 \text{ N}$$

$$F_{r1} = 4169,9 \text{ N}$$

V.R.



$$\sum F_z = 0$$

$$(1) G_{S1} + R_{AV} + G_{Z1} - F_{F1} + R_{BV} = 0$$

$$\sum M_B = 0$$

$$(2) -(F_{F1} - G_{Z1}) \cdot 60 + R_{AV} \cdot 120 + G_{S1} \cdot 185 = 0$$

$$R_{AV} = \frac{(F_{F1} - G_{Z1}) \cdot 60 - G_{S1} \cdot 185}{120}$$

$$R_{AV} = \frac{(9534,32 - 11,72) \cdot 60 - 21 \cdot 185}{120}$$

$$R_{AV} = 4728,93 \text{ N}$$

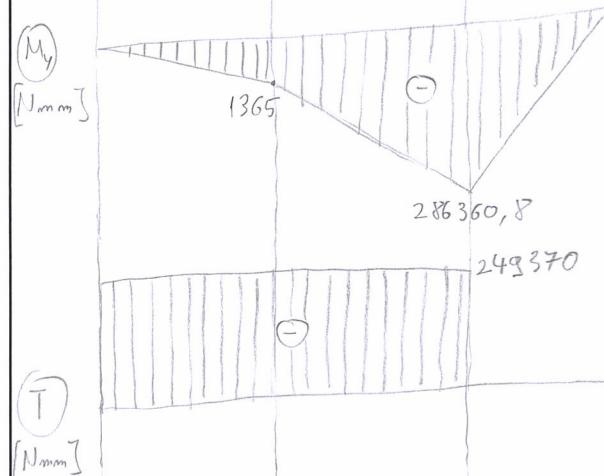
12 (1):

$$R_{AV} + R_{BV} = 9501,6 \text{ N}$$

$$R_{BV} = 9501,6 - 4728,93$$

$$R_{BV} = 4772,68 \text{ N}$$

$$R_{AV} = 4728,93 \text{ N}$$



$$\sum F_y = 0$$

$$R_{AH} + R_{BH} = F_{Fr} \quad (1)$$

$$\sum M_B = 0$$

$$R_{AH} \cdot 120 - F_{Fr} \cdot 60 = 0 \quad (2)$$

$$R_{AH} = F_{Fr} \cdot \frac{60}{120} = 4169,9 \cdot \frac{1}{2}$$

$$R_{AH} = 2084,7 \text{ N}$$

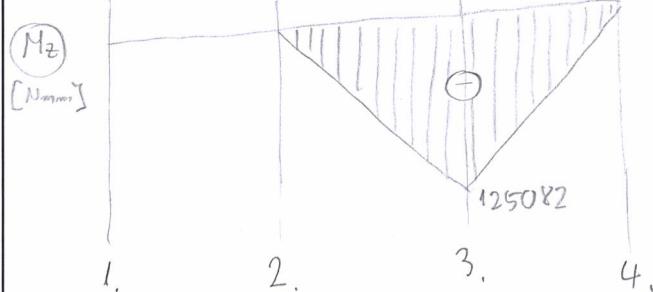
12 (1):

$$R_{BH} = F_{Fr} - R_{AH}$$

$$= 4169,9 - 2084,7$$

$$R_{BH} = 2084,7 \text{ N}$$

$$R_{AH} = 2084,7 \text{ N}$$



$$R_4 = \sqrt{R_{4H}^2 + R_{4V}^2} = \sqrt{2084,7^2 + 4728,93^2} = 5168,05 \text{ N}$$

$$R_B = \sqrt{R_{B4}^2 + R_{BV}^2} = \sqrt{2084,7^2 + 4772,68^2} = 5208,11 \text{ N}$$

Promjeri vratića:

$$d \geq \sqrt[3]{\frac{100M_f + 75d_o M_f}{\sigma_{dop}}}$$

$$d_o = \frac{\sigma_{FDN}}{\sqrt{3} \sigma_{DN}} = \frac{640}{\sqrt{3} \cdot 370} = 0,999 \approx 1$$

$$\sigma_{FDN} = 640 \frac{\text{N}}{\text{mm}^2} (\text{Tb. 28., Redoblar dr. 67., C5421})$$

$$\sigma_{DN} = 370 \frac{\text{N}}{\text{mm}^2} (\text{Tb. 28., Redoblar dr. 67., C5421})$$

$$\sigma_{dop} = \frac{\sigma_{FDN}}{4} = \frac{640}{4} = 160 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma_{dop} = 160 \frac{\text{N}}{\text{mm}^2}$$

$$d_1 \geq \sqrt[3]{\frac{100 \cdot 0 + 75 \cdot 249370^2}{160}} = 23,81 \text{ mm}$$

$$d_1 = 30 \text{ mm} \quad \text{ODABEANO}$$

$$d_1 = 30 \text{ mm}$$

$$\text{kontrola pera! } d_1 - t_1 \geq 23,81$$

$$30 - 4,1 \geq 23,81$$

$$25,9 \geq 23,81 \quad \text{ZADOVOLJIVA}$$

$$d_2 \geq \sqrt[3]{\frac{100 \cdot 1365^2 + 75 \cdot 249370^2}{160}} = 23,81 \text{ mm}$$

$$d_2 = 30 \text{ mm}$$

$$d_2 = 30 \text{ mm} \quad \text{ODABEANO}$$

$$d_3 \geq \sqrt[3]{\frac{100 \cdot (286360,8^2 + 125082^2) + 75 \cdot 249370^2}{160}} = 28,74 \text{ mm}$$

$$d_3 = 35 \text{ mm}$$

$$d_3 = 35 \text{ mm} \quad \text{ODABEANO}$$

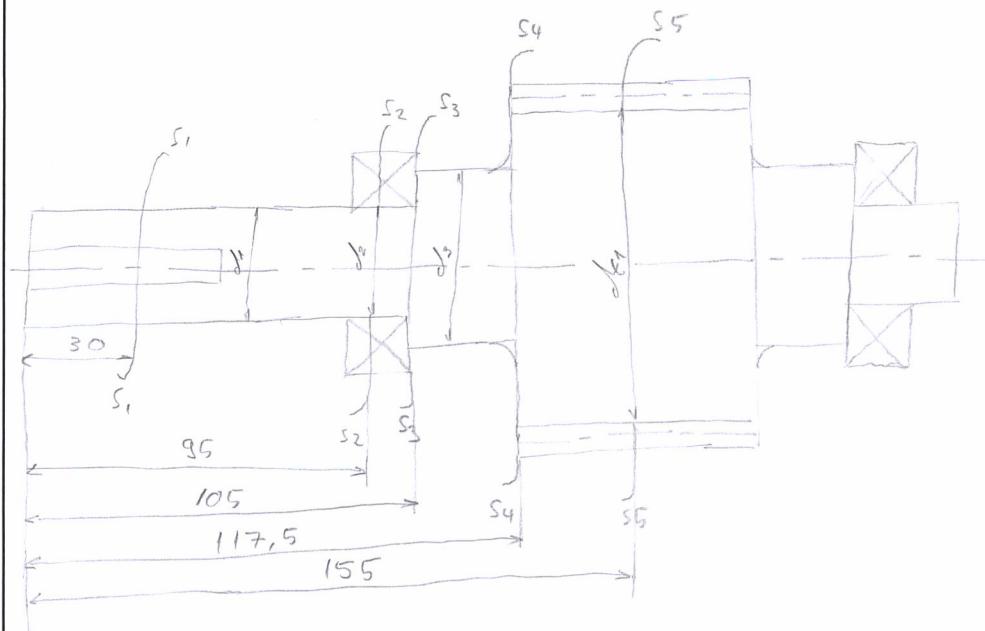
$$d_4 \geq \sqrt[3]{\frac{100 \cdot 0 + 75 \cdot 0}{160}} = 0$$

$$d_4 = 30 \text{ mm}$$

$$d_4 = 30 \text{ mm} \quad \text{ODABEANO}$$

Umfangsmaßmomente ma presjecima!

List 17/35



$$S_1: M_{f1} = 0 \text{ Nmm}, T_1 = 249370 \text{ Nmm}$$

$$S_2: M_{f2} = 1365 \text{ Nmm}, T_2 = 249370 \text{ Nmm}$$

$$S_3: M_{f3} = \sqrt{\left[M_{f2} + 10(R_{Av1} + G_{c1})\right]^2 + [R_{AH} \cdot 10]^2}$$

$$= \sqrt{[1365 + 10(4728,93 + 21)]^2 + [2084,7 \cdot 10]^2}$$

$$= 53125,49 \text{ Nmm}$$

$$T_3 = 249370 \text{ Nmm}$$

$$S_4: M_{f4} = M_{f3} + \sqrt{\left[12,5(R_{Av1} + G_{s1})\right]^2 + [12,5 \cdot R_{AH}]^2} =$$

$$= 53125,49 + \sqrt{[12,5(4728,93 + 21)]^2 + [12,5 \cdot 2084,7]^2}$$

$$= 117966,41 \text{ Nmm}$$

$$T_4 = 249370 \text{ Nmm}$$

$$S_5: M_{f5} = \sqrt{286360,8^2 + 125082^2} = 312489,18 \text{ Nmm}$$

$$T_5 = 249370 \text{ Nmm}$$

$$M_{f1} = 0 \text{ Nmm}$$

$$T_1 = 249370 \text{ Nmm}$$

$$M_{f2} = 1365 \text{ Nmm}$$

$$T_2 = 249370 \text{ Nmm}$$

$$M_{f3} = 53125,49 \text{ Nmm}$$

$$T_3 = 249370 \text{ Nmm}$$

$$M_{f4} = 117966,41 \text{ Nmm}$$

$$T_4 = 249370 \text{ Nmm}$$

$$M_{f5} = 312489,18 \text{ Nmm}$$

$$T_5 = 249370 \text{ Nmm}$$

Kontrola presjeka:

S1 (urez za pero)

$$\sigma_{red,1} = \sqrt{3 \cdot (\beta_{bf} \cdot \frac{T_1}{W_{t1}})^2}$$

$\beta_{bf} = 1,9$  (Vrdlo. str. 38., Tb. 4.,  $R_m = 600 \frac{N}{mm^2}$ , Babilik)

$$W_{t1} = 0,2 (d_1 - t_1)^3 = 0,2 (30 - 4,1)^3 = 3893 \text{ mm}^3$$

$$\sigma_{red,1} = \sqrt{3 \left( 1,9 \cdot \frac{249370}{3893} \right)^2} = 210,8 \frac{N}{mm^2}$$

$$W_{t1} = 3893 \text{ mm}^3$$

$$\sigma_{red,1} = 210,8 \frac{N}{mm^2}$$

$$S_1 = \frac{b_1 b_2 \sigma_{FON}}{\sigma_{red,1}}$$

$b_1 = 0,9$  ( $d = 30 \text{ mm}$ , Vrdlo str. 35, Dij. 2.)

$b_2 = 0,76$  ( $\ell_{max} = 10 \mu\text{m}$ ,  $R_m = 1300 \frac{N}{mm^2}$ , Vrdlo str. 35, Dij. 3.)

$$S_1 = \frac{0,9 \cdot 0,76 \cdot 640}{210,8} = 2,08 > 1,5$$

$$S_1 = 2,08$$

Zadovoljava

S2 (stezni spoj)

$$\sigma_{red,2} = \sqrt{(\beta_{bf} \cdot \frac{M_{f2}}{W_{f2}})^2 + 3 \left( \beta_{bf} \cdot \frac{T_2}{W_{t2}} \right)^2}$$

$\beta_{bf} = 2,25$  (Vrdlo str. 38., stezni spoj)

$\beta_{bf} = 1,46$  (Vrdlo str. 38., stezni spoj)

$$W_{f2} = 0,1 d_2^2 = 0,1 \cdot 30^2 = 2700 \text{ mm}^3$$

$$W_{t2} = 0,2 d_2^2 = 0,2 \cdot 30^2 = 5400 \text{ mm}^3$$

$$\sigma_{red,2} = \sqrt{\left( 2,25 \cdot \frac{1365}{2700} \right)^2 + 3 \left( 1,46 \cdot \frac{249370}{5400} \right)^2} \\ = 116,78 \frac{N}{mm^2}$$

$$W_{f2} = 2700 \text{ mm}^3$$

$$W_{t2} = 5400 \text{ mm}^3$$

$$\sigma_{red,2} = 116,78 \frac{N}{mm^2}$$

$$\left. \begin{array}{l} b_1 = 0,9 \\ b_2 = 0,76 \end{array} \right\} \text{ist das Kao u S1}$$

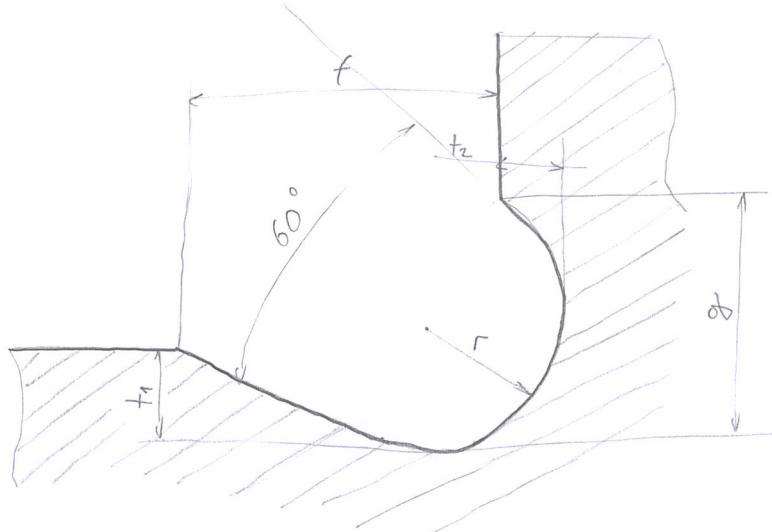
List 19/35

$$S_2 = \frac{\sigma_{\text{FON}} b_1 b_2}{\sigma_{\text{red}_2}} = \frac{640 \cdot 0,9 \cdot 0,76}{116,78} = 375 > 1,5$$

$$S_2 = 3,75$$

ZADODNOGJED

S3 (DIN 509)



DIN 509:2006 - H ( $R_a 3,2 \mu\text{m}$ )

$$d = 30 \text{ mm} \quad r = 0,8 \text{ mm} \quad t_2 = 0,05^{+0,05} \text{ mm}$$

$$D = 35 \text{ mm} \quad t_1 = 0,3^{+0,1} \text{ mm} \quad f = 2^{+0,2} \text{ mm} \quad g = 1,1 \text{ mm}$$

$$\beta k_f = 1,96 \left( R_m = 1300 \frac{N}{mm^2}, f = 0,8, D = 35 \text{ mm}, d = 30 \text{ mm} \right) \quad \left. \begin{array}{l} \text{Vrdlo str. 36,} \\ \text{Dij 4. i Dij. 5} \end{array} \right\}$$

$$\beta k_t = 1,86 \left( R_m = 1300 \frac{N}{mm^2}, f = 0,8, D = 35 \text{ mm}, d = 30 \text{ mm} \right) \quad \left. \begin{array}{l} \text{Vrdlo str. 36,} \\ \text{Dij 4. i Dij. 5} \end{array} \right\}$$

$$W_{f3} = W_{f2} = 2700 \text{ mm}^3$$

$$W_{t3} = W_{t2} = 5400 \text{ mm}^3$$

$$W_{f3} = 2700 \text{ mm}^3$$

$$W_{t3} = 5400 \text{ mm}^3$$

$$\begin{aligned} \sigma_{\text{red}_3} &= \sqrt{\left(\beta k_f \cdot \frac{M_{f3}}{W_{f3}}\right)^2 + 3 \left(\beta k_t \cdot \frac{I_3}{W_{t3}}\right)^2} \\ &= \sqrt{\left(1,96 \cdot \frac{53125,49}{2700}\right)^2 + 3 \left(1,86 \cdot \frac{249370}{5400}\right)^2} \\ &= 153,69 \frac{N}{mm^2} \end{aligned}$$

$$\sigma_{\text{red}_3} = 153,69 \frac{N}{mm^2}$$

$b_1 = 0,875$  ( $d = 35 \text{ mm}$ , VnDlo str. 35., Dj. 2.)

$b_2 = 0,7$  ( $R_{\max} = 25 \mu\text{m}$ ,  $R_m = 1300 \frac{N}{mm^2}$ , VnDlo str. 35., Dj. 3.)

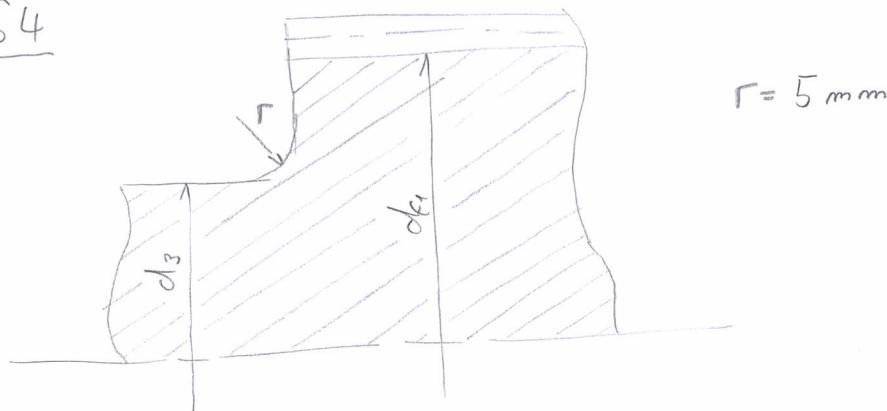
List 20/35

$$S_3 = \frac{\sigma_{FON} b_1 b_2}{\sigma_{red3}} = \frac{640 \cdot 0,875 \cdot 0,7}{153,69} = 2,55 > 1,5$$

$S_3 = 2,55$

Zuladung 1

S4



$\beta_{kF} = 1,64$  ( $R_m = 1300 \frac{N}{mm^2}$ ,  $\delta = 5 \text{ mm}$ ,  $D = 46,95 \text{ mm}$ ,  $d = 35 \text{ mm}$ , VnDlo str. 36., Dj. 4.)

$\beta_{kF} = 1,40$  ( $R_m = 1300 \frac{N}{mm^2}$ ,  $\delta = 5 \text{ mm}$ ,  $D = 46,95 \text{ mm}$ ,  $d = 35 \text{ mm}$ , VnDlo str. 36., Dj. 5.)

$$W_{f4} = 0,1 d_3^3 = 0,1 \cdot 35^3 = 4287,5 \text{ mm}^3$$

$$W_{t6} = 0,2 d_3^3 = 0,2 \cdot 35^3 = 8575 \text{ mm}^3$$

$$W_{f4} = 42875 \text{ mm}^3$$

$$W_{t6} = 8575 \text{ mm}^3$$

$$\begin{aligned} \sigma_{red4} &= \sqrt{\left(\beta_{kF} \cdot \frac{M_{f4}}{W_{f4}}\right)^2 + 3\left(\beta_{kF} \cdot \frac{T_4}{W_{t6}}\right)^2} \\ &= \sqrt{\left(1,64 \cdot \frac{117966,41}{4287,5}\right)^2 + 3\left(1,4 \cdot \frac{249370}{8575}\right)^2} \\ &= 83,72 \frac{N}{mm^2} \end{aligned}$$

$$\sigma_{red4} = 83,72 \frac{N}{mm^2}$$

$b_1 = 0,835$  ( $d = 46,95 \text{ mm}$ , VnDlo str. 35., Dj. 2.)

$b_2 = 0,75$  ( $D_{\max} = 10 \mu\text{m}$ , VnDlo str. 25., Dj. 3.)

$$S_4 = \frac{\sigma_{FAN} b_1 b_2}{\sigma_{red4}} = \frac{640 \cdot 0,835 \cdot 0,75}{83,72} = 4,85 > 1,5$$

$$S_4 = 4,85$$

zulässig

S5

$$\sigma_{red5} = \sqrt{\left(\frac{M_{f5}}{W_{f5}}\right)^2 + 3 \left(\frac{T_5}{W_{t5}}\right)^2}$$

$$W_{f5} = 0,1 \cdot d_f^3 = 0,1 \cdot 46,95^3 = 12462,54 \text{ mm}^3$$

$$W_{t5} = 0,2 \cdot d_f^3 = 0,2 \cdot 46,95^3 = 24925,08 \text{ mm}^3$$

$$\sigma_{red5} = \sqrt{\left(\frac{312489,18}{12462,54}\right)^2 + 3 \left(\frac{249370}{24925,08}\right)^2} \\ = 30,48 \frac{N}{mm^2}$$

$$W_{f5} = 1246,54 \text{ mm}^3$$

$$W_{t5} = 24925,08 \text{ mm}^3$$

$$\sigma_{red5} = 30,48 \frac{N}{mm^2}$$

$$\begin{aligned} b_1 &= 0,835 \\ b_2 &= 0,75 \end{aligned} \quad \left. \begin{array}{l} \text{1. Stab karo} \\ \text{2. Stab karo} \end{array} \right\} \underline{S_4}$$

$$S_5 = \frac{\sigma_{FAN} b_1 b_2}{\sigma_{red5}} = \frac{640 \cdot 0,835 \cdot 0,75}{30,48} =$$

$$S_5 = 13,33 > 1,5$$

zulässig

$$S_5 = 13,33$$

## 2.1.2. Odabir ležaja za V1

List 22/35

- oba ležaja biramo prema  $R_B$

$$d = 30 \text{ mm}$$

$$P_r = R_B = 5203,46 \text{ N}$$

$$R_B = 5203,46 \text{ N}$$

$$C_1 = P_r \left( \frac{60 \cdot m_{min} \cdot L_{1oh\_min}}{10^6} \right)^{\frac{1}{\xi}}$$

$L_{1oh\_min} = 16000 \text{ h}$  (Redatelj str. 48., Tb. 12., prijenosnic za opću upotrebu)

$$\xi = \frac{10}{3} \text{ (teoretski dodir u crti)}$$

$$m_{min} = 1420 \text{ min}^{-1}$$

$$C_1 = 5203,46 \left( \frac{60 \cdot 1420 \cdot 16000}{10^6} \right)^{\frac{1}{\frac{10}{3}}}$$

$$C_1 = 45358,65 \text{ N}$$

$$C_1 = 45358,65 \text{ N}$$

ODABRANO! NJP 2206 ECP

$$C = 55000 \text{ N} \quad C_o = 49000 \text{ N}$$

$$B = 20 \text{ mm} \quad D = 62 \text{ mm}$$

$$d = 30 \text{ mm}$$

$$\text{maslom: } d_1 = 41,2 \text{ mm} \quad d_3 < d_1$$

$$35 < 41,2$$

zadovoljiva

$$L_{1oh} = \frac{10^6}{60 \cdot m_{min}} \left( \frac{C}{P_r} \right)^{\xi} > L_{1oh\_min}$$

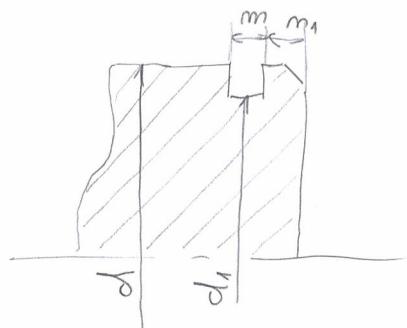
$$> \frac{10^6}{60 \cdot 1420} \left( \frac{55000}{5203,46} \right)^{\frac{10}{3}} > 16000$$

$$30417,86 > 16000$$

$$L_{1oh} = 30417,86 \text{ h}$$

zadovoljiva

- slobodno ležajno mjesto A osiguravamo  
šlj udaljenost od poklopca vratila na  
kućištu
- desni ležaj B čemo osigurati sa gaggerom  
ustrojnikom na kraju vratila

