MAP N°: 40C-350-511

NIEUWE SCHUTSLUIS TE WEURT.

INHOUD MAP 1:

1. Berekening deurbeweging.
2. Belastingscoëfficiënten φ en ψ.
3. Berekening kabelevenaar.
4. Berekeningen onderdelen kabelevenaar.
5. Berekening tussenas met koppeling.
6. Berekening frame machinewerk.
7. Berekening tandwielkast 2A3-110 Spec.(Hoofdmotorgedeelte
8. Berekening tandwielkast 2A3-110 Spec.(Noodmotorgedeelte)
9. Berekening Turboflexkoppeling HBS 6700-8X.

INHOUD ACHTERMAP:

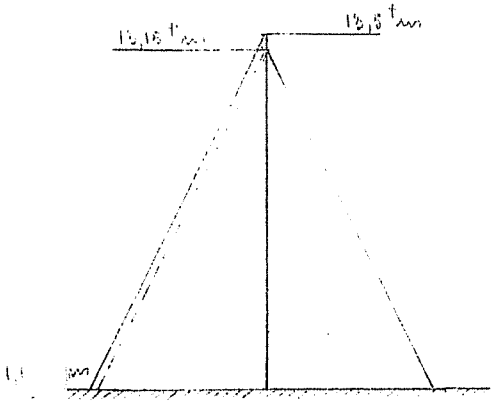
1. Overzicht Waalhoofd.
2. Diversen.

40C-350-511

NIEUWE SCHUTSLUIS TE WEURT.

1. BEREKENING DEURBEWEGING.

1974



Waterdruk op dam:

wand schuin [illegible] = 13,5 t/m

horizontaal schuin = 0,35 "

diepte onderkant = 17 "

Δ = 0,35 kg/cm² = 3,5 t/m²

$F_1 = (13,5 - 1,5) \cdot 17 = 198$ m²

$F_2 = 0,35 \cdot 17 = 5,95$ "

$R_1 = 198 \cdot 0,35 = 69,3$ t

$R_2 = 5,95 \cdot 0,35 \cdot \frac{1}{2} = 1,04$ "

70,34 t

met $\mu = 0,6$

$R_w = 0,6 \cdot 70,34 = 42,2$ t

Volgens K. Kuipers

[illegible] = 5,7 "

47,8 t

opwaartse druk bij close waterstand (13,5 t/m')

opw. druk onderkant = 20 t

" dam = 12,6 "

horizontaal = 11,9 " / 12 = 12 t/m

44,1 "

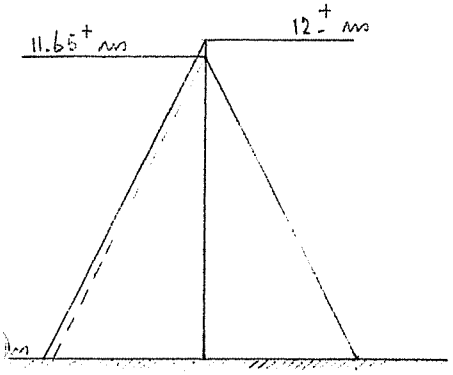
Veiligheid door waterdruk = 47,8 t

opw. druk = 44,1 "

blijft 3,7 "

bg schuifpad : 12⁺ mv (1x per 2 jaar)
Min. aanw. schuif : 0,35 mv

$\Delta p = 0{,}35\ t/m^2$



$F_1 = (11{,}65 - 1{,}5) \cdot 17 = 172{,}55\ m^3$
$F_2 = 0{,}35 \cdot 17 = 5{,}95$ "

$P_1 = 172{,}55 \cdot 0{,}35 = 60{,}39\ t$
$P_2 = 5{,}95 \cdot 0{,}35 \cdot \frac{1}{2} = 1{,}04$ "
61,43 "

Inv. $\mu = 0{,}6$
$P_{\mu} = 0{,}6 \cdot 61{,}43 = 36{,}9\ t$
wandgewicht 5,6 "
42,5 "

opwaartse druk bg 12⁺ mv
opw. druk fundering ca. 1
druk 12,6 "
32,6 "

Totaal kracht door waterdruk 42,5 t
toe. druk 32,6 "
blijft 9,9 "

Nodig tov 13⁺ mv : 9,9 - 3,7 = 5,2 t.

grond dicht waterstand
0,20 m 110 m/s ... [illegible]
[illegible]

$F_1 = (8,2 - 1,5) \cdot 17 = 113,9\ m^2$ $P_1 = 113,9 \cdot 0,35 = 39,87$
$F_2 = 3,95$ " $P_2 = 1,04$
40,91

$R_{[illegible]} = 0,6 \cdot 40,91 = 24,5$ t
wand [illegible] 5,6 "
30,1 "

[illegible] 20 t
dan [illegible] · 10,6 = 8 "
= 28 "

Verschil trekkracht [illegible]
30,1 - 28 = 2,1 t

[illegible] 2,1 t
dus verschillen in [illegible] geeft weinig
verschil in trekkracht aan dan.

H = 400 ft

$\lambda_{WS} = 71{,}62 \cdot \frac{H^{0,2}}{T^{0,6}} = 19{,}1$ ft

$\frac{21{,}6}{19{,}1} = 1{,}6$ Anodig koppel

Aanvaardbaar $\lambda_{WS} = 24{,}2 + 7{,}4 = 21{,}6$ ft/sec

Aantal $H = 450$ ft

$\lambda_1 = 1{,}1 \cdot 19{,}1$ ft/sec

$\lambda_1 = 71{,}62 \cdot \frac{H^{0,2}}{T^{0,6}} = 21{,}1$ ft/sec

$\frac{31{,}4}{21{,}1} = 1{,}43$ Aanvaardbaar koppel

Aantal Aanvaardbaar aanvaardbaar, dan is optie

en ongeveer, 1,5 Aanvaardbaar koppel Aanvaardbaar

Motor:

$n = 4150$ 1/min

$M = 1460$ /min

$M_1 = 9{,}55 \cdot \frac{4150}{1460} = 22{,}1$ Nm

Kegelrad: $i = 2{,}1$

$d_{m1} = 2{,}8 \cdot 2{,}5 = 4{,}36$ cm

$d_{m1} = 2{,}8$ cm

$m_m = 1{,}6$ mm $z = 16$

$b = 2{,}7$ cm $x_c = 0{,}5$ mm

für Kegelrad $F_{t1} = \frac{2 \cdot 22{,}1}{4{,}36} = 21{,}8$ kg

$P_t = \frac{218}{12{,}8} = 17$ kg

$\sigma_b = \frac{P_t \cdot y_1}{b \cdot m_m} = \frac{17 \cdot 2{,}1}{2{,}7 \cdot 1{,}6} = 8{,}6$ kg/mm²

b_g = Breite, m_m = Modul

(Annahme: $\sigma_b = 10$ kg/mm² zulässig)

Kontaktpressung:

$\sigma_c = 1{,}1 \sqrt{\frac{P_t}{b \cdot d_{m1}} \cdot \frac{i+1}{i}}$

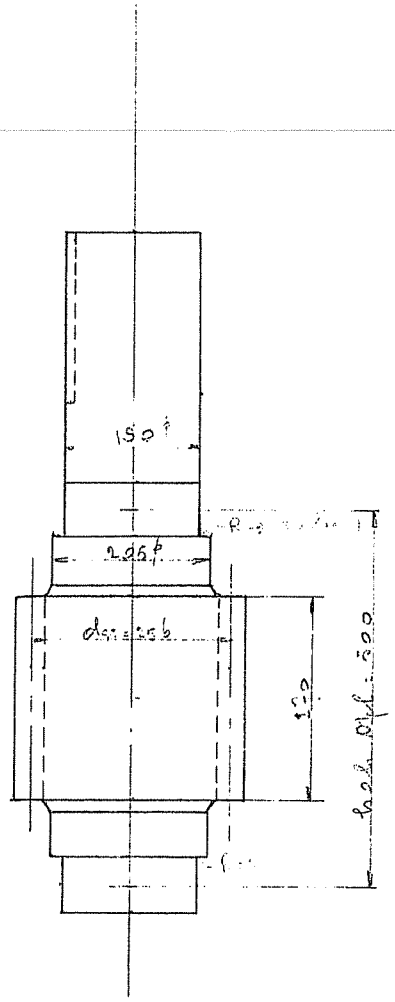
$= 1{,}1 \cdot 1550 \sqrt{\frac{17}{2{,}7 \cdot 2{,}8} \cdot \frac{2{,}1+1}{2{,}1}}$

$= 1{,}1 \cdot 1550 \sqrt{2{,}16 \cdot 1{,}1} = 1{,}1 \cdot 1550 \sqrt{2{,}376}$

$= 1{,}1 \cdot 1550 \cdot 1{,}54 = 8060$ kg/cm²

$n_1 = \frac{1460}{2{,}1} = 69{,}5$ 1/min

$d_{m1} = 6{,}61{,}2$ cm $P_t = 17$ kg



Rondelad:

$M_1 = 218$ t/cm

$P_t = 17$ t/m (kõrgus)

$P_{tg} = 17 \cdot 0{,}35 \cdot 9 = 6{,}15$ t

$\frac{P_t}{F_{rõnga}} = \frac{17}{0{,}9 \cdot 9} = 18{,}1$ t/m²

Ava lõikejõud:

$Q = 1 \cdot (18{,}1 \cdot (2{,}0 - 0{,}75)) \cdot 19{,}05 \cdot 18{,}75 = 218$ t/cm

$d_{ava} = 256$ mm

$W = 0{,}1 \cdot 20{,}5^3 = 1148$ cm³

$\sigma_b = \frac{349}{1148} = 0{,}211$ t/cm² normaalpinge

$\tau_L = \frac{218}{2 \cdot 16{,}1 \cdot 5} = 0{,}066$ " äärepinge

Rõnga lõik:

$\sigma_b = \frac{17 \cdot 3{,}1^2}{2 \cdot 1{,}2} = 0{,}849$ t/cm²

äärepinge $\tau = \frac{Q}{F_{lõik}} \cdot \frac{1}{2}$

Ava nõrgendatud

$F_{nõrk} = 164{,}7$ cm²

$\tau_{ka} = \frac{218}{2 \cdot 164{,}7} = 0{,}247$ t/cm²

Rõnga lõik

$\tau_{ka} = \frac{218}{1144} = 0{,}19$ t/cm²

$F_{rõngas} = \frac{1}{2} \cdot 45 \cdot 90 \cdot 225$

$M_1 = 218$ t/cm

$\sigma = \frac{M_1}{q \cdot a \cdot l} = \frac{218}{5{,}1 \cdot 1{,}25 \cdot 2} = \frac{218}{179{,}7} = 1{,}26$ t/cm²

$= 12{,}41$ N/mm²

Conclusie:

SKF 23036 CC/W33

C = 64 kN

C_0 = 69,5 kN

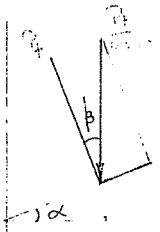
D_1 = 150 mm

D_2 = 250 mm B = 24 mm

afrondingsgetal $r_{1,2}$ = 1,5 mm

Belasting per lager: $\frac{F_r}{2}$ = 15 kN : 2 = 7,5 kN

$\frac{C}{P}$ = $\frac{69,5}{9}$ = 7,7 (minimale vereiste $\frac{C}{P}$)



Lagerstoel

aanrakendat P_1 = r_1 = 198 mm

$\tan\alpha$ = $\frac{198}{150}$ = 0,32

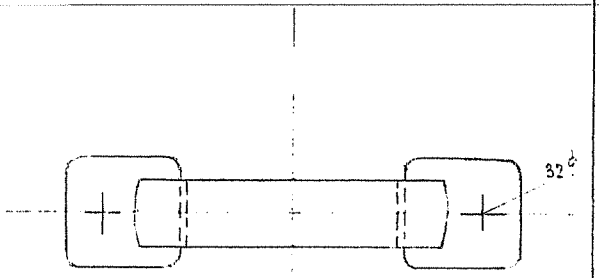
α = 20° 13' $\tan\alpha$ = 0,364

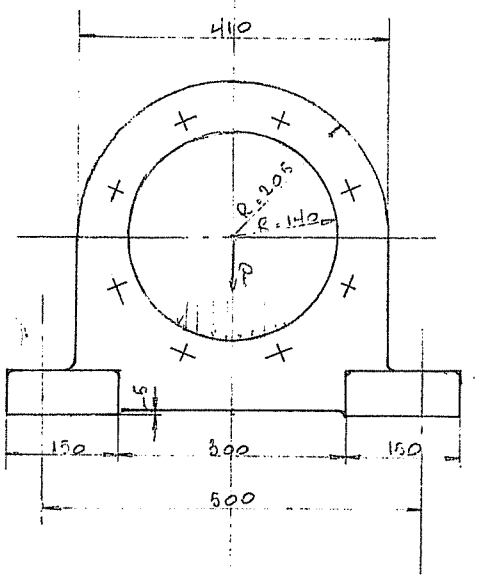
β = 20°

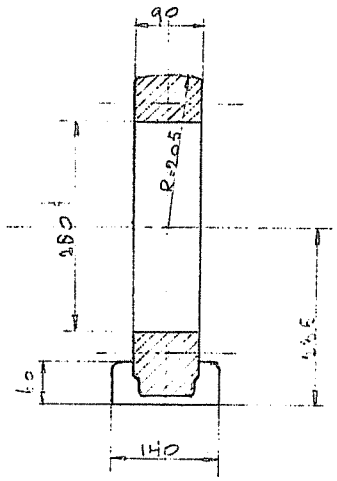
$\frac{P_1}{\sin 20°}$ = 19,7 kN P_1 = 6,2 kN

Lagerstoel aan andere steunpunt wordt dezelfde afstand als lager in lagerstoel

dus lagerstoel P_2 = 9 kN







haakbout voor handgat

bij voorspanning

per bout $P = \ldots \cdot 15 = \ldots$ kN

$M = \frac{1}{2} P \left(\frac{15}{2} - \frac{11}{21} \right) \cdot 4{,}5 \cdot 10 = \ldots$ kNmm

$W = \frac{1}{6} \cdot 9 \cdot 9^2 = \ldots$ mm³

$\sigma_b = \frac{M}{W} = \ldots$ kN/mm² (spanning op)

Kabel:

max. Kabelbruchkraft $F_1 = 10$ kN

Kabel: 39 [illegible] · 8,31 Warrington-[illegible]

kleinster Ø 1,90 mm

Preis = 8,41 € / lfd. m · Kabelgewicht

Gewicht = 16,85 kg / 100 m

$V_1 = \frac{8,41}{10} = 7$ (m = 1,2)

$V_2 = \frac{16,85}{10} = 8,9$

Anzahl Kabelklemmen erforderlich

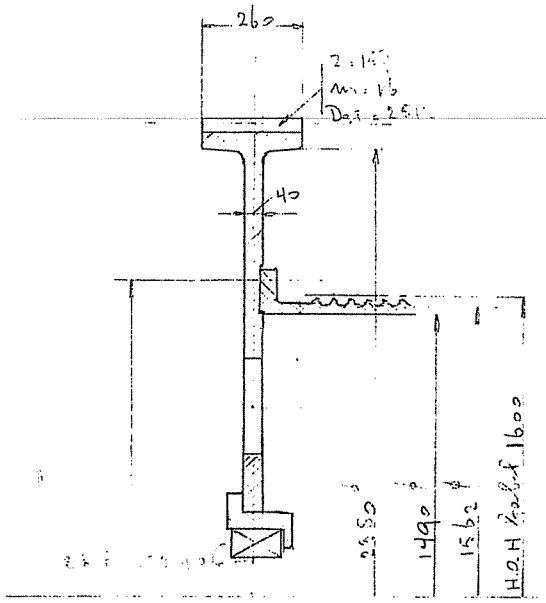
$\frac{D}{d} = \frac{16,2}{5,8} = 12$

$\frac{D}{d} = \frac{16,20}{1,9} = 8,10$

Anzahl Spannschlösser

$\frac{L}{D} = \frac{13,38}{30} = 3,5$

$\frac{L}{D} = \frac{[illegible]}{[illegible]} = 7,0$


260
40
2550
1490
1562
H.G.H. rail 1600

Rk [illegible]

$R_{[illegible]}$ = [illegible] 12 [illegible]

D [illegible] 16,5 [illegible]

[illegible] 12

$P_{t,q}$ = [illegible]

P_{q} = [illegible]

P_{t} = 16,8

E_C [illegible] 2,24 [illegible] E_C [illegible] 0,3105

[illegible] 4,5 [illegible] E_C [illegible] ≈ 0,8

E_1 [illegible] 0,8

Opbrengst [illegible]:

$R_1 = 12 + [illegible] = 14,15$

$R_2 = 14,15 + 2,24 - 16,8 = 0,12$

[illegible] E_1 [illegible]:

$R_1 = 14,15 - 0,4 = 13,75$

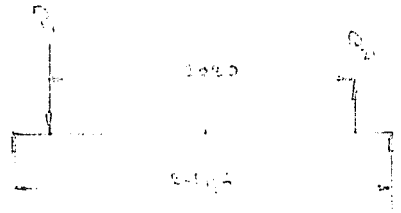
$R_2 = 0,12 - 0,4 = -0,28$

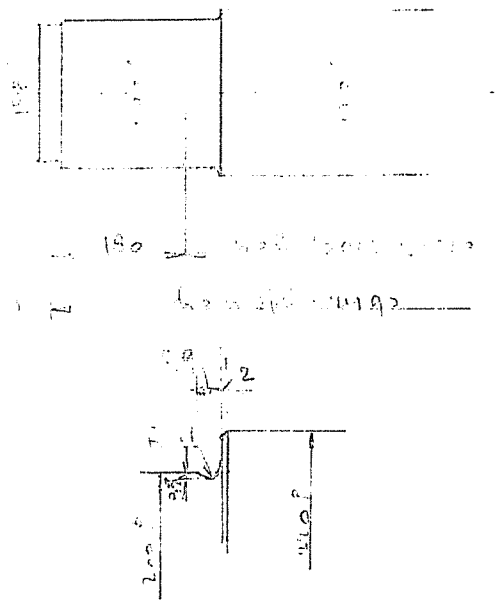
[illegible]

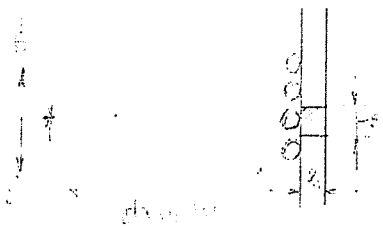
$C \cdot C_0 = 115$

$C = \frac{115}{14,15} = 8,13$

[illegible]







Endauflager Trapezblech

$R_1 = 13{,}75$ t

Innenauflager $R_B = 2 \cdot 13{,}75 = 27{,}5$ t

Nachweis Druck σ_b

$\sigma_b = 1{,}414 \left(1 - \frac{2}{3} \frac{D_{a1}}{D}\right) \cdot \frac{N}{D^2}$

$= 1{,}414 \left(1 - \frac{2}{3} \cdot \frac{30}{149}\right) \cdot \frac{27{,}5 \cdot 10^3}{14{,}9^2}$

$= 1{,}414 \left(1 - 0{,}2681\right) \cdot \frac{27{,}5 \cdot 10^3}{14{,}9^2}$

$= 1{,}12 \cdot 173 = 193$ kp/cm²

Auflager Trapezblech

$\frac{d_1}{D} = \frac{30}{149} = 0{,}20$

$\varphi_u = 0{,}7$

$\sigma_b = \varphi_u \cdot \sigma_{b,1} = 0{,}7 \cdot \frac{27{,}5 \cdot 10^3}{14{,}9^2} = 0{,}7 \cdot 173 = 120$ kp/cm²

$\sigma_{b,zul} = 0{,}7 \cdot 172 = 120$ kp/cm²

Zwischenauflager

$\varphi = 0{,}75$ Interpolation

$\sigma_b = \varphi \cdot \sigma_{b,1} = 0{,}75 \cdot \frac{27{,}5 \cdot 10^3}{14{,}9^2} = 0{,}75 \cdot 173 = 129$ kp/cm²

$\varphi_u = 0{,}34$ Interpolation

$\sigma_{b,zul} = 0{,}34 \cdot 172 = 59$ kp/cm²

b) [illegible]

Endauflager Stahlträger

$R = 13{,}75$ t

gew. gef. $d = 1020$ mm $d_a = 210$ mm

Breite Auflager $2 \cdot 30 = 60$ mm

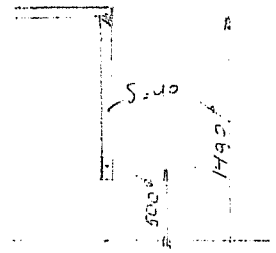
$z_1 = \frac{1}{2} \cdot \pi \cdot 600 = 52{,}5$ cm

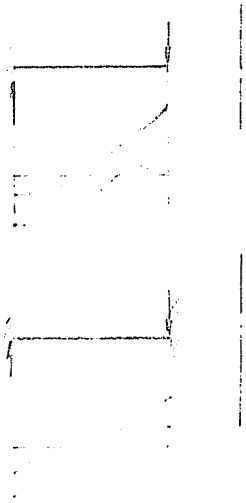
$l_{max} = 52{,}5 - 25 = 27{,}5$ cm

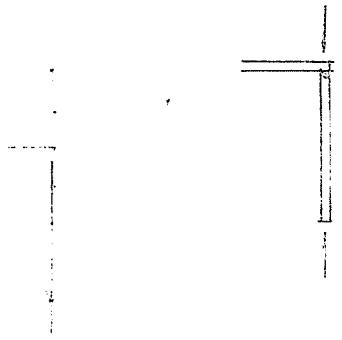
$\sigma_c = \frac{13{,}75 \cdot 10^3}{11 \cdot 1{,}5} = 125$ kp/cm² < 500 kp/cm² ✓

$\lambda = \frac{l}{i} = \frac{4 \cdot 27{,}5}{2 \cdot 1{,}5} = 36{,}7 \rightarrow \omega = 1{,}13$

$\sigma_c = 1{,}13 \cdot 125 = 141$ kp/cm² < 500 kp/cm² ✓







by interpolating in between

$L = 6 \cdot \pi \cdot 1149 = 7,5$ cm

$\sigma_0 = \frac{\pi \cdot 1,5^2}{4 \cdot 7,5} = 1,14$ kg/cm²

$h_{Pl} = 2 \cdot 7,5 = 15$ cm

$\lambda = \frac{150}{7,1^{1/3}} = 130 \quad \rightarrow 2,1 \cdot 2,9$

$\sigma_B = 4,1 \cdot 4,29 = 159$ kg/cm²

Damping ratio of the second order by steel

Logarithmic decay of Euler (Lindemann)

$\psi = \beta_0 \frac{e^{2\pi\mu}}{e^{2\pi\mu} - 1}$ with $\beta_0 = \frac{1}{6}$

$\alpha = 2\pi : \psi = \frac{\beta}{6} \cdot \frac{e^{2\pi\mu}}{e^{2\pi\mu} - 1}$

$\mu = 2,14 \cdot 2\pi\mu = 0,88$

$e^{0,88} = 2,4 \qquad \frac{2,4}{1,4} = 1,71$

$\beta = \frac{\psi}{\beta_0} \cdot 1,71 = \frac{13,75 \cdot 10^3}{8,2 \cdot 10^3} \cdot 1,11 = 29,4$ kg/cm²

$\sigma_{Dynamic} = \frac{29,4}{4} = 7,4$ kg/cm²

Up to yield point

$\sigma_B = 7,4 \cdot 4,29 = 318$ kg/cm²

With the yield point $P_1 = 500$ kg

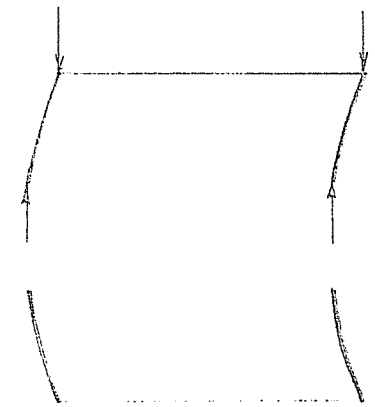
$\beta_{max} = \frac{13,75 \cdot 10^3}{8,2 \cdot 10^3} \cdot 1,71 = 4,10$ kg/cm²

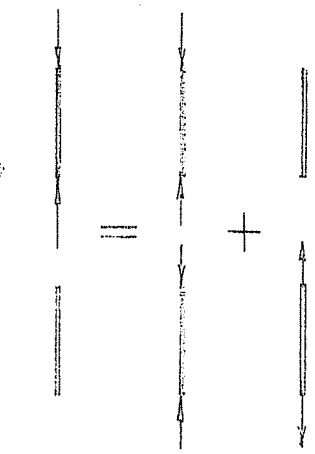
$\sigma_S = \frac{47,2}{4} = 11,8$ kg/cm²

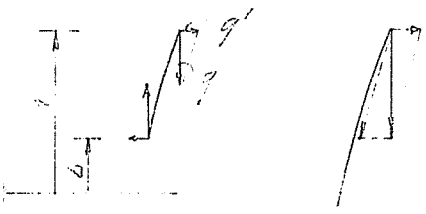
Ultimate load

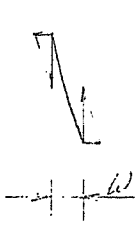
$\sigma_S = \frac{151,5}{21,5} \cdot 11,8 = 2,26$ kg/cm²

$\sigma_B = 1,13 \cdot 2,26 = 2,54$ kg/cm²









STABILITA PRUTU (ZUPLATEK)

HMOTNOST PRUTU

$$\omega = \frac{K_1 \cdot F \cdot q^2}{E \cdot \delta^3} \qquad F = q' \cdot 2\pi \cdot a \qquad q' = q \cdot \frac{w}{a \cdot b}$$

$$= w' \cdot q \cdot \frac{2\pi}{(1 - a/a_1)}$$

$$K' = \frac{q a \cdot b \cdot 2\pi \cdot a^2}{E \delta^3 (1 - a/a_1)} \cdot K_1$$

$$f_k = \frac{E \cdot \delta^3 \cdot (1 - a/a_1)}{2\pi K_1 \cdot a^2}$$

$2a = 152,5$ mm $\qquad a/b = 152,5/49 = 5 \Rightarrow K_1 = 0,252$

$2b = 49,0$ mm

$\delta = 6,3$ mm

$E = 2,1$ MPa

$$f_k = \frac{2100 \cdot 10^3 \cdot 4^3 \cdot (1 - 1/5)}{2\pi \cdot 0,252 \cdot 76,2^2} = 3,53 \text{ kg/mm}$$

$$f' = \frac{12 \cdot J}{a^3} = \frac{12 \cdot \frac{1 \cdot 4^3}{12}}{76,2^3} = 2,5 \text{ kg/mm} < 2,00 \text{ kg/mm}$$

UPNUTI ZPUSOBUJICI ZTRATU

$$\omega = \frac{K \cdot F}{\delta^3} \qquad F = \pi \cdot \delta / K \qquad a/b = 5 \Rightarrow K = 2,0$$

$$F = \frac{\pi \cdot 4^3}{2,0} = 31 \text{ kg}$$ (SKUTECNA HMOTNOST)

Bauteile einer Teilmenge von Tonnen ist

$R_{1,0} = 1$

was = Anteil durch Emulsion

mit

$p = p_0 \cdot e^{\frac{\mu \cdot x}{\cos \alpha}}$ $\qquad p_0 = \frac{1}{e}$

Anteil der ausfällt $\alpha = 0 \pi = 360°$

$\mu \cdot x = 0,1 \cdot 1$

$2\pi \cdot \mu = 1,55$

$e^{\dots} = 5,11$

$p_{max} = \frac{P}{R} \cdot \frac{5,11}{0,11} = \frac{P}{R} \cdot 1,71$

30 Emulsionen mit Anteil an

Transmission $\beta = \frac{\pi}{11} = 12°$

$P_{ges} = p_{max} \cdot R \cdot p =$

$= 1,11 \cdot \frac{P}{R} \cdot R \cdot \frac{2\pi}{30}$

$= 1,11 \cdot \frac{2\pi}{30} \cdot P = 10,1 \cdot \frac{P}{30}$

$P_1 = P_{ges}$

$\Rightarrow$ auf $P_0 = 10,1 \cdot \frac{P}{30} / 1,11 = \frac{10,8}{30} \cdot P$

$= \frac{10,8}{30} \cdot 12 = \underline{4,32\ \%}$

Emulsion mit 10 g $P_0 = 22\ \%$

Anteil $\mu = 0,1$

$P_{ab} = 21,8 \cdot 0,1 = 5,87\ \% = 11,2\ \dots$

ab

$P_0 = \frac{P}{0,1} \cdot P_0 = 22$

$P = P_{ab} \cdot 2\pi = 2 \cdot 11,2 \cdot 3,1 = 2,04$

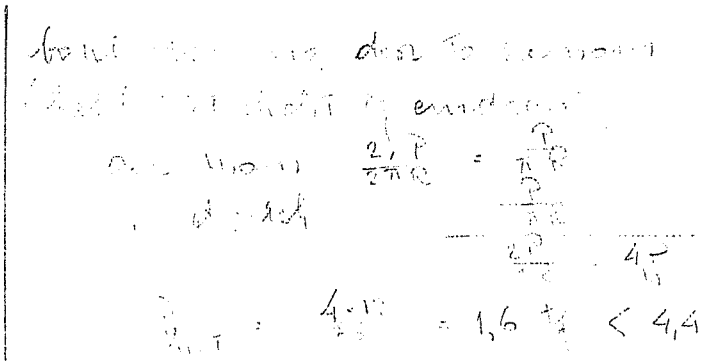
Bauteil mit Anteil von Emulsion

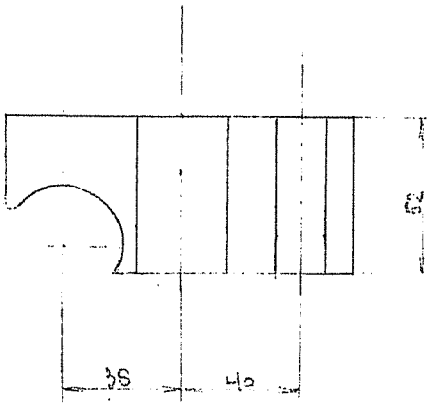
Durchmesser $7 - 2 = 5$ cm $\quad 15 = 2 \cdot 11 \cdot 6$

$2\pi \cdot 2,5 = 15,7$ cm

$F = 15,7 \cdot 7 = 7,85$ cm²

$I_0 = \frac{4,32}{7,85} = \underline{2,55}$ g/cm²

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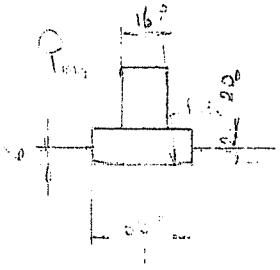
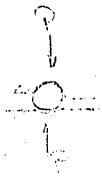
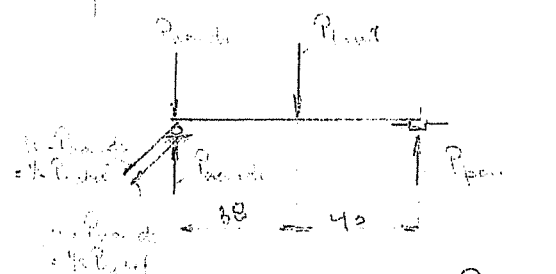

16

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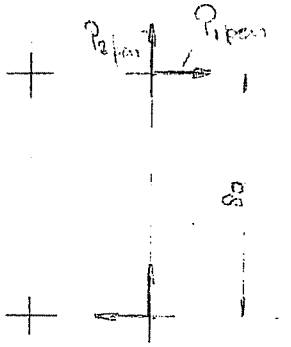
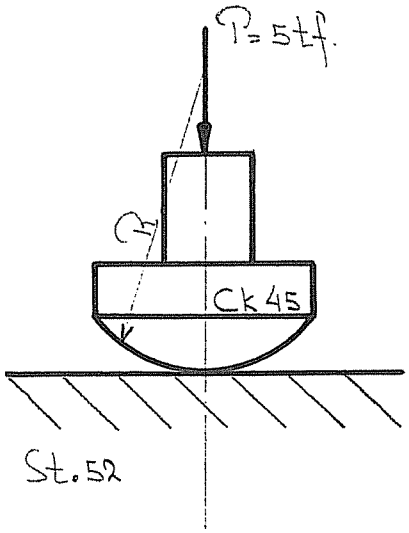




Berekening contactspanning tussen pos 25 en vlakke plaat. (2e tek 457186)

Principe belasting: Bol op vlakke plaat

R = 36cm Materiaal: plaat St. 52
pen Ck 45

$$q_0 = 0{,}388 \left(\frac{P \cdot E^2}{R^2} \right)^{1/3}$$

$$q_0 = 0{,}388 \left(\frac{5000 \cdot 2{,}1^2 \cdot 10^{12}}{36^2} \right)^{1/3}$$

$$q_0 = 0{,}388 \cdot 2{,}572 \cdot 10^4$$

$$\underline{\underline{q_0 = 9979 \ kgf/cm^2}} \qquad \bar{q}_0 = 9360 \ kgf/cm^2 \text{ voor St. 5}$$

$$\bar{q}_0 = 10800 \ kgf/cm^2 \text{ voor Ck4}$$

---

* R wordt 46cm

De hierbij behorende contactspanning bedraagt

$$q_0 = 9979 \times \frac{36^{2/3}}{46^{2/3}} = 9979 \times \left(\frac{36}{46} \right)^{2/3} = \underline{\underline{8474 \ kgf/cm^2}}$$

Schuifspanning in
FIJNLIJMBEDEN worden $\leq$ 4 !

$P_{s,h} = 4{,}3 \cdot 2{,}0 \cdot 0{,}89 = 7{,}7$ t
$< 1{,}43$ t/

Een A'tal waarden en formules:

$P_s = 1{,}43$ t/
16 t $\quad F_s = 2{,}01$ cm²
$\tau_s = 0{,}71$ t/cm² = τ_{toel} voor ...
(...)
(...)

P_s is de toelaatbare afschuifspanning door middel van hout met de vezels.

Dus 1,43 t/ in hout
geldt in dwarsrichting van de vezels ...
$M = 1{,}43 \cdot 1 = 1{,}43$ tm/cm
$W = 0{,}1 \cdot 3{,}2^2 = 3{,}28$ cm³
$\sigma_b = \frac{1{,}43}{3{,}28} = 0{,}435$ t/cm²

Aandrukkracht:
$P_1 = k \cdot 8{,}7 = 4{,}35$ t
F_o / cm² - ... $= 6{,}03$ cm²
$\sigma_o = \frac{4{,}35}{6{,}03} = 0{,}722$ t/cm² > 0,435 t/cm²
dus ... bezwijken ...

Klemkrachten:
$P_{kl} = k \cdot 8{,}9 \cdot \frac{7{,}8}{4} = 8{,}7$ t
Totale ... M16 ... $M_{16} = 11$ ...
... M16 ... $F_{o,t} = 3{,}53$ cm²
$P_{kl} = 6{,}4 \cdot 3{,}53 = 22{,}6$ t
max $P_t = 0{,}9 \cdot 1{,}8 \cdot 22{,}6 = 16{,}3$ t
$\Delta M_a = 0{,}18 \cdot d \cdot P_v = 71$ kgcm
Aanwezig $P_v = 8{,}7$ volgens 10 t/
... $\Delta M_a = 416$ kgcm
$\Rightarrow P_v = \frac{71}{4{,}16} = 10{,}6$ t/ ...

Stahlträger

durchlaufender Träger über 3 Öffnungen

$F_m = 5{,}2\,(15{,}6 - \ldots - 3) = 5{,}2 \cdot 9{,}1 = 58\ cm^2$

$W_m = 16 \cdot 9{,}1 \cdot 5{,}2^2 = 412{,}3\ cm^3$

mit $P_T = 5{,}6$ t/m

Belastung $P_{Bel.} = 6{,}6 \cdot 2 \cdot \frac{7}{7{,}5} = 6{,}9$ t/m

$M_D = 6{,}9 \cdot 3{,}5 = 41{,}4$ tm

$T_b = \frac{41{,}4}{412{,}3} = 0{,}99$ t/cm²

Stauchungsbeanspruchung aus der Spitze

$\frac{a}{R_i} = \frac{1}{2{,}1} = 96$

$\frac{a}{D} = \frac{2 \cdot 31}{16{,}6} = 9{,}4$

Wert $K_1 = 1{,}9$

$T_{max} = 1{,}9 \cdot 0{,}99 = 1{,}56$ t/cm²

F_c ...

Stabilisierung

Obere Gurtung

$M_y = 2{,}5 \cdot 3{,}5 = 9{,}5$ tm

$I_y = 2 \cdot 5{,}2 \cdot 15{,}6^3 = 1646$ cm⁴

$\ldots = 2 \cdot 3{,}1 \cdot 4^2 = 256$ "

1902

$W_y = \frac{1390^3}{7{,}5} = 178$ cm³

$\sigma_y = \frac{9{,}5}{178} = 0{,}054$ t/cm²

Last ...

Stocken

Nachweis der Normalspannungen

Nachweis der Normalspannungen

maßgebende Querkraft $Q_1 = 14{,}15$ t

Nachweis der Kehlschweißnaht

maßgebende Querkraft (= Normalspannung)

$R_{II} = 1{,}2 \cdot 24 = 29$

$kq_1 = k \cdot \sqrt{0{,}7 + 0{,}3 \cdot k^2}$ $\quad \frac{0{,}5}{24{,}5} = 0{,}02$

angenommen maßgebende Querkraft $Q = 24{,}5$ t

Nachweis Querschnitt 300 · 540 · 37

$F_o = 30 \cdot 54 = 1620$ cm²

$W = \frac{1}{6} \cdot 54 \cdot 3^2 = 810$ cm³

Nachweis der Kehlnaht

$M = 24{,}5 \cdot (15 - 1{,}5) = 331$ tcm

$\sigma_o = \frac{24{,}5 \cdot 10^3}{1620} = 15{,}1$ kg/cm²

$\sigma_1 = \frac{331 \cdot 10^3}{810} = 40{,}9$ "

Summe $= 56{,}0$ "

Nachweis der Kehlnaht am Anschnitt

Nachweis der Kehlnaht am Anschnitt

$\tau_o = \frac{24{,}5 \cdot 10^3}{3 \cdot 54} = 151$ kg/cm²

(angenommen $s = 4{,}0$ cm)

Spannung im Schwerpunkt der Schweißnaht

Summe $= \frac{24{,}5 \cdot 10^3}{11 \cdot 54} = 41{,}1$ kg/cm²)

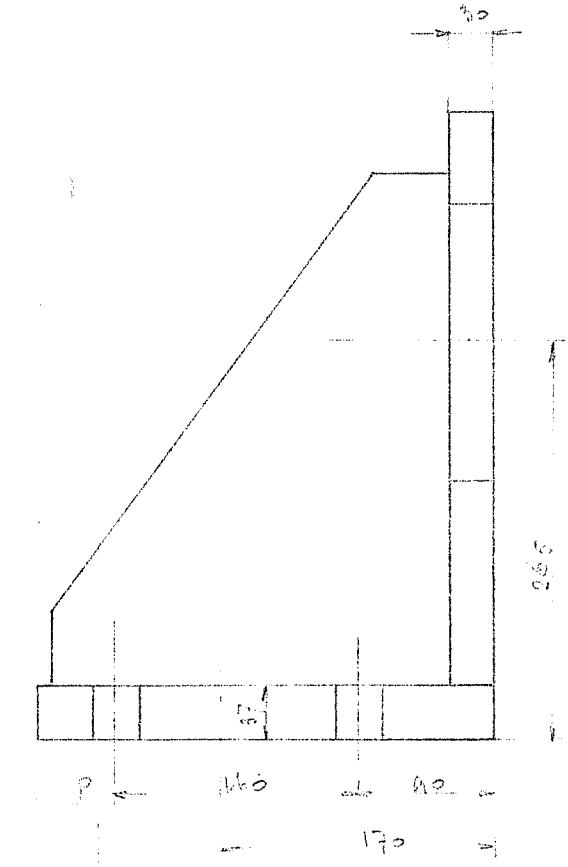
Auflager

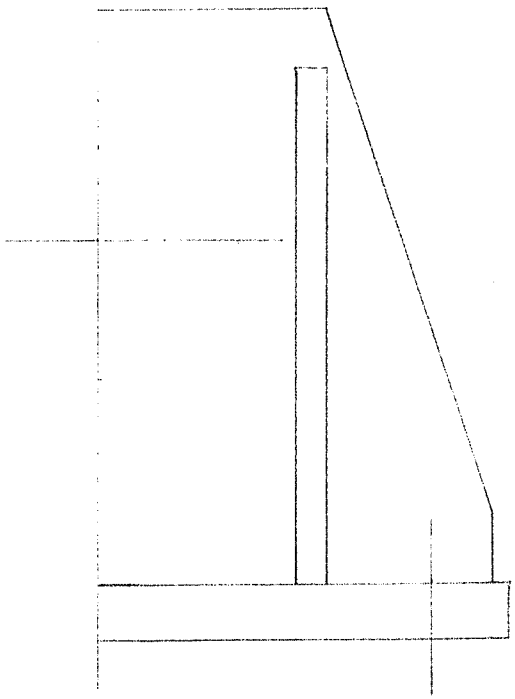
$P = \frac{2{,}8 \cdot Q}{16{,}3}$ $\quad (M = 1{,}5 \cdot 17{,}5 = 26$

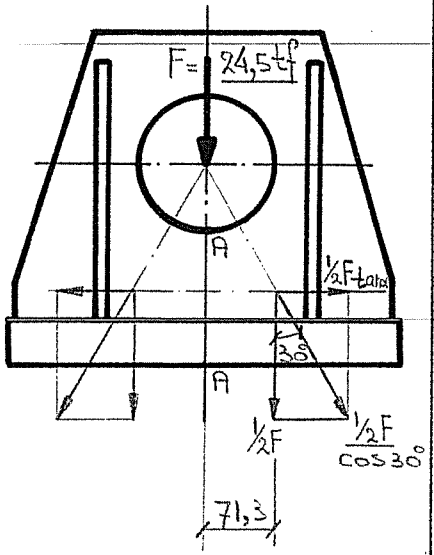
$P = \frac{2{,}8 \cdot 24{,}5}{16{,}3} = 4{,}2$ t

$P_1 = -\frac{4{,}2}{1{,}0} = -4{,}1$ t/m

$P_o = 8{,}5$ t/m





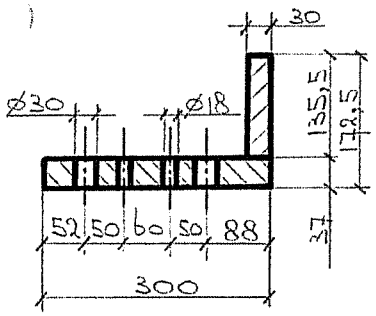


Berekening stoel (pos 2) van tek. A 57189.

Bepaling weerstandsmoment doorsnede A-A.

ΣF (cm²)	ΣS (cm³)
$30\times3,7-2\times3\times3,7-2\times1,8\times3,7 = 75,48$	$75,48 \times 1,85 = 139,638$
$13,55\times3 = 40,65$	$40,65 \times 10,475 = 425,809$
$\Sigma F = 116$	$\Sigma S = 565$

Doorsnede A-A



$$e_o = \frac{565}{116} = 4,87 \Rightarrow e_o = 49\,mm \qquad e_b = 123,5$$

$$I_x = \tfrac{1}{12}.3.13,55^3 + 40,65.5,575^2 + \tfrac{1}{12}.30.3,7^3 + 111.3,05^2 - 2\left[\tfrac{1}{12}.3.3,7^3 + 3.3,7.3,05^2\right] - 2\left[\tfrac{1}{12}.1,8.3,7^3 + 1,8.3,7.3,05^2\right]$$

$$= 2674\ cm^4$$

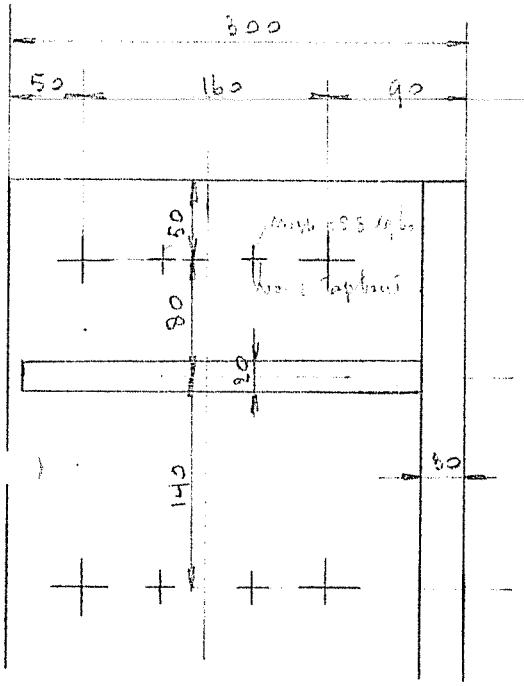
$$W_o = \frac{2674}{4,9} = 546\ cm^3 \qquad W_b = \frac{2674}{12,35} = 217\ cm^3$$

$$\sigma_t = \frac{12250.\tan 30^\circ}{116} = 61\ kgf/cm^2$$

$$\sigma_{b_{max}} = \frac{12250\times7,13}{217} = 403\ kgf/cm^2$$

$$\tau = \frac{12250}{13,55\times3} = 301\ kgf/cm^2$$

$$\sigma_i = \sqrt{(403+61)^2 + 3.301^2} = 698\ kgf/cm^2$$

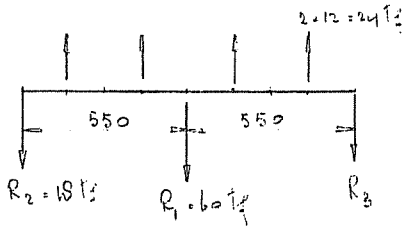

300
50
160
90
50
80
20
140
30

Stool kabelwielen in deur

per stool 4 kabelwielen

kabeltrek = 12 t

Tot aan stool 4 · 12 · 2 = 96 t



As als ligger op 3 steunpunten

$R_1 = \frac{5}{8} \cdot 48 = 60$ t

$R_2 = R_3 = \frac{3}{8} \cdot 48 = 18$ t

$M_{max} = \frac{11}{125} q l^2$

$= \frac{11}{125} \cdot 48 \cdot 5,5 = 6 \cdot 55 = 330$ tcm

$\sigma_b = 2600$ t/cm² $W = 134$ cm³ IPE 240

$W = 0,1 \cdot h^3 = 1331$ cm³

(zonder kerven)

$\sigma_b = \frac{330}{134} = 2,46$ t/cm² < 2,6 t/cm²

$D_{max} = 60$ t

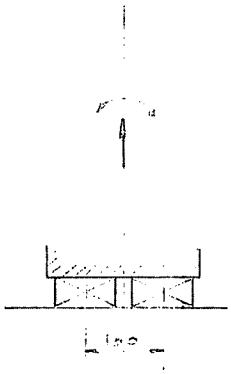
$\tau_{gem} = \frac{60}{134} = 0,1$ t/cm²

als op plaat

$\tau = \frac{60}{5,6 \cdot 1,2} = 0,834$ t/cm²

< 1,2 t/cm²

Lager:



cilindrisch IHA SLO 1/4940

ϕ 280/200 50

$C_d = 60$ t

$C_0 = 77$ t

2 lagers per koppeling

per lager: $R = 1 - 1$ t

$\frac{C_0}{R} = \frac{77}{2} = 38,5$ t

met $P_m = 0,1 \cdot 24 = 2,4$ t/cm²

nu lager $P_1 = \frac{2,4 \cdot 57}{60} = 13,7$ t

max per lager: 12 + 13,7 = 25,7 t

$\frac{C_0}{T} = \frac{77}{25,7} = 2,98$

Oogplaat

middelste plaat:

$\delta = 40 - 2 \cdot 2 = 36$ mm.

$P_{max} = b_0 \cdot t_1$

$K = \frac{b_0 - b}{t_0 - t_1} = 0,5$

$K_0 = 3$ | $K = 4,15$

$K_1 = 1,38$

$F = 2,(30-b) \cdot \frac{3}{4} b = 144$ cm²

$\sigma = \frac{P}{144} = 0,417$ t/cm²

$K_0 \cdot \sigma_0 = 3 \cdot 0,417 = 1,251$ t/cm²

$\sigma_A = \sigma_{dyn} = \frac{4,5 \cdot 3}{36} = 0,625$ t/cm²

$\beta_1 = 1$

$\nu = \frac{0,625}{2,12} + \frac{1,38 \cdot 0,625 \cdot 3}{2,12} = \frac{1}{2,12 + 0,495} = \frac{1}{0,618} = 1,62 > 1$

Berekening van wigtype:

van middelste plaat.

Eventuele bovenbelasting door as aangenomen

naar buitenste platen.

6 bouten in wigplaat gedacht

als een wig:

per bout: $P_1 = \frac{b_0}{6} = \frac{30}{6} = 5$ t

van 24 tot : $F_3 = 11,59$ cm²

$0,9 \cdot P_{0,2} = 37,2$ t

$P_2 = 0,8 \cdot 37,2 = 29,8$ t

van dyn. tot max $P_1 = 10$ t

$\lambda = 4,15$

$\Gamma_0 = 2,0$ t/cm²

$\bar{\sigma} = 1,20$ t/cm²

$\sigma = 2,5 / 4,15 = 1,20$ t/cm²

2e plaatbreuk

$P = 4 \cdot 7,5 = 30$ t

$\sigma = \frac{30}{4 \cdot 9} = 0,54$ t/cm²

10 K: $\sigma_0 = 1$ t/cm²

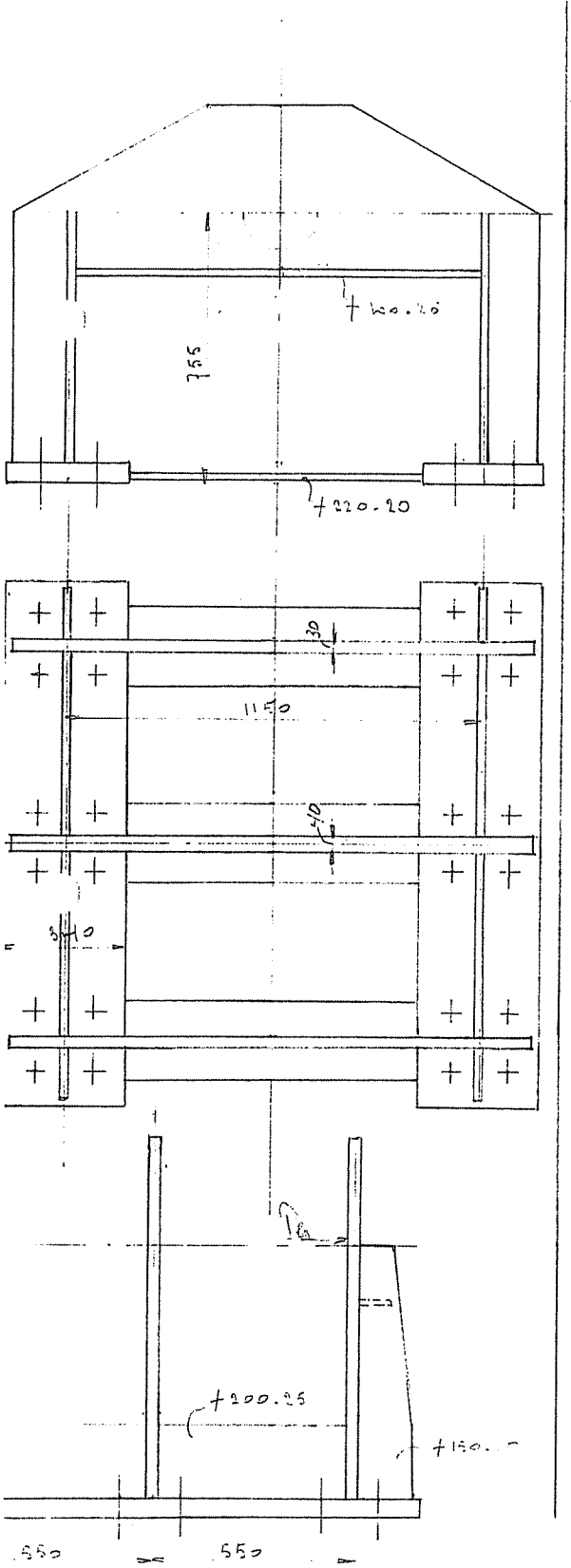
Innen. platen

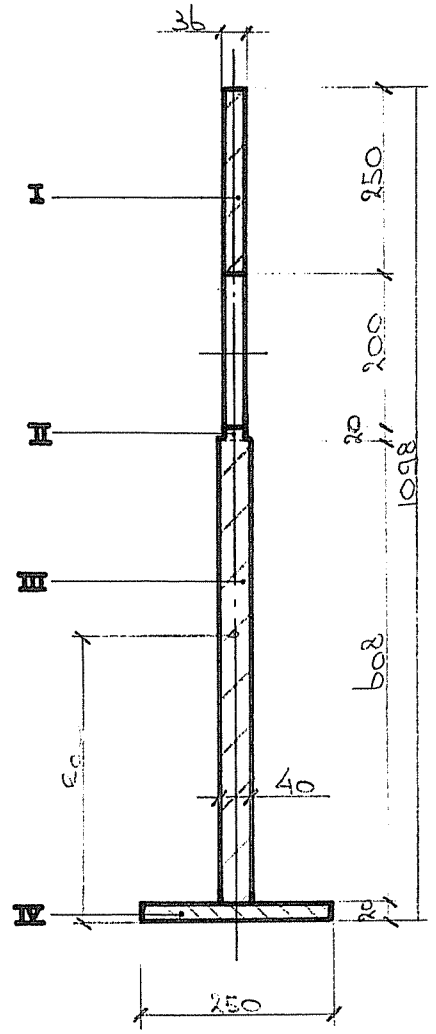
$\delta = 30 - 2 = 28$ mm

$P = 19$ kN

$\sigma_{zul} = 0{,}161$ kN/mm²

$V = 4{,}1$


+300.20
755
+220.20
1150
+200.25
+150.-
550
550



Totaal doorsnede

Berekening stoel (pos 1) van tek. A 57189.