DIN 417

$$d = 30 \text{ mm}$$

$$m = 1,6 \text{ i } 1,8$$

$$m_1 = 1,5 \text{ mm}$$

$$d_1 = 28,6 \text{ h } 11$$

2.1.3. Kontrola pera spojke 1 na  
bočni pritisak

## - PERO VISOKO OBLIK D

$$T = 249370 \text{ mm}$$

$$p_{\text{dop}} = 70 \frac{\text{N}}{\text{mm}^2} (\text{Decker et al. 1994})$$

$$d = 30 \text{ mm}$$

$$b \times h \quad t_1 = 4,1 \text{ mm}$$

$$8 \times 7$$

$$L > \frac{2T}{p_{\text{dop}} \cdot t_1 \cdot d}$$

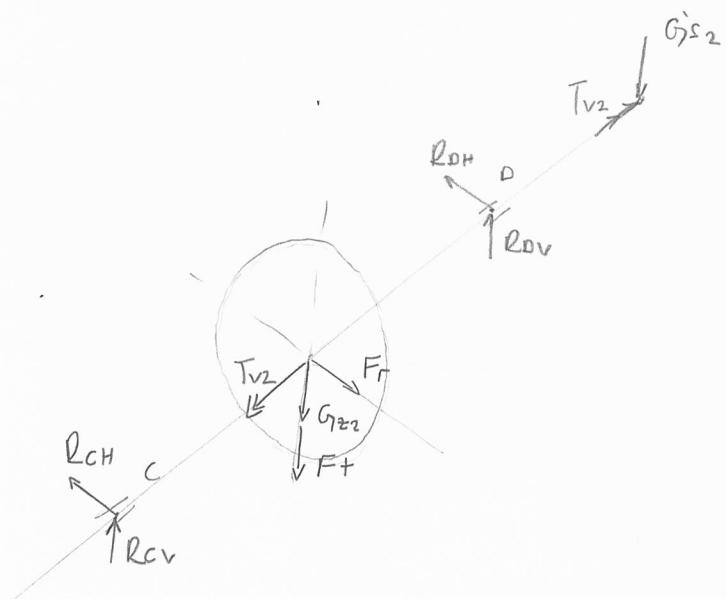
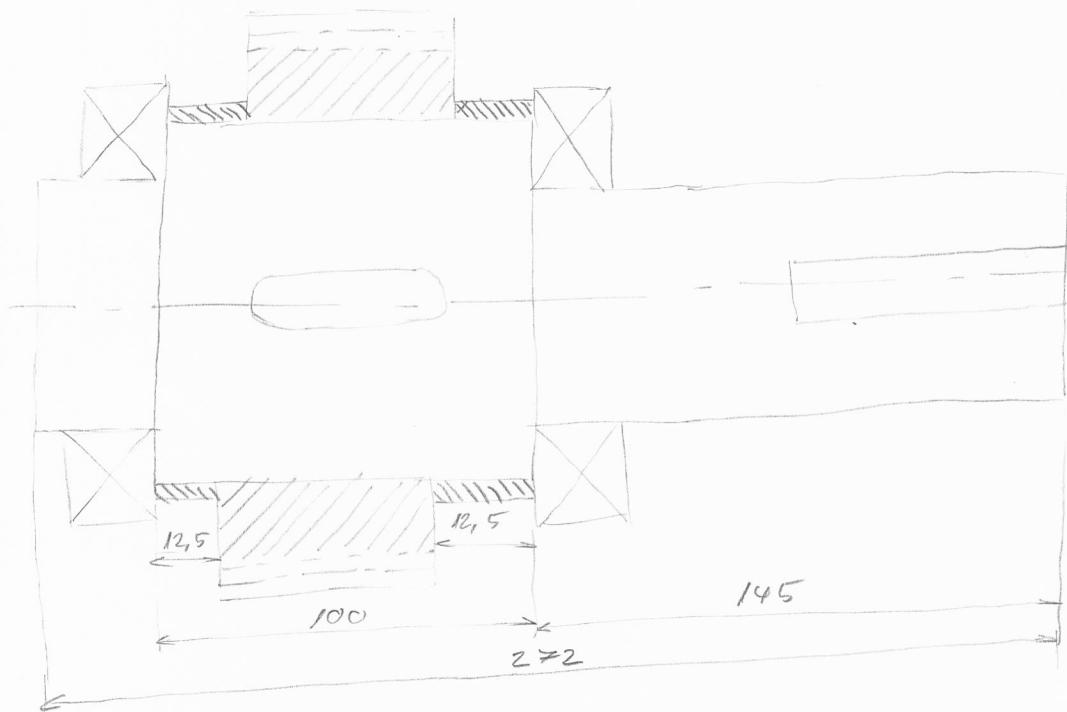
$$L > \frac{2 \cdot 249370}{70 \cdot 4,1 \cdot 30} = 57,9$$

$$L = 60 \text{ mm oštpran}$$

$$L = 60 \text{ mm}$$

2.2. Pracovní dimenziomiranie  
vratila 2.

List 24/35



Síle ma vrat. 10 2. :

$$G_{S_2} = \frac{G_{S_2}}{2} = \frac{140}{2} = 70 \text{ N}$$

$$G_{Z_2} = \frac{d_2 \pi}{4} \cdot b \cdot g = \frac{(144 \cdot 10^{-3})^2 \pi}{4} \cdot 0,075 \cdot 7800 \cdot g$$

$$G_{S_2} = 70 \text{ N}$$

$$G_{Z_2} = 93,46 \text{ N}$$

$$T_{V_2} = T_{S_2} + T_E = 626,7 + \frac{(f_{es} + f_{s_2}) \cdot m_2}{375,7} \cdot F_U$$

$$= 626,7 + \frac{72,85 \cdot 502,83}{375,7} = 703,74 \text{ Nm}$$

$$F_{T_2} = 4169,4 \text{ N}$$

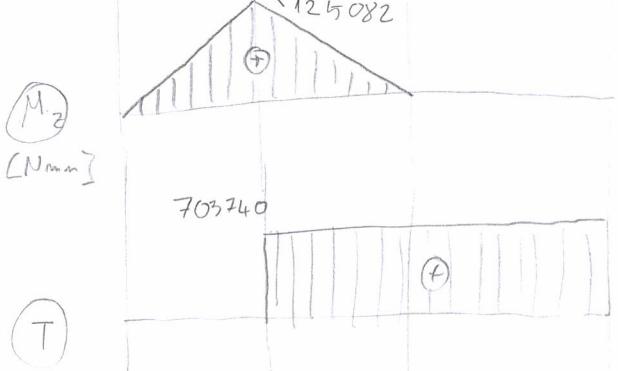
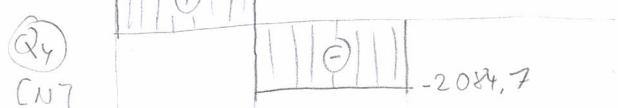
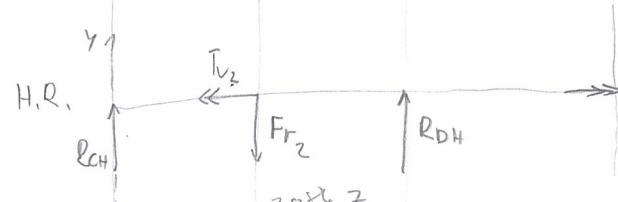
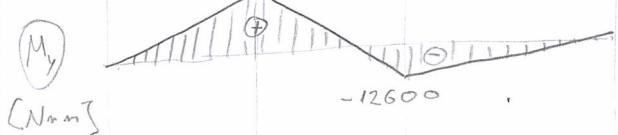
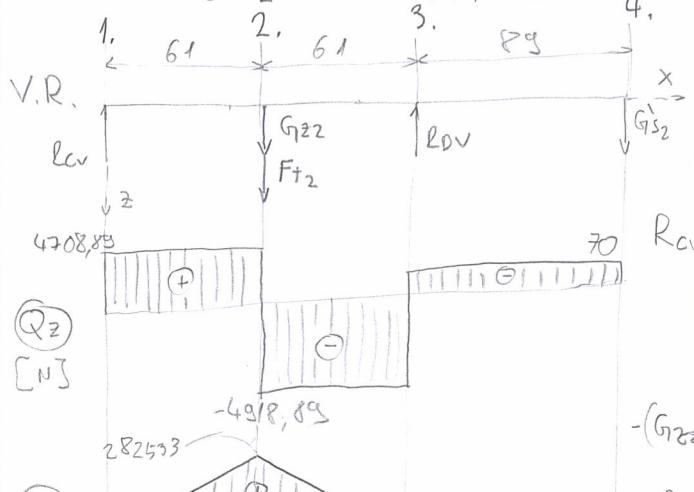
$$G_{Z_2} = 93,46 \text{ N}$$

$$T_{V_2} = 703,74 \text{ Nm}$$

$$F_{T_2} = 4169,4 \text{ N}$$

$$F_{T_2} = 9534,32 \text{ N}$$

$$F_{T_2} = \frac{2 \cdot T_{V_2}}{d_{W_2}} = \frac{2 \cdot 626,7 \cdot 10^3}{147,69} = 9534,32 \text{ N}$$



List 25/35

$$G_{Z_2} = \frac{d_2 \pi}{4} \cdot b \cdot g = \frac{(144 \cdot 10^{-3})^2 \pi}{4} \cdot 0,075 \cdot 7800 \cdot g$$

$$G_{S_2} = 70 \text{ N}$$

$$G_{Z_2} = 93,46 \text{ N}$$

$$T_{V_2} = 703,74 \text{ Nm}$$

$$F_{T_2} = 4169,4 \text{ N}$$

$$F_{T_2} = 9534,32 \text{ N}$$

$$\sum F_x = 0$$

$$R_{Cv} + R_{Dv} = 93,46 + 9534,32 + 70$$

$$R_{Cv} + R_{Dv} = 9767,78 \text{ N}$$

$$\sum M_{cy} = 0$$

$$-(G_{Z_2} + F_{T_2}) \cdot 61 + R_{Dv} \cdot 122 - G_{S_2} \cdot 211 = 0$$

$$R_{Dv} = \frac{70 \cdot 211 + 61(9534,32 + 93,46)}{122} = 5058,89 \text{ N}$$

$$R_{Dv} = 5058,89 \text{ N}$$

$$R_{Cv} = 9767,78 - R_{Dv}$$

$$= 9767,78 - 5058,89 = 4708,89 \text{ N}$$

$$= 4708,89 \text{ N}$$

$$\sum F_y = 0$$

$$R_{DH} + R_{CH} = F_{T_2}$$

$$R_{DH} + R_{CH} = 4169,4 \text{ N} \quad (1)$$

$$\sum M_{cz} = 0$$

$$122 \cdot R_{DH} = F_{T_2} \cdot 61$$

$$R_{DH} = \frac{1}{2} F_{T_2} = \frac{1}{2} 4169,4$$

$$R_{DH} = 2084,7 \text{ N}$$

$$12 \cdot (1): R_{CH} = 4169,4 - 2084,7$$

$$R_{CH} = 2084,7 \text{ N}$$

$$R_{DH} = 2084,7 \text{ N}$$

$$R_{CH} = 2084,7 \text{ N}$$

Promjeri vratila:

List 26/35

$$d_3 \geq \sqrt[3]{\frac{100M_e^2 + 75L_o \cdot T^2}{\sigma_{dop}}}$$

$$L_o = \frac{\sigma_{FDN}}{\sqrt{3} \cdot \tilde{\sigma}_{FDN}} = \frac{190}{\sqrt{3} \cdot 110} = 0,997 \approx 1$$

$$\sigma_{FDN} = 190 \frac{N}{mm^2} (\text{Tab. 28, Red. do dr. 67., č. 0461}).$$

$$\tilde{\sigma}_{FDN} = 110 \frac{N}{mm^2} (\text{Tab. 28, Red. do dr. 67., č. 0461})$$

$$\sigma_{dop} = \frac{\sigma_{FDN}}{4} = \frac{190}{4} = 47,5 \frac{N}{mm^2}$$

$$d_1 \geq 0 \quad d_1 = 60 \text{ mm} \quad \text{OPARANO}$$

$$d_2 \geq \sqrt[3]{\frac{100 \cdot (\sqrt{282533,4^2 + 125082^2})^2 + 75 \cdot 703740^2}{47,5}} = 52,4 \text{ mm}$$

$$d_2 = 65 \text{ mm} \quad \text{ODABANO}$$

$$d_3 \geq \sqrt[3]{\frac{100 \cdot 12600^2 + 75 \cdot 703740^2}{47,5}} = 50,44 \text{ mm}$$

$$d_3 = 60 \text{ mm} \quad \text{OPARANO}$$

$$d_4 \geq \sqrt[3]{\frac{75 \cdot 703740^2}{47,5}} = 50,44 \text{ mm}$$

$$d_4 = 60 \text{ mm} \quad \text{ODABANO}$$

$$d_1 = 60 \text{ mm}$$

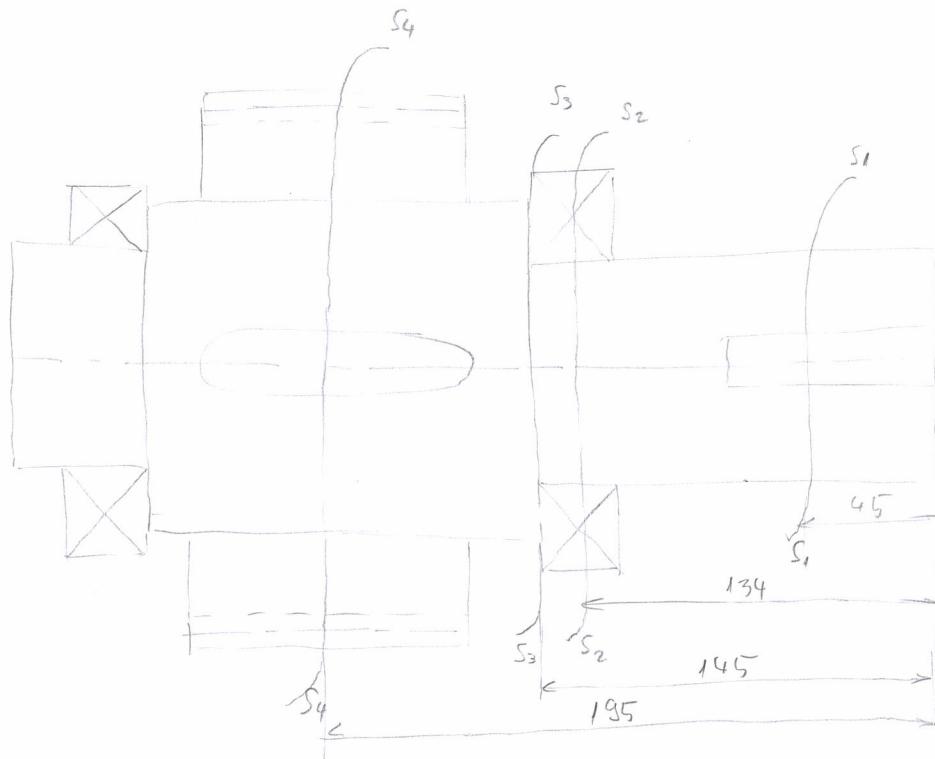
$$d_2 = 65 \text{ mm}$$

$$d_3 = 60 \text{ mm}$$

$$d_4 = 60 \text{ mm}$$

Umstnde momenti ma presocima!

List 27/35



$$S1: M_{f1} = 0 \quad T_1 = 703740 \text{ Nmm}$$

$$S2: M_{f2} = 12600 \text{ Nmm} \quad T_2 = 703740 \text{ Nmm}$$

$$S3: M_{f3} = \sqrt{(M_{f2} - 4918,6g \cdot 11)^2 + (R_{Dh} \cdot 11)^2} = \\ = \sqrt{(12600 - 4918,6g \cdot 11)^2 + (20847 \cdot 11)^2} = 42111,1 \text{ Nmm}$$

$$T_3 = 703740 \text{ Nmm}$$

$$S4: M_{f4} = \sqrt{282533,4^2 + 125082^2} = 308983,22 \text{ Nmm}$$

$$T_4 = 703740 \text{ Nmm}$$

$$M_{f1} = 0$$

$$T_1 = 703740 \text{ Nmm}$$

$$M_{f2} = 12600 \text{ Nmm}$$

$$T_2 = 703740 \text{ Nmm}$$

$$M_{f3} = 42111,1 \text{ Nmm}$$

$$T_3 = 703740 \text{ Nmm}$$

$$M_{f4} = 308983,22 \text{ Nmm}$$

$$T_4 = 703740 \text{ Nmm}$$

Kontrola presjeka:

S1 (pera spojke 2)

$$\sigma_{\text{red},1} = \sqrt{3 \left( \beta_{bf} + \frac{T_1}{W_{t1}} \right)^2}$$

$\beta_{bf} = 1,9$  (Vrdlo, dr. 38, Tb. 4,  $R_m = 500 \text{ N/mm}^2$ , Bokil)

$$W_{t1} = 0,2 (d - t_1)^3 = 0,2 (60 - 6,8)^3 = 30113,75 \text{ mm}^3$$

$$\sigma_{\text{red},1} = \sqrt{3 \cdot (1,9 \cdot \frac{703740}{30113,75})^2} = 26,91 \text{ N/mm}^2$$

$$\sigma_{\text{red},1} = 26,91 \text{ N/mm}^2$$

$b_1 = 0,8$  (d = 60 mm, Vrdlo dr. 35, Dj. 2.)

$b_2 = 0,9$  (Rm = 500 N/mm<sup>2</sup>, Rmax = 10 mm, Vrdlo dr. 35, Dj. 3.)

$$S = \frac{b_1 b_2 \sigma_{\text{FON}}}{\sigma_{\text{red},1}} = \frac{0,8 \cdot 0,9 \cdot 19,0}{26,91} =$$

$$S_1 = 1,78 > 1,5$$

$$S_1 = 1,78$$

Zadovoljava

S2 (sterni spoj.)

$$\sigma_{\text{red},2} = \sqrt{\left( \beta_{bf} \frac{W_{f2}}{W_{t2}} \right)^2 + 3 \left( \beta_{bf} + \frac{T_2}{W_{t2}} \right)^2}$$

$\beta_{bf} = 2,25$  (Vrdlo dr. 38., sterni spoj.)

$\beta_{bf} = 1,46$  (Vrdlo, dr. 38., sterni spoj.)

$$W_{t2} = 0,2 \cdot d^3 = 0,2 \cdot 60^3 = 43200 \text{ mm}^3$$

$$W_{f2} = 0,1 \cdot d^3 = 0,1 \cdot 60^3 = 21600 \text{ mm}^3$$

$$W_{t2} = 43200 \text{ mm}^3$$

$$W_{f2} = 21600 \text{ mm}^3$$

$$\sigma_{\text{red},2} = \sqrt{\left( 2,25 \cdot \frac{12600}{21600} \right)^2 + 3 \left( 1,46 \cdot \frac{703740}{43200} \right)^2}$$

$$\sigma_{\text{red},2} = 41,22 \text{ N/mm}^2$$

$$\sigma_{\text{red},2} = 41,22 \text{ N/mm}^2$$

$$\left. \begin{array}{l} b_1 = 0,8 \\ b_2 = 0,9 \end{array} \right\} \text{ist kao } S_1$$

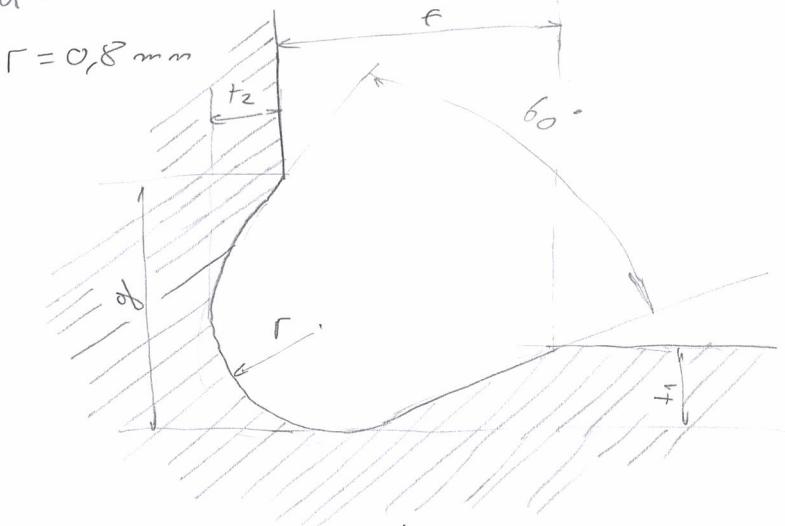
$$S_2 = \frac{b_1 b_2 \sigma_{FON}}{\sigma_{red_2}} = \frac{0,8 \cdot 0,9 \cdot 190}{41,22} = 3,32 > 1,5$$

$$S_2 = 3,32$$

24000V4VA

S3 (DIN 502: 2006-H)

$$d = 60 \text{ mm} \quad f = 2 \text{ mm} \quad t_2 = 0,05^{+0,05}_{-0,05} = 1,1 \text{ mm} \quad t_1 = 0,3^{+0,1}_{-0,1} \text{ mm}$$



$$\beta_{kf} = 1,37 \quad (R_m = 500 \frac{N}{mm^2}, f = 0,8, D = 65 \text{ mm}, d = 60 \text{ mm})$$

(Volllo str. 36, D, 4.)

$$\beta_{ft} = 1,44 \quad (R_m = 500 \frac{N}{mm^2}, f = 0,8, D = 65 \text{ mm}, d = 60 \text{ mm})$$

(Volllo str. 36, D, 5.)

$$\sigma_{red_3} = \sqrt{(\beta_{kf} \cdot \frac{M_{f3}}{W_{f3}})^2 + 3 \left( \beta_{ft} \frac{T_3}{W_{t3}} \right)^2}$$

$$W_{f3} = W_{f2} = 21600 \text{ mm}^3$$

$$W_{t3} = W_{t2} = 43200 \text{ mm}^3$$

$$\sigma_{red_3} = \sqrt{(1,37 \cdot \frac{42111,1}{21600})^2 + 3 \left( 1,44 \frac{703740}{43200} \right)^2}$$

$$\sigma_{red_3} = 40,72 \frac{N}{mm^2}$$

$$W_{f3} = 21600 \text{ mm}^3$$

$$W_{t3} = 43200 \text{ mm}^3$$

$$\sigma_{red_3} = 40,72 \frac{N}{mm^2}$$

$$b_1 = 0,8 \quad (d = 65, \text{Volllo str. 35, D, 2.})$$

$$b_2 = 0,875 \quad (R_m = 500 \frac{N}{mm^2}, \text{Volllo str. 35, D, 3, } l_{max} = 25 \text{ mm})$$

$$S_3 = \frac{b_1 b_2 \sigma_{FON}}{\sigma_{red_3}} = \frac{0,8 \cdot 0,875 \cdot 190}{40,72} = 3,27 > 1,5$$

$$S_3 = 3,27$$

24000V4VA

S4 (preo oklik+)

List 30/35

$$\sigma_{red4} = \sqrt{\left(\beta_{kf} \frac{W_{f4}}{W_{t4}}\right)^2 + 3 \left(\beta_{kt} \frac{T_4}{W_{t4}}\right)^2}$$

$\beta_{kf} = 1,5$  (Vadlo, sk. 38., T64, Rm=500, oklik A)

$\beta_{kt} = 1,9$  (Vadlo, sk. 38., T64, Rm=500, oklik A)

$$\sigma_{red4} = \sqrt{\left(1,5 \frac{308983,22}{19713,74}\right)^2 + 3 \left(1,9 \frac{703740}{39427,47}\right)^2}$$
$$= 63,27 \frac{N}{mm^2}$$

$$\sigma_{red4} = 63,27 \frac{N}{mm^2}$$

$$\begin{aligned} b_1 &= 0,8 \\ b_2 &= 0,9 \end{aligned} \quad \left. \begin{aligned} \text{islo kao} \\ \underline{s3} \end{aligned} \right\}$$

$$S_4 = \frac{b_1 b_2 \sigma_{red4}}{W_{red4}} = \frac{0,8 \cdot 0,9 \cdot 190}{63,27} = 2,16 > 1,5$$

$$S_4 = 2,16$$

ZADOVOLJIVA

$$W_{f4} = 0,1 \cdot (d - t_1)^3 = 0,1 (65 - 6,8)^3 = 19713,74 mm^3$$

$$W_{f4} = 19713,74 mm^3$$

$$W_{t4} = 0,2 (d - t_1)^3 = 0,2 (65 - 6,8)^3 = 39427,47 mm^3$$

$$W_{t4} = 39427,47 mm^3$$

## 2.2.2. Odabir ležaja za V2

- ova ležaja biramo prema R<sub>D</sub>

$$d = 60 mm$$

$$P_r = R_D = 5471,6 N$$

$$P_r = 5471,6 N$$

$$C_1 = P_r \left( \frac{60 \cdot m_{min} \cdot L_{1oh-min}}{10^6} \right)^{\frac{1}{3}}$$

$L_{1oh-min} = 16000 h$  (bedikt druk. T. 12, prijedoci za opću upotrebu)

$$\xi = \frac{10}{3} \text{ (teoretski dodir u crti)}$$

$$m_{min} = 502,83 mm^{-1}$$

$$C_1 = 5471,6 \left( \frac{60 \cdot 502,83 \cdot 16000}{10^6} \right)^{\frac{1}{3}} = 34931,9 N$$

$$C_1 = 34931,9 N$$

$$d = 60 \text{ mm} \quad D = 110 \text{ mm} \quad B = 22 \text{ mm}$$

NASLON:  $d_a = 68 \text{ mm} > d_3 = 65 \text{ mm}$

$$C = 108000 \text{ N} > C_1 = 34931,9 \text{ N}$$

ZADANIE 4

$$L_{10h} = \frac{10^6}{60 \cdot m_{min}} \left( \frac{C}{P_f} \right)^{\frac{10}{3}}$$

$$= \frac{10^6}{60 \cdot 502,83} \left( \frac{108000}{5471,6} \right)^{\frac{10}{3}} = 688851,51 \text{ h} \quad L_{10h} = 688851,51 \text{ h}$$

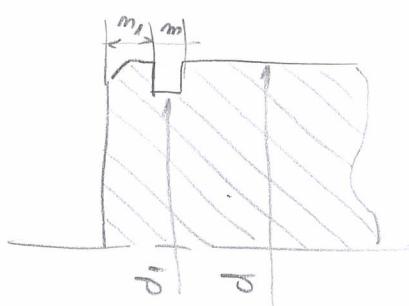
$$L_{10h} > L_{10h\_min}$$

$$688851,51 > 16000$$

ZADANIE 5

- ležajno mjesto (C) čemo učiniti saggescum uskoćnikom a ležajno mjesto (D) čemo ostaviti slabodno

### DIN 417



$$m_1 = 2,85 \text{ mm} \quad m = 2,15 \text{ mm}$$

$$d_1 = 57 \text{ mm} \quad b = 2 \text{ mm}$$

$$d = 60 \text{ mm}$$

2. 2. 3. Kontrola pera na  
vratilu 2.

List 32/35

PERO ZUPČANÍKA 1:

OBLIK A

$b \times h$   $t_1 = 6,8 \text{ mm}$   
 $18 \times 11 \text{ mm}$

$$\rho_{dop} = 70 \frac{N}{mm^2} (\text{Decker dr. 14g.})$$

$$L_1 \geq \frac{2T}{\rho_{dop} \cdot t_1 \cdot d_2} = \frac{2 \cdot 703740}{70 \cdot 6,8 \cdot 65} = 45,49$$

$$L_1 = 50 \text{ mm} \quad \text{ODAŘENO}$$

$$L_1 = 50 \text{ mm}$$

PERO SPOJKY 2:

OBLIK D

$b \times h$   $t_1 = 6,8 \text{ mm}$   
 $18 \times 11 \text{ mm}$

$$\rho_{dop} = 70 \frac{N}{mm^2} (\text{Decker dr. 14g.})$$

$$L_2 \geq \frac{2T}{\rho_{dop} \cdot t_1 \cdot d_4} = \frac{2 \cdot 703740}{70 \cdot 6,8 \cdot 60} = 49,28 \text{ mm}$$

$$L_2 = 50 \text{ mm} \quad \text{ODAŘENO}$$

$$L_2 = 50 \text{ mm}$$

### 3. Ostvarivanje potrebne bočne zračnosti primicanjem alata

List 33/35

$$Z_{W12} = \frac{Z_{12}}{\pi} \left( \operatorname{tg} d_{x12} - \operatorname{evd} \right) - \frac{2 \cdot X_{12} \cdot \operatorname{tg} d}{\pi} + 0,5 = \\ = \frac{17}{\pi} \left( 0,5304 - \operatorname{ev} 20^\circ \right) - \frac{2 \cdot 0,575 \cdot \operatorname{tg} 20^\circ}{\pi} + 0,5 = \\ = 3,16 \dots = 3 \text{ zuba}$$

$$Z_{W12} = 3$$

$$\operatorname{tg} d_{x12} = \sqrt{\operatorname{tg}^2 d + \frac{4 \left( \frac{X_{12}}{Z_{12}} \right) \left( 1 + \frac{X_{12}}{Z_{12}} \right)}{\cos d}} = 0,5304$$

$$\operatorname{tg} d_{x12} = 0,5304$$

$$W_{12} = m \cos d \left( \pi (Z_{W12} - 0,5) + Z_{12} \operatorname{evd} + 2 X_{12} \operatorname{tg} d \right) = \\ = 3 \cdot \cos 20^\circ (\pi (3 - 0,5) + 17 \cdot 0,014904 + 2 \cdot 0,575 \cdot \operatorname{tg} 20^\circ) \\ = 24,04 \text{ mm}$$

$$W_{12} = 24,04 \text{ mm}$$

#### Izbor bočne zračnosti

$m = 3 \text{ mm}$  (Dodatak str. 40., Dž 2.)

$$j_{\max} = 175 \mu\text{m} \quad j_{\min} = 100 \mu\text{m}$$

$$j_{\max} = 175 \mu\text{m}$$

$$j_{\min} = 100 \mu\text{m}$$

#### Izbor goničnih odstupanja rovnaka

vratila (Dodatak str. 42., Tb. 3.)

118

$$A_{\text{ug}, d} = \pm 27 \mu\text{m}$$

$$a = 100 \pm 0,027 \text{ mm}$$

$$-(A_{\omega_1,d} + A_{\omega_2,d}) = j_{\max} \cos \alpha - 2 \cdot A_{Ag} \sin \alpha = \\ = 175 \cos 20^\circ - 2 \cdot 27 \sin 23,62^\circ \\ = 142,81 = 143 \mu m$$

$$-(A_{\omega_1,g} + A_{\omega_2,g}) = j_{\min} \cos \alpha - 2 \cdot A_{Ag} \sin \alpha = \\ = 100 \cos 20^\circ - 2 \cdot (-27) \sin 23,62^\circ \\ = 115,61 = 116 \mu m$$

(Radialär st. 40, Tb. 6, m=3 mm)

$$A_{\omega_1,g} = -88 \mu m \quad (f) \quad A_{\omega_2,g} = -144 \mu m \quad (e) \\ A_{\omega_1,d} = -132 \mu m \quad (e) \quad A_{\omega_2,d} = -192 \mu m \quad (d)$$

$$j_{\min} > 2(T''_{i,1} + T''_{i,2}) \cdot \tan \alpha \\ j_{\min} > 2(99 + 105) \tan 23,62^\circ = 178 \mu m$$

$$T''_{i,1} = 99 \mu m \\ T''_{i,2} = 105 \mu m$$

Kontrola:

$$j_{\min} = -\frac{(A_{\omega_1,g} + A_{\omega_2,g})}{\cos \alpha} + 2 \cdot A_{Ag} \tan \alpha = \\ = -\frac{(-88 - 144)}{\cos 20^\circ} + 2 \cdot (-27) \tan 23,62^\circ = 223 \mu m$$

$$j_{\min} = 223 \mu m \rightarrow 178 \mu m$$

$$j_{\min} = 223 \mu m$$

ZADOVOLJIVA

$$j_{\max} = -\frac{(A_{\omega_1,d} + A_{\omega_2,d})}{\cos \alpha} + 2 \cdot A_{Ag} \tan \alpha = \\ = -\frac{(-132 - 192)}{\cos 20^\circ} + 2 \cdot 27 \tan 23,62^\circ = 368 \mu m$$

$$j_{\max} = 368 \mu m > 178 \mu m$$

$$j_{\max} = 368 \mu m$$

ZADOVOLJIVA

Zupčanik 21: IT8 fe  $A_{w1g} = -88 \mu\text{m}$   $A_{w1d} = -132 \mu\text{m}$

Zupčanik 22: IT8 cd  $A_{w2g} = -144 \mu\text{m}$   $A_{w2d} = -192 \mu\text{m}$

Ostvarena srednja vrijednost brzine  
začnosti:

$$j = (223 + 268) \frac{1}{2} = 246 \mu\text{m}$$

$$j = 246 \mu\text{m}$$

alat treba primaknuti:

$$j_r = \frac{j}{4 \cdot \operatorname{tg} \alpha_w} = \frac{246}{4 \cdot \operatorname{tg} 23,62^\circ} = 141 \mu\text{m}$$

$$j_r = 141 \mu\text{m}$$

#### 4. Priklučma smaga elektromotora

$$T_{EM} = \frac{T_{v1}}{\eta_{s1}} = \frac{249,37}{0,975} = 255,76 \text{ Nm}$$

$$T_{EM} = 255,76 \text{ Nm}$$

Potrebljena smaga kod uključivanja:

$$\begin{aligned} P_{EM0} &= T_{EM} \cdot \omega_{EM} = 255,76 \cdot 148,702 \\ &= 38,03 \text{ kW} \end{aligned}$$

$$P_{EM0} = 38,03 \text{ kW}$$

Smaga koja se predaje u normalnom  
pogonu:

$$P_p = \frac{P_{es}}{\eta_{ok}} = \frac{33}{0,93} = 35,48 \text{ kW}$$

$$P_p = 35,48 \text{ kW}$$

IZBOR ELEKTROMOTORA:

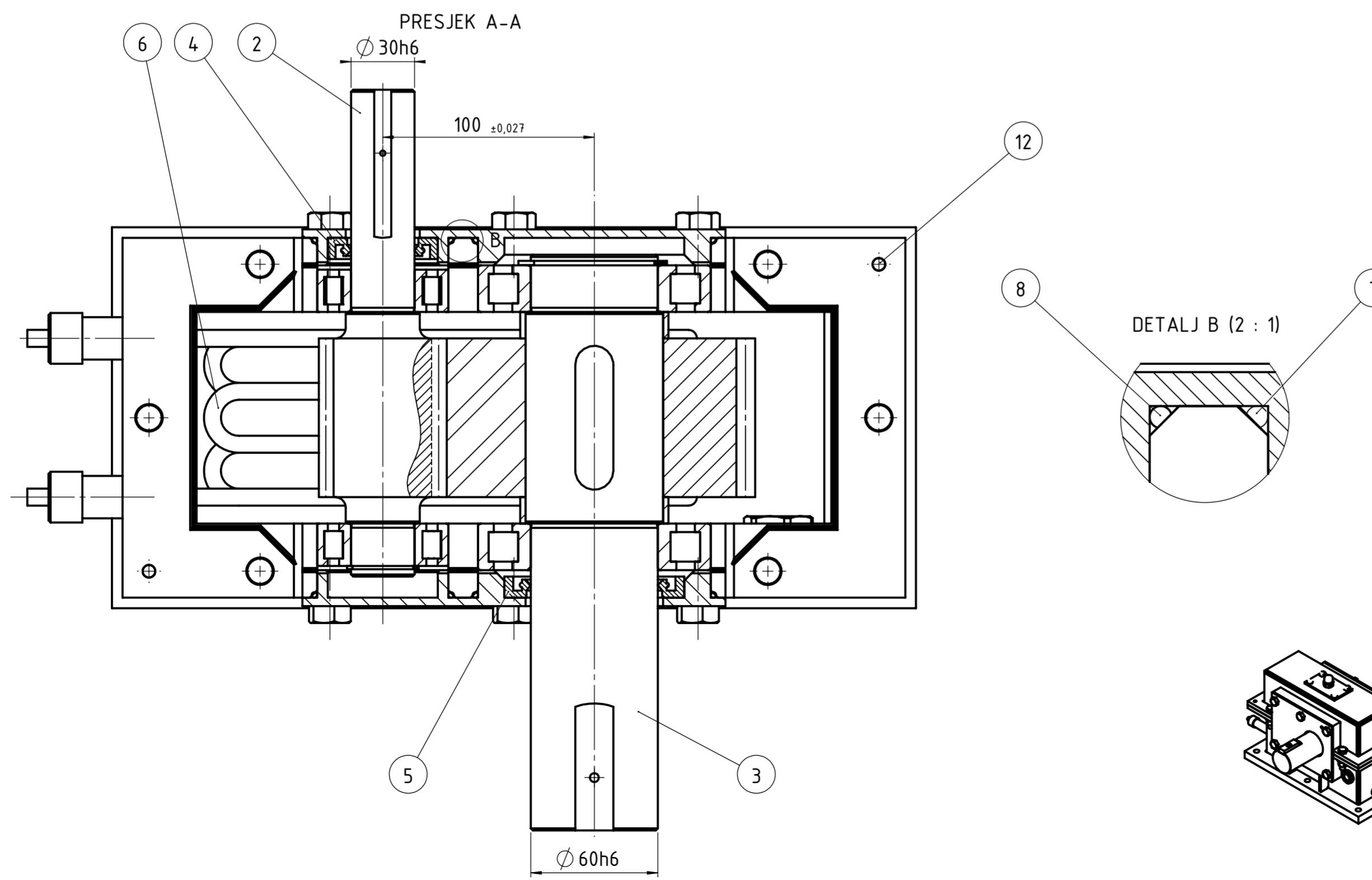
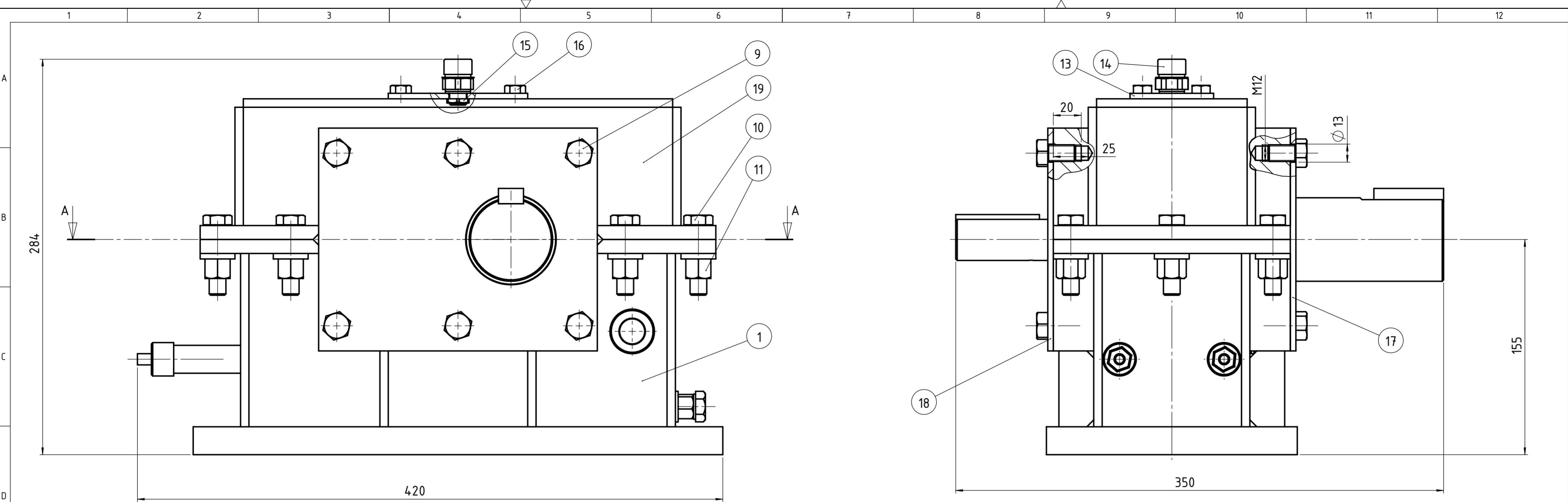
$$P_d = \frac{P_{EM} \cdot 1,5}{1,5} - P_p = \frac{38,03}{1,5} - 35,48 = 2,55 \text{ kW}$$

$$P_d = 2,55 \text{ kW}$$

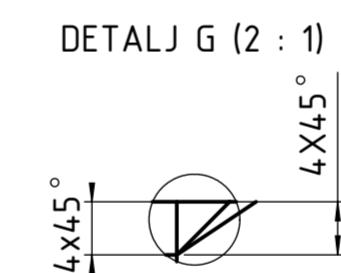
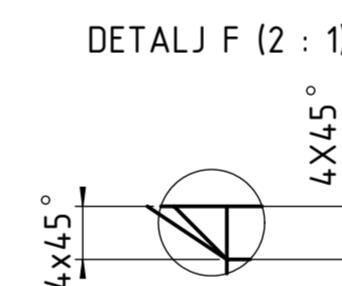
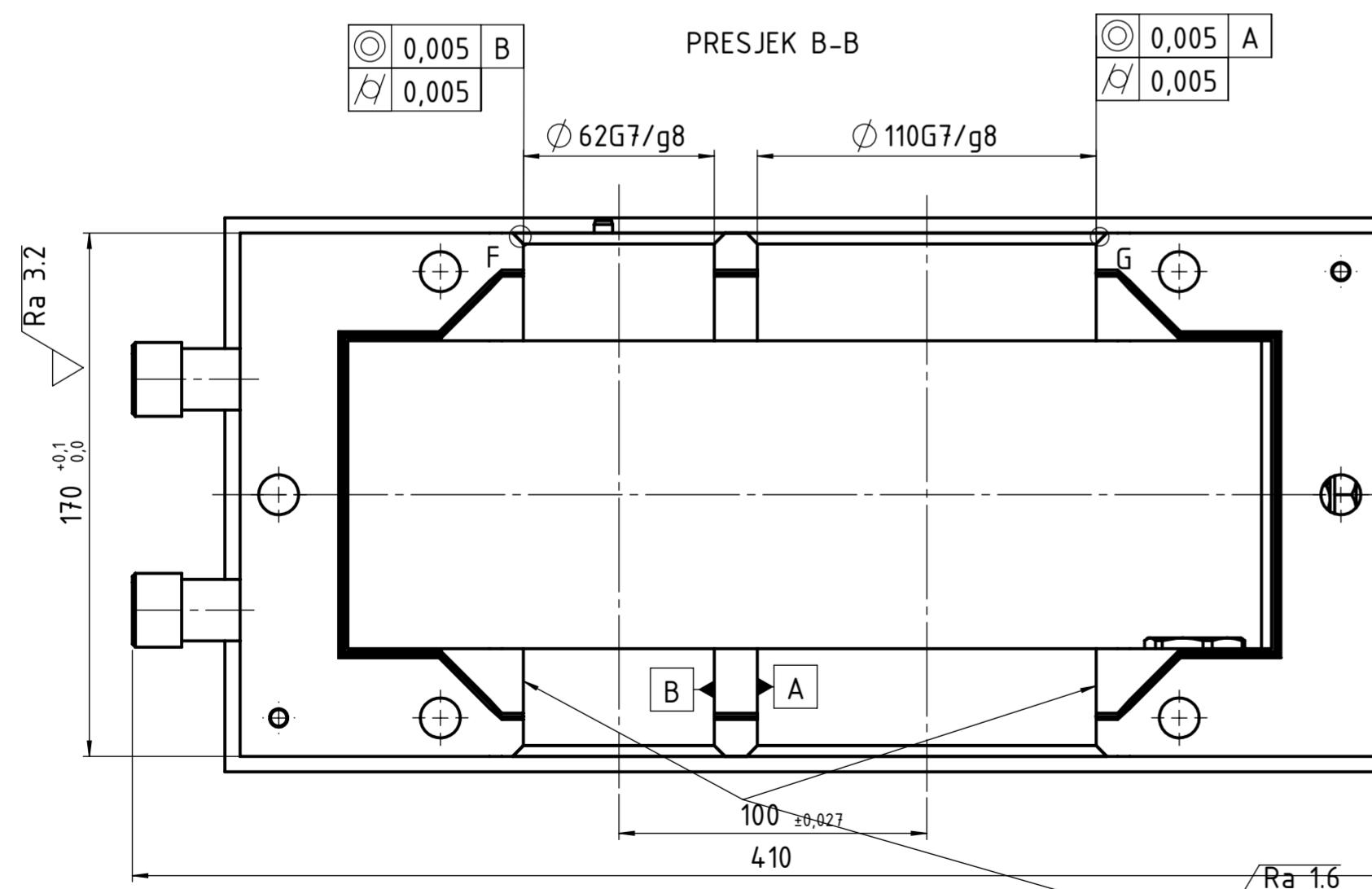
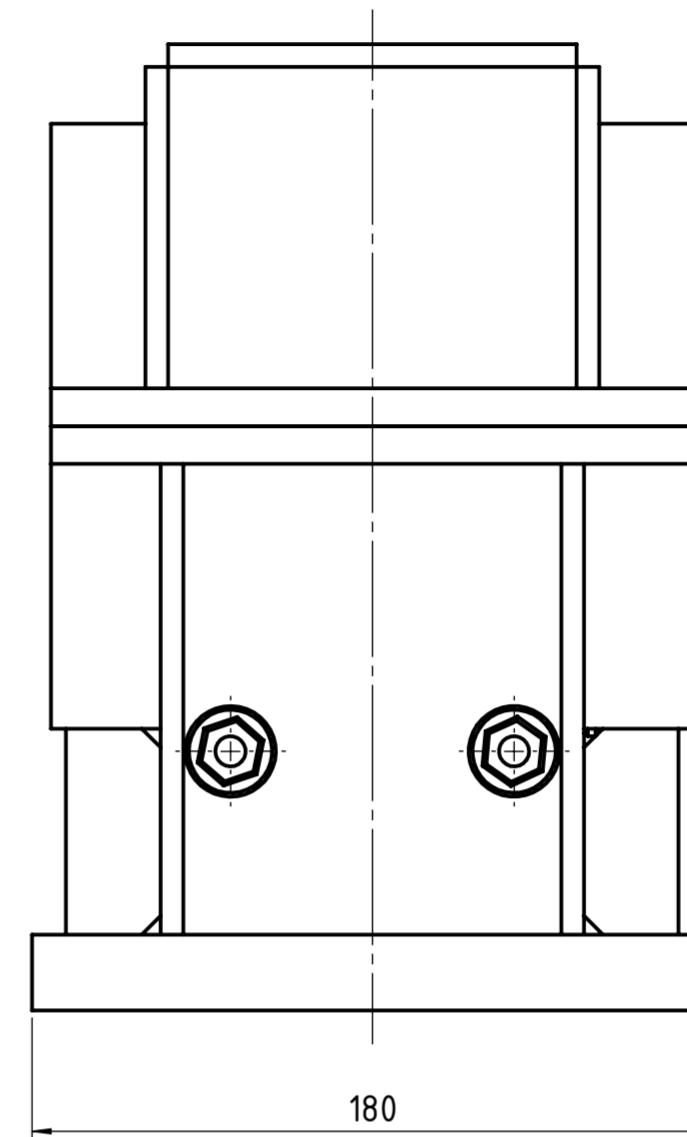
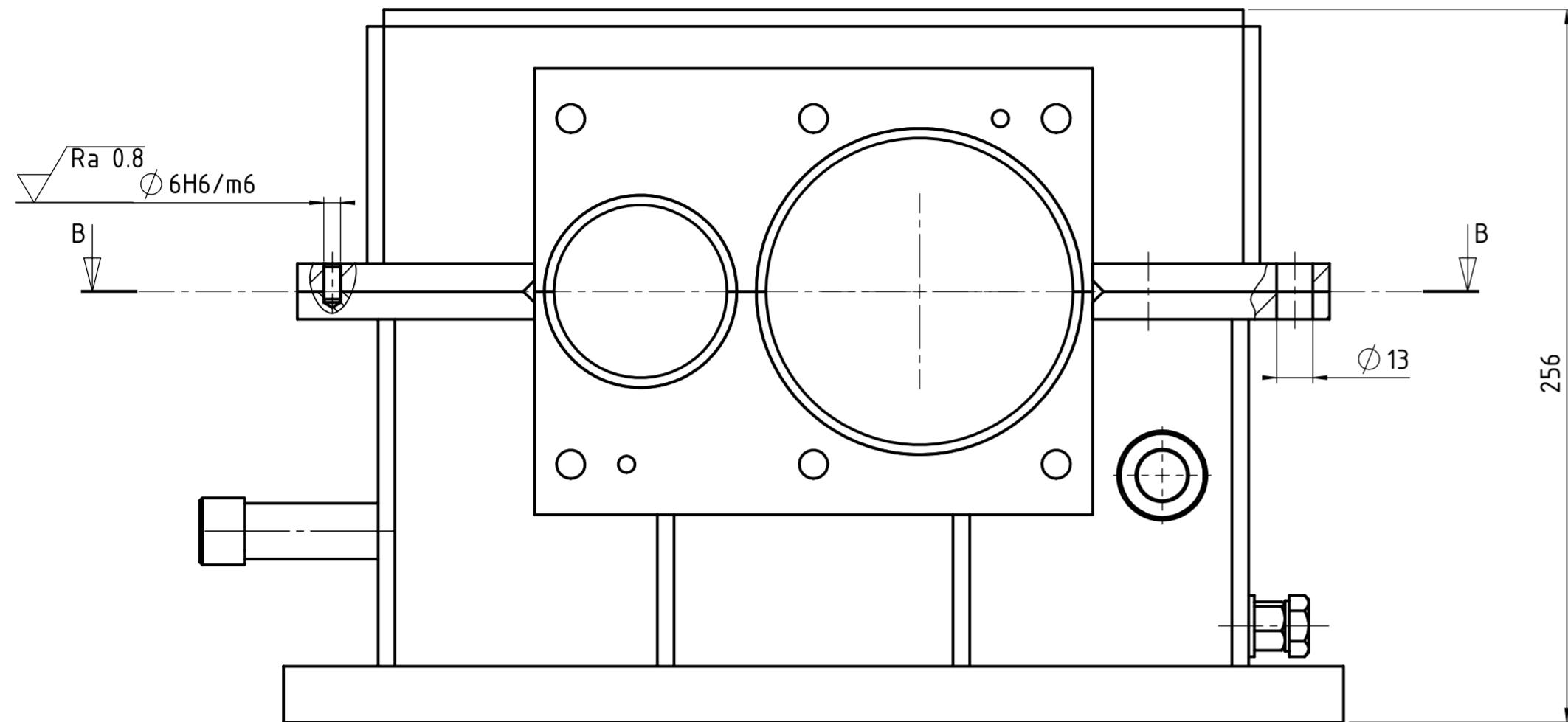
$$P_{EM} = P_p + P_d = 35,48 + 2,55 = 38,03 \text{ kW}$$