Bepaling weerstandsmoment middendoorsnede.

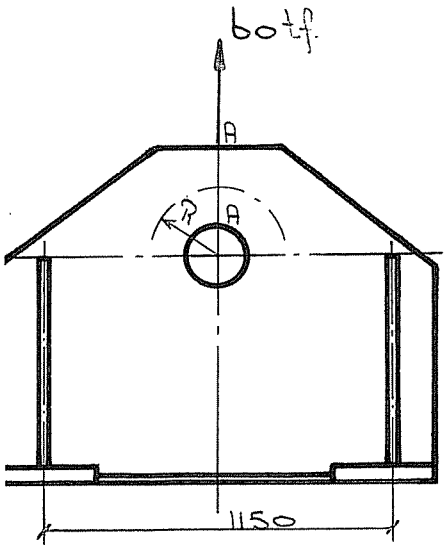
Opp. nr.	ΣF (cm²)	ΣS (cm³)
I	25 × 3,6 = 90	25 × 3,6 × 97,3 = 8757
II	2 × 3,6 = 7,2	2 × 3,6 × 63,8 = 459,4
III	60,8 × 4 = 243,2	60,8 × 4 × 32,4 = 7879,7
IV	25 × 2 = 50	25 × 2 × 1 = 50
	ΣF = 390,4	ΣS = 17146,1

$$e_o = \frac{17146,1}{390,4} = 43,9 \text{ cm} \qquad e_o = 439 \text{ mm}$$

$e_b = 659$ mm

$$I_x = 1/12 \cdot 3,6 \cdot 25^3 + 90 \times 53,4^2 + 1/12 \cdot 3,6 \cdot 2^3 + 7,2 \times 19,9^2$$
$$+ 1/12 \cdot 4 \cdot 60,8^3 + 243,2 \cdot 11,5^2 + 1/12 \cdot 25 \cdot 2^3 + 50 \times 42,9^2$$

$$I_x = 463301 \text{ cm}^4$$



$$W_o = \frac{463301}{43,9} = 10554 \text{ cm}^3$$

$$W_b = \frac{463301}{65,9} = 7030 \text{ cm}^3$$

Weerstandsmoment deel doorsnede A-A

$$W_{A-A} = 1/6 \cdot 3,6 \cdot 25^2 = 375 \text{ cm}^3$$

$R = 225$

Berekening spanningen in de totaal doorsned.

$M_b = \frac{1}{4} \cdot 60000 \cdot 115 - \frac{1}{5} \cdot 60000 \cdot 22{,}5 = 1455000$ kgcm

$$\sigma_{b_o} = \frac{1455000}{10554} = \underline{\underline{138}}\ kgf/cm^2$$

$$\sigma_{b_b} = \frac{1455000}{7030} = \underline{\underline{207}}\ kgf/cm^2$$

$$\tau = \frac{30000}{340{,}4} = \underline{\underline{88}}\ kgf/cm^2$$

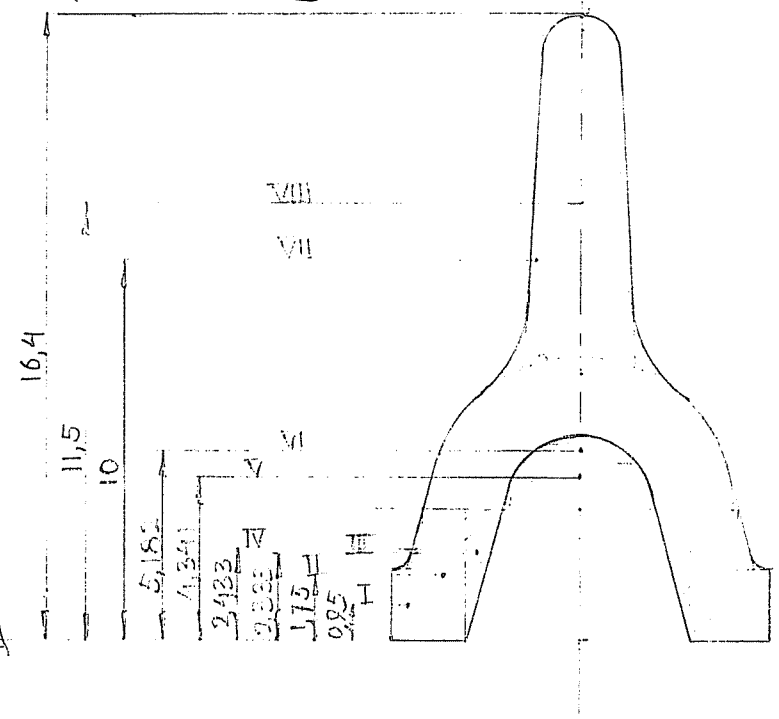
Spanningen in de deel doorsnede A-A

$M_b = \frac{1}{5} \cdot 60000 \cdot 22{,}5 = \underline{270.000}$ kgcm

$$\sigma_b = \frac{270000}{375} = \underline{\underline{720}}\ kgf/cm^2$$

$\sigma_{b\,tot.} = 720 + 207 = \underline{\underline{927}}\ kgf/cm^2$

Berekening kaapwiel, pos 1 tek. A 57188



2× I : 0,859 × 1,9
2× II : 1,133 × 3,5
2× III : 0,938 × 3,5 × ½
2× IV : 0,429 × 1,6 × ½ .
V : ⅓ π . 2²
VI : ½ π . 4²
2× VIII : 0,472 × 9 × ½ .
VIII : 4 × 9

totale hoogte : 16,4 cm.

Bepaling van z.

	opp.		afst. tot z	stat. mom.
I	2 × 0,859 × 1,9	= 3,264	0,95	3,101
II	2 × 1,133 × 3,5	= 7,931	1,75	13,879
III	2 × 0,938 × 3,5 × ½	= 3,283	2,333	7,659
IV	2 × 0,429 × 1,6 × ½	= 0,686	2,433	1,670
V	− ½ . π 2²	= − 6,283	4,341	− 27,275
VI	½ . π . 4²	= 25,133	5,182	130,238
VII	0,472 × 9 × ⅔ × 2	= 4,248	10	42,480
VIII	2 × 9	= 18,	11,5	207,000
		56,262		378,752

afstand tot z = 378,752 / 56,262 = 6,732.

Traagheidsmoment t.o.v. A – A

I $(\frac{1}{12} . 0,859 . 1,9^3 + 0,95^2 . 3,264) 2$ = 6,874 cm⁴
II $\frac{1}{12} . 1,133 . 3,5^3 + 1,75^2 . 7,931) 2$ = 56,674
III $(\frac{1}{36} . 0,938 . 3,5^3 + 2,333^2 . 3,283) 2$ = 37,972
IV $(\frac{1}{36} . 0,429 . 1,6^3 + 2,433^2 . 0,686) 2$ = 8,219
V $-\frac{1}{64} \pi . 2^4 + \frac{1}{2} - 4,341^2 . 6,341$ = − 119,865
VI $\frac{1}{64} \pi . 4^4 + \frac{1}{2} + 5,182^2 . 25,38$ = 687,278
VII $(\frac{1}{36} . 0,472^2 . 3^3 + 10^2 . 4,248) 2$ = 868,716
VIII $\frac{1}{12} . 2 . 9^3 + 11,5^2 . 18$ = 2502,000
4047,868

I t.o.v. z.

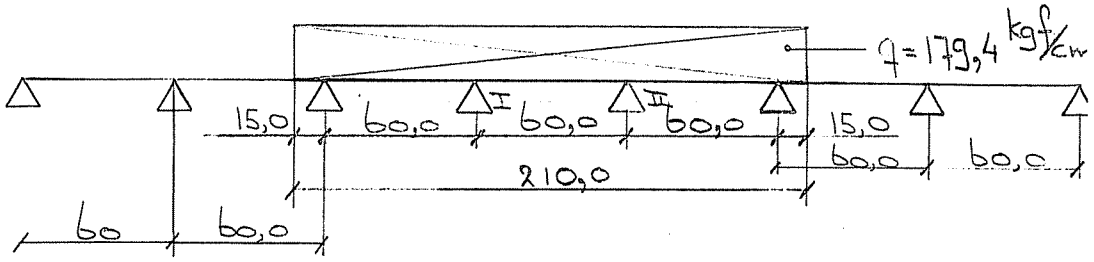
$I_z = I_{xx} - z^2 \cdot A$

$= 4047,868 - 6,732^2 \cdot 36,432 = 1490,380 \text{ cm}^4$

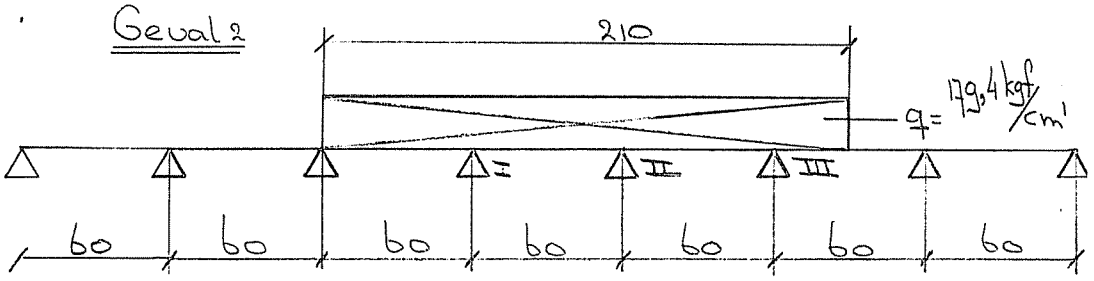
$W = 1490,380 / 16,1 - 6,732 = 1671,156 \text{ cm}^3$

Max. belasting per kabel = 12 tf $\quad q = F_{kabel} / R = 12000 / 66,9 = 179,4$

Geval 1 : Afstanden in cm. $\quad n = \infty$ aantal steunpunten



Geval 2



M = Tw.P.L

Geval 2 $\quad M_{max} = -0,1 \cdot 179,4 \cdot 60^2 = -64584 \text{ kgcm}$ (bij I)

$D_{max} = -0,607 \cdot 179,4 \cdot 60 = -6535 \text{ kgf}$ (bij I)

$\sigma_b = \frac{64584}{154,156} = 419 \text{ kgf/cm}^2$

$\tau = \frac{6535}{56,262} = 116 \text{ kgf/cm}^2$

$\sigma_i = \sqrt{419^2 + 3 \cdot 116^2} = 465 \text{ kgf/cm}^2$

Geval I $q = 12000/66,9 = 179,4\ kgf/cm^1$

$M_{max} = -0,1 \times 179,4 \times 60^2 = -64584\ kgcm$ (bij I)

$D_{max} = -0,6 \times 179,4 \times 60 = -6458\ kgf$ (bij I)

$\sigma_b = \frac{64584}{154,156} = 419\ kgf/cm^2$

$\tau = \frac{6458}{56,262} = 115\ kgf/cm^2$

$\sigma_i = \sqrt{419^2 + 3.115^2} = 464\ kgf/cm^2$

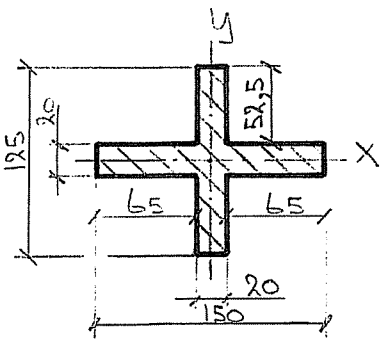
Berekening spaken. $\varphi = 51,428571^\circ$

Belasting per spaak $= q.\varphi.r = 179,4.\varphi.66,9$

$\varphi = 0,8976$ rad

$\varphi = 0,8976 \times 179,4 \times 66,9 = 10773\ kgf$

C middelde doorsnede



$A = 12,5 \times 2 + 2[6,5 \times 2] = 51 cm^2$

$I_x = 1/12.2.12,5^3 + 2[1/12.6,5.2^3] = 334 cm^4$

$I_y = 1/12.2.15^3 + 2[1/12.5,25.2^3] = 569 cm^4$

$i_{min} = \sqrt{\frac{I_{min}}{F}} = \sqrt{\frac{334}{51}} = 2,559105235$

$\lambda = \frac{L_k}{i_{min}}$ knikl. lengte $= 2L$ $\lambda = \frac{2.66,9}{2,559105235} = 52$

$\lambda = 52 \Rightarrow \omega = 1{,}29$ voor $G_s - 52$

$\omega . \sigma \leq \bar{\sigma}_o \qquad \bar{\sigma}_o = 1600 \text{ kgf/cm}^2$

$1{,}29 . \frac{10773}{EI} = \underline{272} \text{ kgf/cm}^2 < 1600 \text{ kgf/cm}^2$

40C-350-511

NIEUWE SCHUTSLUIS TE WEURT.

2. BELASTINGSCOËFFICIËNTEN $\ddot{\varphi}$ EN $\ddot{\psi}$.

1975

Vaart - kabelkrachten (deur onder water)

Deur	120
Schuifbeugel	6
Kl. wielen + afdekken	1,5
Gr. wielen	2,5
Schijven + kabels	6
Us + slib	7,5
Beugel	3,8
Wrijving onder water 33,46 =	33,46
Lagerwielen	1,2
Hydr. cilinders water	1,0
Zeewaarde	- 32,6
Windwaarde	1,2
Deur "gewicht" totaal	163,66 kN

Kracht op trommel $\frac{163,66}{4} \times 0,26_2 = 11,006$ kN

Kabelkrachten (deur boven water)

Deur	120,
Schuifbeugel	6,
Kl. wielen + afdekken	1,5
Gr. wielen	2,5
Schijven + kabels	6,
Us + slib	15,
Wrijving water	0,3
Windweerstand	1,2
Deur "gewicht" totaal	152,5 kN

Kracht op trommel $\frac{152,5}{4} \times 0,26_{02} = 10,256$ kN

Wenst = belastingcoëfficiënt

Algemene gegevens:

Deur 2 lagen onder water T traagheid per kabel = 11,206 tf.

Deur 2 lagen lucht water T traagheid per kabel = 10,256 tf.

i trommel = overbrenging = 9,5125

i tak = 21

} i = 9,5125 . 21 = 206,0625

n motor = 1500 omw/min

N nom. =

M nom = 200 kgf/m M max = 250 kgf/m

R trommel = 80 cm

D kabeltrommel = 1,328 m.

η trommel + lagers = 0,9

η tak = 0,94

} η tot = 0,9 . 0,94 = 0,846

V deur = 15 cm/sec. valsnelheid = 10 cm/sec.

deur valbed na el. verbinden = 1 cm/sec

remschijven tot 60° = 30 kg/m².

M rem normaal 370 kgf/m per rem

in stor 60° = 40 kg/m²

Deur loopt per motor 10 sec

Kabel W.S. ϕ 38 8 x 31 E = 0,85 . 10⁶ kg/cm².

Deur opdrempel l kabel = (40,4 − 13,8) + (40,4 − 13,8) + (42,35 − 13,8)
+ 1,5 π 1,338 = 115,355 m.

Deur boven in l kabel = 115,355 − 4 . 16 = 51,355 m.

A kabel = 5 / 3(2,1 + 1,1) = 6,26 mm²

C = EA Δl / L

C₁ = 0,85 . 10⁶ . 6,26 . 1 / 11535,5 = 461 kg/cm

C₂ = 0,85 . 10⁶ . 6,26 . 1 / 5135,5 = 1036 kg/cm.

Deur gaat boven water: 151 tf.

J deur op motoras = 151000/981 . 1/16 . 80² / 206,0625² = 1,45 kgcm sec²

M normaal boven water = 4 . 10256 . 80 / 206,0625 = 1592,7 kg/cm.

M max stal = 4 . 11006 . 80 / 206,0625 = 1709,2 kg/cm.

Wand - Belastungskoeffizient

$\frac{1}{\eta} = \frac{1}{98,6} = 1,15$

Umfang: $\frac{10000}{4,98} = 148,38$ kg/cm²

$\theta = \frac{1,182 \cdot 1,15}{178,38g + 1,182 \cdot 1,15} = 0,009$ g/cm².

$\rho = \frac{R}{i} = 80 / 206,062 = 0,388$ g.

Moment beim Ablauf des elektrischen Vorgangs

F Puffer = 4725 kg (Last auf Boden, Puffer ganz los).
F Puffer = 6425 kg (Last auf Boden, Puffer ganz belastet)
$\Delta F = 6425 - 4725 = 1700$ kg.
Δ Kabel = $\frac{210}{120} \cdot \frac{1700}{12} / 461 = 3,23$ cm.
Δ Kabel äqu. induzierten Puffer = $\frac{120}{210} \cdot 5 = 2,86$ cm
Δ Kabel ges. = 3,23 + 2,86 = 6,09 cm.
φ Normal: Δ Kabel / R_m = 6,09 / 80 = 0,0761 rad.
φ Motor = $\varphi_n \cdot i = 0,076 \cdot 206,062 = 15,687$ rad.
ω Motor max = $\frac{2\pi \cdot 1500}{60} = 157,08$ rad/sec
t = 10 sec
$\dot{\omega} = \omega_n / t = 157,08 / 10 = 15,708$ rad/sec²
$\varphi = \frac{1}{2} \dot{\omega} t^2$ $t_\varphi = \sqrt{\frac{2 \cdot \varphi}{\dot{\omega}}} = \sqrt{\frac{2 \cdot 15,687}{15,708}} = 1,413$ sec.

$v_{Normal} = \frac{R \cdot \omega_{Motor\ 2,1\ sec}}{i} = \frac{80 \cdot 15,708 \cdot 1,413}{206,062} = 8,617$ cm/sec.

$m_{Gew} = \frac{G_{Gew}}{g} \cdot \frac{1}{98} \cdot \frac{1}{16} = \frac{10000}{98 \cdot 16} = 9,566$ kg cm/sec²

Normal load ...

Aanlopen of remmen

$M_1 = \{ 15927 + [illegible] \} / 0,846 = 18962 \text{ kgf.m}$

$\alpha = 0,0002$ 1/s

$M_{1,max} = 18826 \text{ kgf.m}$

$M_{1,min} = [illegible]$

$\varphi = \frac{M_{1,max} + M_{2,nom} \cdot (1 - \alpha \cdot t)}{M_{1,nom}} = \frac{18962,2 \cdot 0,9916 + 18826 \cdot (1 - 2,0 \cdot 0,0002 \cdot 16)}{20000}$

$= 3,3414$

Bij aanlopen of remmen:

$M_{2,\eta} = 15927 \text{ kgf.m}$

$\varphi = \frac{M_{2,\eta} + \alpha \cdot (M_{1,nom} + M_{2,\eta})}{M_{nom}} = \frac{15927 + 0,0002 \cdot 16 \cdot (18962 + 15927)}{20000}$

$= 3813$

Bij stationair

$M_2 = 17092 / 0,846 = 20203$

$\rho = 0,[illegible]$

$V_0 = 8,617 \text{ m/s}$

$C = 461 \text{ kgf/cm}$

$m = 0,62 \text{ kgf cm}^{-1} \text{ s}^2$

$\varphi = \frac{M_2 + 0,9 \cdot \rho \cdot V_0 \sqrt{C \cdot m}}{M_{nom}} = \frac{20203 + 0,9 \cdot 0,[illegible] \cdot 8,617 \sqrt{461 \cdot 0,62}}{20000}$

$= 1,03$

Noodstop

$M_{1,max} = 3[illegible]000 \text{ kgf/cm}$

$M_{2,max} = [illegible]$

Bij remmen (mbv rem)

Vast belasting

$$\varphi = \frac{M_{1,max} \cdot 2a + M_{2,max}(1-2a)}{M_{nom}}$$

$$= \frac{37000 \cdot 2 \cdot 0{,}0009216 + 1888{,}2(1-2 \cdot 0{,}0009216)}{20000}$$

$$= 0{,}1586.$$

$P_{vrij\ 1ste\ rem} = \frac{\pi \cdot 0{,}0009}{8} \cdot \frac{\pi \cdot 0{,}6^2}{4} = 12879\ kgf.$

Inwaller 2e rem gebeurt 1 sec na het inwallen van 1e rem.

$J_{tot} = 178{,}38 kg + 1{,}15 = 179{,}53 kg\,cm\,sec^2$

$n_{motor} = 100$ omw/min.

$M_{rem} = 37000$ kgfcm.

$i_D = \frac{M}{J} = \frac{37000}{179{,}53} = 206{,}88\ rad/sec^2$

$\omega_D = \frac{2\pi \cdot 100}{60} = 10{,}472\ rad/sec.$

$\omega_D = i_D \cdot t \quad t = \frac{\omega_D}{i_D} = \frac{10{,}472}{206{,}88} = 0{,}05\ sec.$

motor moet stil zijn 1e rem inwalt.

Belasting motor bij remmen

$M_1 = 37000$ kgfcm. $M_2 = 1509{,}2$ kgfcm $\varphi = 0{,}8$.

$$\varphi = \frac{37000 \cdot 0{,}8 + 1509{,}2 \cdot |(1-2 \cdot 0{,}8)|}{20000} = 3{,}41.$$

$$\varphi = 1509{,}2 + \frac{0{,}8(37000 + 1509{,}2)}{20000} = 2{,}913.$$

Berekening spanning in de motoras tijdens remme

Hoofdmotor:

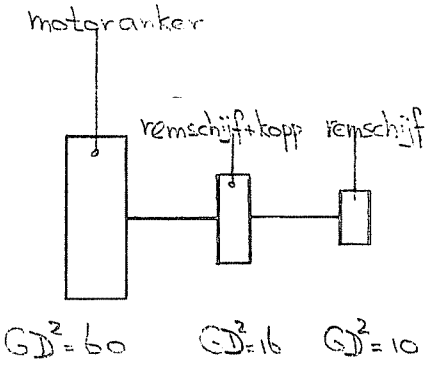
$N = 450$ pk $n = 1500$ omw/min $d_{as} =$ gem.

$$\tau_w = \frac{71620 \times {}^{450}/_{1500}}{\pi/16 \times g^3} = \underline{150}\ kgf/cm^2 \text{ (Bij nom koppel)}$$

Noodmotor:

$N = 25$ pk $n = 1500$ omw/min $d = 48$ mm

$$\tau_w = \frac{71620 \times {}^{25}/_{1500}}{\pi/16 \times 4{,}8^3} = \underline{55}\ kgf/cm^2$$



$$x = \frac{60}{60+16+10} = \underline{0{,}7}$$

Bepaling belastingcoëfficient bij remmen (normale belast

$M_1 = 37000$ kgcm $\alpha = 0{,}7$ $M_2^* = 0$ kgcm $M_{nom} = 21486$ kgcm

$\eta = 0{,}846$

$$\varphi_1 = \frac{M_1 . 2\alpha + M_2 (1-2\alpha)}{M_{nom}} = \frac{37000 . 2 . 0{,}7}{21486} = \underline{2{,}411}^{**}$$

Kerffactor $\beta = 1{,}29$

$\tau = 1{,}29 \times 2{,}411 \times 150 = \underline{467}\ kgf/cm^2$ (te hoog)

$\tau = {}^{570}/_{\sqrt{3}} = \underline{329}\ kgf/cm^2$ voor St. 60

Om de toelaatbare spanning niet te overschrijden dient de faktor φ_1 te worden ${}^{329}/_{150 \times 1{,}29} = 1{,}700$

Het remmoment dient dan ingesteld te worden op:

$\frac{x . 2 . 0{,}7}{21486} = 1{,}7 \Rightarrow x = \underline{26090}$ kgcm

* in deur 02 [illegible]

** Bij deze in gehoven [illegible] hoger

Berekening remtijd en uitloopweg deur.

Remkoppel = $M_{rem} - M_2$

M_2 = koppel dat in het normale geval nodig is om de deur zonder invloed van versnellings- of vertragingskrachten te bewegen (dalen dus zonder G)

$R = 26090 - 15927 = 10163$ kgfcm $= \underline{101{,}63}$ kgfm

$\dot{\omega}$ (hoekvertraging) $= \dfrac{M_{rem} - M_2}{\Sigma J}$

ω_o (hoeksnelheid motoras) $= \dfrac{2\pi n}{60} = \dfrac{2\pi . 1500}{60} = \underline{157{,}08}$ rad/s

$\Sigma J = \dfrac{60}{4.9{,}81} + \dfrac{16}{4.9{,}81} + \dfrac{10}{4.9{,}81}$

$\Sigma J = \underline{2{,}191641182}$ kgfm sec^2

$\dot{\omega} = \dfrac{101{,}63}{2{,}191641182} = \underline{46{,}37164187}$ rad/sec^2

Opm.
Tijdens elektrisch retarderen is
$\omega_{retarderen} = 1/15\,\omega_o$

$t = \dfrac{1/15\,\omega_o}{\dot{\omega}} = \dfrac{1/15 . 157{,}08}{46{,}37164187} = \underline{0{,}226}$ sec

$\varphi = 1/2 . \dot{\omega} . t^2 = 1/2 . 46{,}37164187 . 0{,}226^2 = \underline{1{,}184238gg}$ ra

$\varphi = \underline{67{,}85189605}^\circ$

Doorlopen hoek trommel $= \dfrac{67{,}85189605}{206{,}0625} = \underline{0{,}329278233}$

$s_{trommel} = \dfrac{0{,}329278233}{360} \times 2\pi . 80 = \underline{0{,}460}$ cm

$s_{deur} = 0{,}460/4 = 0{,}115$ cm $= \underline{1{,}2}$ mm

Berekening koppeling. (Zie tek. A 57175)

Penco koppeling type P 110 N D_B = 500 mm

Nominaal motorkoppel = $71620 \times \frac{450}{1500} = 21486$ kgcm

In geval van remmen wordt het maximale koppel op de koppeling: (bij remkoppel 3 pfg)

$M_{koppeling} = 21486 \times 2,41 = 51803$ Kgfcm

$M_{max\ toelaatbaar}$ = 40000 kgcm

In geval het remkoppel is ingesteld op 2 bfg

$M_{koppeling} = 21486 \times 1,7 = 36526$ Kgcm

$\frac{1}{n} \times C = {}^{450}/_{1500} \times 1,7 \times 1,5 = 0,77$

$\frac{N}{n}$ toelaatbaar = $0,41 \times 1,36 = 0,56$

Hieruit blijkt dat de koppeling te klein is gedimensioneerd. Dit geldt zeer zeker - is het max. remkoppel van 370 kgm - wordt uitgeoefend op de koppeling. Het verdient daarom aanbeveling het remkoppel te verlagen tot 260 kgm. Aanbevolen wordt een zwaardere koppeling te nemen.

NIEUWE SCHUTSLUIS TE WEURT.

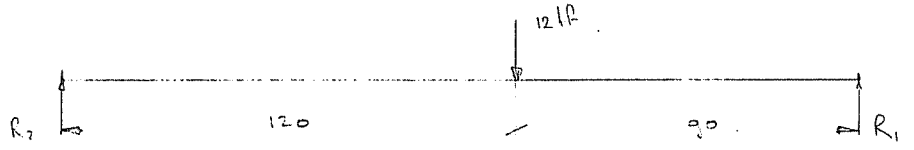
3. BEREKENING KABELEVENAAR.

1975

11-2-95.

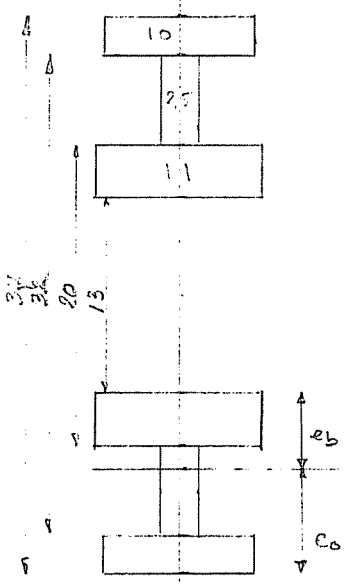
Werk kabelverraan

Frame. Belasting 2 x volf.



$R_1 = \frac{120}{210} \times 12 = 6{,}857$ kN $\qquad R_2 = 12 - 6{,}857 = 5{,}143$ kN.

Doorsnede ruggen.



Meewerkende breedte ruggen.

$h_{gem} = (12+20)/2 = 8{,}25$ cm

$b^2/R.d = 5{,}5^2/8{,}25.35 = 1{,}047$

$b = 2.0{,}67 \cdot 5{,}5 = 7{,}37$ cm

Meewerkende breedte flens v. dekplaten:

$\frac{1}{5}$ l $R_2 = 12$ cm. $\qquad b = \frac{1}{5}.120 = 24$ cm.

$M_{1,2} = R_2.120 - \frac{1}{5}.R_{1,2}.l_{R_2}$.

Zwaartelijn doorsnede

$J_1 = 2.\frac{1}{12}.10.2{,}5^3 + 17{,}25^2.2.25 = 14904$

$J_2 = 2.\frac{1}{12}.2{,}5.6^3 + 13^2.2.15 = 5160$

$J_3 = 2.\frac{1}{12}.7{,}37.3{,}5^3 + 8{,}25^2.2.258 = 3564$

$J = 23628$ cm^4

$W_1 = 23628/18{,}5 = 1277$ cm^3

Deeldoorsnede:

$A_1 = 7{,}37 \times 3{,}5 = 25{,}8$ $\qquad S_1 = 25{,}8 \times 10{,}25 = 264{,}45$ $\qquad e_o = 7{,}07$ cm

$A_2 = 2{,}5 \times 6 = 15$ $\qquad S_2 = 15 \times 5{,}5 = 82{,}5$ $\qquad e_b = 4{,}93$ cm

$A_3 = 4 \times 2{,}5 = 10$ $\qquad S_3 = 10 \times 1{,}25 = 12{,}5$ $\qquad R_z = 11{,}43$ cm

$50{,}8$ cm^2 $\qquad 359{,}45$ $\qquad h = 12$ cm.

Frame Kabelreservoir Ubersicht

$J_1 = \frac{1}{12} \cdot 7{,}5 \cdot 3{,}5^3 + 2{,}5 \cdot 3{,}18^2 = 28{,}2$
$J_2 = \frac{1}{12} \cdot 2{,}5 \cdot 6^3 + 15 \cdot 1{,}57^2 = 81{,}9$
$J_3 = \frac{1}{12} \cdot 4 \cdot 2{,}5^3 + 10 \cdot 5{,}82^2 = 343{,}9$
$713\ cm^4$

$W_o = 713 / 7{,}07 = 100{,}8\ cm$
$W_b = 713 / 4{,}93 = 144{,}6\ cm$

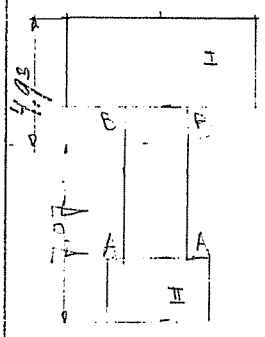
$M = 5143 \cdot 120 - \frac{1}{8} \cdot 12000 \cdot 11{,}43^2 = 589725\ kgf/cm$
$W = 1277\ cm^3$ $\quad \sigma = 589725 / 1277 = 462\ kgf/cm^2$.

$M_{ondergat} = 12000 \cdot 11{,}43 \cdot 0{,}2 = 27432\ kgf/cm$.
$W_o = 100{,}8\ cm^3$ $\quad \sigma_o = 27432 / 100{,}8 = 272\ kgf/cm^2$
$W_b = 144{,}6\ cm^3$ $\quad \sigma_b = 27432 / 144{,}6 = 190\ kgf/cm^2$.

$\sigma_{onder\ zijde\ u.h.\ profiel} = 462 + 272 = 734\ kgf/cm^2$.
$\sigma_{ondergat} = \frac{6{,}5}{18{,}5} \times 462 - 190 = -28\ kgf/cm^2$.

Sprong belasting $\sigma = 9{,}5\ kgf/cm^2$

Schuifspanning kassen ring en Plens.



$D_{max} = \frac{1}{4} \cdot 12 + \frac{1}{2} \cdot 6{,}85 \cdot 7 = 6128\ kg$.

$S_I = 3{,}5 \cdot 7{,}07 \cdot (4{,}93 - 1{,}75) = 82\ cm^3$
$S_{II} = 2{,}5 \cdot 4 \cdot (7{,}07 - 1{,}25) = 58{,}2\ cm^3$

$F_{SI} = \frac{6128 \cdot 82}{713} = 709\ kgf/cm$

$F_{SII} = \frac{6128 \cdot 58{,}2}{713} = 525\ kgf/cm$

Dwarsk

$\sigma_{dwars\ AA} = 462 \cdot \frac{16}{18{,}5} + \frac{4{,}57}{7{,}07} \cdot 272 = 575\ kgf/cm^2$.
Schuifspanning mm.
$\tau_{AA} = 525 / 1{,}8 = 292\ kgf/cm^2$ $\quad \sigma_v = \sqrt{575^2 + 3 \cdot 292^2} = 696\ kgf/cm^2$.
$\sigma = 3{,}15\ kg/cm^2$.

Frame Dubbelverdieping Deurt.

Rvan BB

$\sigma_{druk} = \frac{12000}{20.\pi . \frac{1}{4}.1,8} = 424$ kg/cm².

$\tau = 7^{200}/1,8 = 411$ kg/cm².

$\sigma_v = \sqrt{424^2 + 1,8 . 411^2} = \underline{\underline{626}}$ kg/cm²

Ryan naast gat

$J = \frac{1}{12}.2,5.32^3 + 2.\frac{1}{12}.10.2,5^3 + 22.5.17,25^2 = 21731$ cm⁴

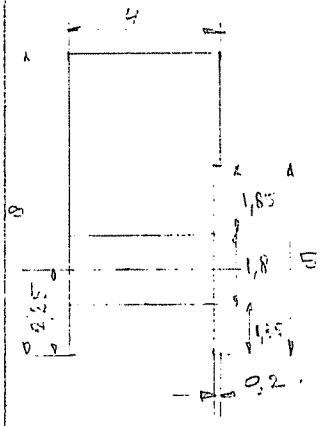
$W = 21731 / 18,5 = 1174$ cm³

$M_{midden} \approx 5143.12,0 = 617160$ kgcm

$\sigma = 617160/1174 = \underline{\underline{526}}$ kg/cm²

$\tau = 685 . 1,5 / 2,5.32 = \underline{\underline{129}}$ kg/cm².

Doorsnede v.d. kozijn



$A_1 = 3 \times 4 = 12$ $\quad S_1 = 12 . 6,5 = 78$

$A_2 = 1,85 \times 3,8 = 7,03$ $\quad S_2 = 7,03 . 4,075 = 28,64$

$A_3 = 1,35 \times 3,8 = 5,13$ $\quad S_3 = 5,13 . 0,675 = 3,46$

$24,16$ cm² $\quad 110,1$ cm

$e_o = 110,1 / 24,16 = 4,55$ cm $\quad e_b = 3,45$ cm.

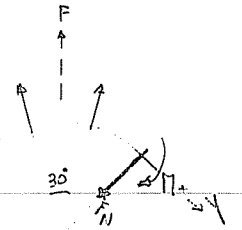
$J_1 = \frac{1}{12}.4.3^3 + 12.1,95^2 = 54,6$ $\quad W_o = 136/4,55 = 29,9$ cm³

$J_2 = \frac{1}{12}.3,8.1,8^3 + 7,03.0,475^2 = 3,6$ $\quad W_b = 136/3,45 = 39,4$ cm³

$J_3 = \frac{1}{12}.3,8.1,35^3 + 5,13.3,875^2 = 77,8$

136 cm⁴

Frame kabelrenvoer Noord



$M = -0{,}39\,F_z = -0{,}39 \cdot 685 \cdot (8+4{,}55) = 34181$ kgf/cm.

$\sigma_o = 34181 / 29{,}9 = 1143.$

$\sigma_b = 34181 / 39{,}4 = 867.$

$F_N = 0{,}51 \cdot 685 = 3548$ kgf. $\sigma_{druk} = 3548 / 24{,}16 = 147$ kgf/cm²

$Q = 0{,}55 \cdot 685 = 4515$ kgf $\tau_{gem} = 4515 / 24{,}16 = 187$ kgf/cm²

$\sigma_{totaal} = 1147 + 143 = 1290$ kgf/cm².

$\sigma_t = 918$ kgf/cm².

* Wyziging.

* Gaten boutenin midden v.d. dwarsrode.

* $h_{ligf} = 33$ cm. $d_{gat} = 1{,}50$ cm.

$I = \frac{1}{12} \cdot 3{,}8 \cdot 8{,}5^3 - \frac{1}{12} \cdot 3{,}8 \cdot 1{,}5^3 = 192{,}6$ cm⁴. $W = 45{,}3$ cm³.

$M = -12{,}25 \cdot 0{,}39 \cdot 685 = 3364$ kgf/cm $\sigma_t = 736$ kgf/cm²

$A = (8{,}5 - 1{,}8) \cdot 3{,}8 = 25{,}46$ cm²

$F_N = 0{,}51 \cdot 685 = 349{,}8$ kgf $\sigma_{druk} = 349{,}8 / 25{,}46 = 139$ kgf/cm².

$\sigma_{tot} = 875$ kgf/cm²

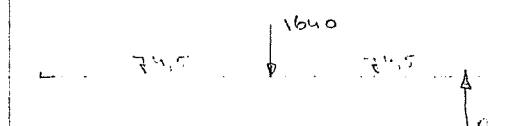
$\tau = 4515 / 25{,}46 = 177$ kgf/cm²

Zijdelingse belasting 2 x 820 kgf.

$F_z = 1640$ kgf. Liggen ingeklemd tpv midden v.d. verticale profielen

Volvo

Frame kabelovenaar Dwarsst



$R_A = 1640 \cdot \frac{1}{12,6^2} / (126 + 133) = 9,1$ kgf

Moment $= \frac{2 \cdot 1640 \cdot 9,1^2}{126^3} = 27,37$ kgf

$I = \frac{1}{12} \cdot 5\ 10^2 + \frac{1}{12} \cdot 4 \cdot 7,37^2 + \frac{1}{12} \cdot 12 \cdot 2,5^3 = 665,8$ cm⁴ $W = 665,8 / 5 = 133$ cm³

$\sigma = 27373 / 133 = 206$ kgf/cm²

$\sigma_{v\,flens} = \underline{940}$ kgf/cm²

$M_{maart\,hoek} = 974 \cdot 22 = 21428$ kgf cm

$I = \frac{1}{12} \cdot 5 \cdot 10^2 + \frac{1}{12} \cdot 32 \cdot 2,5^3 = 458$ cm⁴ $W = 458 / 5 = 91,6$ cm³

$\sigma_b = 234$ kgf/cm²

$M_{xx} = 6852 \cdot 22 = 150854$ kgf cm $W = 1124$ cm³ $\sigma_b = 128$ kgf/cm²

$\sigma_v = \underline{362}$ kgf/cm²

Balans 6x52 $\bar{E}$ spoorstaal = 800 kgf/cm²

Oog verende balans

R = 12,5 cm $W = \frac{1}{6} \cdot 6 \cdot 6^2 = 47,1$ cm³ $M = 0,39 \cdot 2 \cdot 9,25 \cdot 12000 = 44088$ kgf

t = 6 cm $A = 6 \cdot 6 = 36$ cm² $\sigma_b = 44088 / 47,1 = 936$ kgf/cm²

b = 6 cm $P_z = 6 \cdot 325 = 975$ kg

$F_{II} = 9,5 \cdot 1 \cdot 12000 = 6200$ kgf $\sigma_v = 6200 / 36 = 172$ kgf/cm²

$\sigma = 936 + 172 = \underline{1108}$ kgf/cm²

$D = 9,5 \cdot 1 \cdot 12000 = 6200$ kgf $\sigma = 6200 / 34 = 182$ kgf/cm²

Uitvoering.

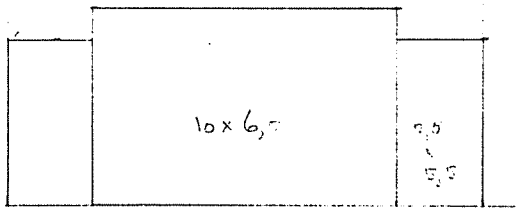
Balans hijsel ovenaar (Vleut

Meewerkende breedte flens middenpaal:

$R_n = \frac{11,5 + 17}{2} = 14,25$ cm (gem).

$S = 5,5$ cm (gem)

$b' = 0,32 \sqrt{14,25 \cdot 5,5} = 2,8$ cm.



$A_1 = 5,6 \cdot 5,5 = 30,8$

$A_2 = 10 \cdot 6,5 = 65$

$95,8$ cm²

$S_1 = 30,8 \cdot 2,75 = 84,7$ $z_1 = 3,1$ cm $z_2 = 11,5 + 3,1 = 14,6$ cm

$S_2 = 65 \cdot 3,25 = 211,25$ $z_2 = 3,4$ cm.

$295,95$ cm³

$J_1 = \frac{1}{12} \cdot 5,6 \cdot 5,5^3 + 30,8 \cdot 0,35^2 = 81,4$ $W_{o1} = 100,5$ cm²

$J_2 = \frac{1}{12} \cdot 10 \cdot 6,5^3 + 65 \cdot 0,15^2 = 230,3$ $W_{b1} = 91,6$ cm²

$311,7$ cm⁴

Zoekelo doorsnede.

$J = \frac{1}{12} \cdot 5,6 \cdot 34^3 + \frac{1}{12} \cdot 10 \cdot 36^3 - \frac{1}{12} \cdot 13 \cdot 23^3 = 44041$

$W = 44041 / 18 = 2446$ cm³

$M = 12000 \cdot 40 - \frac{1}{5} \cdot 211000 \cdot 14,6 = 409920$ kgcm.

$\sigma_{boven} = 409920 / 2446 = 168$ kg/cm².

$M_{onderzijde} = \frac{1}{5} \cdot 211000 \cdot 14,6 = 70080$ kgcm

$\sigma_{onder} = 70080 / 91,6 = 765$ kg/cm²

* $\sigma_{totaal} = 765 + 168 = 933$ kg/cm².

$M_{midden\ yy} = 800 \cdot 40 = 32000$ kgcm.

$J_{yy} = \frac{1}{12} \cdot 2 \cdot 5,5 \cdot 15,6^3 + \frac{1}{12} \cdot 2 \cdot 2 \cdot 10^3 = 3813$ cm⁴ $W = 3813 / 7,8 = 488$ cm³

Balans hoekel ongelijk (Wind)

$\sigma = 32800 / 1488 = 67$ kgf/cm²

* σ_v 1000 kgf/cm²

Doorsnede 16 cm uit het midden v.d. balans:

$h = 33$ $b = 10$ cm

$W_x = \frac{1}{6} \cdot 10 \cdot 33^2 = 1815$ cm³ $W_y = \frac{1}{6} \cdot 33 \cdot 10^2 = 550$ cm³

$M_x = 11000 \cdot 2{,}4 = 288000$ kgf cm $\sigma_x = 159$ kgf/cm²

$M_y = 5720 \cdot 2{,}4 = 19680$ kgf cm $\sigma_y = 36$ kgf/cm²

$\sigma_1 = 195$ kgf/cm²

Wyriging. oorgaande balans...

$R = 14$ $W = \frac{1}{2} \cdot 6{,}7 \cdot 8^2 = 71{,}1$ cm³

$r = 6$ $A = 6{,}7 \cdot 5 = 33{,}5$ cm²

$h = 8$ $h_z = 6+4 = 10$ cm.

$M_b = 0{,}2942 \cdot 10 \cdot 12000 = 11664$ kgf cm $\sigma_b = 667$ kgf/cm²

$N = 0{,}5174 \cdot 12000 = 6209$ kgf $\sigma_N = 115$ kgf/cm²

$\sigma = 782$ kgf/cm²

$D = 0{,}6585 \cdot 12000 = 7902$ $\tau = 147$ kgf/cm²

[illegible] = 2815 kgf/cm²

Balkenlagerung Wand.

h_{tot} = 28 cm

Öffnung 35 + 33 + 2 = 36 cm.

R_1 = 10

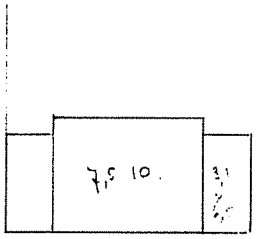
R_2 = 15 ...

Mauerwerksdruckfestigkeit = 1,0 $\sqrt{\frac{2}{3}}$ · 6 = 6,2 N/mm²

$I_x = \frac{1}{12} \cdot 16{,}2 \cdot 38^3 - \frac{1}{12} \cdot 16{,}2 \cdot 31^3 = 57651$ cm⁴

$W_x = 57651 / 19 = 3034$ cm³

W_{vorh}



$A_1 = 6{,}2 \cdot 6{,}5 = 40{,}3$ $\quad S_1 = 40{,}3 \cdot 3{,}25 = 130{,}9$

$A_2 = 7{,}5 \cdot 10 = 75$ $\quad S_2 = 75 \cdot 3{,}75 = 281{,}2$

115,3 cm² $\quad$ 412,1 cm³

$e_o = 3{,}57$ $\quad e_k = 3{,}93$ $\quad R_2 = 11{,}5 + 3{,}57 = 15{,}07$

$I_1 = \frac{1}{12} \cdot 6{,}2 \cdot 6{,}5^3 + 40{,}3 \cdot 0{,}32^2 = 146$ cm⁴ $\quad W_o = 140$ cm³.

$I_2 = \frac{1}{12} \cdot 10 \cdot 7{,}5^3 + 75 \cdot 3{,}18^2 = 354$ cm⁴ $\quad W_k = 127$ cm³.

500 cm⁴.

$I_{yy} = \frac{1}{12} \cdot 13 \cdot 16{,}2^3 + \frac{1}{12} \cdot 2 \cdot 10^3 = 4772$ cm⁴

$W = 4772 / 8{,}1 = 589$ cm³

$M_x = 12000 \cdot 40 - \frac{1}{8} \cdot 12000 \cdot 15{,}07 = 407664$ kg/cm

$\sigma_b = 407664 / 3034 = 134$ kg/cm²

$M_{Konsole} = \frac{1}{2} \cdot 12000 \cdot 15{,}07 = 72336$ kg/cm

$\sigma_{Konsole} = 72336 / 127 = 570$ kg/cm².

$M_y = 50 \cdot 40 = 2000$ kg/cm

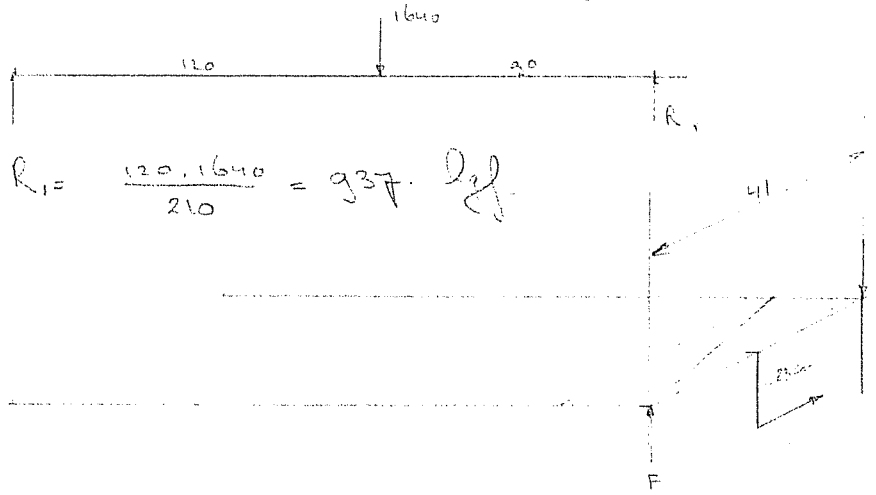
$\sigma = 32800 / 589 = 56$ kg/cm²

Randspannung $= 134 + 570 + 56 = 760$ kg/cm² $\quad$ V = 80 kg/cm²

Eigenlast Wand $= 1{,}8 \cdot 0{,}25 \cdot 40 = 18$ kg/cm

Weeg-Kabel overvoer kraan

zijdelingse belasting 1640 kgf.



$R_1 = \frac{120 \cdot 1640}{210} = 937$ kgf.

$F = 937 \cdot 23 / 41 = 526$ kgf

$M = 210 \cdot 526 / 2 = 55200$ kgfcm

Kokvr.

$A_{gem.} = 19,8 \times 34,5 = 372,6$ cm²

$\sigma = \frac{55200}{2 \cdot 12 \cdot 372,6} = 62$ kgf/cm²

Nieuwe Schuttelwis Wandt

Belasting kabel bij breuk

$C = \frac{0{,}85 \cdot 10^6 \cdot 6{,}26}{3175{,}5} = 1675{,}6$ kgf/cm.

Periode 76,25 kf.

$\delta_{0\ \text{boven}} = \frac{76{,}25}{16 \cdot 1{,}6756} = 2{,}844$.

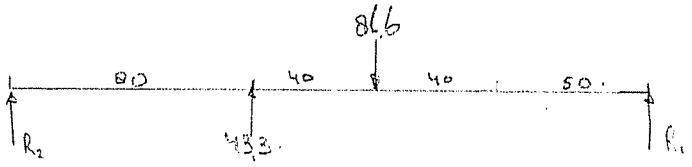
$h_{0\ \text{boven}\ max} = 7/4 = 1{,}75$ cm

$F_{max} = \left\{1 + \sqrt{1 + 2 \cdot 1{,}75 / 2{,}844 \ldots}\right\} 76{,}25 = 190{,}13$ kf.

$F_{kabel} = 190{,}13 / 4 = \underline{47{,}5}$ kf.

$h_0 = 0{,}875$ $\quad F_{max} = \underline{43{,}29}$ kf. $\quad \frac{F_{max}}{F_{kabel}} = \underline{3{,}C}$

Frame



$R_1 = \frac{120 \cdot 866 + \ldots - 80 \cdot 433}{210} = 32{,}99$ kf.

$R_2 = 43{,}3 - 32{,}99 = 10{,}31$ kf

Spanning oog $R_1 = \frac{16500}{6857} \times 875 = 2106$ kgf/cm^2.

Spanning midden

$M = (20{,}62 \cdot 120 + 43{,}3 \cdot 40) \frac{1}{2} - \frac{1}{5} \cdot 433 \cdot 11{,}43 = 2004{,}2$ kgcm $W = 271$ cm^3 $\quad \sigma = 1{,}6 \cdot$ kgf/cm^2

doorkant $M = 43{,}3 \cdot 11{,}43 \cdot 0{,}2 = 98{,}90$ kgcm $\quad W = 100{,}8$ cm^3 $\quad \sigma = 98$ kgf/cm^2

$\sigma_t = 2551$ kgf/cm^2

Weerd frame bij labelbrug

F = 43,9 kN

Las pijp aansluiting

$\sigma = 21650 / 2 \cdot \pi \cdot 9,8 \cdot 800$ N/cm²

Doorsnede:

Moment A_x = 43 cm

F = 43200 / 1000 N/cm²

NIEUWE SCHUTSLUIS TE WEURT.

4. BEREKENING ONDERDELEN KABELEVENAAR.

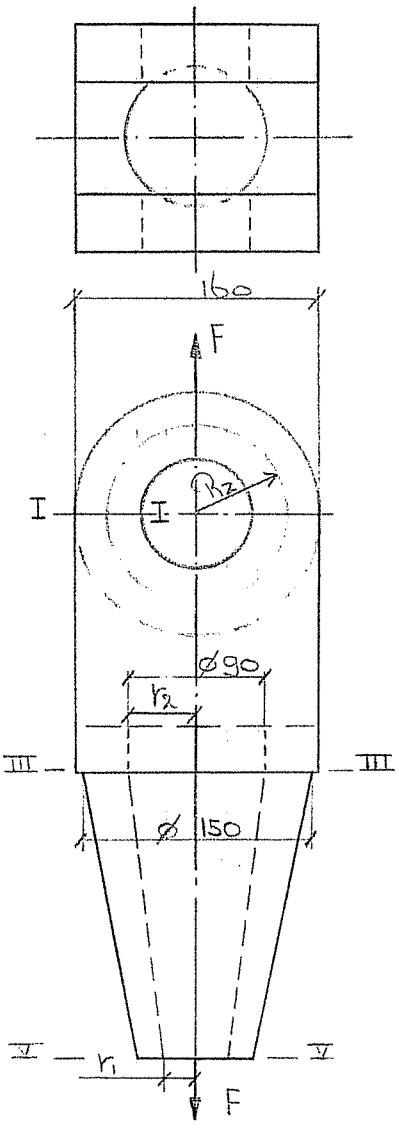
1975

Berekening kabelsok (Pos 3 tek A 57203)

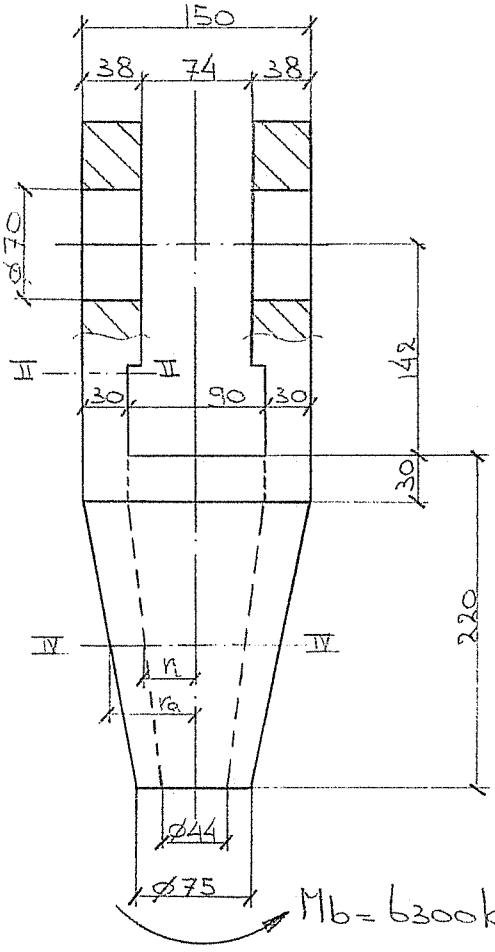
Zie ook staalkabels - Den Haan - eindverbinding nummer 12

Werkbelasting één kabel : 12 tf

Belasting in één kabel bij kabelbreuk : 43,3 tf.