odabirao:  $P_{EM} = 40 \text{ kW}$

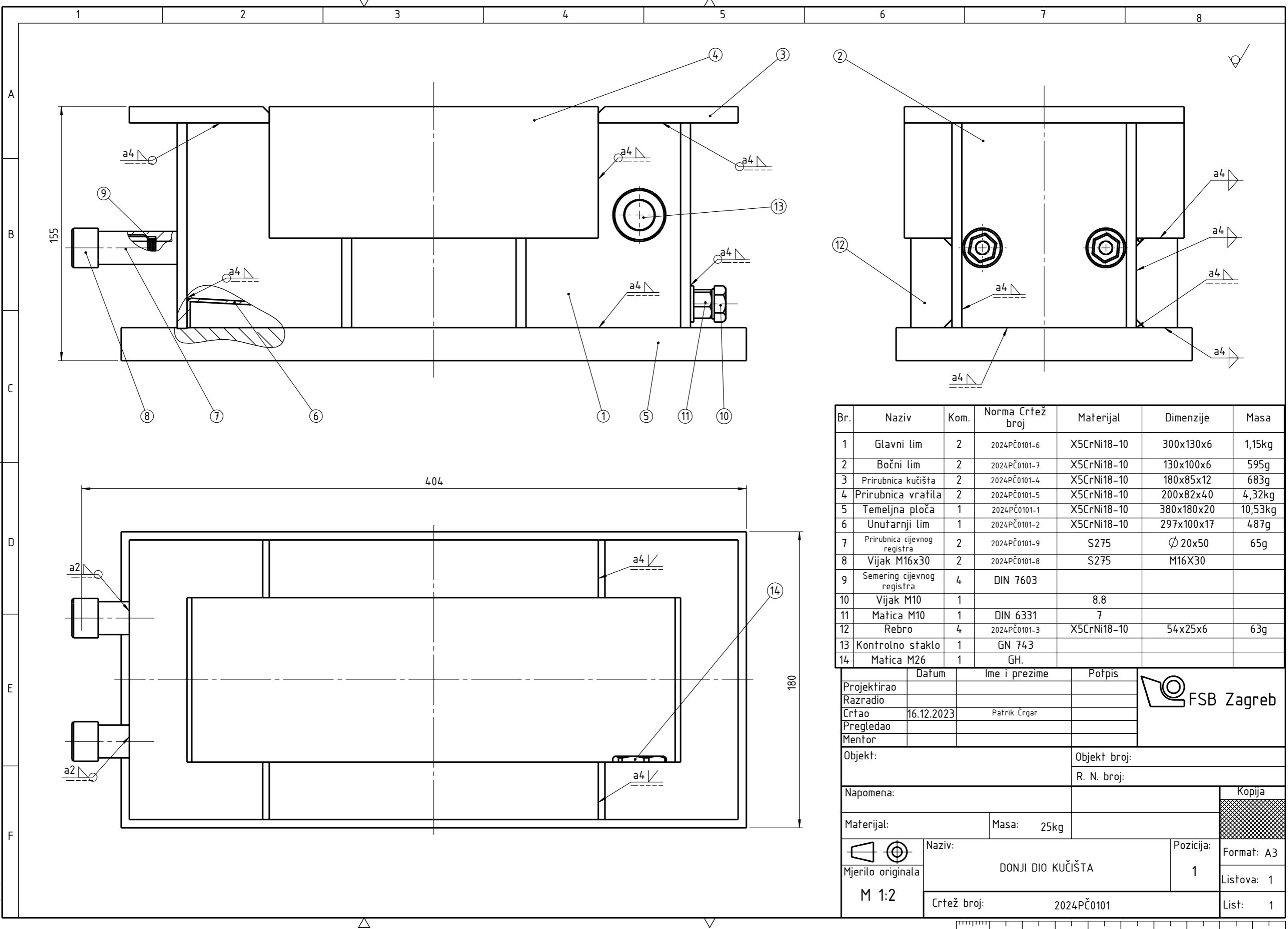
$$P_{EM} = 40 \text{ kW}$$

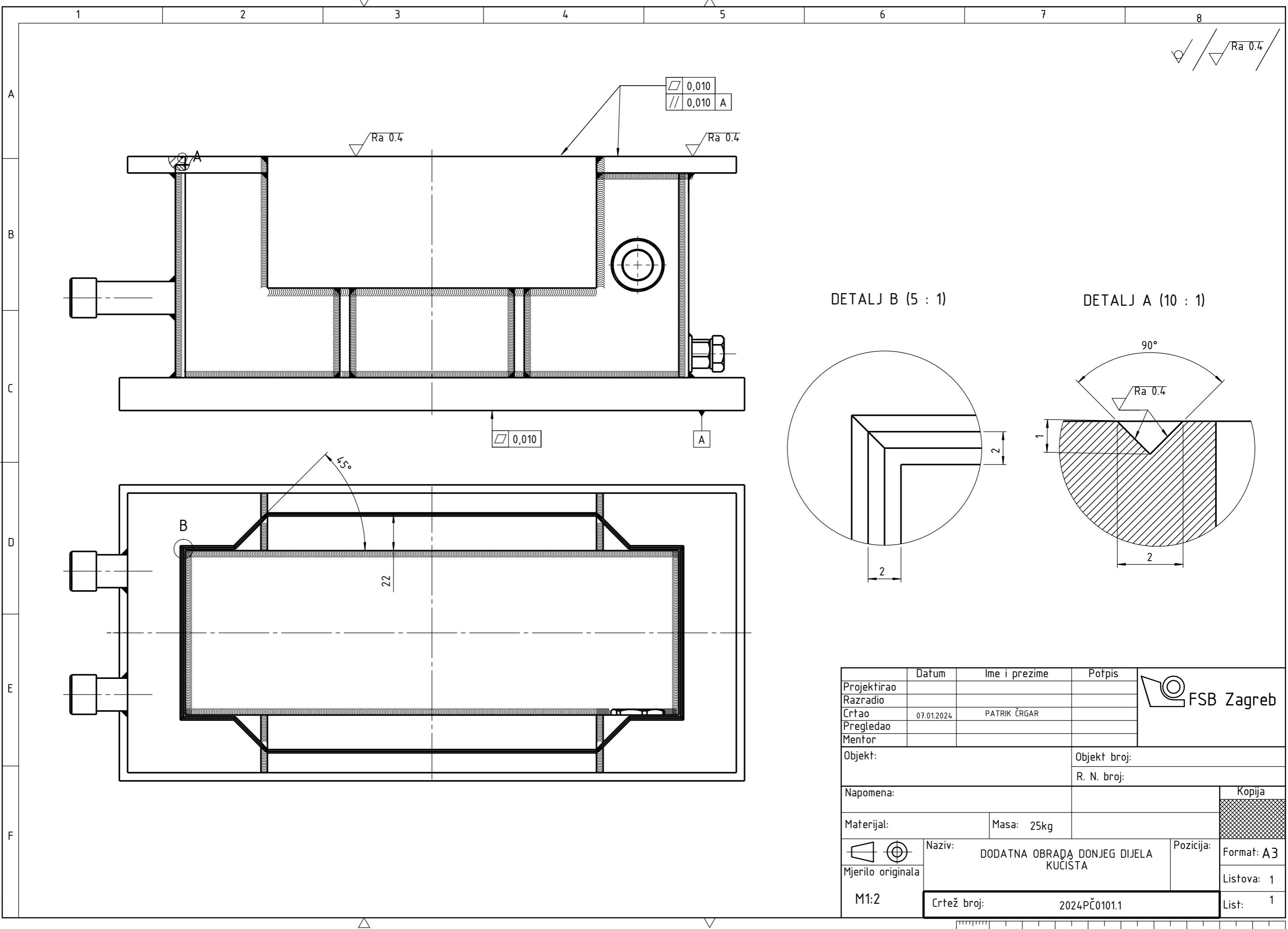


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Projektirao						
Razradio						
Crtao	09.01.2024			PATRIK ČRGAR		
Pregledao						
ISO - tolerancije						
Ø 30h6	0 -0,013					
Ø 60h6	0 -0,019					
Objekt:					Objekt broj:	
Napomena:					R. N. broj:	
Materijal:					Kopija	
Mjerilo originala						
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Naziv:						
Pozicija:						
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Listova: 2						
Crtež broj:	2024PČ01					
List:	1					



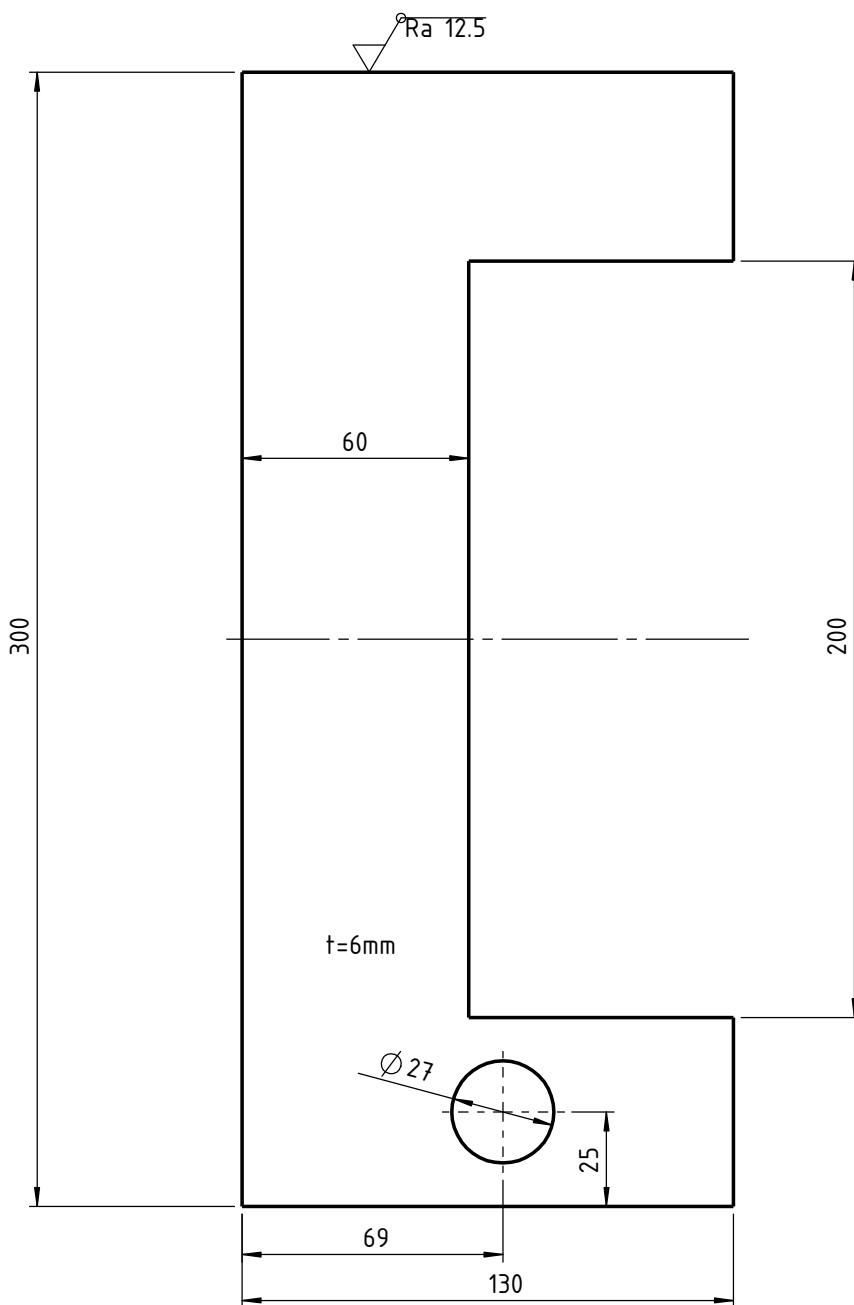
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		Razradio			
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		Pregledao			
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	+0,020				
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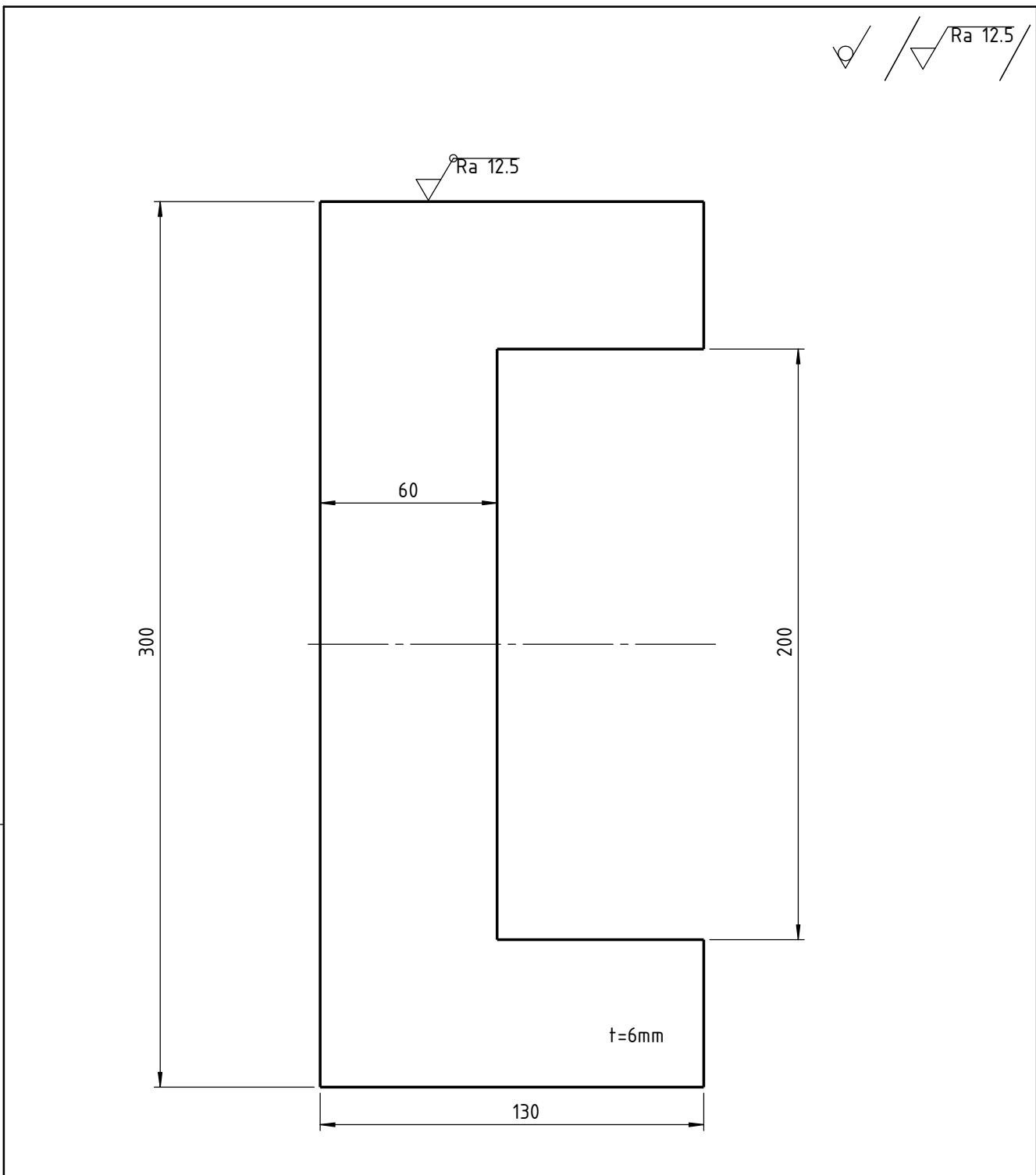


NAPOMENA:  
Konfiguracija s pravrtom za kontrolno staklo

✓ / Ra 12.5



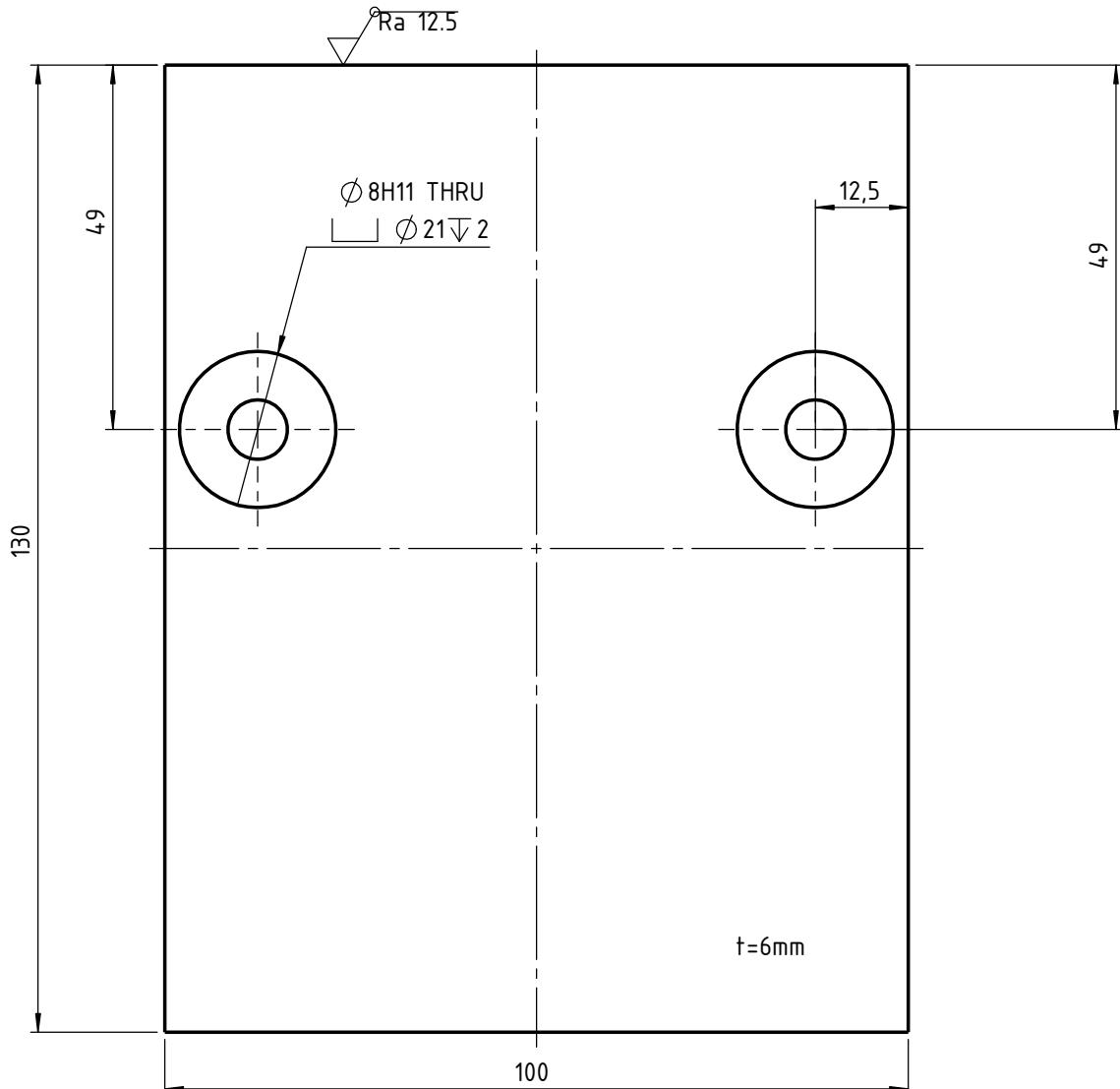
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Pregledao:				
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		R. N. broj:		
Napomena:				Kopija
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				Format: A4
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NAPOMENA:  
Konfiguracija bez provrta za kontrolno staklo

NAPOMENA:  
Konfiguracija cijevni registrar

Ra 12.5

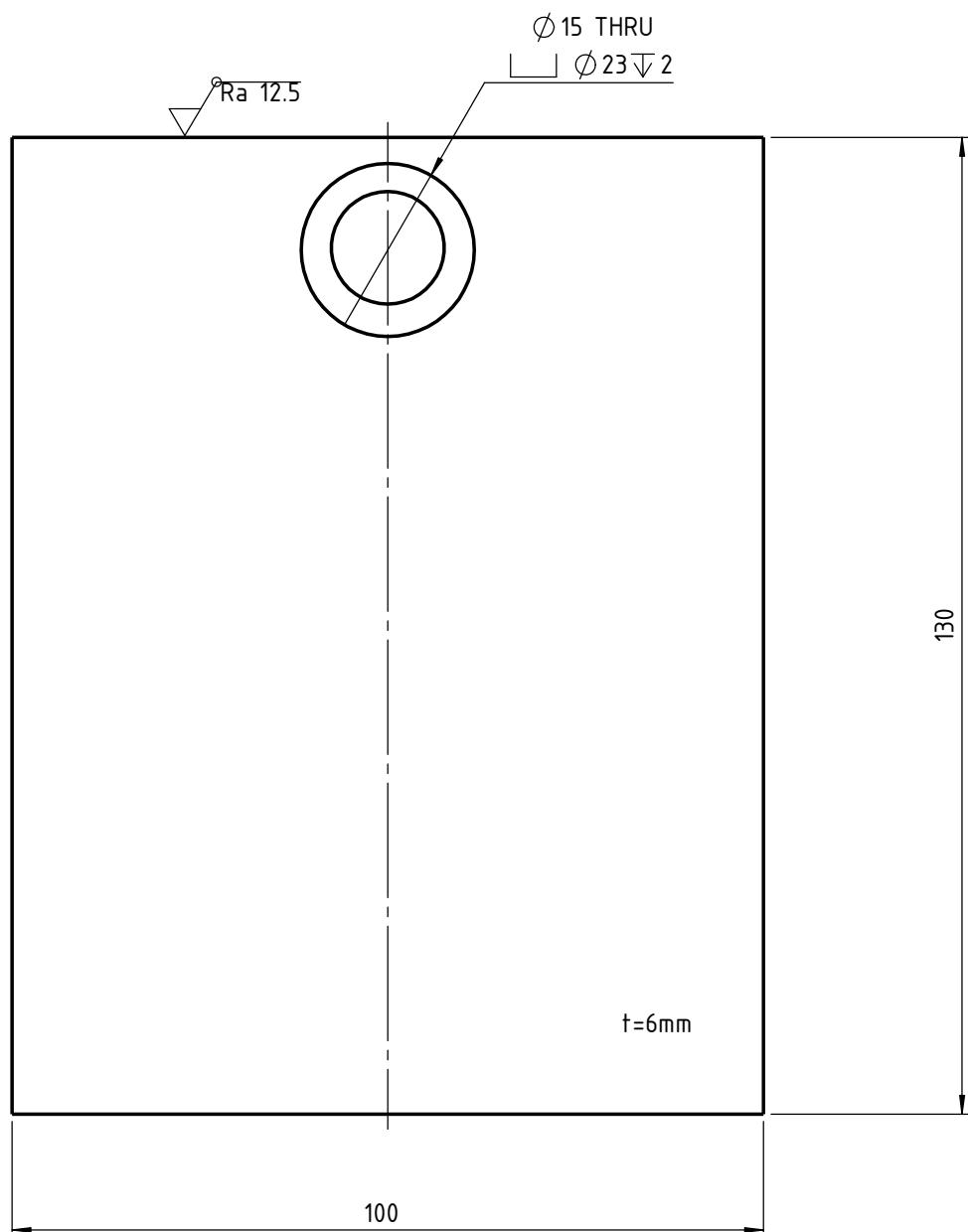


105

Broj naziva - code	Datum	Ime i prezime	Potpis
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	Razradio		
	Črtao	07.01.2024	PATRIK ČRGAR
	Pregledao		
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Ø 8H11	+0,027 0		R. N. broj:
		Napomena:	Kopija
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Design by CADlab		Naziv: BOČNI LIM	Pozicija: 2
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NAPOMENA:  
Konfiguracija ispust ulja