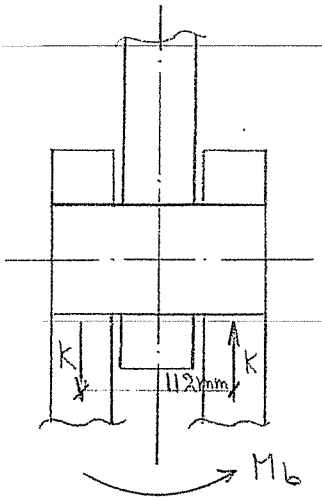


F_{max} = 12 tf.



Mb = 6300 kgcm

Het buigend moment in de kabelsok veroorzaakt door wrijving in het bolscharnier heeft een grootte van 6300 kgcm



Berekening oog kabelsok. Doorsnede I-I

Extra belasting t.p.v. oog door buigend moment bedraagt:

$$K \times 11{,}2 = 6300 \Rightarrow K = \underline{563}\ \text{kgf}.$$

Totale belasting per oog $= {}^{12000}/_{2} + 563 = \underline{6563}$ kgf

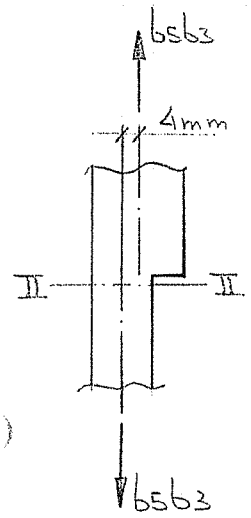
Berekening volgens artikel 6

$$\sigma = \frac{0{,}5 \times 6563}{4{,}5 \times 3{,}8} + \frac{0{,}171 \times 6563 \times R_2}{W_{I-I}}$$

$R_2 = 57{,}5$ mm

$W_{I-I} = \frac{1}{6} \cdot 3{,}8 \cdot 4{,}5^2 = 12{,}8\ \text{cm}^3$

$$\sigma = \frac{0{,}5 \times 6563}{17{,}1} + \frac{0{,}171 \times 6563 \times 5{,}75}{12{,}8} = \underline{697}\ \text{kgf/cm}^2$$



$\sigma \leq 805\ \text{kgf/cm}^2$ voor Gst 52k volgens artikel

Berekening doorsnede II-II

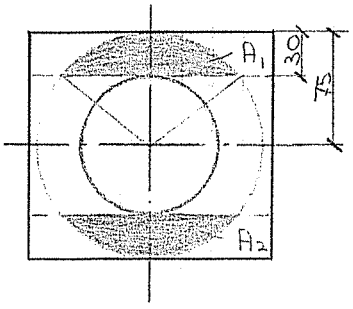
$$\sigma = \sigma_t + \sigma_b = \frac{6563}{3 \times 16} + \frac{6563 \times 0{,}4}{\frac{1}{6} \cdot 16 \cdot 3^2} = \underline{247}\ \text{kgf/cm}^2$$

$\bar{\sigma} = 805\ \text{kgf/cm}^2$

Berekening conus. Doorsnede III-III

1) Doorsnede III-III

$A_{tot} = A_1 + A_2$



$A_1 = A_2 = 25{,}2\ \text{cm}^2 \Rightarrow A = 50{,}4\ \text{cm}^2$

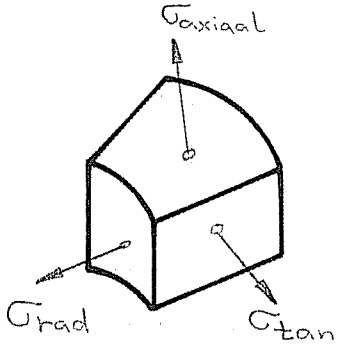
$\sigma_{tan\ max} = 248 \cdot \frac{3{,}8}{1{,}8} = \underline{525}$ kg/

$$\sigma_{t\ max} = \frac{6563}{25{,}2} = \underline{261}\ \text{kgf/cm}^2$$

$\sigma_{rad.\ max} = -p = \underline{-248}$ kgf/cr

$\bar{\sigma} = 805\ \text{kgf/cm}^2$

Doorsnede IV-IV



2) $p = \frac{F}{\pi(r_2^2 - r_1^2)} = \frac{12000}{\pi(4{,}5^2 - 2{,}2^2)} = \frac{12000}{48{,}5} = \underline{248}\ kgf/cm^2$

Volgens Dubbel blz 405 - 1966

$\sigma_{tan\ max.} = p \cdot \frac{z^2+1}{z^2-1}$ $\qquad z = \frac{r_a}{r_i} = \frac{5{,}625}{3{,}35} = 1{,}68$

$\sigma_{tan.max} = 248 \cdot \frac{1{,}68^2+1}{1{,}68^2-1} = \underline{520}\ kgf/cm^2$

$\sigma_{rad.max} = -p = \underline{-248}\ kgf/cm^2$

$\sigma_{axiaal} = \frac{p}{z^2-1} = \frac{248}{1{,}8224} = \underline{136}\ kgf/cm^2$

Volgens Hütte blz. 850

$\sigma_{max} = p.\sqrt{3} \cdot \frac{r_a^2/r_i^2}{\frac{r_a^2}{r_i^2}-1} = 248.1{,}73.\frac{1{,}68^2}{1{,}68^2-1} = \underline{665}\ kgf/cm^2$

$\sigma = 805\ kgf/cm^2$

Doorsnede V-V

$\sigma_{tan.max} = 248.\frac{3{,}93}{1{,}93} = \underline{506}\ kgf/cm^2$

$\sigma_{rad.max} = -p = \underline{-248}\ kgf/cm^2$

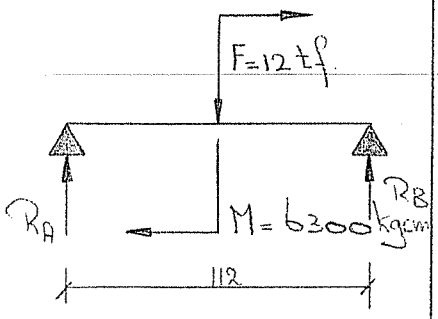
$\sigma_{axiaal} = \frac{248}{1{,}93} = \underline{129}\ kgf/cm^2$

Vlaktedruk tussen pen en oog

$\sigma_d = \frac{6563}{7 \times 3{,}8} = \underline{247}\ kgf/cm^2$

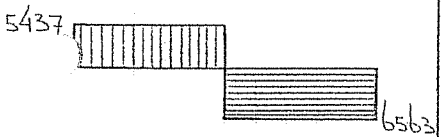
Berekening pen in kabelsok

Materiaal as 2C45 - ø70 - Zie tek. A 57203
Het materiaal 2C45 komt qua mechanische eigenschappen met St. 60 overeen



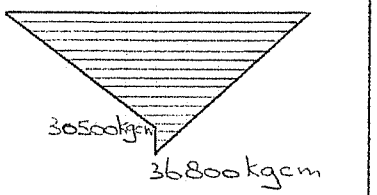
$R_A \times 11{,}2 - 12000 \times 5{,}6 + 6300 = 0 \Rightarrow R_A = 5437\ kgf$

$R_A + R_B = 12000\ kgf \Rightarrow R_B = 6563\ kgf$



$$\sigma_b = \frac{M_b}{W_b} = \frac{36800}{0{,}1 \cdot 7^3} = \frac{36800}{34{,}3} = \underline{1070}\ kgf/cm^2$$

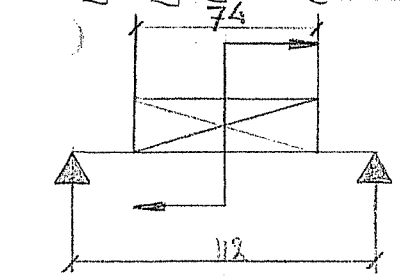
$$\hat{\tau} = \frac{D}{F} = \frac{6563}{\pi/4 \cdot 7^2} = \frac{6563}{38{,}5} = \underline{170}\ kgf/cm^2$$



$$\sigma_v = \sqrt{1070^2 + 3 \cdot 170^2} = \underline{1110}\ kgf/cm^2$$

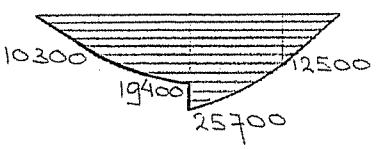
In werkelijkheid is de aanname van een puntlast wat te ongunstig gekozen.
Gaan we van een gelijkmatige belasting uit dan vinden we de volgende spanningen:

Mb t.g.v. gelijkmatige bel



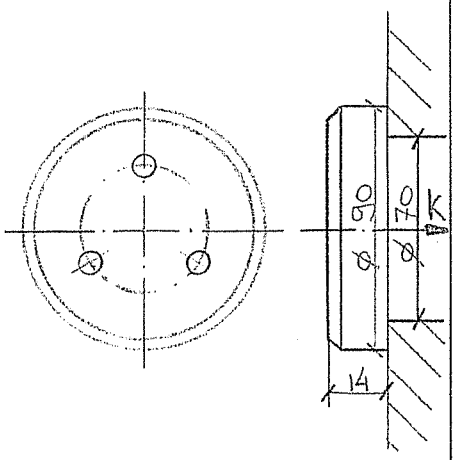
$$\sigma_b = \frac{85700}{34{,}3} = \underline{750}\ kgf/cm^2$$

$$\hat{\tau} = \frac{6563}{38{,}5} = \underline{170}\ kgf/cm^2$$ (Niet helemaal juist aangezien in middendoorsnede)



$$\sigma_v = \sqrt{750^2 + 3 \cdot 170^2} = \underline{805}\ kgf/cm^2$$

$$\bar{\sigma} = 1015\ kgf/cm^2$$



Berekening opsluitplaat pen. (Tek. A5718b pos 29)

Kruipkracht : $k = 0{,}4 \times \frac{1}{2}F = 0{,}2 \times 12000 = \underline{2400}$ kgf

Ulakte druk tussen plaat en kabelsok:

$$\sigma_o = \frac{2400}{\pi/4\,(9^2 - 7^2)} = \underline{96}\ kgf/cm^2$$

Berekening plaatspanning : Materiaal Fe 360 I

$$\sigma = \frac{\frac{1}{3}P_{bout}}{\frac{1}{6}.8^2} = \frac{\frac{1}{3}.800}{\frac{1}{6}.1{,}4^2} = \underline{816}\ kgf/cm^2$$

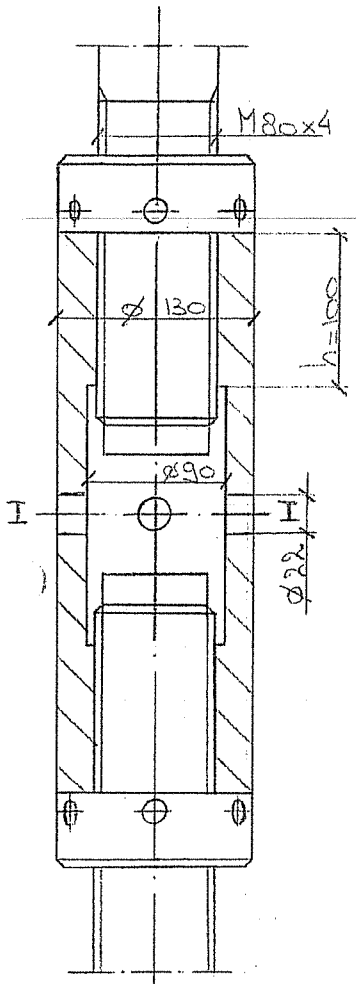
$\bar{\sigma} = \underline{1015}\ kgf/cm^2$ volgens tabel 2.1.1

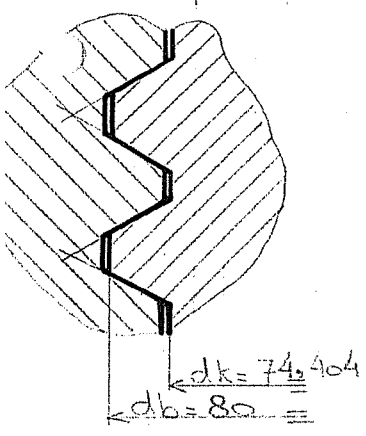
Berekening bouten in opsluitplaat

Drie bouten $M_{12} \Rightarrow P_{bout} = 2400/3 = \underline{800}$ kgf

Materiaal 8.8 $\bar{\sigma} = 0{,}8\,\sigma = 0{,}8 \times 1755 = 1405\ kgf/cm^2$
vlg tabel 2.1.1

$$\sigma = \frac{800}{A_k} = \frac{800}{0{,}72} = \underline{1110}\ kgf/cm^2$$





Berekening kabelspanner.

Belastingen : $M_b = 6300$ kgcm $F = 12$ tf.
Materiaal 2C 35 - overeenkomend met St. 50

Doorsnede I-I

$$A = \pi/4 (13^2 - 9^2) - 4 \times 2{,}2 \times 2 = 69{,}2 - 17{,}6 = \underline{51{,}6\ cm^2}$$

$$\sigma_t = \frac{12000}{51{,}6} = \underline{232\ kgf/cm^2}$$

W_b verzwakte doorsnede $= 124\ cm^3$

$$\sigma_b = \frac{6300}{124} = \underline{51\ kgf/cm^2}$$

$\sigma_{totaal} = 232 + 51 = \underline{283\ kgf/cm^2}$ $\bar{\sigma} = 885\ kgf/cm^2$

Vlakte druk tussen de draadgedeelten.

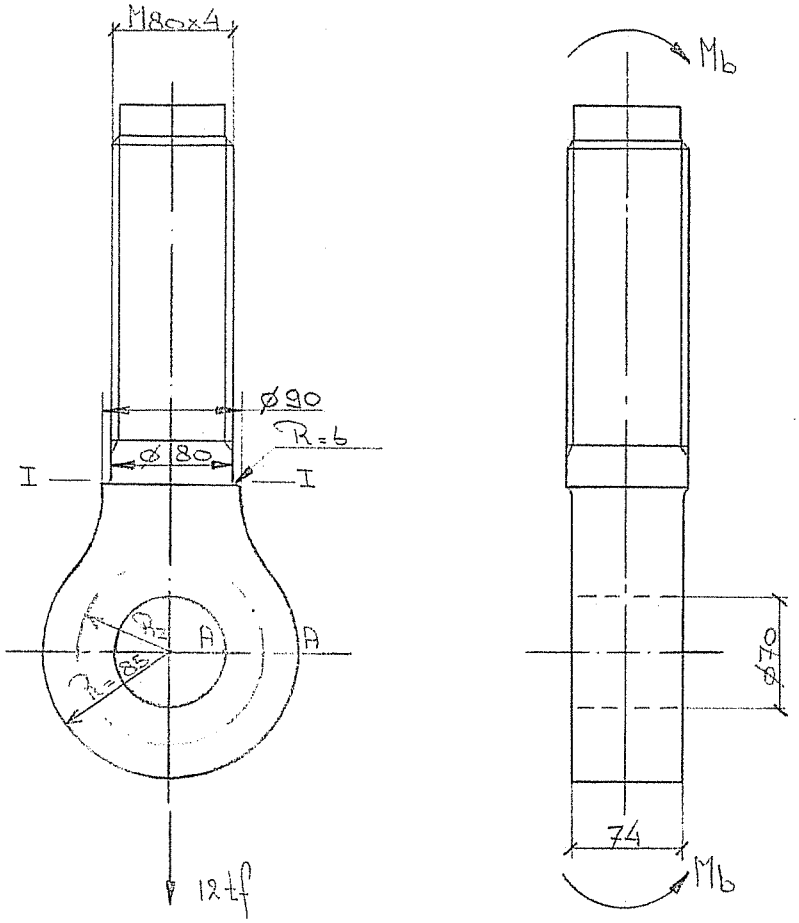
$h = h \times s \Rightarrow 100 = h \times 4 \Rightarrow h = 25$ gangen

$$\sigma_o = \frac{F}{\pi/4 (d_b^2 - d_k^2) . n} = \frac{12000}{\pi/4 (8^2 - 7{,}404^2) . 25} = \underline{71\ kgf/cm^2}$$

Opm. De kabelspanners worden pas verdraaid wanneer de kracht in de kabels is teruggelopen tot de vereiste voorspanning. Er hoeft bij bovenstaande berekening danook niet met een extra wringspanning rekening te worden gehouden

Berekening pos 13 (oogstang) tek. A 57190.

Zie ook smeedstaal tekening A boggs.



Het buigende moment in de oogstang wordt veroorzaakt door wrijving in het bol-scharnier. Als wrijvingscoëfficient f is 0,1 gerekend.

$M_b = 0{,}1 \times 12000 \times 5{,}25$ Straal bolscharnier = 5,25 cm

$M_b = \pm 6300$ kgcm. (Wisselend moment)

Doorsnede I-I: Hier behoeft geen rekening te worden gehouden met speciale kerffactoren. Berekening volgens artikel b.1.1 uit voorstel herziening U.O.B.E jan 1975

Materiaal 2C45 Treksterkte 63-78 kgf/mm^2
Overeenkomend met St. 60

Doorsnede A-A

$$\sigma = \frac{0{,}5\,F}{A} + \frac{0{,}171 \cdot F \cdot R_2}{W_{A\text{-}A}} + \frac{M_b}{W_{tot}} \leq \bar{\sigma}$$

$F = 12000\ kgf$

$A = 5 \times 7{,}4 = 37\ cm^2$

$R_2 = 6\ cm$

$W = \frac{1}{6} \cdot 7{,}4 \cdot 5^2 = 30{,}8\ cm^3$

$W_{tot} = 91{,}3\ cm^3$

$$\sigma = \frac{0{,}5 \cdot 12000}{37} + \frac{0{,}171 \cdot 12000 \cdot 6}{30{,}8} + \frac{6300}{91{,}3} \leq 1015\ kgf/cm^2$$

$\sigma = 631\ kgf/cm^2$ Ulaktedruk: $\sigma_d = \frac{12000}{7 \times 7{,}4} = 232\ kgf/cm$

Berekening schroefdraad.

M80x4 - Reeks B volgens uitgave Schroefdraad van het HCNN juli 1953 - blz 43

Berekening volgens artikel 2.2

$d_{kern} = 74{,}404\ mm$

$$\sigma_t = \frac{F}{A_{kern}} \qquad A_{kern} = \pi/4\ d_k^2 = \pi/4 \cdot 7{,}404^2 = 43{,}48\ cm^2$$

$$\sigma_t = \frac{F}{43{,}48} = \frac{12000}{43{,}48} = 276\ kgf/cm^2$$

Sprongbelasting $\Rightarrow \bar{\sigma} = 490\ kgf/cm^2$

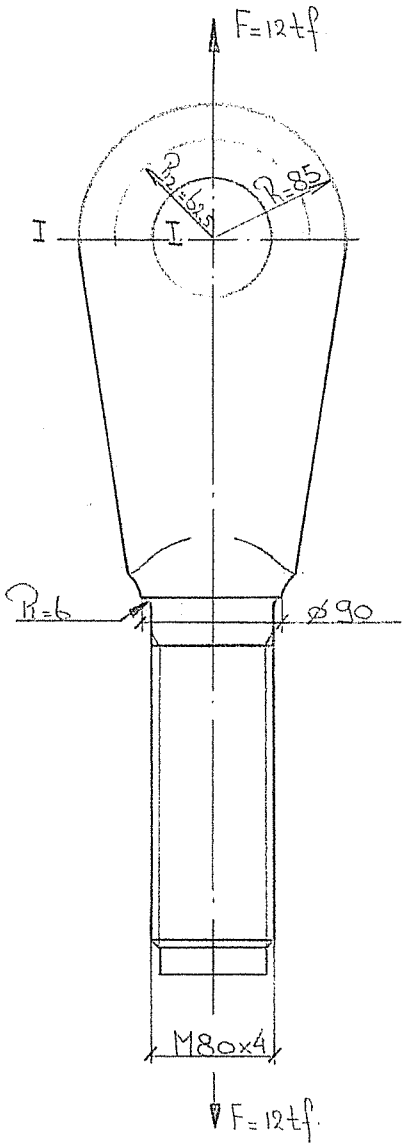
$\sigma_t + \sigma_b \leq \bar{\sigma} \Rightarrow \sigma_t + \sigma_b \leq 490\ kgf/cm^2$

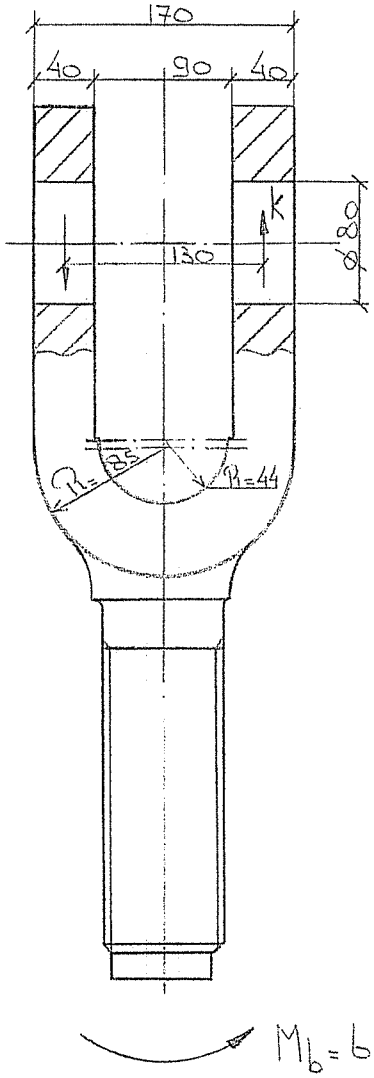
$$\sigma_b = \frac{M_b}{W_b} = \frac{6300}{0{,}1\,d^3} = \frac{6300}{0{,}1 \cdot 8^3} = \frac{6300}{51{,}2} = 123\ kgf/cm^2$$

$\sigma = \sigma_t + \sigma_b = 276 + 123 = 399\ kgf/cm^2 < 490\ kgf/cm^2$

$\bar{\sigma} = 490\ kgf/cm^2$

Berekening oaffel. (Zie tek. A boggs - pos 14)





Materiaal 2C45 (St 60)

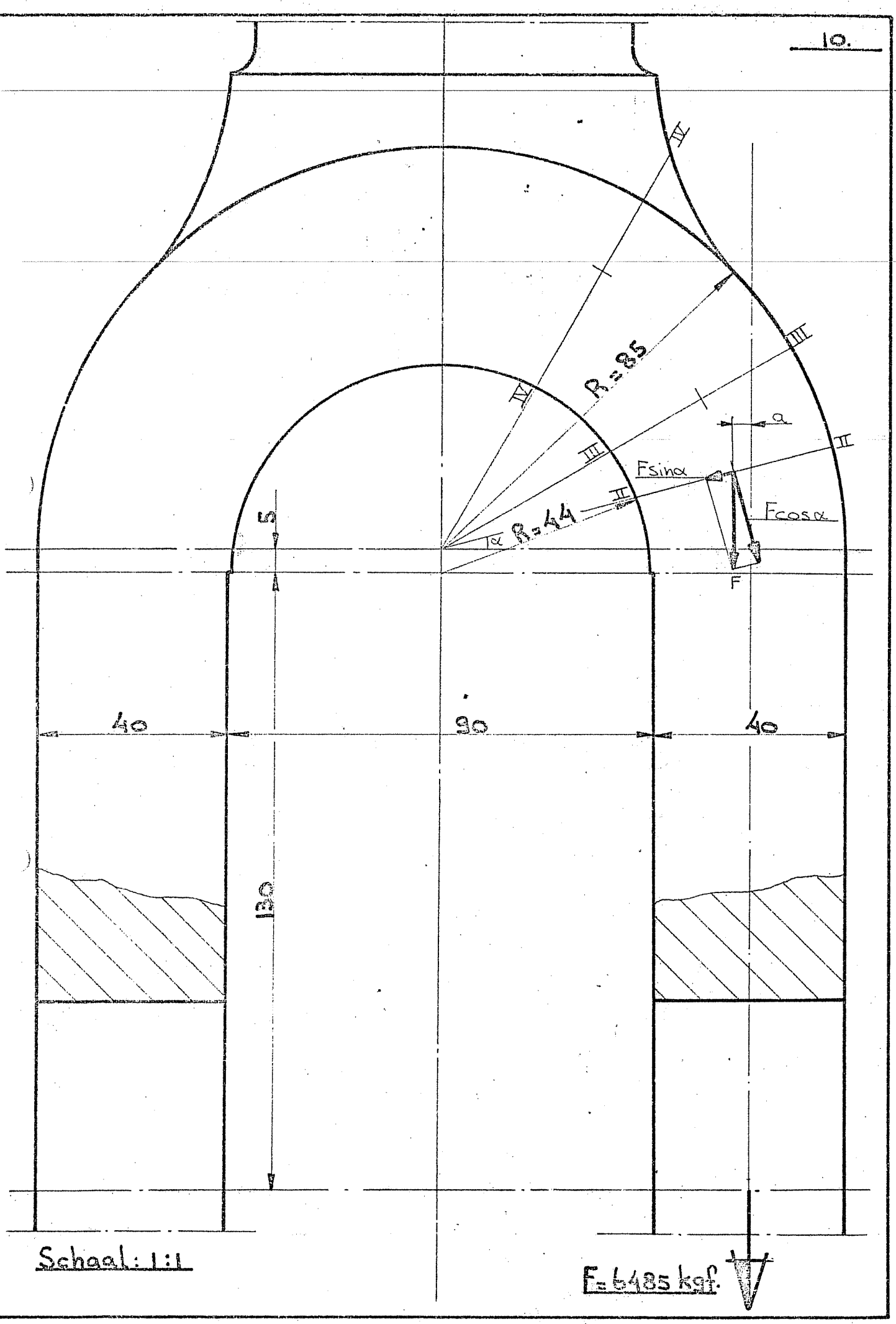
Berekening oog: Doorsnede I-I

$K \times 13 = 6300 \Rightarrow k = 485\ kgf.$

Maximale belasting per oog = 6000 + 485 = 6485 kgf

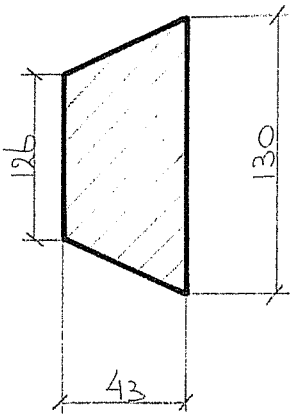
$$\sigma = \frac{0{,}5 \times 6485}{4 \times 4{,}5} + \frac{0{,}171 \cdot 6485 \cdot 6{,}25}{1/6 \cdot 4 \cdot 4{,}5^2} = 692\ kgf/cm^2$$

$\bar{\sigma} = 1015\ kgf/cm^2$ uit tabel 2.1.1



Schaal: 1:1

F=6485 kgf.



$A = \frac{1}{2} \cdot 4{,}3\,(13 + 12{,}6)$

$= \underline{55\,cm^2}$

$W_b = \frac{\frac{1}{4{,}3^2} \cdot \frac{6 \cdot 12{,}6^2 + 6 \cdot 12{,}6 \cdot 0{,}4 + 0{,}4^2}{12\,(3 \cdot 12{,}6 + 0{,}4)}}{}$

$= \underline{39{,}6\,cm^3}$

Doorsnede II-II ($\alpha = 15°$) (Zie blad 10)

$F = \underline{6485\,kgf}$ $\quad F\sin\alpha = 6485 \times 0{,}2588 = \underline{1680\,kgf}$

$F\cos\alpha = 6485 \times 0{,}9659 = \underline{6284\,kgf}$

$$\sigma_t = \frac{F\cos\alpha}{A} = \frac{6284}{55} = \underline{115\ kgf/cm^2}$$

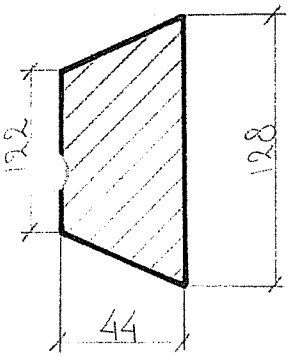
$$\sigma_b = \frac{F.a}{W_b} = \frac{6485 \times 0{,}4}{39{,}6} = \underline{66\ kgf/cm^2}$$

$\sigma_{tot} = 115 + 66 = \underline{181\ kgf/cm^2}$

$$\tau = \frac{F\sin\alpha}{A} = \frac{1680}{55} = \underline{31\ kgf/cm^2}$$

$\sigma_L = \sqrt{181^2 + 3 \cdot 31^2} = \underline{189\ kgf/cm^2}$

Doorsnede III-III ($\alpha = 30°$)



$A = \frac{1}{2} \cdot 4{,}4\,(12{,}2 + 12{,}8) = \underline{55\,cm^2}$

$W_b = \frac{1}{6} \cdot 12{,}5 \cdot 4{,}4^2 = \underline{40{,}4\,cm^3}$

$F\sin\alpha = 6485 \times 0{,}5 = \underline{3243\,kgf}$

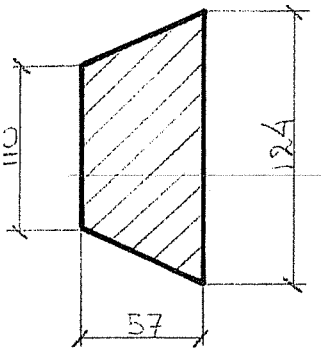
$F\cos\alpha = 6485 \times 0{,}8660 = \underline{5630\,kgf}$

$$\sigma_t = \frac{5630}{55} = \underline{103\ kgf/cm^2}$$

$$\sigma_b = \frac{6485 \times 1{,}1}{40{,}4} = \underline{176\ kgf/cm^2} \qquad \sigma_{tot} = \underline{279\ kgf/cm^2}$$

$$\tau = \frac{3243}{55} = \underline{59\ kgf/cm^2}$$

$\sigma_L = \sqrt{279^2 + 3 \cdot 59^2} = \underline{297\ kgf/cm^2}$



$A = \frac{1}{2}\ 5{,}7\ (12{,}4 + 11) = \underline{95\ cm^2}$

$I_x = \frac{6.11^2 + 6.11.1{,}4 + 1{,}4^2}{12\,(3.11 + 2.1{,}4)} \cdot 5{,}7^2 =$

$= \underline{62\ cm^3}$

Doorsnede IV-IV ($\alpha = 60°$)

$F \sin\alpha = 6485 \times 0{,}8660 = \underline{5630\ kgf}$

$F \cos\alpha = 6485 \times 0{,}5000 = \underline{3243\ kgf}$

$$\sigma_t = \frac{3243}{95} = \underline{34\ kgf/cm^2}$$

$$\sigma_b = \frac{6485 \times 3{,}2}{62} = \underline{335\ kgf/cm^2}$$

$$\tau = \frac{5630}{95} = \underline{59\ kgf/cm^2}$$

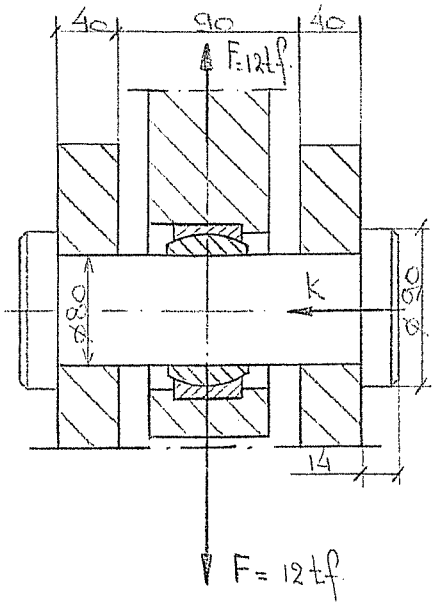
$$\sigma_{tot} = 335 + 34 = \underline{369\ kgf/cm^2}$$

$$\sigma_i = \sqrt{369^2 + 3\,59^2} = \underline{383\ kgf/cm^2}$$

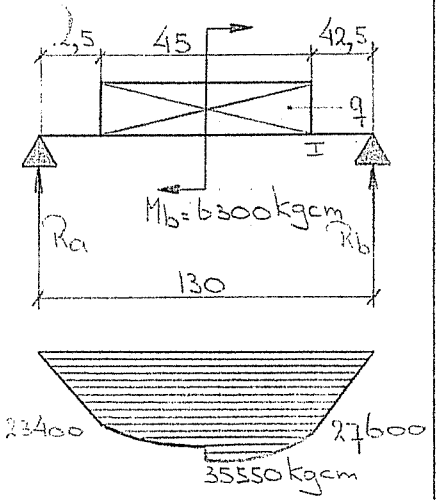
Vlaktedruk tussen pen en oog

$$\sigma_o = \frac{6485}{8 \times 4} = \underline{202\ kgf/cm^2}$$

De berekening van de schroefdraad is dezelfde als uitgevoerd voor de oogstang op blz 8.



Belastingsituatie.



Berekening pen in gaffel. (Zie tek. A boggs - pos 6)

Materiaal: 2C45 (komt overeen met St. 60)
$\bar{\sigma} = 1015\ kgf/cm^2$ volgens tabel 2.1.1

$q = 12000/4,5 = 2660\ kgf/cm'$

$Ra \times 13 - 12 \times 6,5 + 6,3 = 0 \Rightarrow Ra = \underline{5,5\ tf}$

$Rb = \underline{6,5\ tf}$

$$\sigma_{b\,max} = \frac{35550}{0,1.8^3} = \frac{35550}{51,2} = \underline{695}\ kgf/cm^2$$

$$\sigma_b\ (\text{Doorsnede I}) = \frac{27600}{51,2} = \underline{540}\ kgf/cm^2$$

$$\tau = \frac{6500}{\pi/4.8^2} = \frac{6500}{50,3} = \underline{130}\ kgf/cm^2$$

$$\sigma_i = \sqrt{540^2 + 3.130^2} = \underline{585}\ kgf/cm^2$$

Vlaktedruk tussen pen en gaffel

$$\sigma_o = \frac{6500}{8 \times 4} = \underline{203}\ kgf/cm^2$$

Berekening opsluitplaat pen.

$K = 0,4 \times \frac{1}{2}F = 2400\ kgf$

$\tau_{bout} = K/3 = 800\ kgf$

$$\sigma_{plaat} = \frac{\frac{1}{3}\tau_{bout}}{\frac{1}{6}\delta^2} = \frac{\frac{1}{3}.800}{\frac{1}{6}.1,4^2} = \underline{816}\ kgf/cm^2$$

$\bar{\sigma} = 1015\ kgf/cm^2$

Berekening v.d. spanning in de bouten (Zie blz. 2)

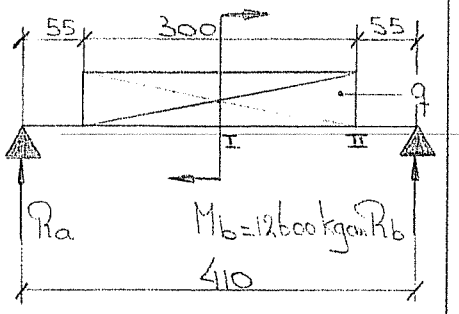
Drie bouten M12 - 8.8

$$\sigma_{tr} = \frac{800}{A_k} = \frac{800}{0,72} = \underline{1110}\ kgf/cm^2$$

Berekening pen in balans. Zie tek. Aboggs proef

Materiaal: 2 C 45 (komt overeen met St. 60)
$\bar{\sigma}$ = 1015 kgf/cm² volgens tabel 2-1-1
Afmetingen: asdiameter = 130 lang 520

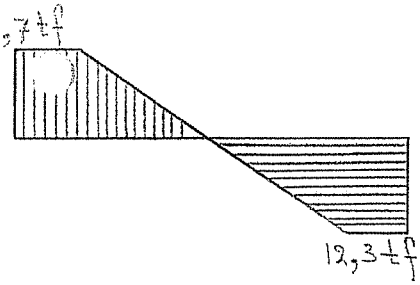
Belastingsituatie:



$q = 24000/30 = 800$ kgf/cm

$R_a \times 41 - 24 \times 20{,}5 + 12{,}600 = 0$

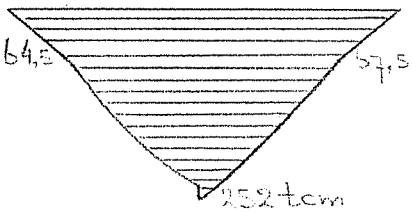
$R_a = 11{,}7$ tf $\Rightarrow R_b = 12{,}3$ tf



$$\sigma_{b\,max.} = \frac{12300 \times 20{,}5}{0{,}1 \times 13^3} = \frac{252000}{219{,}7} = 1150 \text{ kgf/cm}^2$$

(Zie herziene ber. op blz.

Deze spanning treedt op in doorsnede I, zie belastingsituatie.

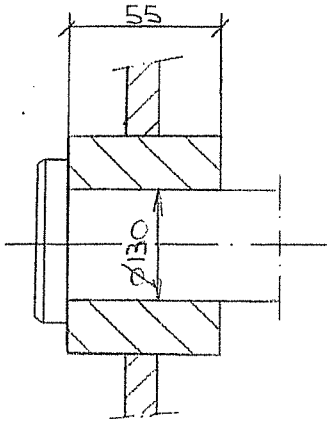


Doorsnede II

$$\sigma_b = \frac{12300 \times 5{,}5}{219{,}7} = \frac{67500}{219{,}7} = 308 \text{ kgf/cm}^2$$

$$\tau = \frac{12300}{\frac{\pi}{4} 13^2} = \frac{12300}{133} = 93 \text{ kgf/cm}^2$$

$$\sigma_i = \sqrt{308^2 + 3.93^2} = 348 \text{ kgf/cm}^2$$

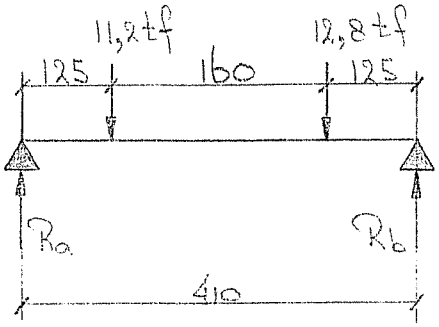


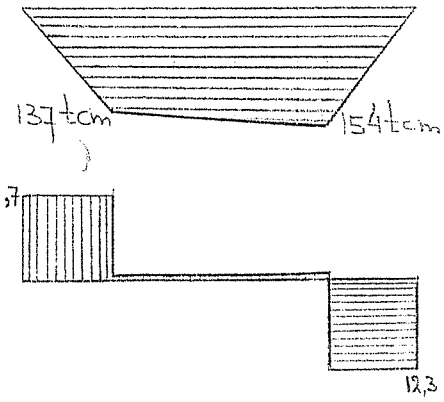
Vlaktedruk pen-frame.

$$\sigma_o = \frac{12300}{5{,}5 \times 13} = 172 \text{ kgf/cm}^2$$

De belastingsituatie als is aangenomen, is gezien de werkelijke omstandigheden wat ongunstig gekozen. Herziene berekening op blz 15.

Belastingsituatie:





Herziene berekening pen in balans.

$Ra \times 41 - 11,2 \times 28,5 - 12,8 \times 12,5 = 0$

$Ra = \underline{11,7\ tf} \Rightarrow Rb = \underline{12,3\ tf}$

$\sigma_b = \frac{154000}{219,7} = \underline{705}\ kgf/cm^2$

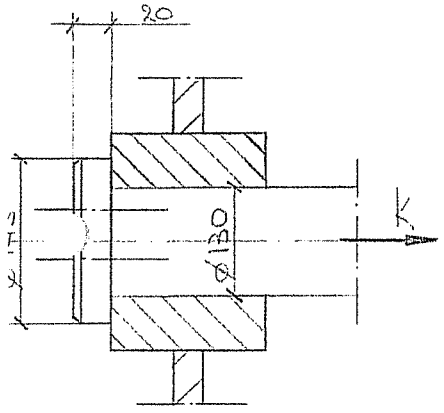
$\tau = \frac{12300}{\pi/4 \times 13^2} = \underline{93}\ kgf/cm^2$

$\sigma_i = \sqrt{705^2 + 3.93^2} = \underline{723}\ kgf/cm^2$

Berekening opsluitplaat. Materiaal: Fe 360 D

$K = 2 \times 820 = \underline{1640\ kgf}$

$\tau_{bout} = k/3 = 547k$



Vlaktedruk tussen plaat en frame:

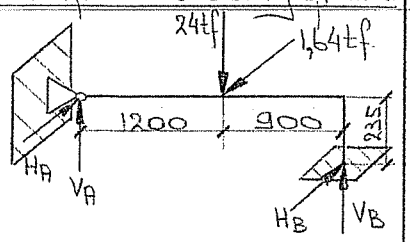
$\sigma_o = \frac{547}{\pi/4(14,5^2 - 13^2)} = \underline{17}\ kgf/cm^2$

Berekening plaatspanning

$\sigma = \frac{1/3 . \tau_{bout}}{1/6 \ \ 8^2} = \frac{1/3 . 547}{1/6 . 2^2} = \underline{274}\ kgf/cm^2$

$\bar{\sigma} = 1015\ kgf/cm^2$ volgens tabel 2.1.1

Principe belasting frame.



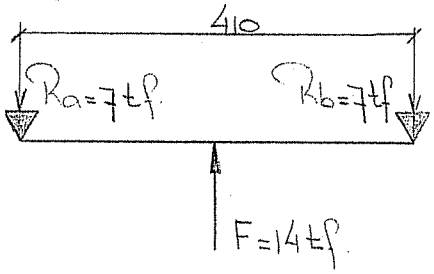
$V_A \times 2100 - 24 \times 900 = 0$

$V_A = \underline{10tf} \Rightarrow V_B = \underline{14tf}$

$H_A \times 2100 - 1{,}64 \times 900 = 0$

$H_A = \underline{0{,}7tf} \Rightarrow H_B = \underline{0{,}94tf}$

Belastingsituatie

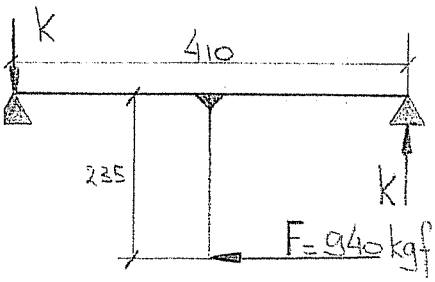


$M_{max} = \frac{1}{4} F L$

$= \frac{1}{4} . 14000 \times 41$

$= \underline{143500 kgcm}$

Reactie verhoging t.g.v. moment door hor. kracht



$F \times 23{,}5 = K \times 41$

$K = \frac{940 \times 23{,}5}{41} = \underline{540kgf}$

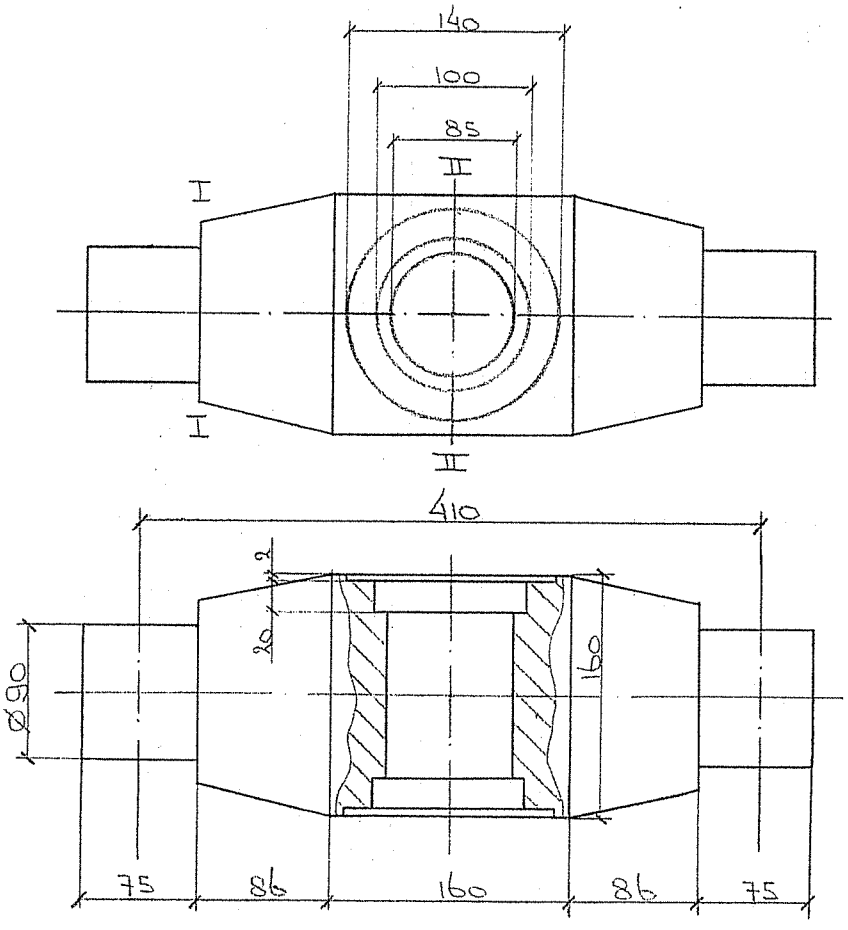
Berekening bouten in opsluitplaat

Drie bouten M20 $\Rightarrow \tau_{bout} = 6550/3 = \underline{2180kgf}$

Materiaal 8.8 $\bar{\sigma} = 0{,}8\sigma = 0{,}8 \times 1755 = \underline{1405} \frac{kgf}{cm^2}$

$$\sigma = \frac{2180}{Ak} = \frac{2180}{2{,}2} = \underline{990} \frac{kgf}{cm^2}$$

Berekening juk (Zie tek. A bo.995 - pos 8)



Materiaal: 2C45 (komt overeen met St 60)

$\bar{\sigma} = 1015 \frac{kgf}{cm^2}$ volgens tabel 2.11

Doorsnede I-I

$$\sigma_b = \frac{7540 \times 3{,}75}{0{,}1 \times 9^3} = \frac{28300}{72{,}9} = \underline{390}\ kgf/cm^2$$

$$\tau = \frac{7540}{\pi/4 \cdot 9^2} = \frac{7540}{63{,}5} = \underline{119}\ kgf/cm^2$$

$$\sigma_i = \sqrt{390^2 + 3.119^2} = \underline{441}\ kgf/cm^2$$

Doorsnede II-II.

$$I_{x-x} = \tfrac{1}{12}.16^4 - \tfrac{1}{12}.8{,}5.11{,}6^3 - \left[\tfrac{1}{12}.10.2^3 + 2.10.6{,}8^2\right].2$$

$$- \left[\tfrac{1}{12}.14.0{,}2^3 + 14\ 0{,}2.7{,}9^2\right].2 = \underline{2140\ cm^4}$$

$$W_{x-x} = \frac{I_{x-x}}{e} = \frac{2140}{8} = \underline{268\ cm^3}$$

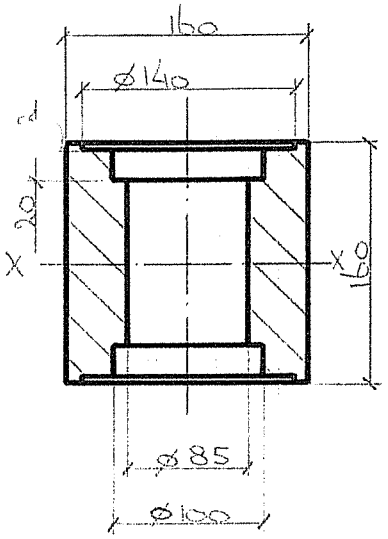
$$\sigma_b = \frac{7540 \times 20{,}5}{268} = \underline{576}\ kgf/cm^2$$

$$\tau = \frac{7540}{112} = \underline{67}\ kgf/cm^2$$

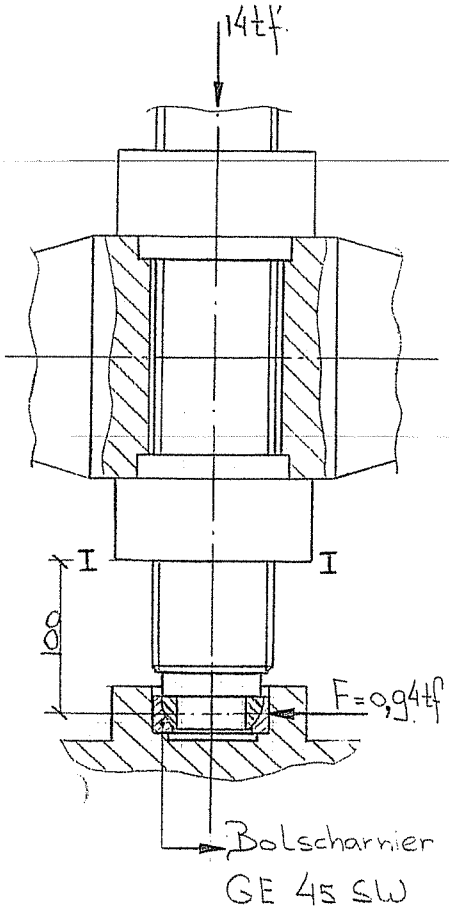
$$\sigma_i = \sqrt{576^2 + 3.67^2} = \underline{588}\ kgf/cm^2$$

Vlaktedruk tussen tap en kns.

$$\sigma_o = \frac{7540}{9 \times 7{,}5} = \underline{112}\ kgf/cm^2$$



$A = 112\ cm^2$



Berekening stelbout in juk. (Tek. A 57190-pos 14)

Materiaal: Ck 45 (komt overeen met St. 60)
Afmetingen: M80

Doorsnede I-I

$$\sigma_d = \frac{14000}{43,48} = \underline{322}\ kgf/cm^2$$

$$\sigma_b = \frac{940 \times 10}{0,1 \times 8^3} = \frac{9400}{51,2} = \underline{184}\ kgf/cm^2$$

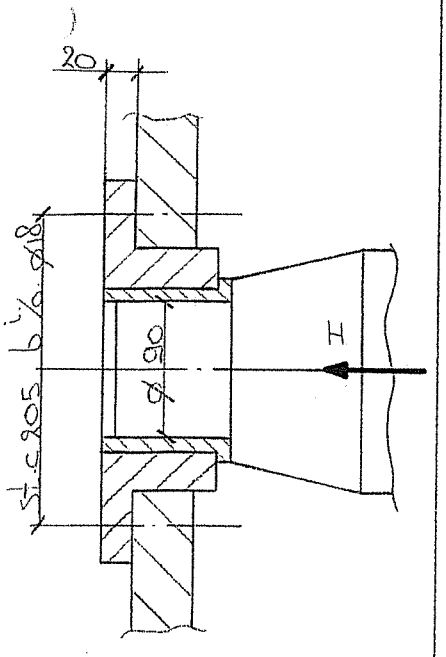
$$\tau = \frac{940}{43,48} = \underline{22}\ kgf/cm^2$$

$$\sigma_{tot} = 322 + 184 = \underline{506}\ kgf/cm^2$$

$$\sigma_i = \sqrt{506^2 + 3 \cdot 22^2} = \underline{507}\ kgf/cm^2 \text{ (Akkoord)}$$

$$\bar{\sigma} = 490\ kgf/cm^2 \text{ (Zie tabel 2.2.1)}$$

Berekening Lagerpot. (pos 9 - tek A 57190)



$H = \underline{940 kgf}$

$$\sigma_{max} = k \cdot \frac{T}{h^2} \quad \text{(volgens Timoshenko)}$$

$k = 0,515$

$$\sigma_{max} = 0,515 \cdot \frac{940}{4} = \underline{121}\ kgf/cm^2$$

Materiaal: Gst 45 k - $\bar{\sigma} = 725\ kgf/cm^2$

Berekening bouten Lagerpot

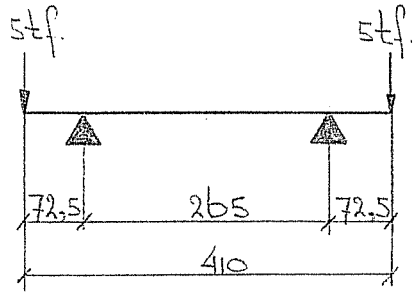
Zes bouten i/o. - M16 - Materiaal: 8.8

Maximale boutkracht: $P_{bout} = {}^{940}/_{6} = \underline{157}$ kgf.

$$\sigma_t = \frac{157}{A_k} = \frac{157}{1{,}41} = \underline{111}\ ^{kgf}/_{cm^2}$$

$$\bar{\sigma} = 0{,}8 \times 1755 = 1405\ ^{kgf}/_{cm^2}$$

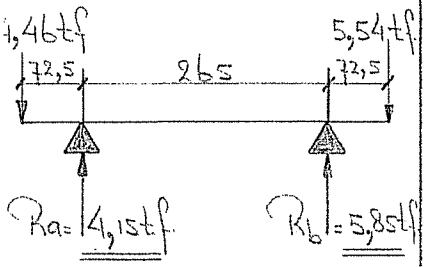
Belastingsituatie.