Ra 12.5



$\pm 0.5$

Format: A4

Listova: 2

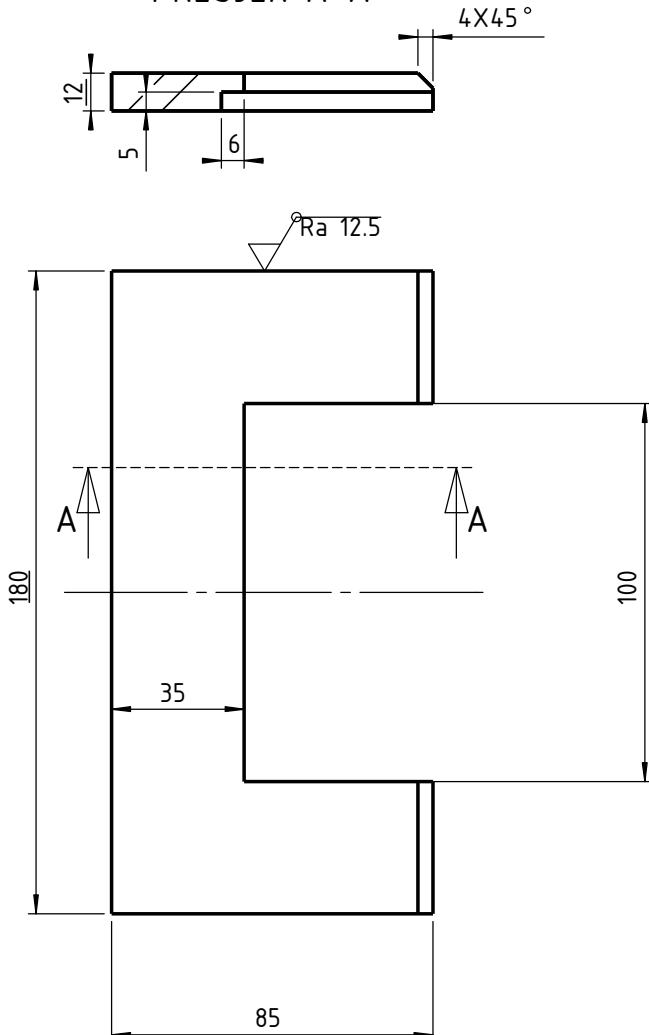
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2024PČ0101-7

List: 2

✓ Ra 12.5

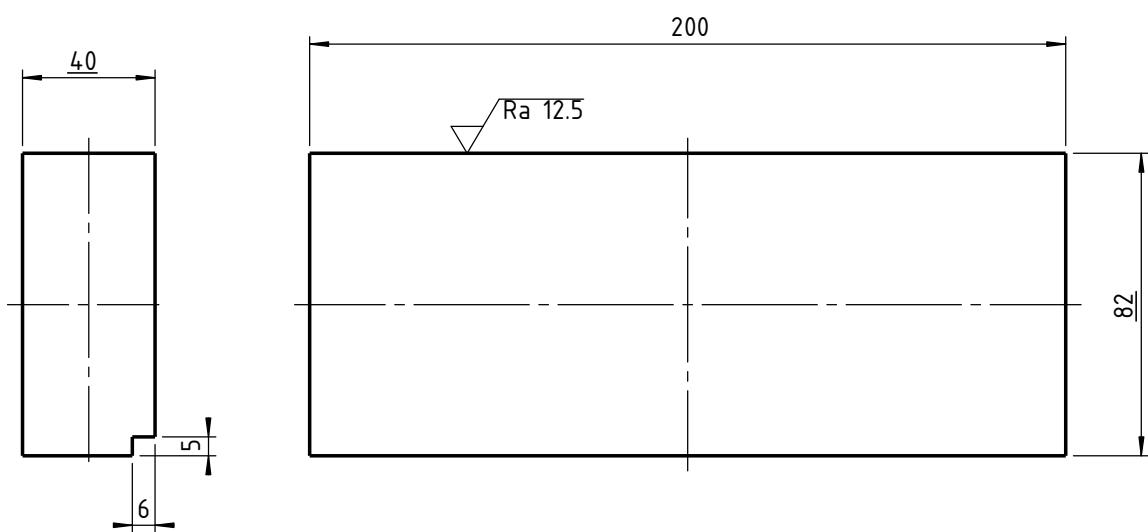
PRESJEK A-A



0.5 0.5

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Projektirao			
Razradio			
Črtao	07.01.2024	PATRIK ČRGAR	
Pregledao			
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		R. N. broj:	
Napomena:			Kopija
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✓ / Ra 12.5



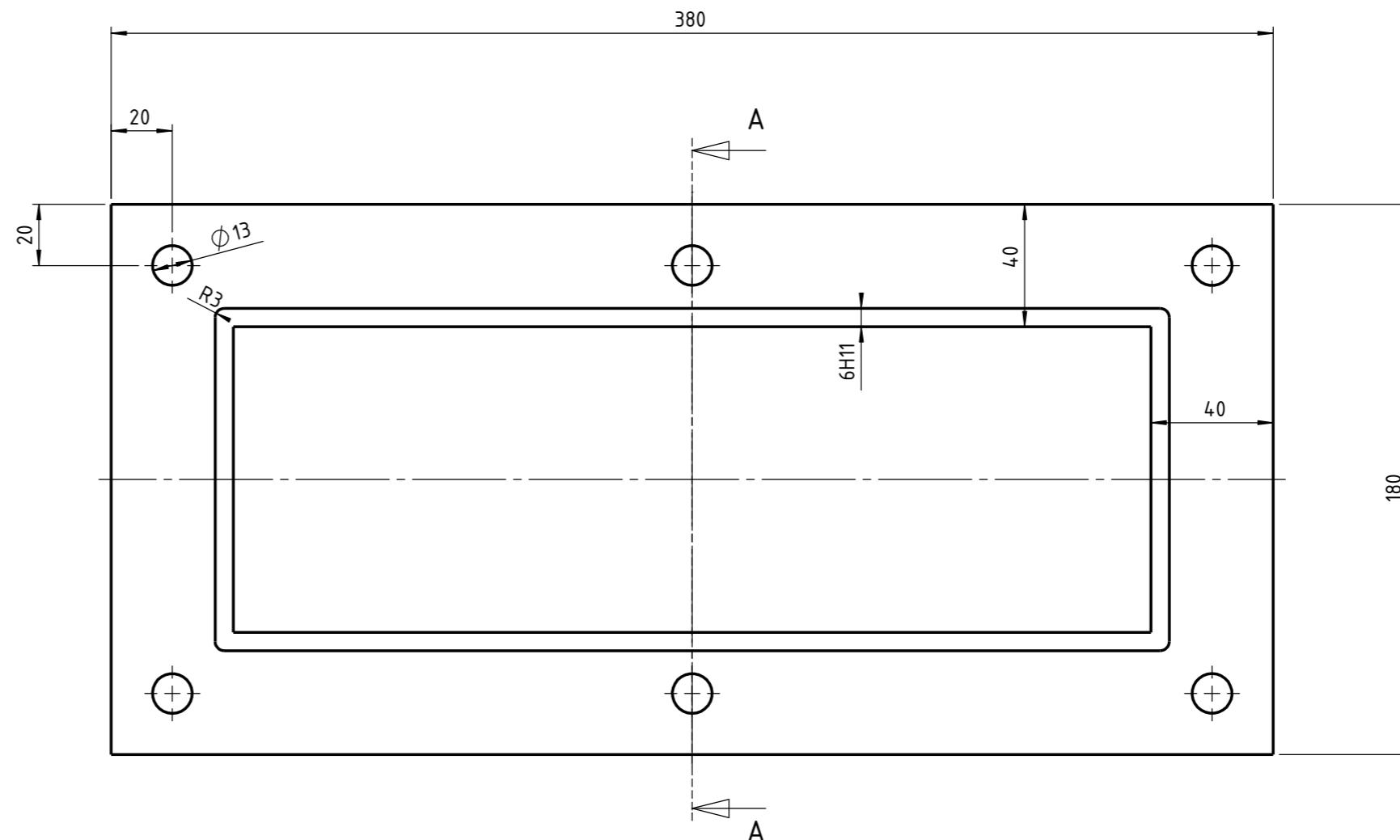
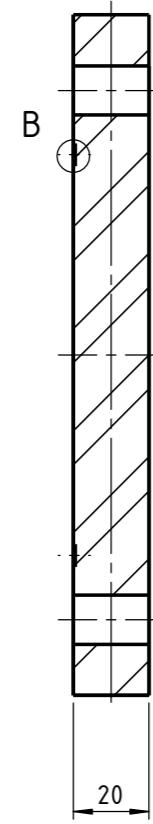
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Datum	Ime i prezime	Potpis	FSB Zagreb
Projektirao			
Razradio			
Črtao	07.01.2024	PATRIK ČRAGR	
Pregledao			
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		R. N. broj:	
Napomena:			Kopija
Materijal: X5CrNi18-10	Masa: 4,32kg		
	Naziv: PRIRUBNICA VRATILA	Pozicija: 4	Format: A4
Mjerilo originala			Listova: 1
M 1:2	Crtanje broj: 2024PC0101-5		List: 1

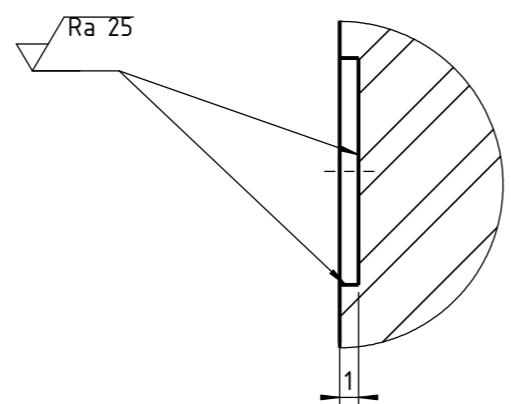
1 2 3 4 5 6 7 8

A  
B  
C  
D  
E  
F

PRESJEK A-A



DETALJ B (m5:1)



Broj naziva - code

Projektirao  
Razradio  
Crtao  
Pregledao  
Mentor

Datum

16.12.2023

Ime i prezime

PATRIK ČRGAR

Potpis

 FSB Zagreb

ISO - tolerancije

6H11 +0,075  
0

Objekt:

Objekt broj:  
R. N. broj:

Napomena:

Materijal: X5CrNi18-10 Masa: 10.53kg

Kopija

Format: A3

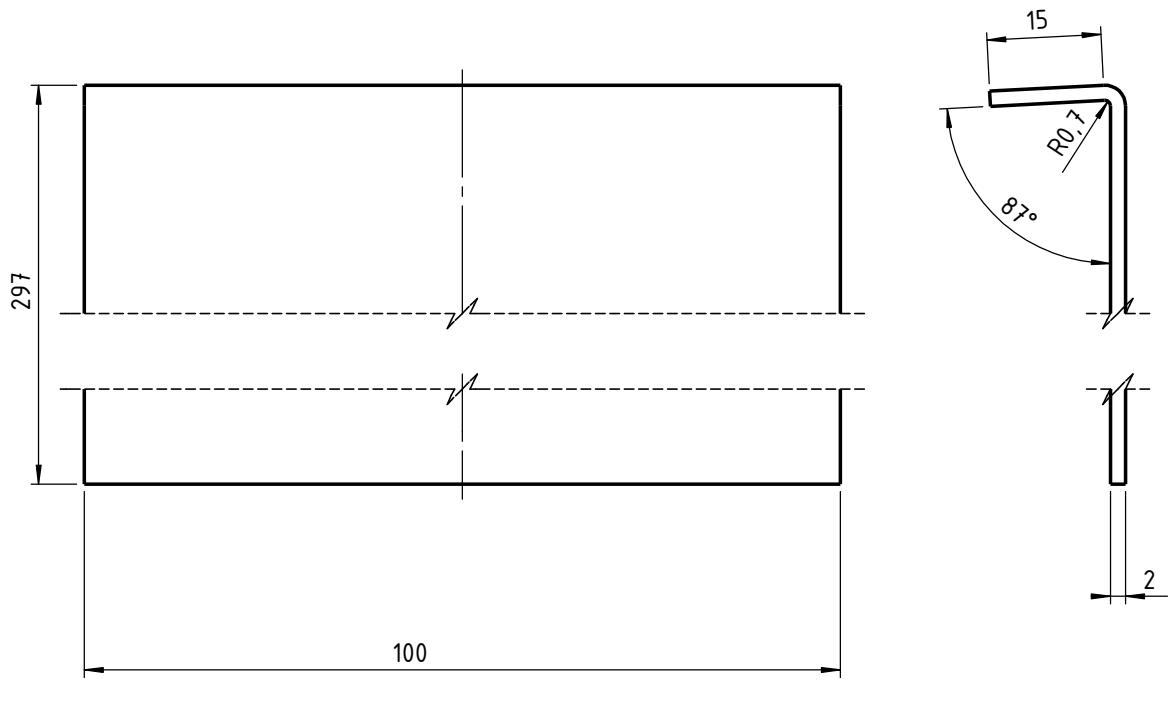
Mjerilo originala

M 1:2

Naziv: TEMELJNA PLOČA Pozicija: 5

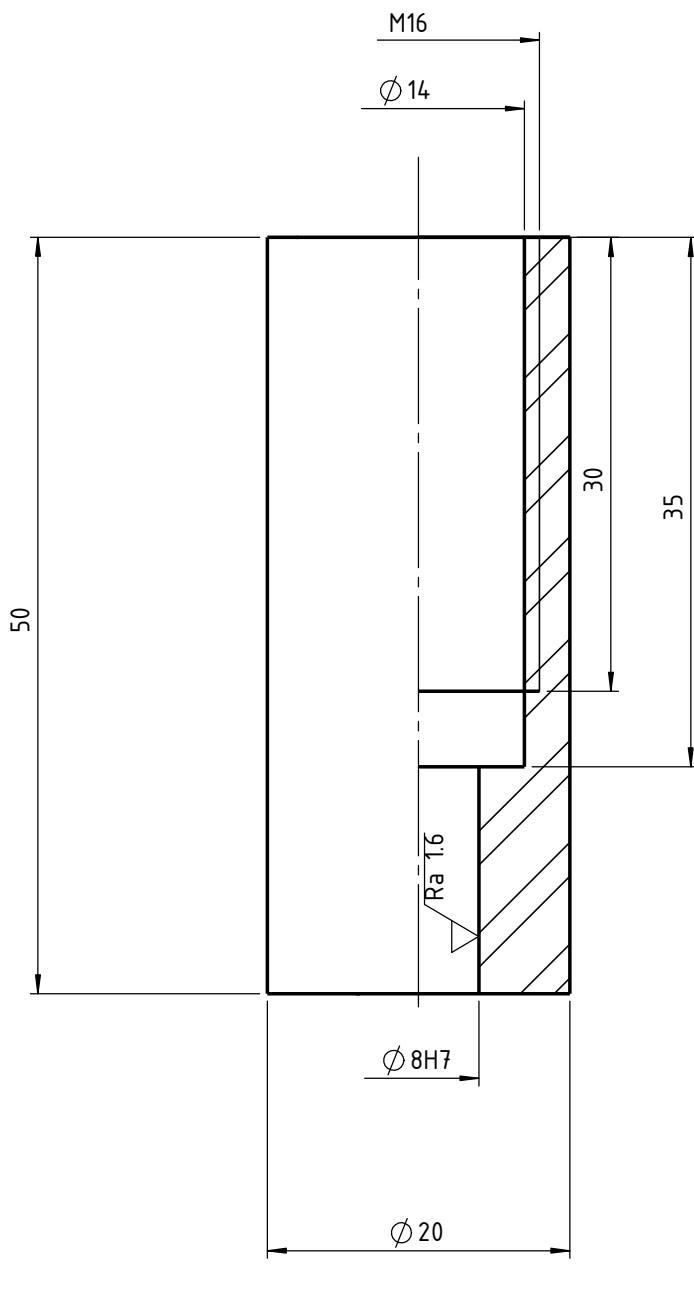
Crtež broj: 2024PČ0101-1 Listova: 1

List: 1



Datum	Ime i prezime	Potpis	FSB Zagreb
Projektirao			
Razradio			
Črtao	06.01.2024	PATRIK ČRGAR	
Pregledao			
Objekt:	Objekt broj:		
Napomena:			Kopija
Materijal: X5CrNi18-10	Masa: 487g		
Mjerilo originala	Naziv: UNUTARNJI LIM	Pozicija: 6	Format: A4
M1:1	Crtanje broj: 2024PČ0101-2		Listova: 1
			List: 1

✓ / Ra 1.6

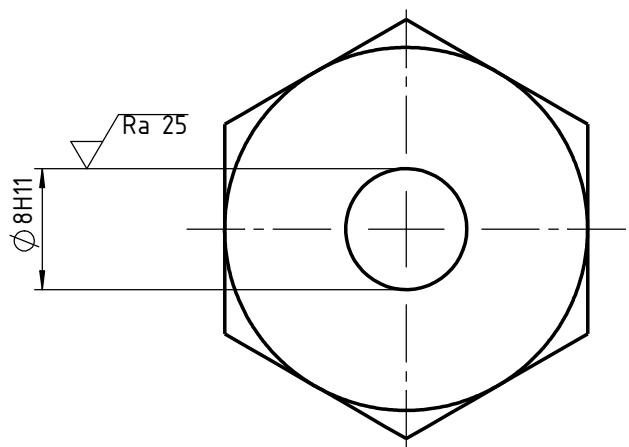
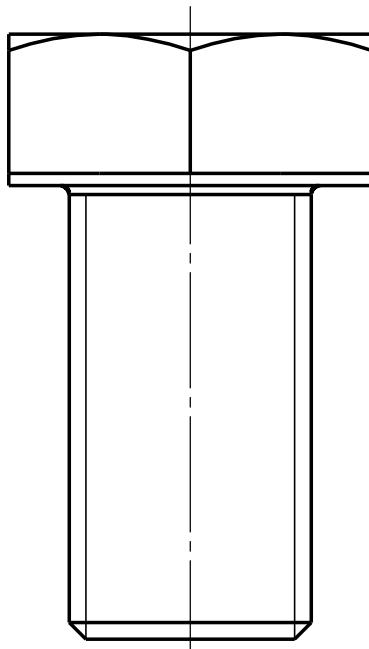


1.05  
1.05

Broj naziva - code		Datum	Ime i prezime	Potpis	 FSB Zagreb		
Projektirao							
Razradio							
Črtao	07.01.2024	PATRIK ČRGAR					
Pregledao							
ISO - tolerancije		Objekt:		Objekt broj:			
Ø 8H7	+0,015						
	0						
		Napomena:			Kopija		
		Materijal: S275		Masa: 65g			
		 Mjerilo originala	Naziv: PRIRUBNICA CIJEVNOG REGISTRA		Pozicija: 7		
					Format: A4		
Design by CADLab	M2:1	Crtanje broj: 2024PČ0101-9			Listova: 1		
					List: 1		

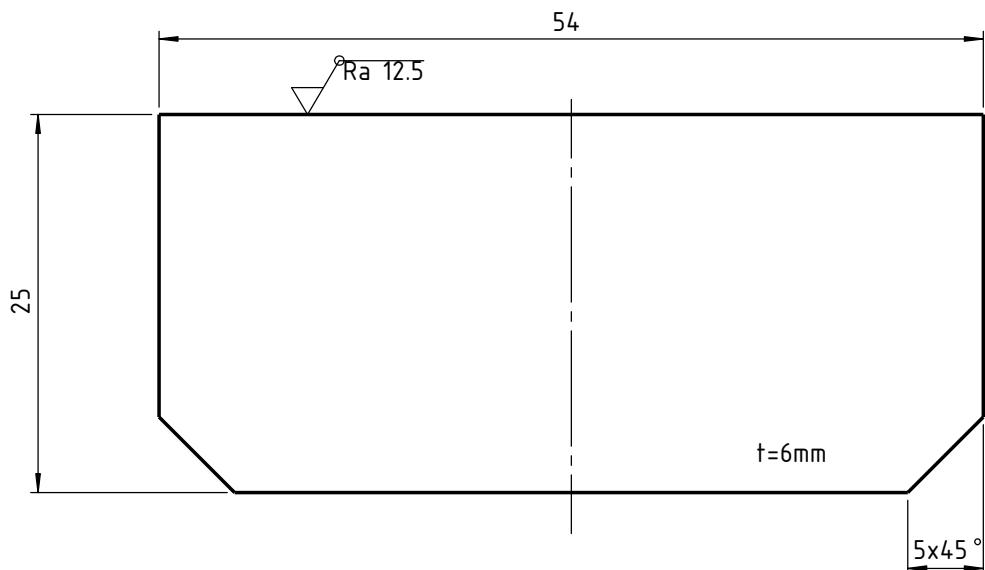
NAPOMENA:  
Vijak M16x30 DIN EN 24017 s provrtom  $\phi$  8 mm