Reactieverhoging door wringend moment.

$$F \times 23{,}5 = k \times 41$$

$$k = \frac{940 \times 23{,}5}{41} = \underline{540}\ kgf$$



$1{,}46 \times 41 + R_a \times 33{,}75 + R_b \times 7{,}25 = 0$

$R_a + R_b = 10\ tf.$

$R_a = 4{,}15\ tf \Rightarrow R_b = 5{,}85\ tf.$

Berekening pen draaipunt. (Zie tek. A 57190 pos b

Materiaal: 2C45 (komt overeen met St. 60)

$$\sigma_b = \frac{5540 \times 7{,}25}{0{,}1 \times g^3} = \underline{551}\ ^{kgf}/_{cm^2}$$

$$\tau = \frac{5540}{\pi/4 \times g^2} = \underline{87}\ ^{kgf}/_{cm^2}$$

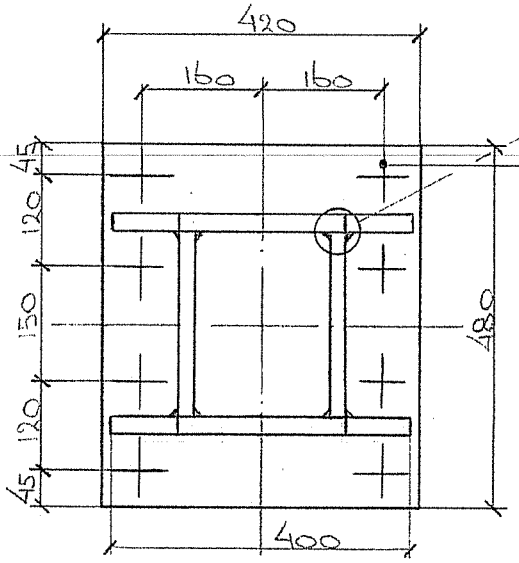
$$\sigma_i = \sqrt{551^2 + 3 \cdot 87^2} = \underline{571}\ ^{kgf}/_{cm^2}$$

$$\bar{\sigma} = 1015\ ^{kgf}/_{cm^2}$$

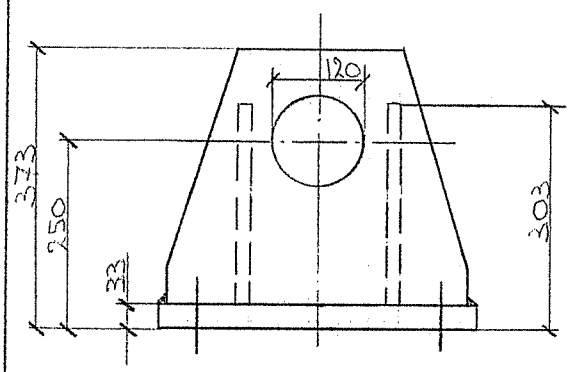
Ulaktedruk tussen pen en Lagerpot: $\sigma_o = \frac{5540}{g \times 7{,}5} = 82\ ^{kgf}/_{cm^2}$

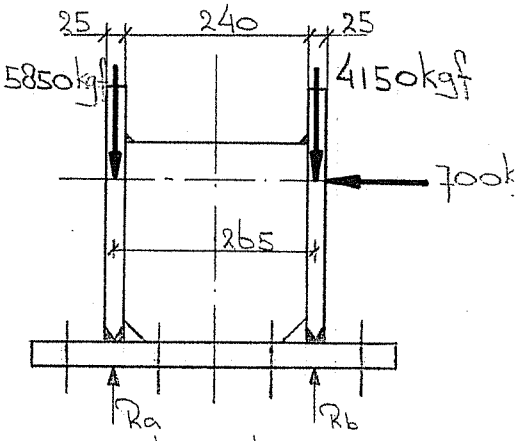
Voor de berekening van de Lagerpot van pos b zie blad 18.

Berekening stoel. (zie tek. A 57190 - pos 7)



Materiaal stoel Fe 36





De optredende krachten zijn berekend op de blz. 16 en vg.

$700 \times 25 = K \times 26{,}5 \quad \Rightarrow \quad K = \underline{660}\ \text{kgf}$

$Ra = 5850 + 660 = \underline{6510}\ \text{kgf}$

$Rb = 4150 - 660 = \underline{3490}\ \text{kgf}$

Vlaktedruk tussen zijplaat en grondplaat

$$\sigma_o = \frac{6510}{40 \times 2{,}5} = \underline{65\ \text{kgf/cm}^2}$$

Ulaktedruk tussen pen en wangplaat.

$$\sigma_o = \frac{6510}{2{,}5 \times 12} = \underline{218}\ kgf/cm^2$$

Berekening van de lassen @

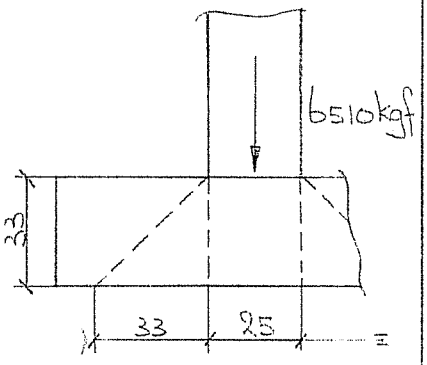
$$L = \frac{700 \times 25}{24} = \underline{729}$$

$$\tau_{//} = \frac{729}{4 \times 27 \times 0{,}6} = \underline{11}\ kgf/cm^2$$

$$\sigma_\perp = \hat{\tau}_{//} = \frac{350.\sqrt{2}}{4 \times 0{,}6 \times 27} = \underline{8}\ kgf/cm^2$$

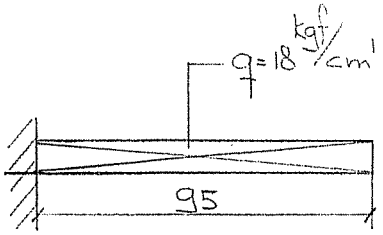
$$\sigma_i = \sqrt{8^2 + 1{,}8(11^2 + 8^2)} = \underline{20}\ kgf/cm^2$$

Berekening grondplaat.



$$\sigma_{d\,beton} = \frac{6510}{40 \times 9{,}1} = \underline{18}\ kgf/cm^2$$

$$M_b = \tfrac{1}{2}.q.l^2 = \tfrac{1}{2}.18.9{,}5^2 = \underline{810}\ kgcm$$



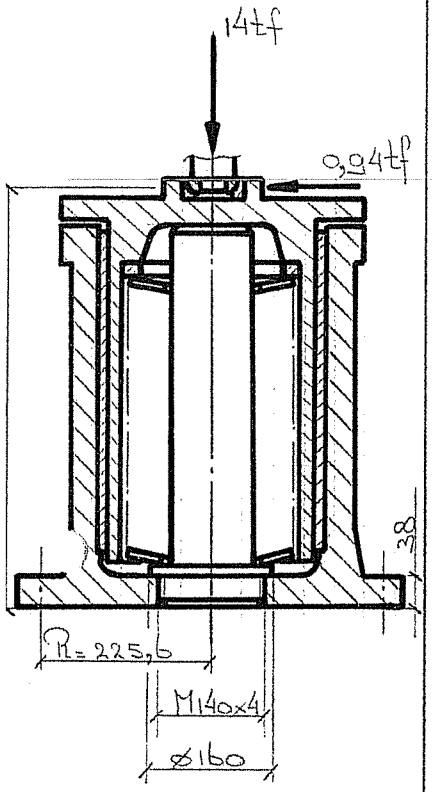
$$\sigma_b = \frac{810}{\tfrac{1}{6}.1.3{,}3^2} = \frac{810}{1{,}815} = \underline{445}\ kgf/cm^2$$

$$\hat{\tau} = \frac{18.9{,}5}{1.3{,}3} = \underline{52}\ kgf/cm^2$$

$$\sigma_i = \sqrt{445^2 + 3.52^2} = \underline{454}\ kgf/cm^2$$

Uit belastingschema blijkt dat de bouten M24 niet belast worden. (Ook niet door zijdelingse kracht

Berekening bufferhuis. (Zie tek A 57190 - posig)



Materiaal: GSt 4sk
Maximale boutkracht $P_b = \frac{2M}{R.n}$

$M = 940 \times 54 = \underline{51000}$ kgcm.

$P_{bout} = \frac{2.51000}{22,56 . 8} = \underline{565}$ kgf. (Trekkracht)

Drukkracht per bout = $14000/8 = \underline{1750}$ kgf.

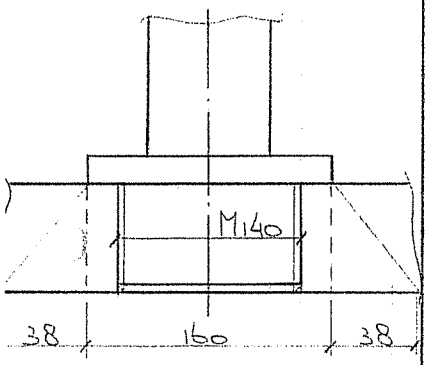
Resulterende drukkracht = 1750 - 565 = $\underline{1185}$ kg

De bouten van de onderflens worden dus niet belast. (Ook niet door horizontale kracht.)

Bepaling vlaktedruk tussen aanslagstang en huis

Terplaatse van onderflens.

$\sigma_o = \frac{14000}{\pi/4(16^2-14^2)} = \frac{14000}{47} = \underline{298}$ kgf/cm²

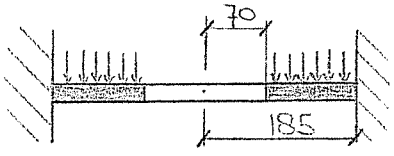


Berekening betonspanning.

$\sigma_{beton} = \frac{14000}{\pi/4(23,6^2-14^2)} = \frac{14000}{282} = \underline{50}$ kgf/cm²

Berekening onderflens.

Belastingprincipe



δ = 38mm.

$\sigma_{max} = k . \frac{q' . a^2}{h^2}$

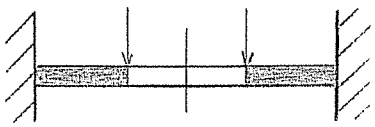
$a/b = 185/70 = 2,62$

$k = 0,602$

$q' = 14000/\pi/4(37^2-14^2) = 15,2$ kgf/cm²

$\sigma_{max} = 0,602 \cdot \frac{15,2 . 18,5^2}{3,8^2} = \underline{217}$ kgf/cm² $\quad \bar{\sigma} = 725$ kgf/cm²

Berekening v.d. werkelijk optredende spanning



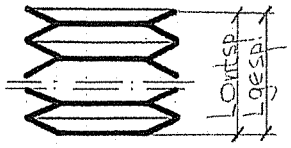
$a/b = 2,62 \Rightarrow k = 0,59$

$$\sigma_{max} = 0,59 \cdot \frac{14000}{3,8^2} = \underline{\underline{572}}\ kgf/cm^2$$

$$\sigma_{werkelijk} = 572 - 217 = \underline{\underline{355}}\ kgf/cm^2$$

Berekening schotelveren.

Opbouw pakket
Schematisch



n = 35 veren

Aantal: 35
Afmetingen: 225 x 112 x 8
Materiaal: Verenstaal Werkslag = 50 mm

Ontspannen lengte: $l_o = h^* + s' = 14{,}5$ mm
$L_{ontsp.} = 35 \times 14{,}5 = \underline{507{,}5}$ mm
Gespannen lengte: $435 - 20 - 52 = \underline{363}$ mm. ($L_{gesp.}$
Totale indrukking $= 507{,}5 - 363 = \underline{144{,}5}$ mm.

Bepaling van de veerconstante.

$$C = \frac{F}{y}$$

$$C_1 = \frac{1270}{0{,}06 \times 35} = \frac{1270}{2{,}1} = \underline{605}\ \text{kgf/cm} \qquad \sigma_{III} = 17\ \text{kgf/mm}^2$$

$$C_2 = \frac{2600}{0{,}13 \times 35} = \frac{2600}{4{,}55} = \underline{571}\ \text{kgf/cm} \qquad \sigma_{III} = 36\ \text{kgf/mm}^2$$

$$C_3 = \frac{3550}{0{,}19 \times 35} = \frac{3550}{6{,}65} = \underline{534}\ \text{kgf/cm} \qquad \sigma_{III} = 52\ \text{kgf/mm}^2$$

$$C_4 = \frac{4600}{0{,}26 \times 35} = \frac{4600}{9{,}1} = \underline{505}\ \text{kgf/cm} \qquad \sigma_{III} = 69\ \text{kgf/mm}^2$$

$$C_5 = \frac{5400}{0{,}32 \times 35} = \frac{5400}{11{,}2} = \underline{482}\ \text{kgf/cm} \qquad \sigma_{III} = 83\ \text{kgf/mm}^2$$

$$C_6 = \frac{6200}{0{,}39 \times 35} = \frac{6200}{13{,}65} = \underline{454}\ \text{kgf/cm} \qquad \sigma_{III} = 98\ \text{kgf/mm}^2$$

$$C_7 = \frac{6800}{0{,}45 \times 35} = \frac{6800}{15{,}75} = \underline{432}\ \text{kgf/cm} \qquad \sigma_{III} = 111\ \text{kgf/mm}^2$$

$$C_8 = \frac{7200}{0{,}485 \times 35} = \frac{7200}{16{,}975} = \underline{424}\ \text{kgf/cm} \qquad \sigma_{III} = 119\ \text{kgf/mm}^2$$

Aangezien de veerconstante voor de verschillende belastingen nogal afwijkt, is het raadzaam de veerkarakteristiek v.h. pakket te tekenen, aan de hand v.d. gegevens ontleend aan CB-Tellerfeder.

Veerkarakteristiek: 35 veren ø225x112x8

Enkelvoudig gestapeld.

7000kgf.

6450kgf

6000kgf

5000kgf

4725kgf

4000kgf

3000kgf

2000kgf

1000kgf.

F

Ge

Gu

G

Werkslag 50mm.

kracht in kgf

9,45

14,45

Indrukking in cm.

Kracht op de veren na werkslag:

De indrukking bedraagt nu nog 507,5 - 413 = 94,5

De kracht die hiermede overeenkomt volgens veerkarakteristiek op blz 24 bedraagt 4725 kg!

De kracht op de veren bij maximale indrukking bedraagt 6450 kgf

Berekening schotelveren op vermoeidheid.

De verhouding $h/s = 0,81$ en $D_a/D_i = 2,008$

Hieruitvolgt dat de spanning op plaats III, volgens handboek Schnorr tabel II blz.18, maatgevend is

$\sigma_o = 103\ kgf/mm^2$ $\sigma_u = 71\ kgf/mm^2$

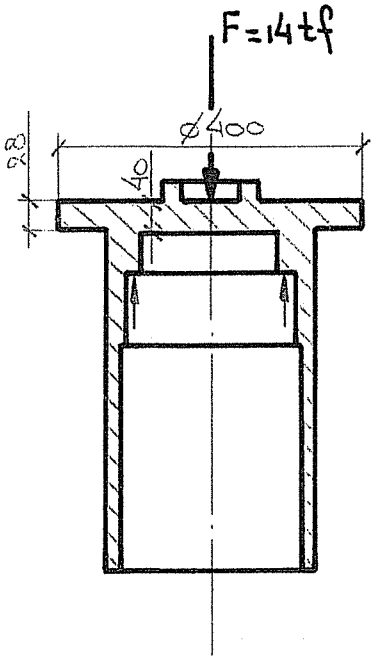
$\sigma_h = \sigma_o - \sigma_u = 103 - 71 = 32\ kgf/mm^2$

Volgens tabel 14 op blz. 21 van Schnorr handboek voor schotelveren bedraagt het aantal belastingswisselingen 8×10^5

$N = 8 \times 10^5$

Stel er wordt 10 maal geschut op één dag

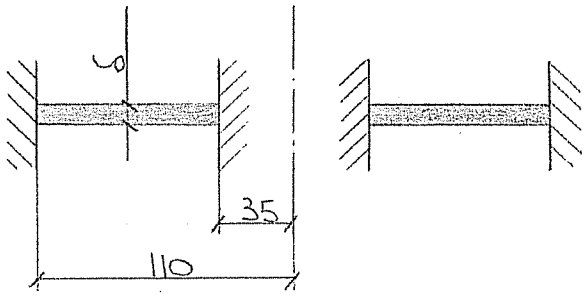
$$L = \frac{8 \times 10^5}{365 \times 10} = 220 \text{ jaar}$$



Berekening bufferzuiger.

Materiaal : GSt 45 k $\bar{\sigma} = 725\ kgf/cm^2$ tabel 2-1-

Belastingprincipe. (flens)

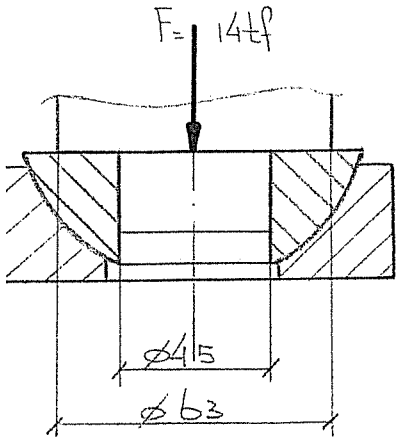


$a/b = 110/35 = 3,14$

$k = 0,735$ Maximale belasting = 6450 kgf

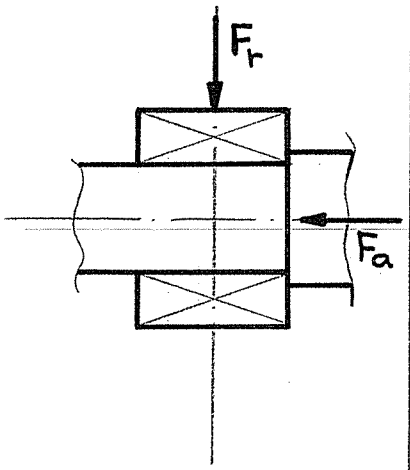
$\sigma_{max} = k \cdot \frac{P}{h^2}$ $h = 4cm$

$\sigma_{max} = 0,735 \quad \frac{6450}{16} = \underline{296\ kgf/cm^2}$



Berekening vlaktedruk-stelbout gelenklager

$\sigma_o = \frac{14000}{\pi/4\,(6,3^2 - 4,5^2)} = \underline{917\ kgf/cm^2}$



Berekening cylinderlager in balans.

Type: SL-01-4934 INA catalogus NL 3c

Grootste belasting per lager is 12,8 tf (Zie blad
Grootste axiale belasting per lager is 1,64 tf
$C_{dynamisch}$ = 37500 kgf.

$C_{statisch}$ = 47000 kgf. $n_{toelaatbaar}$ = 1200 omw./m

Bepaling toelaatbare axiale belasting.

$F_{atoel.} = f \cdot d^2 \cdot p_{toelaatbaar}$

f = 0,0337 Constante axiale belasting

d = boring lager = 170mm
n = aantal toeren per min. = 10 omw./min

$n \cdot d_E = n \cdot 1{,}27\, d = 10 \cdot 1{,}27 \cdot 170 = 2159$ mm./min

p_{toel} (uit diagram) = 4 kgf/mm²

$F_{a\,toelaatbaar} = 0{,}0337 \cdot 170^2 \cdot 4 = \underline{3896}$ kgf

Levensduur:

$$L_h = \frac{16666}{n}\left(\frac{C}{P}\right)^p \qquad p = 10/3 \qquad \frac{C}{P} = 2{,}93$$

$$L_h = \frac{16666}{10}\left(\frac{37500}{12800}\right)^{10/3} = 1666{,}6 \cdot 2{,}93^{10/3} = \underline{\underline{60000}}\ u$$

Aanbevolen voor normaalbedrijf L_h = 30000 u

Berekening gelenklager in balans.

Maximale radiale belasting 12tf
Maximale axiale belasting 0,82tf
Type: GE 80 UK - 2RS (INA katalogus)
$C_{statisch}$ = 109000 kgf
C_{30} = 38800 kgf

$P_{dyn} \leq f_d \cdot C_{30}$ (alleen bij radiale belastin

$P = \sqrt{F_r^2 + F_a^2} \leq f_a \cdot C_{30}$ (Voor geringe beweging

$\sqrt{12^2 + 0{,}82^2} \leq f_a \cdot 38{,}800$

$f_a = 0{,}8$

12,03 < 31,04 Lager akkoord

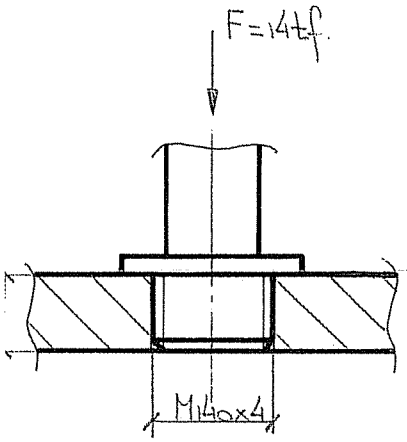
Berekening axiaal gelenklager in bufferzuige

Maximale axiale belasting = 14tf
Maximale radiale belasting = 0,94tf
Type: GE 45 SW
$C_{statisch}$ = 27500 kgf
C_{30} = 11000 kgf.

Statische belasting:

$P = 1{,}2F_r + F_a \leq C_{statisch}$ (Zie SKF katalogus)

15,13 < 27,5 Lager akkoord



Berekening schroefdraad aanslagstang.

Materiaal: 2C45 $\quad \bar{\sigma} = 490\ kgf/cm^2$

$$\sigma_d = \frac{14000}{141,98} = \underline{98\ kgf/cm^2}$$

Vlaktedruk tussen de draadgedeelten.

$$\sigma_o = \frac{F}{\pi/4(d_b^2 - d_k^2).n} = \frac{14000}{\pi/4(14^2 - 13,44^2) \times 9} = \underline{129\ kgf/cm^2}$$

$$n = \frac{h}{s} = \frac{38}{4} = 9 \text{ gangen}$$

40C-350-511

NIEUWE SCHUTSLUIS TE WEURT.

5. BEREKENING TUSSENAS MET KOPPELING.

1975

Schutsluis Weurt.

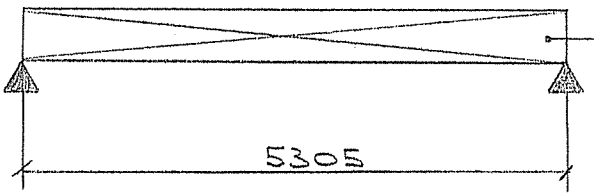
Berekening tussenas. (Zie tek. Hollandia 1. order 27699 - 110875)

Berekening as: $M_w = 451206\ kgcm$

$M_{w_{as}} = 225603\ kgcm$

$$\sigma_w = \frac{451206}{2.0,2.18^3} = \underline{193}\ kgf/cm^2$$

Buigspanning t.g.v. eigengewicht



$$\sigma_b = \frac{1/8.2.530,5^2}{0,1.18^3} = \underline{121}\ kgf/cm^2$$

$$\sigma_v = \sqrt{121^2 + 3.193^2} = \underline{356}\ kgf/cm^2$$

Doorbuiging t.g.v. eigen gewicht

$$f_{max} = \frac{5.2.530,5^4}{384.2,1.10^6.\pi/64.18^4} = \underline{0,19cm}$$

$$f_{toelaatbaar} = 1/3000.\ L = 1/3000.\ 530,5 = \underline{0,18cm}$$

Berekening hoekverdraaiing

$$\varphi = \frac{32}{\pi.18^4} \cdot \frac{225603.100}{8,1.10^5} = 0,00270252\ rad/m = \underline{1/4^\circ/m}$$

$\varphi_{toelaatbaar} = 1/4\ ^\circ/m$

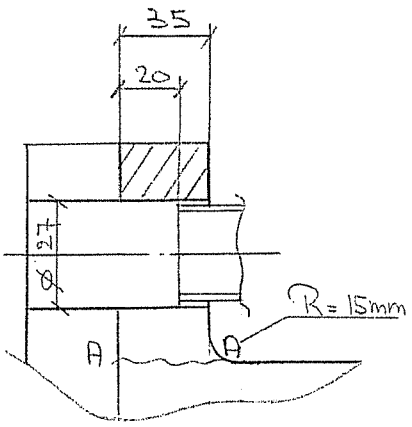
Berekening bouten

8 bouten in omtrek M27

$$\tau_{bout} = \frac{225603}{8 \cdot 13} = 2169 \text{ kgf}$$

$$\tau = \frac{2169}{\pi/4 \cdot 2{,}7^2} = 379 \text{ kgf/cm}^2$$

$$\bar{\tau} = 0{,}8 \cdot 885 = 708 \text{ kgf/cm}^2 \text{ (Staal 50)}$$



Vlaktedruk flens bout

$$\sigma_o = \frac{2169}{2 \cdot 2{,}7} = 402 \text{ kgf/cm}^2$$

Doorsnede A-A

$$\tau_{omtrek} = \frac{225603}{26} = 8677 \text{ kgf.}$$

$$\tau = \frac{8677}{3{,}5 \cdot \pi \cdot 18} = 44 \text{ kgf/cm}^2$$

$$R/35 = 15/35 = 0{,}43 \Rightarrow \text{kerffactor } \beta = 1{,}85$$

Gearceerde doorsnede

$$\sigma_t = \frac{1/2 \cdot 2169}{3{,}5 \cdot 1{,}6} = 194 \text{ kgf/cm}^2$$

NIEUWE SCHUTSLUIS TE WEURT.

6. BEREKENING FRAME MACHINEWERK.

Berekening frame machinewerk (zie tek. A57

Motorbouten: [Totaal gewicht = 10tf machin
wer

4 bouten M30 x 90 - Materiaal 8.8

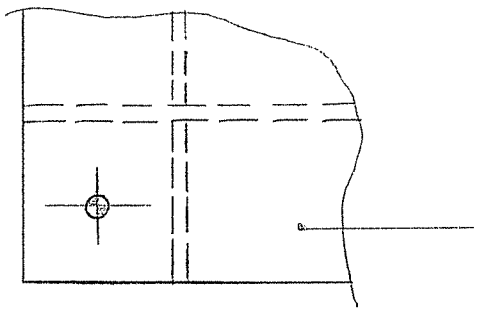
Nominaal motorkoppel $M = 71620 \times \frac{450}{1500} = 21486$ k

$2 \times T_{bout} \times 75 = 21486$

$T_{bout} = 143$ kgf

$$\sigma_t = \frac{143}{F_{kern}} = \frac{143}{4,953} = 29 \text{ kgf/cm}^2 \quad (\bar{\sigma} = 1260 \text{ kgf/cm}^2)$$

Berekening plaatspanningen.