✓ / Ra 25

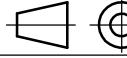


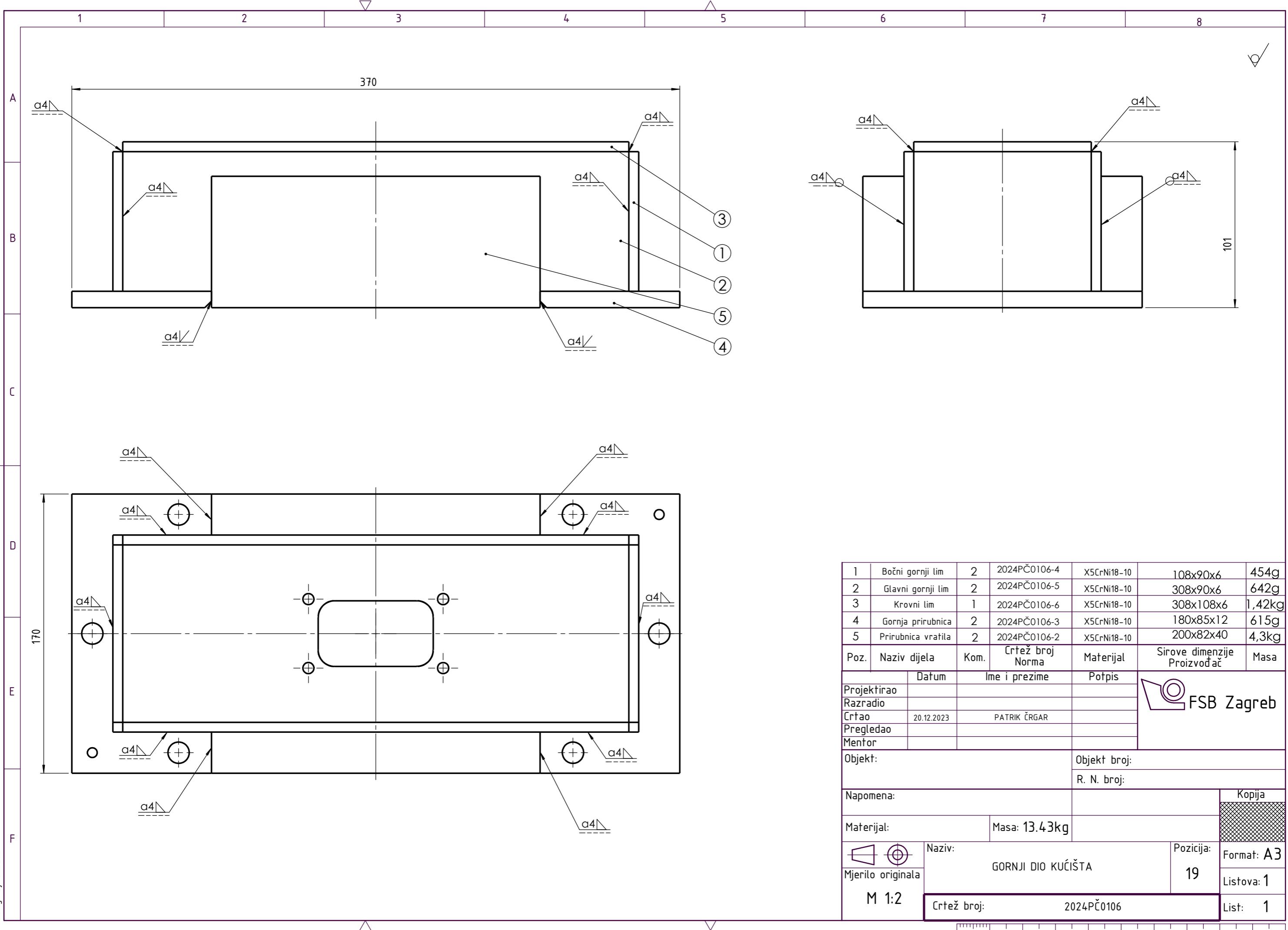
Broj naziva - code		Datum	Ime i prezime	Potpis	 FSB Zagreb		
		Projektirao					
		Razradio					
		Črtao	07.01.2024	PATRIK ČRGAR			
		Pregledao					
ISO - tolerancije		Objekt:		Objekt broj:			
$\phi$ 8H11		+0,090					
		0		R. N. broj:			
		Napomena:			Kopija		
		Materijal:		Masa:			
			Naziv:				
			M16X30				
		Mjerilo originala	Pozicija:		Format: A4		
		M2:1	8		Listova: 1		
		Crtanje broj:			List: 1		
Crtanje broj: 2024PC0101-8							

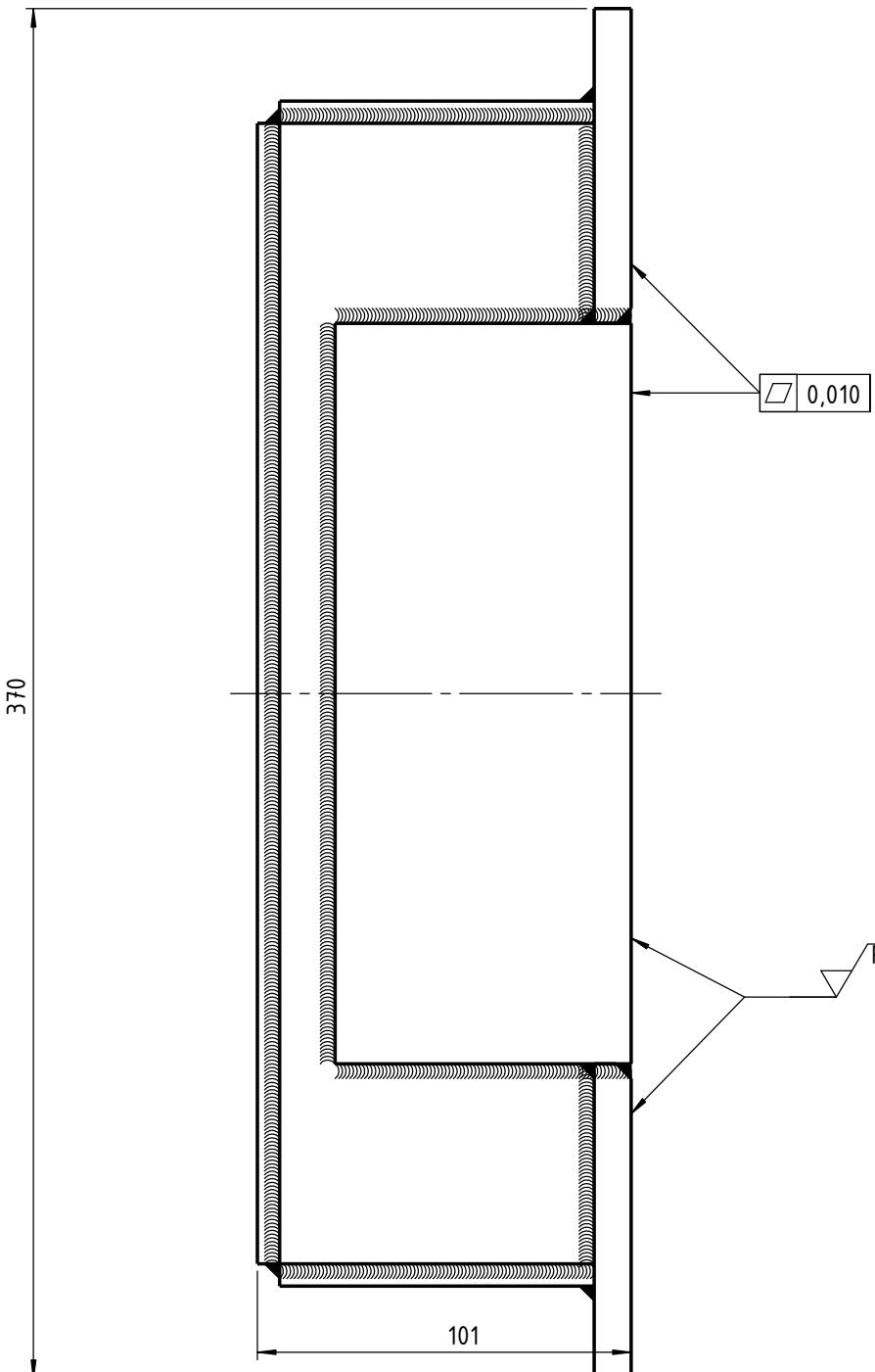
✓ Ra 12.5



10.5

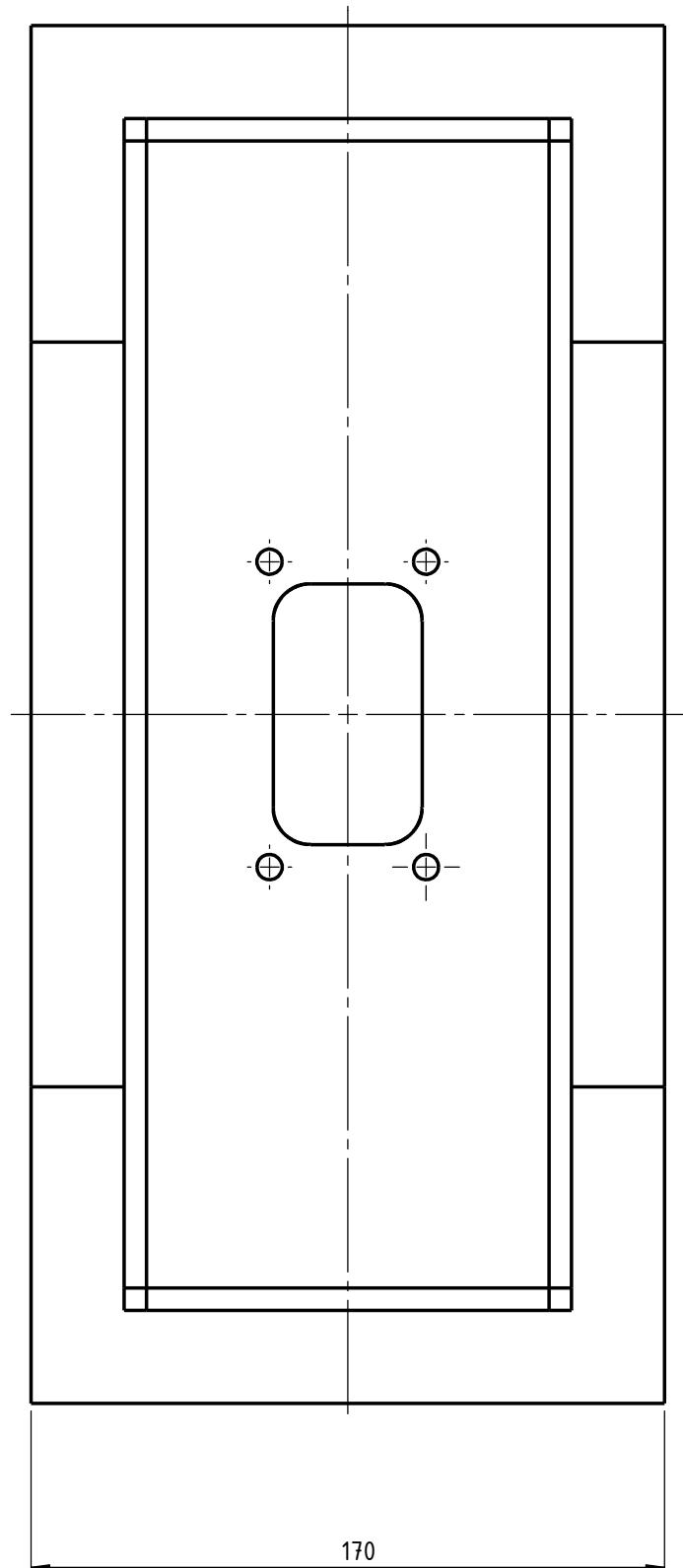
Projektirao	Datum	Ime i prezime	Potpis	 FSB Zagreb
Razradio				
Črtao	07.01.2024	PATRIK ČRGAR		
Pregledao				
Objekt:		Objekt broj:		
		R. N. broj:		
Napomena:				Kopija
Materijal:	X5CrNi18-10	Masa:	63g	
	Naziv:	REBRO	Pozicija:	Format: A4
Mjerilo originala			12	Listova: 1
M2:1	Crtanje broj:	2024PČ0101-3		List: 1



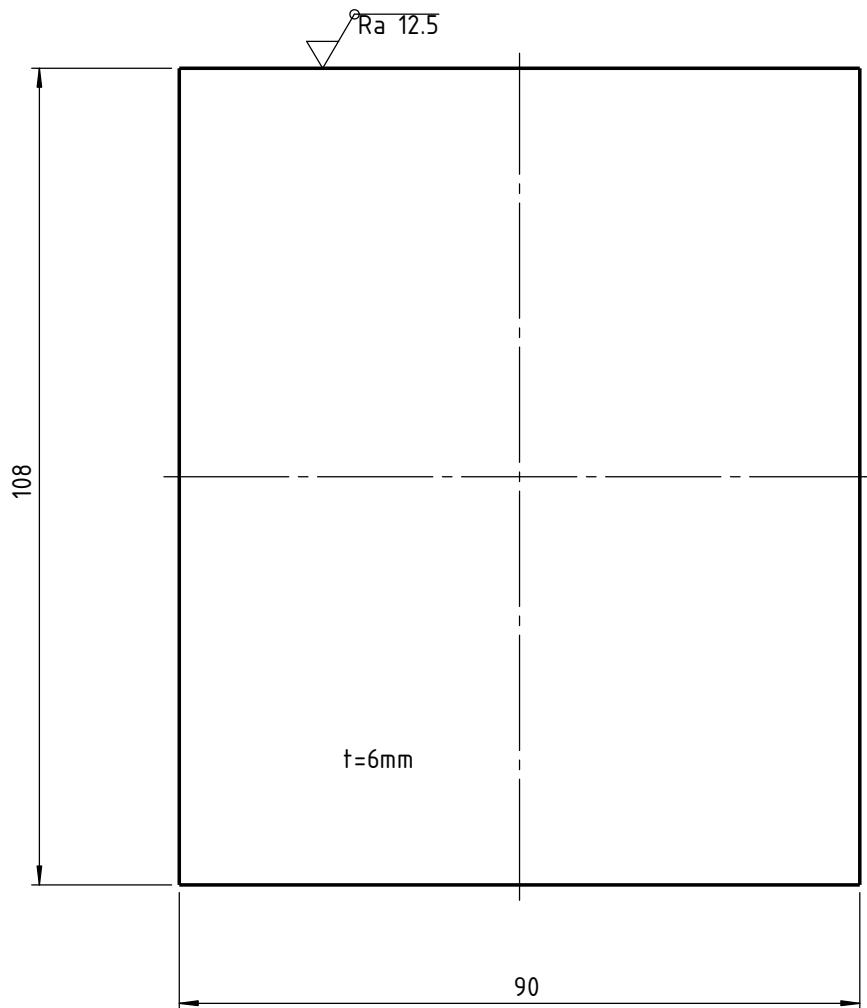


Datum	Ime i prezime	Potpis	FSB Zagreb
Projektirao			
Razradio			
Črtao	07.01.2024	PATRIK ČRGAR	
Pregledao			
Objekt:		Objekt broj:	
		R. N. broj:	
Napomena:			Kopija
Materijal:	Masa:		
	Naziv: DODATNA OBRADA GORNJEG DIJELA KUĆISTA	Pozicija:	Format: A4
Mjerilo originala			Listova: 2
M1:2	Crtanje broj: 2024PČ0106.1		List: 1

✓ / Ra 0.4



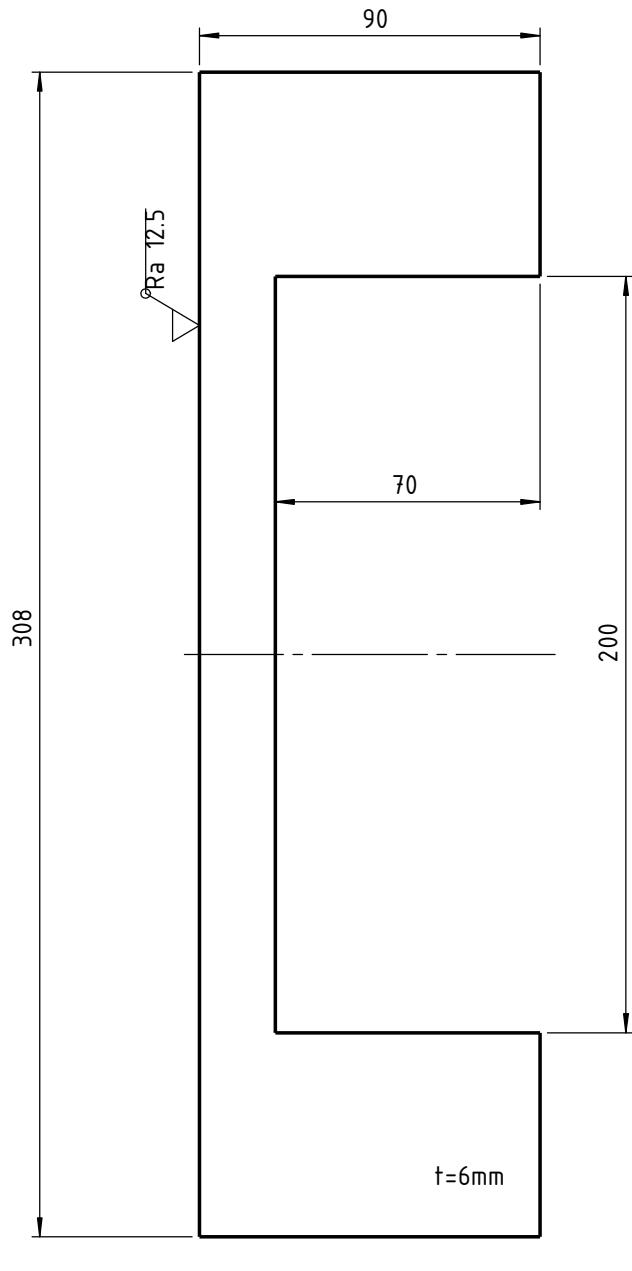
✓ Ra 12.5



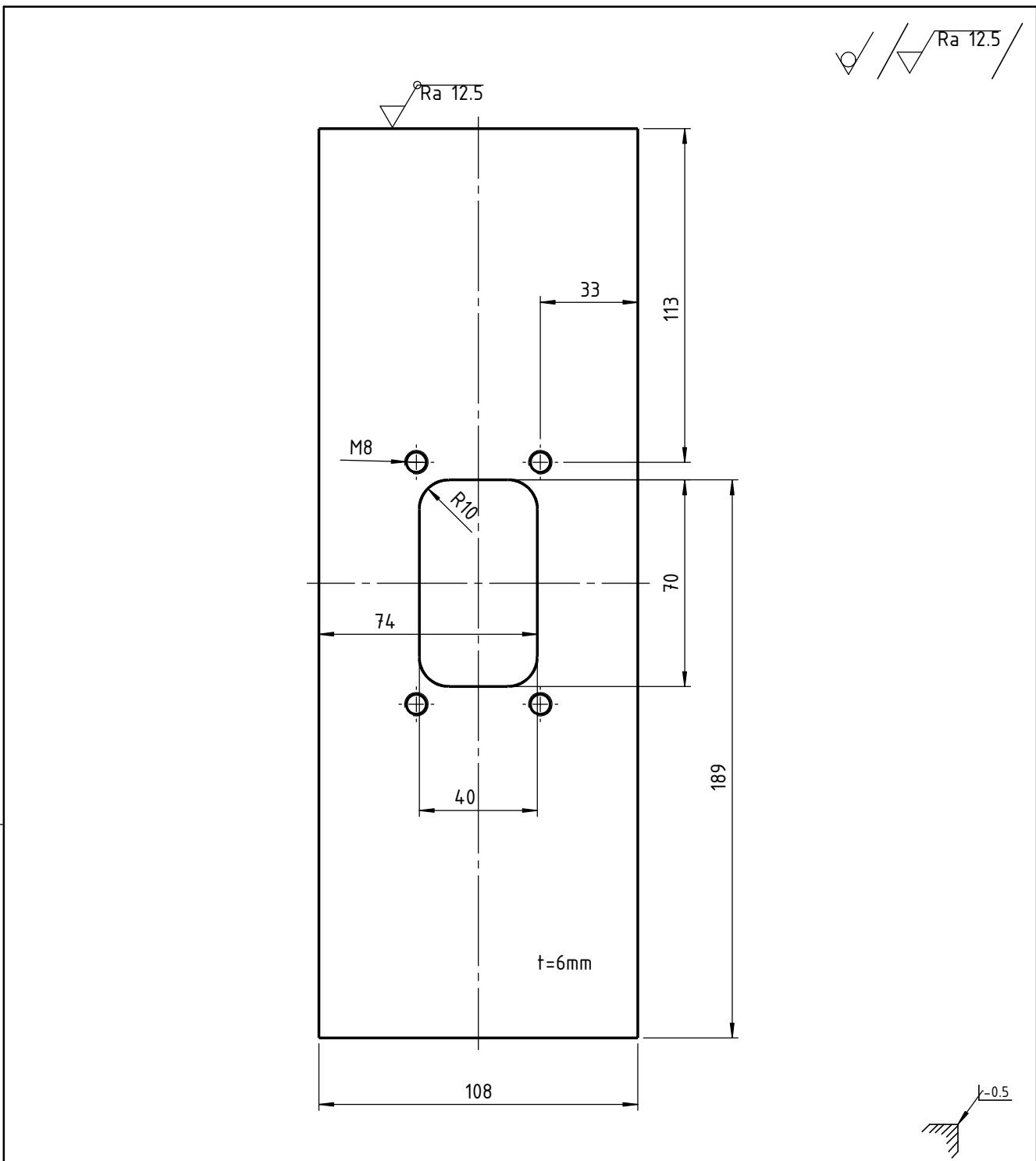
l<sup>0.5</sup>

Projektirao	Datum	Ime i prezime	Potpis	FSB Zagreb
Razradio				
Črtao	07.01.2024	PATRIK ČRGAR		
Pregledao				
Objekt:		Objekt broj:		
		R. N. broj:		
Napomena:				Kopija
Materijal:	X5CrNi18-10	Masa:	454g	
	Naziv:	BOČNI LIM	Pozicija:	Format:A4
Mjerilo originala			1	Listova: 1
M1:1	Crtanje broj:	2024PČ0106-4		List: 1

✓ / ✓ Ra 12.5 /



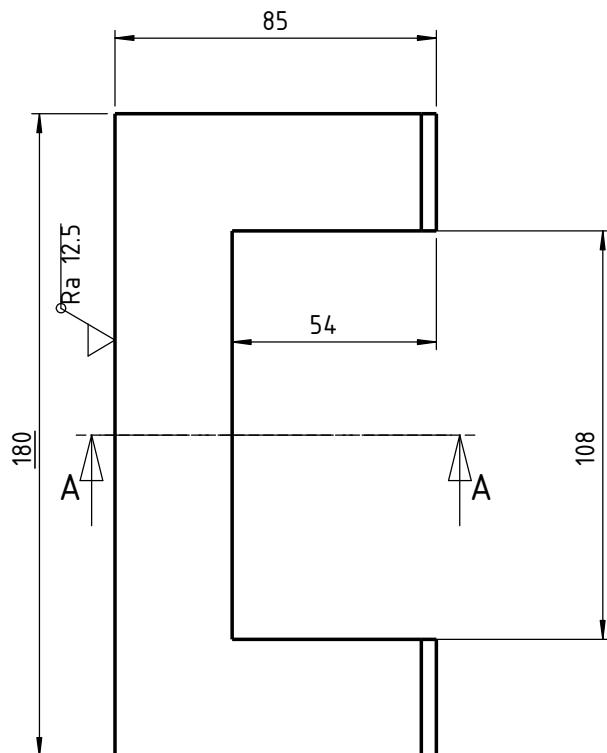
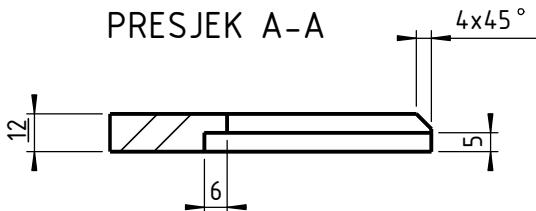
Broj naziva - code	Datum	Ime i prezime	Potpis	 FSB Zagreb
	Projektirao			
	Razradio			
	Črtao	07.01.2024	PATRIK ČRGAR	
	Pregledao			
ISO - tolerancije	Objekt:	Objekt broj:		
		R. N. broj:		
	Napomena:			Kopija
	Materijal: X5CrNi18-10	Masa: 642g		
Design by CADlab	Mjerilo originala	Naziv: GLAVNI LIM	Pozicija: 2	Format:A4 Listova: 1
	M1:2	Crtanje broj: 2024PČ0106-5		List: 1



Broj naziva - code	Datum	Ime i prezime	Potpis	 FSB Zagreb
	Projektirao			
	Razradio			
	Črtao	07.01.2024	PATRIK ČRVAR	
	Pregledao			
ISO - tolerancije	Objekt:		Objekt broj:	
			R. N. broj:	
	Napomena:			Kopija
	Materijal: X5CrNi18-10	Masa: 1.42kg		
	 Naziv: Mjerilo originala	KROVNI LIM	Pozicija: 3	Format:A4 Listova: 1
Design by CADLab	M1:2	Crtež broj: 2024PČ0106-6		List: 1

✓ / Ra 12.5 /

PRESJEK A-A



±0.5 ±0.5

Broj naziva - code

Datum

Ime i prezime

Potpis

Projektirao

Razradio

Črtao

Pregledao

07.01.2024

PATRIK ČRVAR



FSB Zagreb

ISO - tolerancije

Objekt:

Objekt broj:

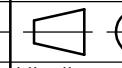
R. N. broj:

Napomena:

Materijal: X5CrNi18-10

Masa: 615g

Kopija



Mjerilo originala

Naziv:

GORNJA PRIRUBNICA

Pozicija:  
4

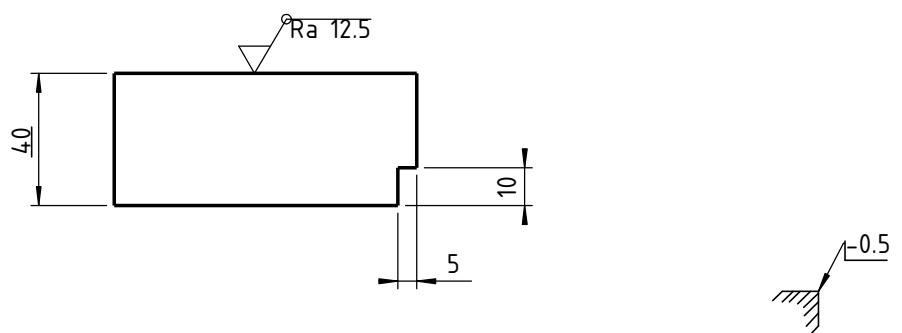
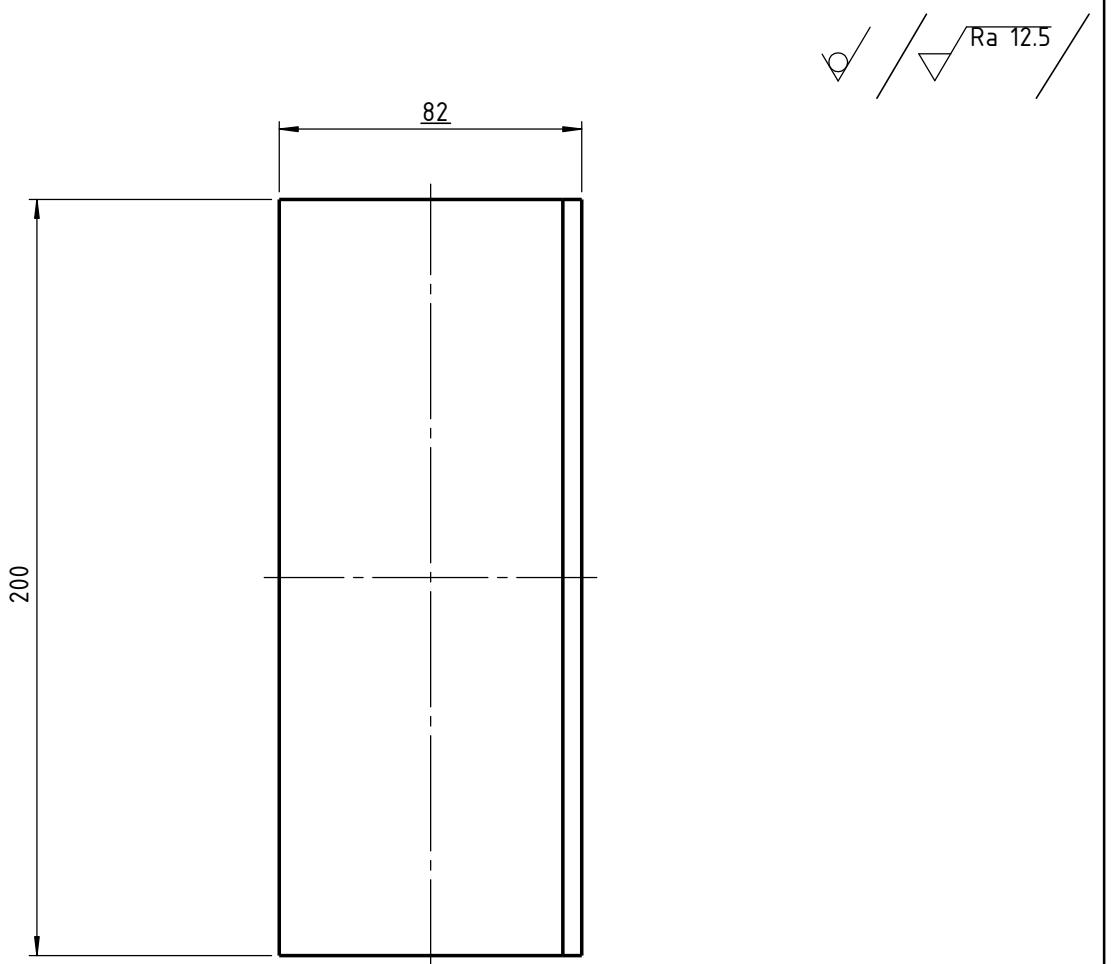
Format:A4  
Listova: 1

M1:2

Crtež broj:

2024PČ0106-3

List: 1



Projektirao	Datum	Ime i prezime	Potpis	 FSB Zagreb
Razradio				
Črtao	07.01.2024	PATRIK ČRVAR		
Pregledao				
Objekt:		Objekt broj:		
		R. N. broj:		
Napomena:				Kopija
Materijal:	X5CrNi18-10	Masa:	4.3kg	
	Naziv:	PRIRUBNICA VRATILA	Pozicija:	
Mjerilo originala			5	Format:A4
M1:1	Crtanje broj:	2024PČ0106-2		Listova: 1
				List: 1

A

E

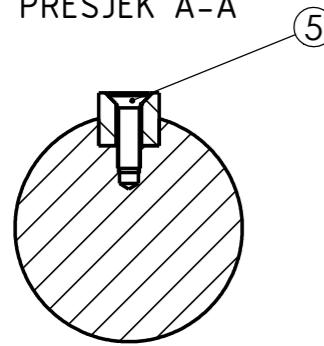
1

1

5

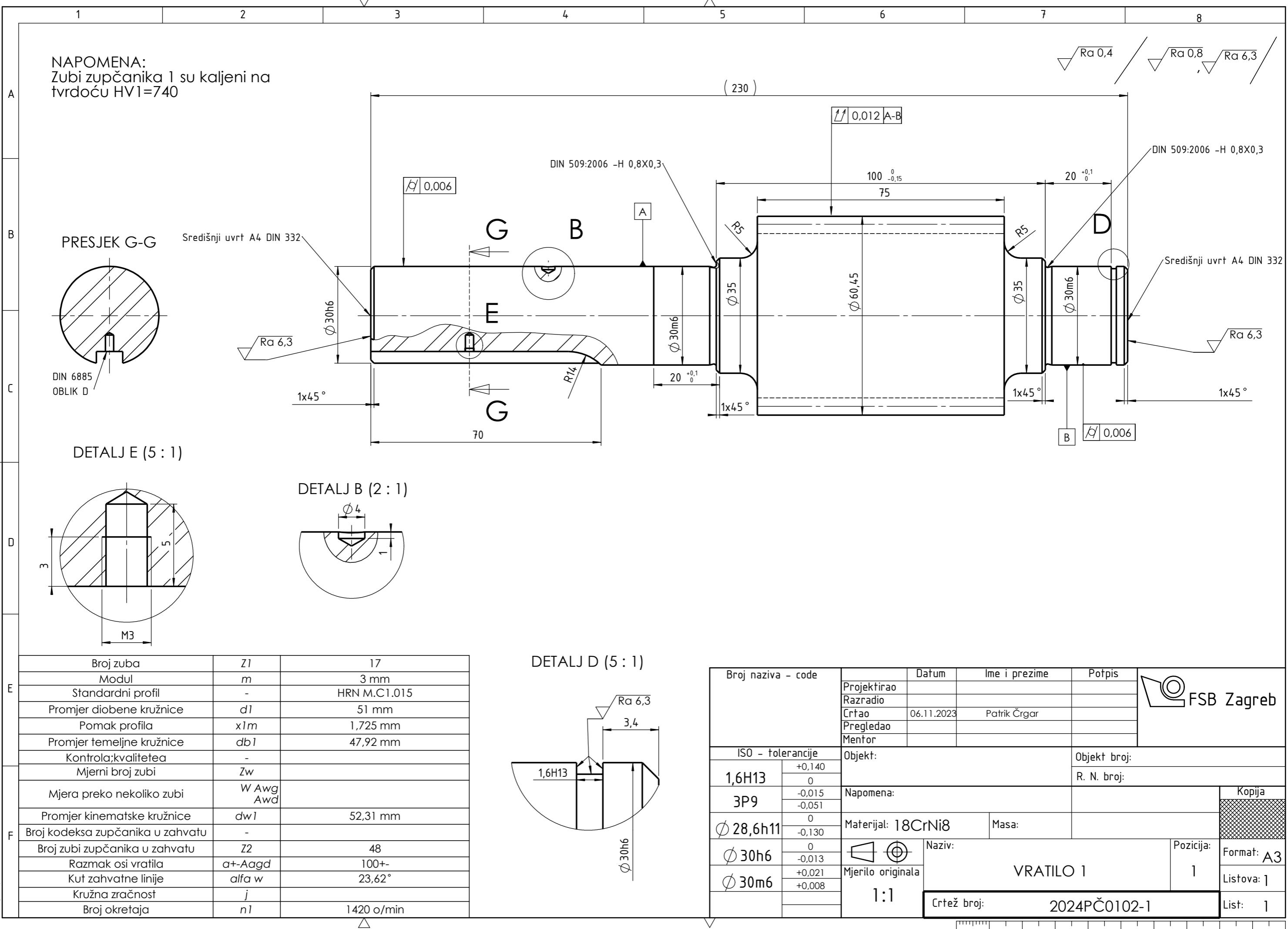
卷之三

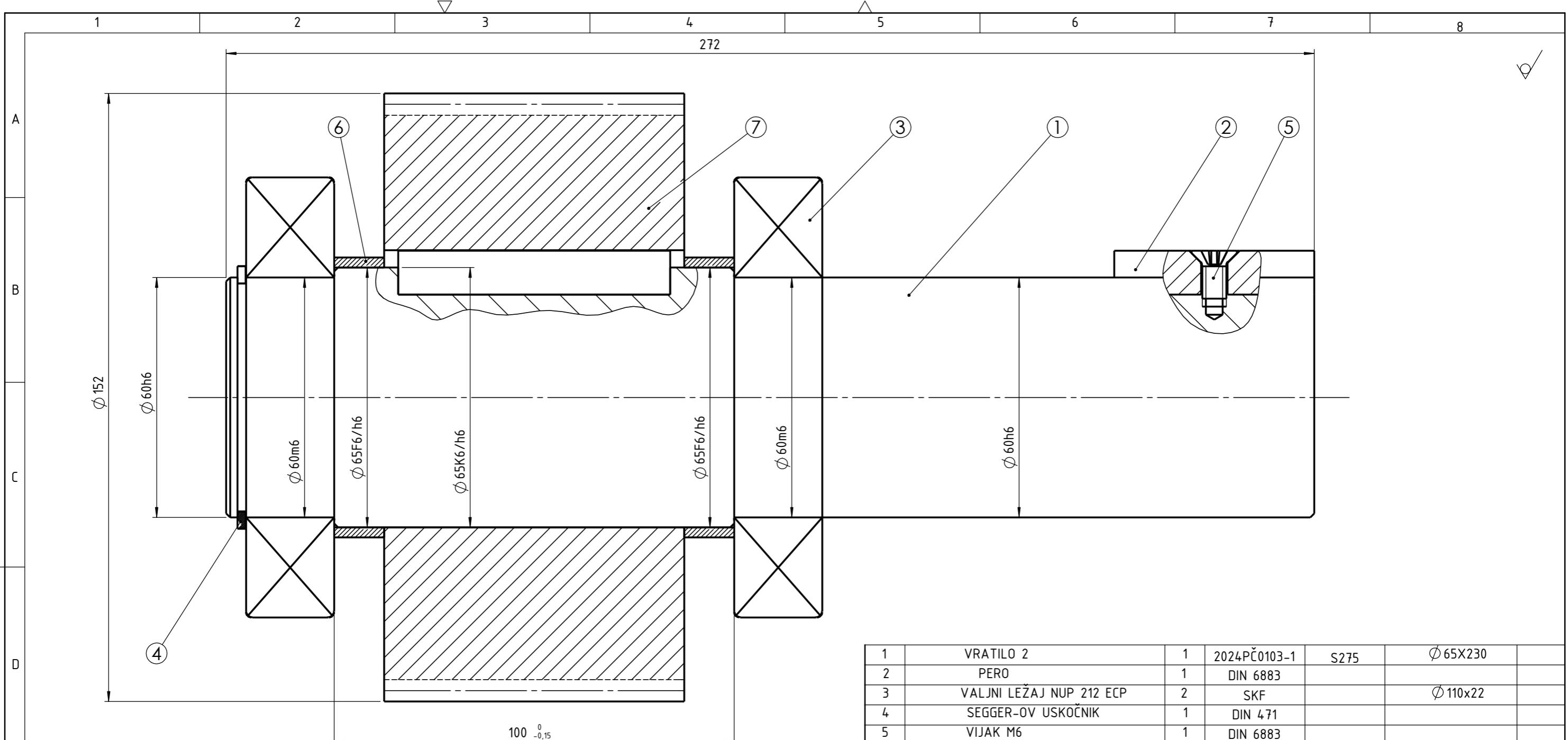
PRESJEK A-A

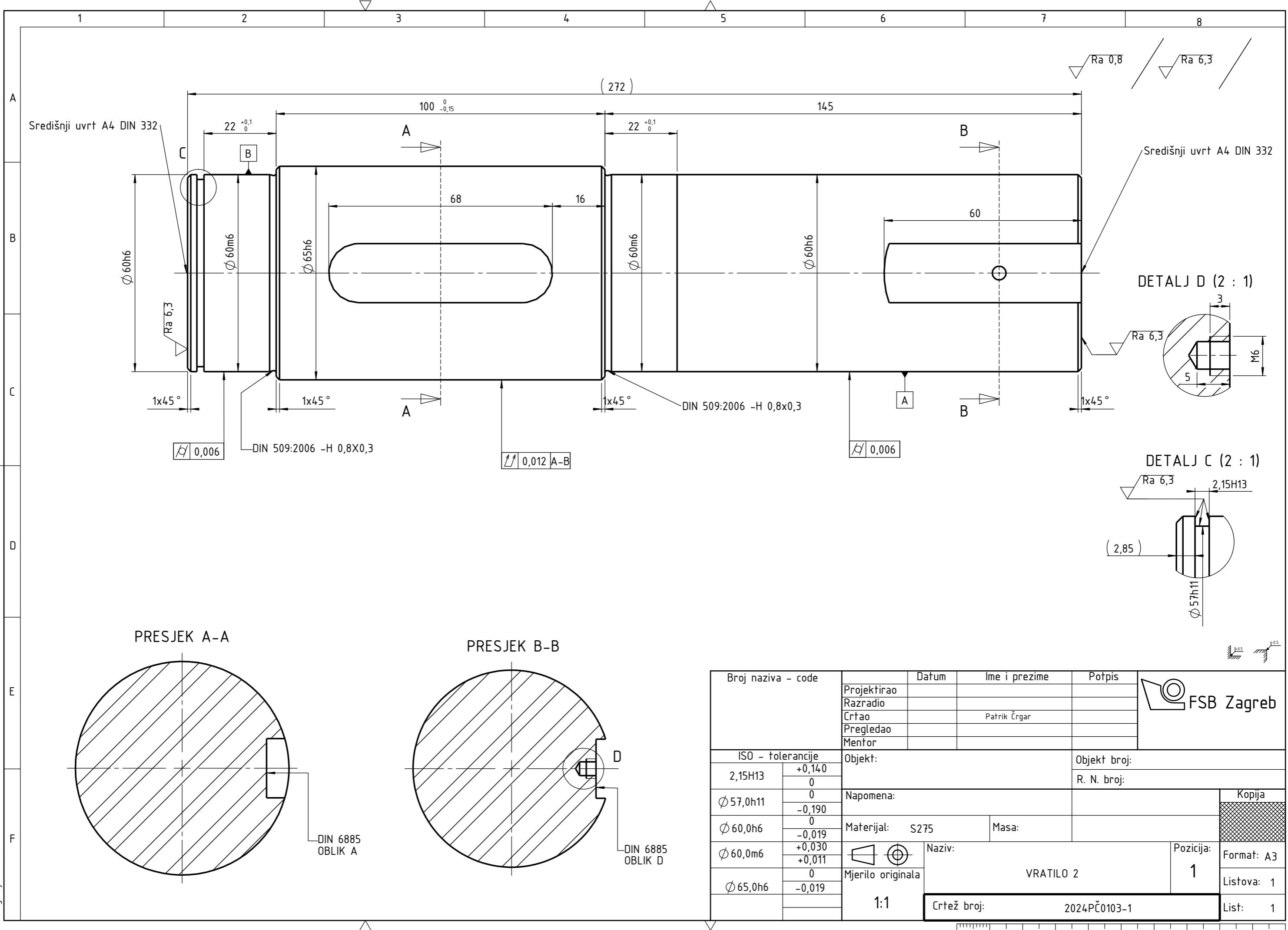


This technical drawing shows a cross-section of a mechanical assembly, specifically section A-A. The diagram illustrates a central vertical column with various features. At the top left, a horizontal slot has a width of  $\phi 30\text{h}6$ . To the right of this slot, there are two vertical sections, each containing a stepped bearing housing. Each housing has an outer diameter of  $\phi 30\text{m}6$  and an inner bore diameter of  $\phi 28,6\text{h}11$ . Between these two sections is a large rectangular housing with a bore diameter of  $\phi 60,45\text{h}6$ . A horizontal dimension line at the bottom indicates a total width of 100, with a tolerance of  ${}^0_{-0,15}$ . The overall height of the assembly is  $\phi 30\text{h}6$ .

1	VRATILO 1	1	2024PČ0102-1	18CrNi8	∅ 65X230			
2	PERO	1	DIN 6883					
3	VALJNI LEŽAJ NUP 2206	2	SKF					
4	SEGGER-OV USKOČNIK	1						
5	VIJAK M3	1	DIN 6883					
Poz.	Naziv dijela	Kom.	Crtež broj Norma	Materijal	Sirove dimenzije Proizvodjač	Masa		
Broj naziva - code		Datum	Ime i prezime	Potpis	 FSB Zagreb			
	Projektirao							
	Razradio							
	Črtao	08.01.2024	PATRIK ČRGAR					
	Pregledao							
	Mentor							
ISO - tolerancije		Objekt:		Objekt broj:				
∅ 28,6h11	0			R. N. broj:				
	-0,130							
∅ 30h6	0	Napomena:				Kopija		
	-0,013							
∅ 30m6	+0,021	Materijal:		Masa:				
	+0,008							
∅ 60,45h6	0	 	Naziv:		Pozicija:	Format: A3		
	-0,019				2			
		Mjerilo originala	PODSKLOP VRATILA 1			Listova: 1		
		M1:1	Crtež broj:	2024PČ0102	List: 1			



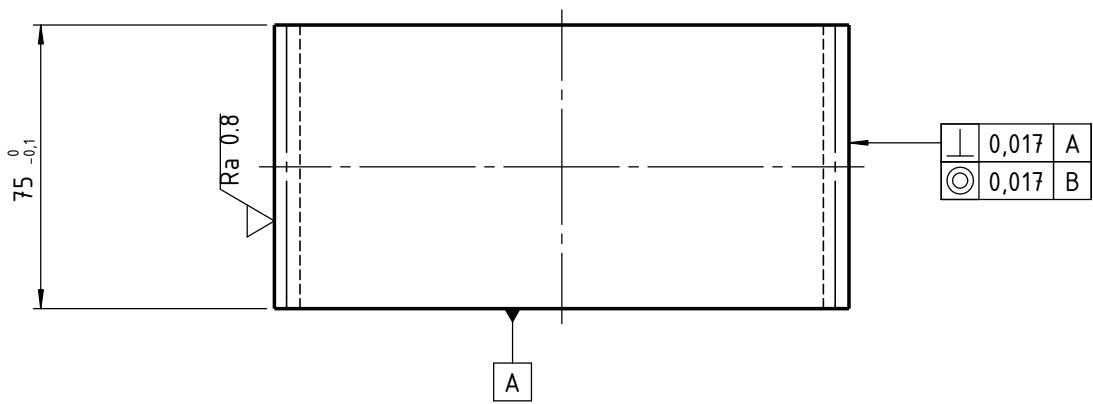
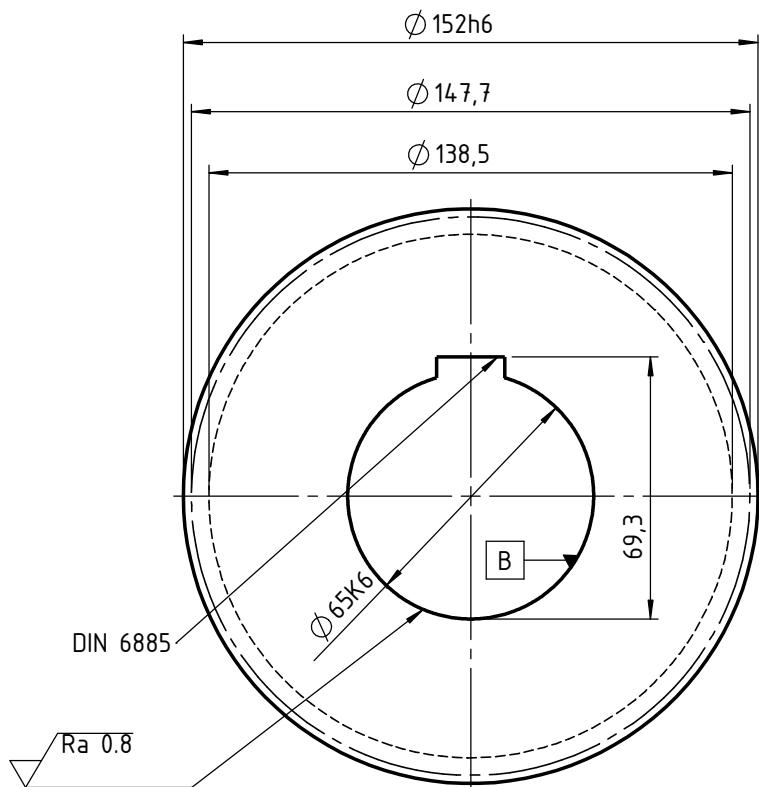




Design by CADLab

NAPOMENA:  
Zubi zakaljeni na HV10=185

Ra 6.3 Ra 0.8



Broj naziva - code

Datum

Ime i prezime

Potpis

Projektirao

Razradio

Crtao 08.01.2024 PATRIK ČRGAR

Pregledao



FSB Zagreb

ISO - tolerancije

Objekt:

Objekt broj:

$\phi 65,0\text{k}6$  +0,004  
-0,015

R. N. broj:

$\phi 152,0\text{h}6$  0  
-0,025

Napomena:

Kopija

Materijal: 18CrNi8 Masa: 9.36kg

Naziv: ZUPČANIK 2

Pozicija: 7

Mjerilo originala

Format: A4

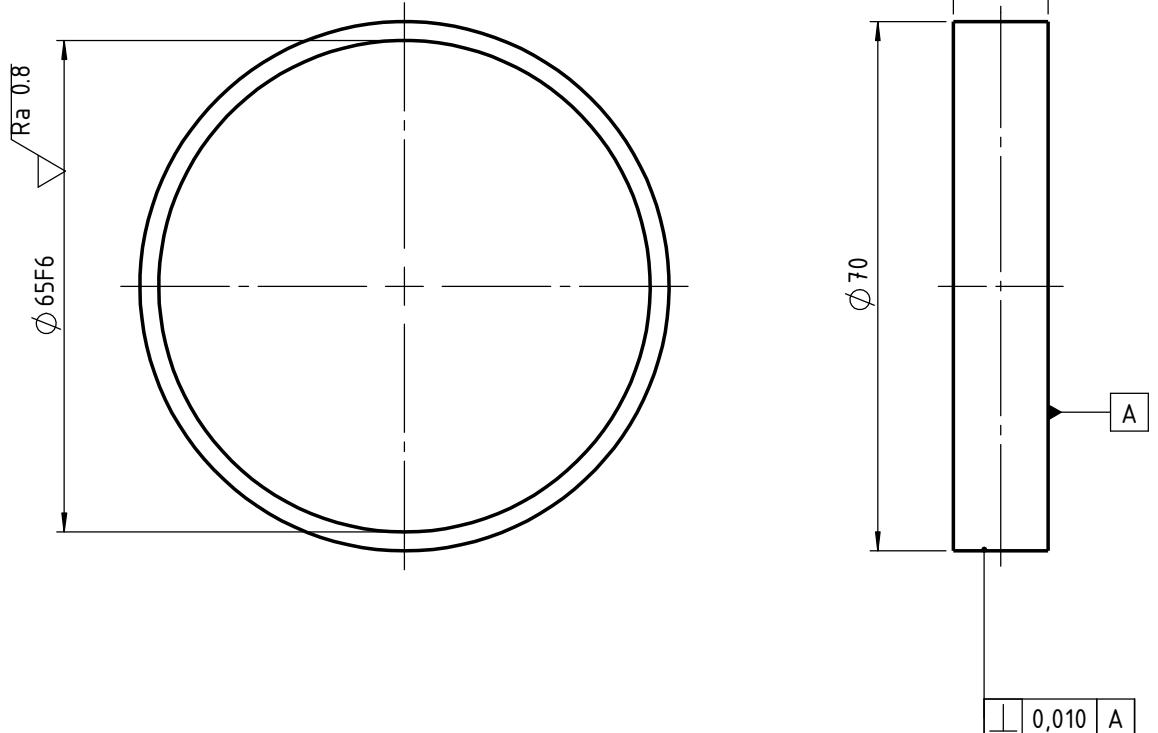
M1:2

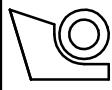
Crtež broj: 2024PČ0103-2

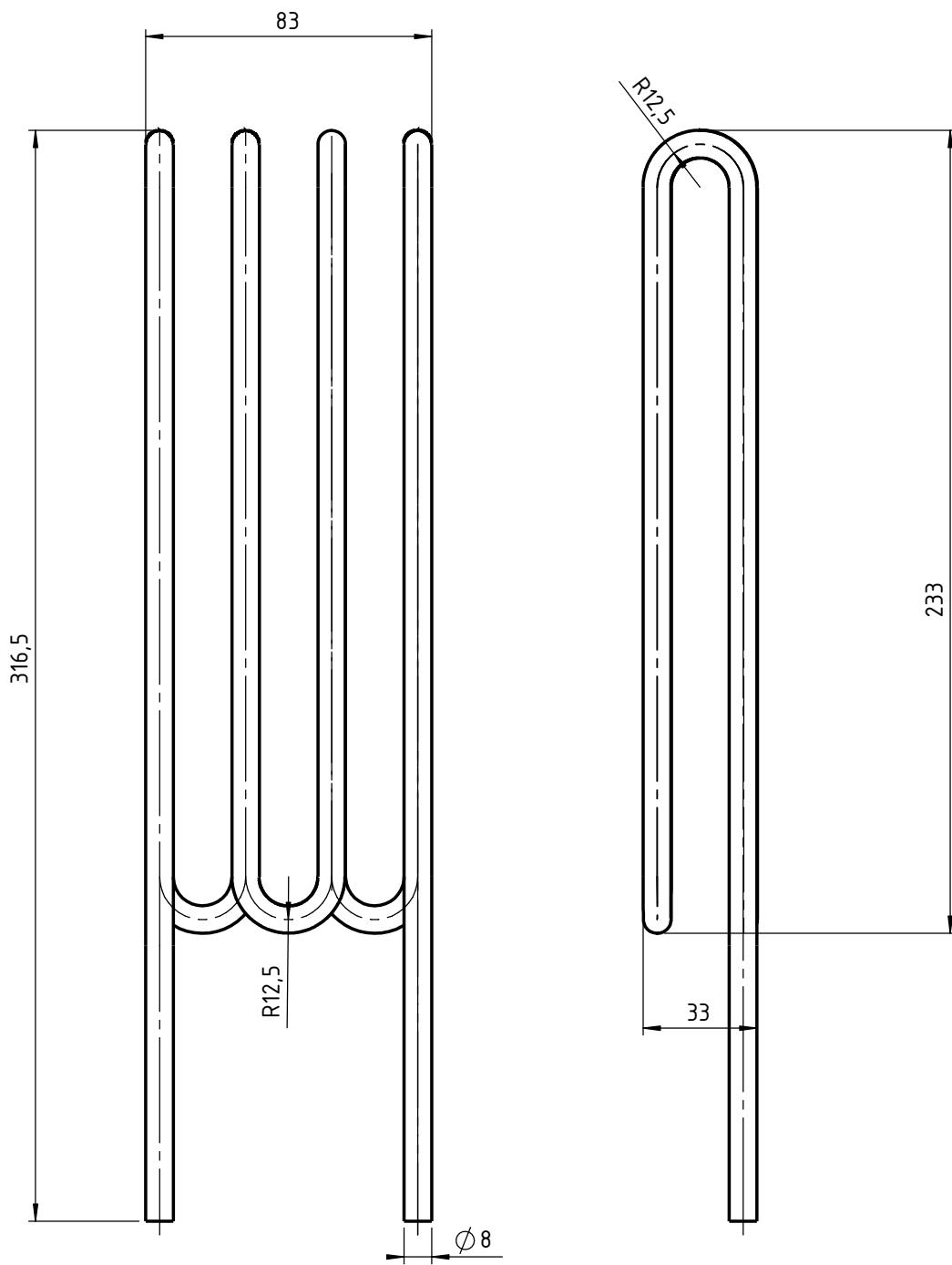
Listova: 2

List: 1

Broj zuba	$z_2$	48
Modul	$m$	3 mm
Standardni profil	-	HRN M.C1.015
Promjer diobene kružnice	$d_2$	144mm
Pomak profila	$x_2m$	0,993mm
Promjer temeljne kružnice	$db_2$	135,32mm
Kontrola;kvalitetea	-	
Mjerni broj zubi	$Z_w$	
Mjera preko nekoliko zubi	$W_{Awg}$ $Awd$	
Promjer kinematske kružnice	$d_{w2}$	147,69mm
Broj kodeksa zupčanika u zahvatu	-	
Broj zubi zupčanika u zahvatu	$Z_1$	17
Razmak osi vratila	$a+A_{Agd}$	100+-
Kut zahvatne linije	$\alpha_{fa w}$	23,62°
Kružna zračnost	$j$	
Broj okretaja	$n_2$	502,83 o/min

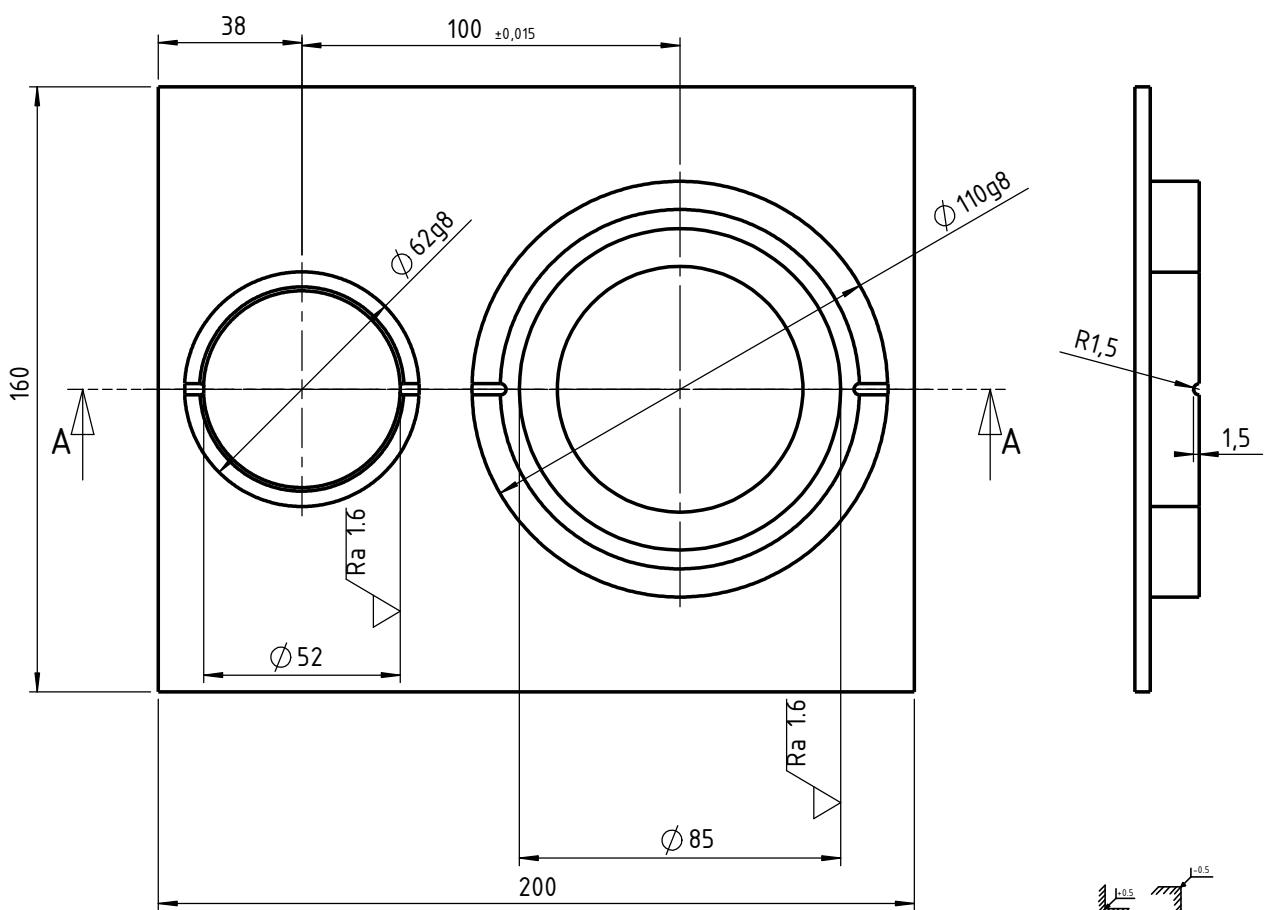
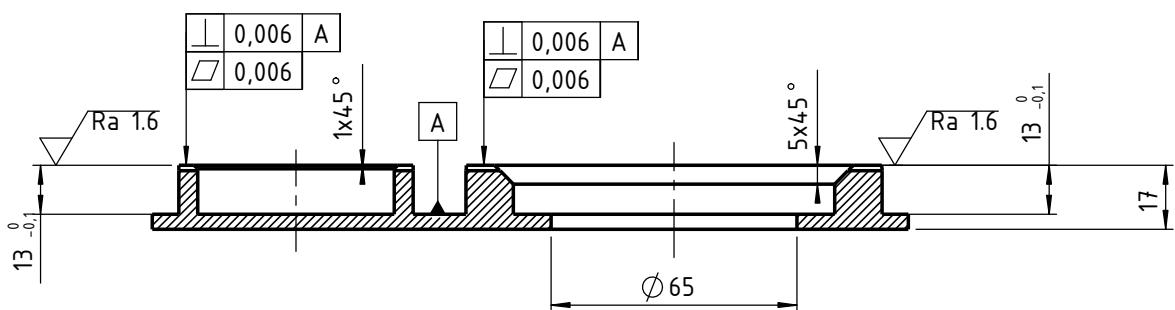


Broj naziva - code		Datum	Ime i prezime	Potpis	 FSB Zagreb	
		Projektirao				
		Razradio				
		Črtao	06.01.2024	PATRIK ČRGAR		
		Pregledao				
ISO - tolerancije		Objekt:		Objekt broj:		
		+0,049				
		+0,030				
		Napomena:				
		Materijal: S235		Masa: 52g		
		 Mjerilo originala M1:1	Naziv: DISTANTNI PRSTEN		Pozicija: 6  Format: A4 Listova: 1 List: 1	
			Crtanje broj: 2024PČ0103-4			



Projektirao	Datum	Ime i prezime	Potpis	FSB Zagreb
Razradio				
Črtao	06.01.2024	PATRIK ČRGAR		
Pregledao				
Objekt:		Objekt broj:		
		R. N. broj:		
Napomena:				Kopija
Materijal:	CuCr1Zr	Masa:	406g	
	Naziv:		Pozicija:	Format: A4
Mjerilo originala		CJEVNI REGISTAR	6	Listova: 1
M1:2	Crtež broj:	2024PČ0104		List: 1

### PRESJEK A-A



Broj naziva - code

Datum

Ime i prezime

Potpis

Projektirao

Razradio

Črtao

Pregledao

06.01.2024

PATRIK ČRGAR



FSB Zagreb

ISO - tolerancije

Ø 62g8

-0.010

-0.056

Ø 110g8

-0.012

-0.066

Objekt:

Objekt broj:

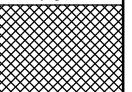
R. N. broj:

Napomena:

Materijal: S235

Masa: 1.42kg

Kopija



Mjerilo originala

M1:2

Naziv:

POKLOPAC VRATILA PREDNJI

4

Format: A4

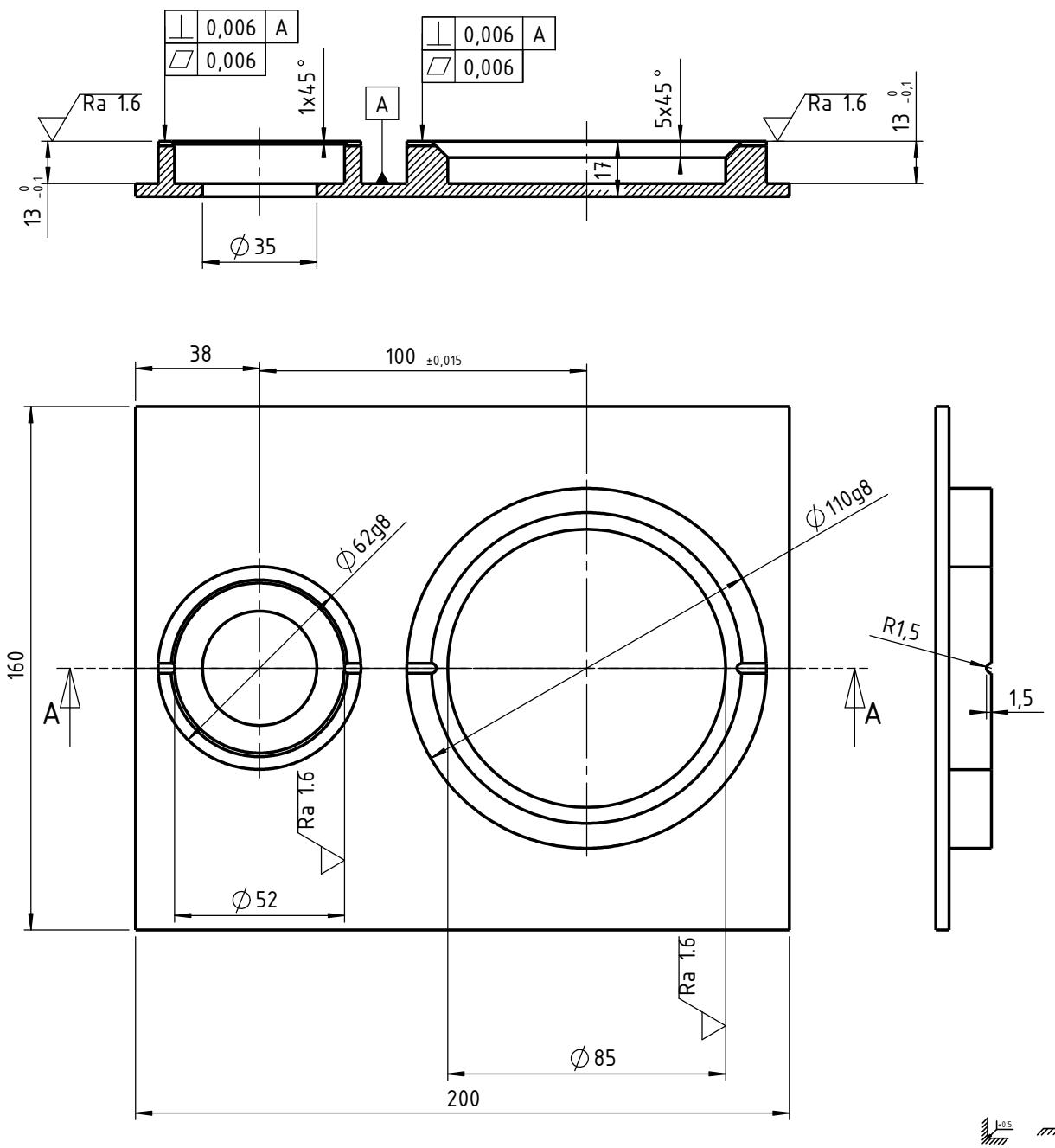
Listova: 1

Crtež broj:

2024PČ0107

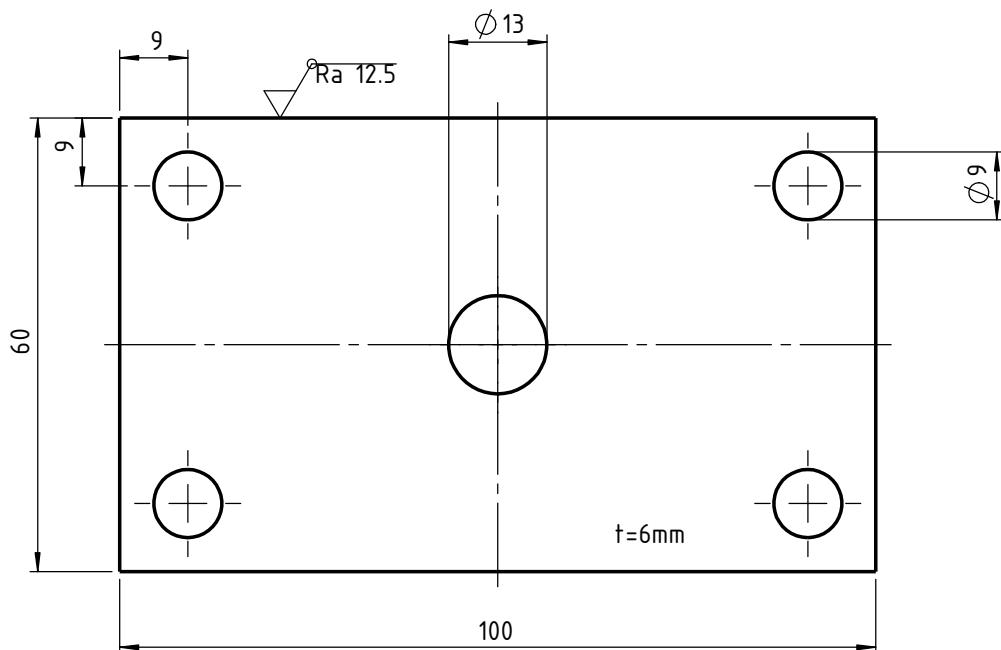
List: 1

## PRESJEK A-A

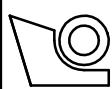


Broj naziva - code			Datum	Ime i prezime	Potpis	 FSB Zagreb
		Projektirao				
		Razradio				
		Črtao	06.01.2024	PATRIK ČRGAR		
		Pregledao				
ISO - tolerancije		Objekt:		Objekt broj:		
$\odot 62g8$	-0,010			R. N. broj:		
	-0,056					
$\odot 110g8$	-0,012	Napomena:				Kopija
	-0,066					
		Materijal: S235	Masa: 1.42kg			
		Naziv: POKLOPAC VRATILA STRAŽNIJ			Pozicija: 3	Format: A4
	Mjerilo originala					Listova: 1
	M1:2	Crtež broj: 2024PC0108				List: 1

✓ / Ra 12.5

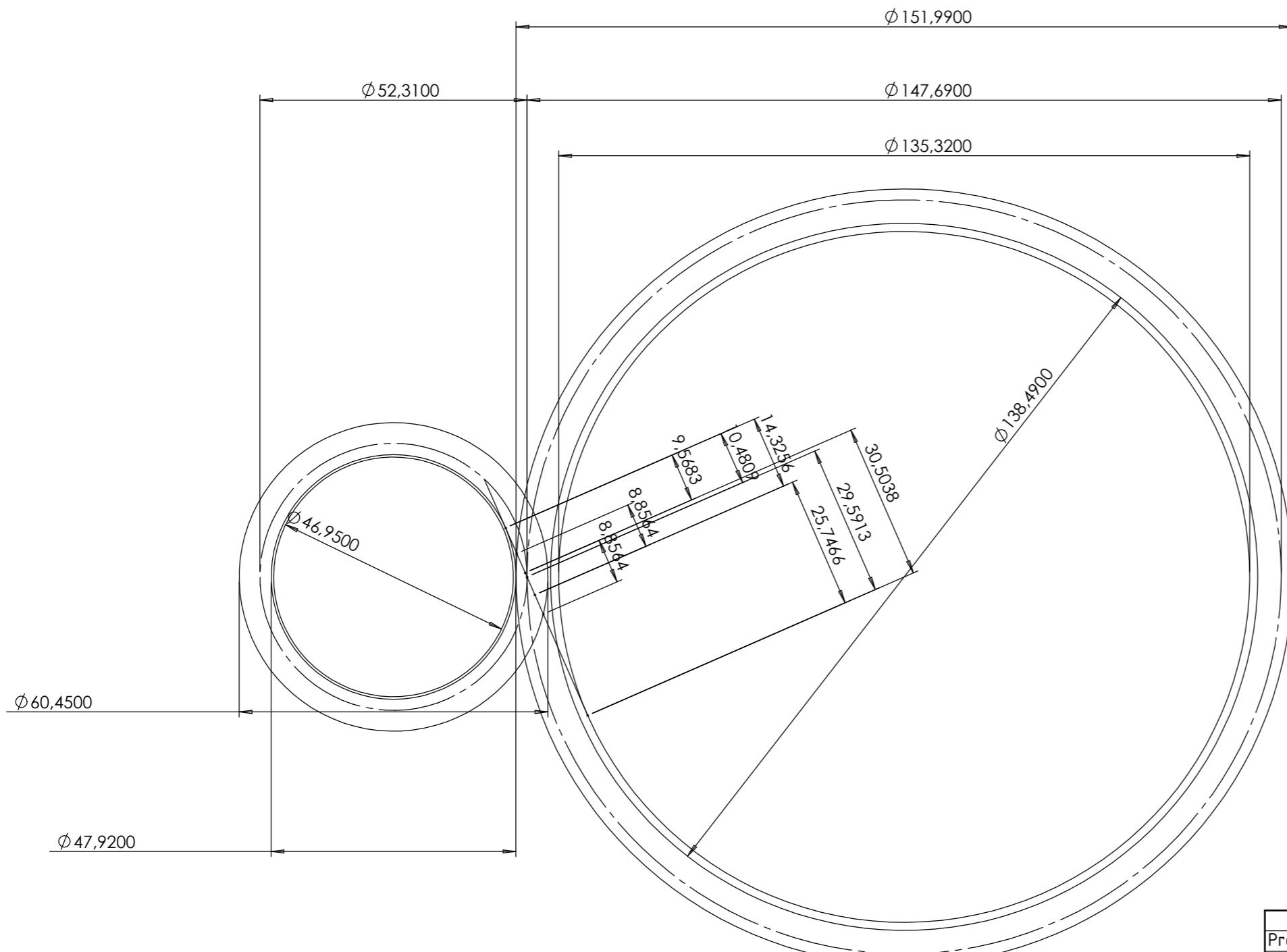


$t^{+0.5}$

Broj naziva - code	Datum	Ime i prezime	Potpis	 FSB Zagreb
	Projektirao			
	Razradio			
	Črtao	07.01.2024	PATRIK ČRGAR	
	Pregledao			
ISO - tolerancije	Objekt:	Objekt broj:		
		R. N. broj:		
	Napomena:			Kopija
	Materijal: X5CrNi18-10	Masa: 175g		
Design by CADLab	 Mjerilo originala M1:1	Naziv: POKLOPAC GORNJI	Pozicija: 13	Format:A4 Listova: 1 List: 1
		Crtanje broj: 2024PC0109		

1 2 3 4 5 6 7 8

A  
B  
C  
D  
E  
F



Projektirao	Datum	Ime i prezime	Potpis
Razradio			
Crtao			
Pregledao			
Mentor			
Objekt:		Objekt broj:	
		R. N. broj:	
Napomena:			Kopija
Materijal:		Masa:	
	Naziv: KONTAKT KRUŽNICA ZUPČANIKA	Pozicija:	Format: A3
Mjerilo originala M1:1			Listova: 1
	Crtež broj: 2024PČ0105		List: 1

Design by CADART

0 10 20 30 40 50 60 70 80 90 100