Materiaal Fe 360 D

$\delta = 15$ mm

$$\sigma_{plaat} = \frac{\frac{1}{2} T_{bout}}{\frac{1}{6} \cdot \delta^2}$$

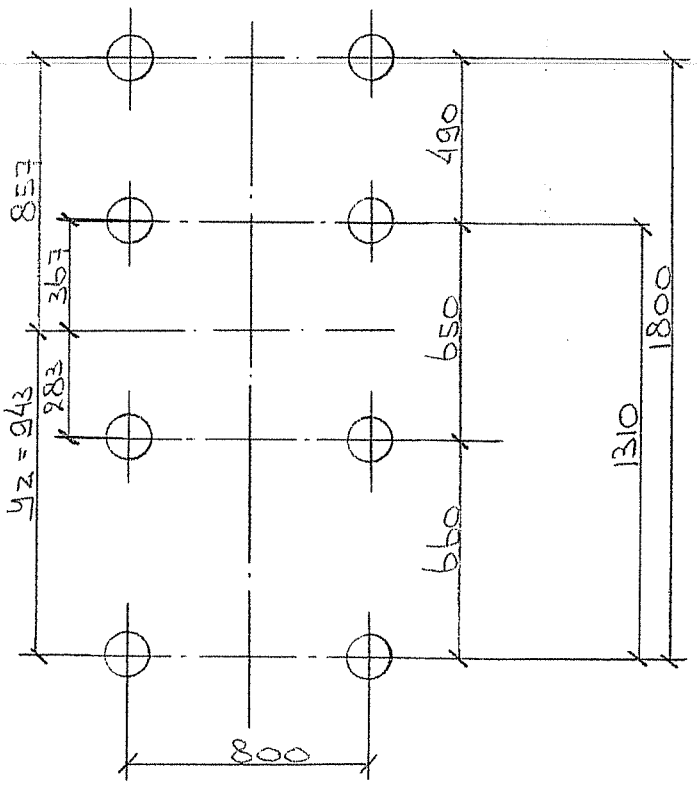
$$\sigma_{plaat} = \frac{\frac{1}{2} \cdot 143}{\frac{1}{6} \cdot 1,5^2} = 191 \text{ kgf/cm}^2 \quad (\bar{\sigma} = 710 \text{ kgf/cm}^2)$$

Bouten tandwielkast. ($i_{tandwielkast} = 21$)

8 bouten M36 x 160 - Materiaal 8.8

$M = 21 \times 21486 = 451206$ kgcm

Bepaling neutrale lijn bouten patroon.



$$y_z = \frac{66 + 131 + 180}{4} = 94{,}25\,cm \approx \underline{943\,mm}$$

$$W = \frac{\Sigma n a^2}{e} \qquad n = \text{aantal bouten}$$

$$W_{min} = \frac{2 \cdot 85{,}7^2 + 2 \cdot 36{,}7^2 + 2 \cdot 28{,}3^2 + 2 \cdot 94{,}3^2}{94{,}3} = \frac{36769{,}52}{94{,}3}$$

$$W_{min} = 390\,cm$$

$$\sigma_{bout} = \frac{M}{W} = \frac{451206}{390} = \underline{1157\,kgf.}$$

$$\sigma_t = \frac{1157}{F_{kern}} = \frac{1157}{7{,}266} = \underline{159}\ kgf/cm^2 \quad (\bar{\sigma} = 560\ kgf/cm^2)$$

Berekening plaatspanning $\quad \delta = 25$ mm.

Bovenplaat.

$$\sigma_{plaat} = \frac{\frac{1}{2} T_{bout}}{\frac{1}{6} \delta^2} = \frac{\frac{1}{2} \cdot 1157}{\frac{1}{6} \cdot 2{,}5^2} = \underline{555}\ kgf/cm^2$$

$(\bar{\sigma} = 710\ kgf/cm^2)$

Berekening ankerkracht (Bout M30x120)

$2 \times T_{bout} \times 201 = 451206$

$T_{bout} = \underline{1122\ kgf.} = T_{anker}$

Bout M30 - Materiaal 8.8

$$\sigma_t = \frac{1122}{4{,}953} = \underline{227}\ kgf/cm^2 \quad (\bar{\sigma} = 560\ kgf/cm^2)$$

Berekening plaatspanning $\quad \delta = 55$

Onderplaat.

$$\sigma_{plaat} = \frac{\frac{1}{2} T_{anker}}{\frac{1}{6} \cdot \delta^2} = \frac{\frac{1}{2} \cdot 1122}{\frac{1}{6} \cdot 5{,}5^2} = \underline{111}\ kgf/cm^2$$

$(\bar{\sigma} = 710\ kgf/$

Een plaat van: $\frac{1}{6} \cdot \delta^2 \cdot 710 = \frac{1}{2} \cdot 1122 \Rightarrow \underline{\delta = 22\ mm}$

is voldoende

Berekening anker. (M24 - L_{ontw} = 472 mm.)
Materiaal Fe 360 DFN

$$L = \frac{T}{\pi . d . \tau_{kleef}} - 10\,d$$

$$l = 180 + \tfrac{1}{2}.\pi.42 = \underline{246\ mm.}$$

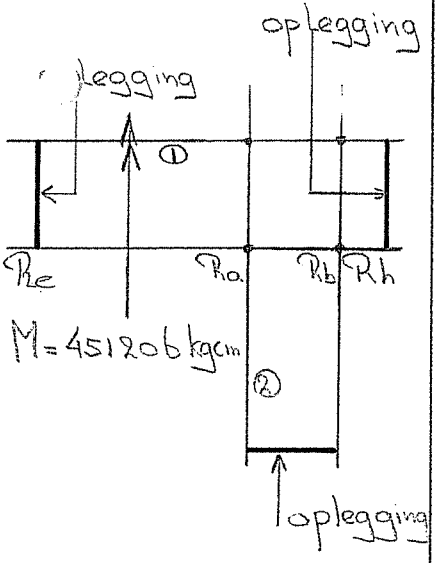
$$T = 1122\ kgf$$

$$24{,}6 = \frac{1122}{\pi . 2{,}4 . \tau} - 10 . 2{,}4$$

$$\tau = \frac{1122}{48{,}6 \times \pi \times 2{,}4} = \underline{3{,}1\ kgf/cm^2} \quad (\bar{\tau} = 5\ kgf/cm^2)$$

Spanning in het anker

$$\sigma_t = \frac{1122}{3{,}082} = \underline{364\ kgf/cm^2} \quad (\bar{\sigma} = 490\ kgf/cm^2)$$

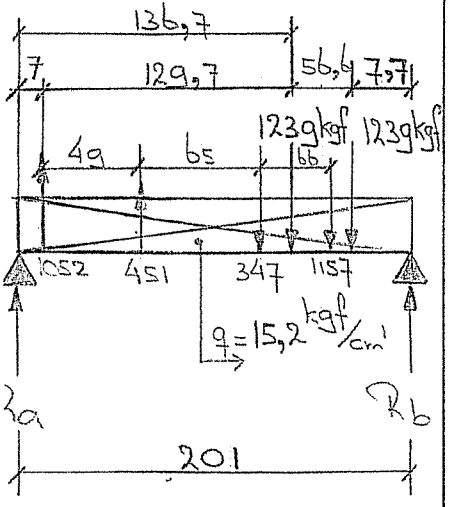


Berekening liggers frame

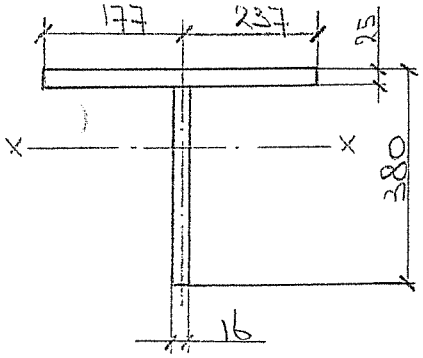
$$p = \frac{10000}{(277{,}5 \times 92) + (129 \times 92)} = \frac{10000}{37398} = \underline{0{,}3\ kgf/cm^2}$$

$$R_A = R_b = \frac{92 \times 179{,}5 \times 0{,}3}{4} = \underline{1239\ kgf}$$

$$R_e = R_h = \frac{92 \times 221 \times 0{,}3}{4} = \underline{1525\ kgf}$$



Doorsnede



Berekening Ligger ①

Bepaling weerstandsmoment doorsnede liggers

Meewerkende plaat breedte $\lambda = 0{,}118 \times 201 = 23{,}7$ cm

ΣF (cm²)			ΣS (cm³)		
$41{,}4 \times 2{,}5$	=	103,5	$103{,}5 \times 36{,}75$	=	3804
$35{,}5 \times 1{,}6$	=	56,8	$56{,}8 \times 17{,}75$	=	1008
	ΣF	160,3		ΣS =	4812

$$e_o = \frac{4812}{160} = 30{,}1 \text{ cm}$$

$$I_{x-x} = \tfrac{1}{12} \cdot 1{,}6 \cdot 35{,}5^3 + 56{,}8 \cdot 12{,}35^2 + \tfrac{1}{12} \cdot 41{,}4 \cdot 2{,}5^3 + 103{,}5 \times 6{,}6$$

$$I_{x-x} = 19259 \text{ cm}^4$$

$$W_o = \frac{19259}{30{,}1} = 640 \text{ cm}^3$$

$$W_b = \frac{19259}{7{,}9} = 2438 \text{ cm}^3$$

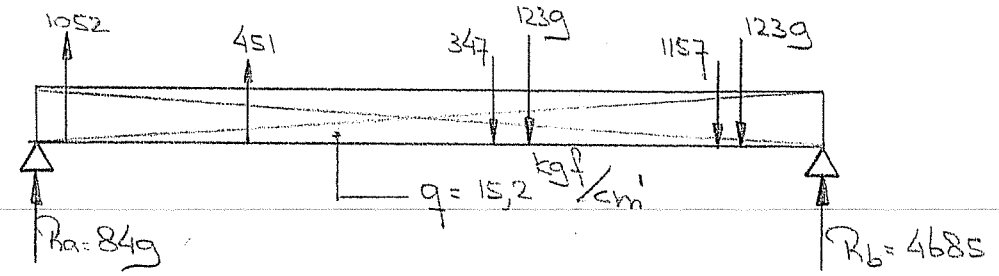
Moment t.o.v. B

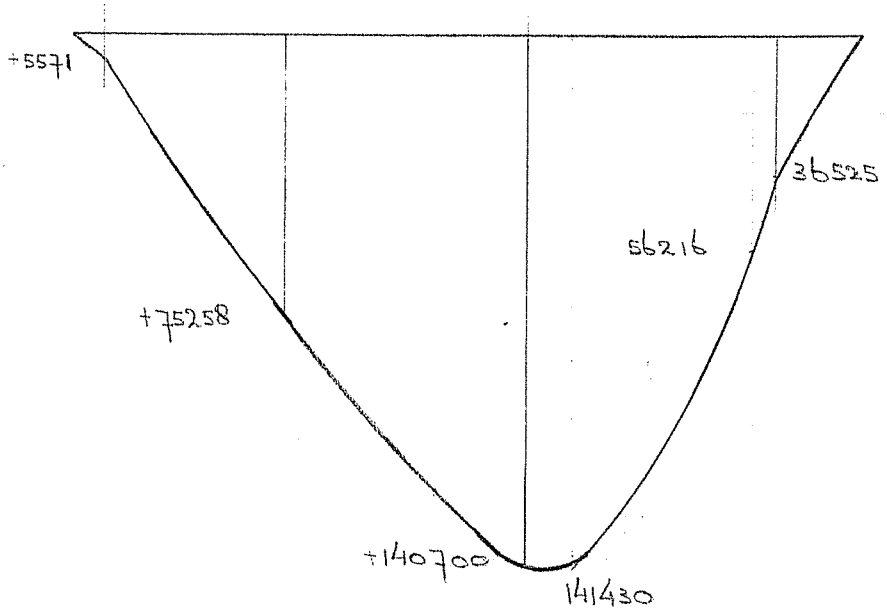
$$Ra \times 201 + 1052 \times 194 + 451 \times 145 - 347 \times 80 - 1157 \times 14 - 1239 \times 64{,}3 - 1239 \times 7{,}7 - 15{,}2 \times 201 \times \tfrac{201}{2} = 0$$

$Ra \times 201 = 170731$ $\qquad$ $Ra + Rb = 5534$ kgf

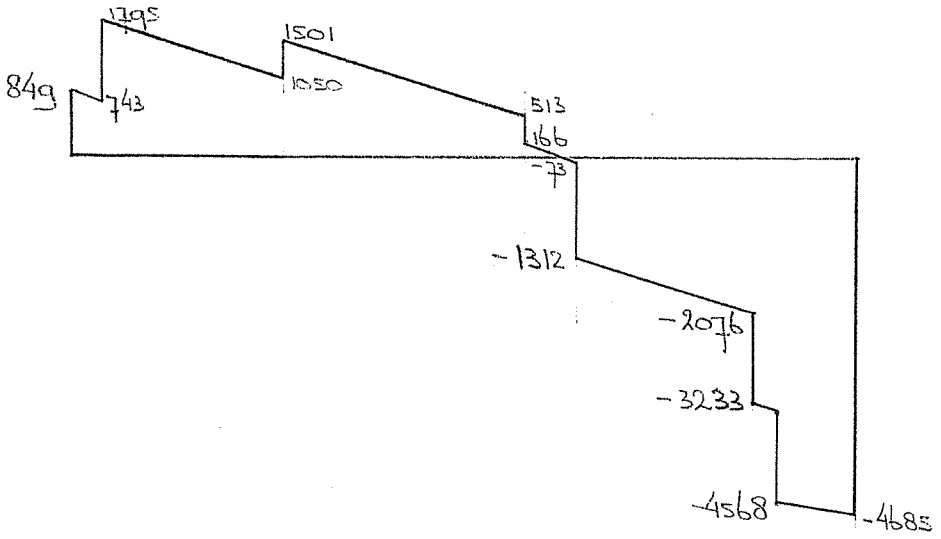
$Ra = 849$ kgf $\qquad$ $Rb = 5534 - 849 = 4685$ kgf.

Momentenlijn



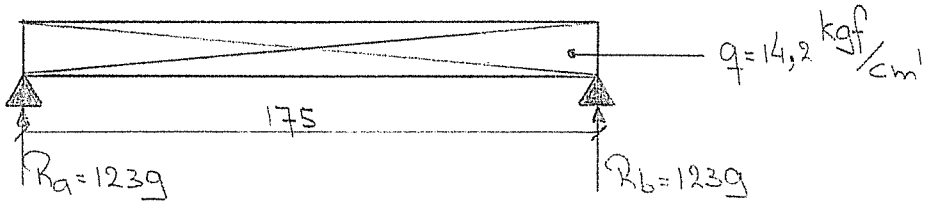


Dwarskrachtenlijn



$$\sigma_{b\,max} = \frac{141430}{640} = \underline{221}\ kgf/cm^2$$

Berekening ligger ②

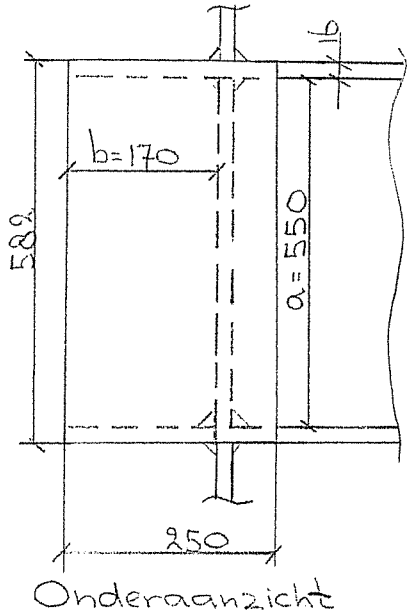


$$\sigma_b = \frac{1/8 \cdot 14{,}2 \cdot 175^2}{640} = \underline{85}\ kgf/cm^2$$

Berekening betonspanningen.

Grootste drukkracht = 2 × 4685 kgf = 9370 kgf

Treedt op onder oplegging balk ①



Onderaanzicht

$$\sigma_o = \frac{9370}{58{,}2 \times 25} = \underline{6{,}4}\ kgf/cm^2$$

Berekening onderplaat (drie zijden opgelegd

$\sigma_o = 6{,}4\ kgf/cm^2$ $\quad q = 6{,}4\ kgf/cm^1$ $\quad \delta = 55\ mm$

Volgens Timoshenko (Plates and shells) blz:

$b/a = 170/550 = 0{,}31$

$M_x = 0{,}0103 \cdot q \cdot a^2$ $\quad x = a/2$ $\quad y = b$

$M_y = -0{,}415 \cdot q \cdot b^2$ $\quad x = a/2$ $\quad y = 0$

$$\sigma_{bx} = \frac{0{,}0103 \cdot 6{,}4 \cdot 55^2}{1/6 \cdot 5{,}5^2} = \underline{40}\ kgf/cm^2$$

$$\sigma_{by} = \frac{-0{,}415 \cdot 6{,}4 \cdot 17^2}{1/6 \cdot 5{,}5^2} = \underline{-152}\ kgf/cm^2$$

Berekening lassen

$$\tau_{//} = \frac{4685}{0{,}5 \times 35{,}5 \times 4} = \underline{66}\ kgf/cm^2$$

NIEUWE SCHUTSLUIS TE WEURT.

7. BEREKENING TANDWIELKAST 2A3-110 Spec.

(HOOFDMOTORGEDEELTE).

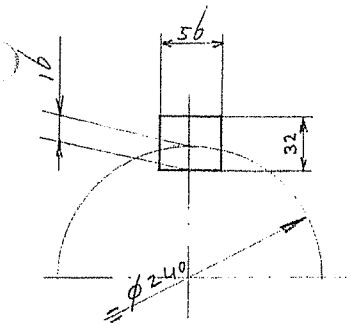
t.w.k. 2A3 - 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Opmerkingen Hoofdmotorgedeelte

1. Contactspanning tandwiel uitgaande as 5696 kg/cm²
   Mat C 45 $\bar{\sigma}_c$ = 4860 kg/cm²
   Levensduur ca 570 h. Dit komt overeen met 7300 openingen

2. Tussenas afronding naast rondsel 5 en 8 mm moeten 10 mm worden.

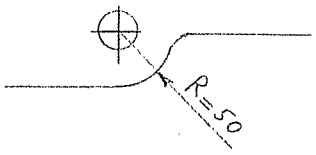
3* Vlaktedruk spie ingaande as ϕ 85 gietijzer 830 kg/cm² te hoog $\bar{\sigma}$ = 500 kg/cm²



4. Vlaktedruk spie tandwiel uitgaande as.
   σ_o = 967 kg/cm² te hoog $\bar{\sigma} \approx 1{,}2 \times 500 = 600$ kg/cm²
   Voorstel d ϕ 240 → $\sigma_{o\ naaf}$ = 667 kg/cm²
   $\sigma_{o\ as}$ = 1080 kg/cm² H/n passing
   naaf ϕ 460 – 480

5. Vlaktedruk astap uitgaande as tussen spie en as 1326 kg/cm² te hoog $\bar{\sigma}$ = 900 kg/cm²
   Voorstel maak as ϕ 205 → $\sigma_o \approx \frac{180}{205} \cdot \frac{25}{28} \cdot 1326 = 1040$ kg/cm²

6. Bout in deksel kast uitgaande as M30 moet worden M36 8.8



* Naaf nodulair gietijzer $\bar{\sigma}$ = 900 kg/cm²

Wijziging t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt.

Wijzigingen hoofdmotorgedeelte

1. 1e overbr. hoofdmotor niet gewijzigd

2. r = 5 en r = 8 gewijzigd in R = 10

3. voorstel asdia ∅ 95 niet uitgevoerd (85 ∅ gebleven)

4. voorstel d ∅ 240 niet uitgevoerd
   as gewijzigd in ∅ 210 nb
   spiediepte in hart 14 mm
   $\Delta t = 105 - \sqrt{105^2 - 25^2} = 3{,}01$ mm
   $\ell_{spie\ werkz.} = 368$ mm
   $b_{spie} = 50$ mm $\rightarrow h_{spie} = 28$ en $s = 1\,^{+0{,}2}_{\ 0}$
   $h_{werkz\ naaf} = 28 - 14 + 3{,}01 - 1{,}2 = 15{,}819$ mm
   $h_{werkz.\ as} = 14 - 3{,}01 - 1{,}2 = 9{,}78$ "

   $F_{werkz.\ naaf} = 368 \times 15{,}819 = 5821{,}6$ mm²
   $F_{werkz.\ as} = 368 \times 9{,}78 = 3599$ "

   $P_{spie} = \frac{457.115\ kgcm}{\frac{21}{2}\ cm} = 43.535\ kg = 43{,}5\ t$ (opm.: η verwaarloosd)

   $\sigma_{o\ op\ naaf\ GG} = \frac{43{,}5\ t}{58{,}21\ cm^2} = 0{,}747\ t/cm^2 > 0{,}500\ t/cm^2$

   $\sigma_{o\ op\ as} = \frac{43{,}5\ t}{35{,}99\ cm^2} = 1{,}209$ " $> 0{,}900\ t/cm^2$

   GG naaf 360 gewijzigd in 370

5. Voorstel wijziging niet uitgevoerd.
6. Gat in kast gewijzigd in ∅ 38 R = 50 niet uitgevoerd
   (R = 42 op tekening)

~~t.w.k. 2 A 3 = 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt~~

Hoofdmotor (zie tek. D 1142)

$N = 450$ P.K. $n = 1500$ $\frac{\text{omw.}}{\text{min}}$

gelijkstroommotor

$i_1 = \frac{111}{24} = 4{,}625$ $\quad m = 6{,}5$ $\quad \beta = 12°$

$i_2 = \frac{106}{23} = 4{,}6$ $\quad m = 10$ $\quad \beta = 5°$

$i_{tot} = i_1 \times i_2 = 4{,}625 \times 4{,}6 = 21{,}275$

Toerentallen

$n_0 = 1500$ omw/min

$n_1 = \frac{1500}{4{,}625} = 324$ omw/min

$n_2 = \frac{324}{4{,}6} = 70{,}4$ "

Aswringmomenten

$M_0 = 71.620 \times \frac{450}{1500} = 21.486$ kgcm

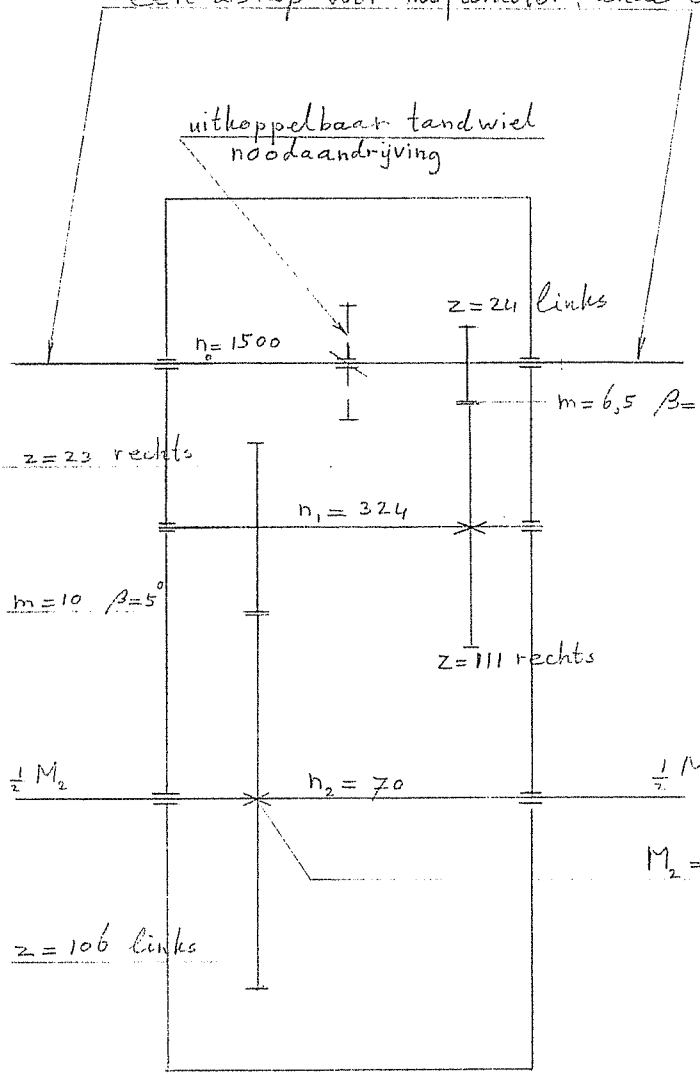
$M_1 = 4{,}625 \times 21.486 = 99.373$ "

$M_2 = 21{,}275 \times 21.486 = 457.115$ " (dit moment wordt aan beide zijde afgegeven dus per astap $\frac{1}{2} M_2 = 228.558$ kgcm

Opm.: η verwaarloosd.

t.w.k. 2 A 3 - 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

één astap voor hoofdmotor, andere astap voor remschijf



$M_0 = 21.486$ kgcm

$M_1 = 99.373$ kgcm

$\frac{1}{2} M_2 = 228.558$ kgcm

$M_2 = 457\,115$ kgcm

t.w.k 2A3 – 110 Spec (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Hoofdmotor reduktie gedeelte

1e overbrenging 111/24 ($m = 6{,}5 \quad \beta = 12°$)

$z_{h_1} = z_1 / \cos^3\beta = 24 / 0{,}9781^3 = 24 / 0{,}936 = 25{,}6$

$z_{h_2} = z_2 / \cos^3\beta = 111 / 0{,}9781^3 = 111 / 0{,}936 = 118{,}6$

$X_1 = \frac{+2{,}3}{m} = \frac{+2{,}3}{6{,}5} = 0{,}35 \rightarrow Y_1 = 2{,}30$

$X_2 = \frac{-0{,}8}{m} = \frac{-0{,}8}{6{,}5} = -0{,}123 \rightarrow Y_2 = 2{,}23$

} Tab 3–1–3

$Stc_1 \approx z_1 m = 24 \times 6{,}5 = 156$ mm $\qquad b = 24$ cm

$P_t = \frac{21.486 \text{ kgcm}}{\frac{15{,}6}{2} \text{ m}} = 2755$ kg

$v = \frac{\pi \cdot 0{,}156\,[m] \times 1500}{60} = 12{,}25$ m/sec

$c_v = \sqrt{\frac{5{,}6 + \sqrt{12{,}25}}{5{,}6}} = \sqrt{1{,}62} = 1{,}27 \qquad c_o = 1$

$c_\beta = 1 - \frac{\beta}{120} = 1 - \frac{12}{120} = 0{,}9$

$\sigma_{rondsel} = \frac{F.Y}{b\,m} c_v c_o c_\beta = \frac{2755 \times 2{,}30}{24 \times 0{,}65} \times 1{,}27 \times 1 \times 0{,}9 = 464$ kg/cm²

mat. rondsel 2C60 $\rightarrow \sigma_{sprong} = 1140$ kg/cm² (Tab 2–1

" tandwiel 2C45 $\sigma = 1015$

$\sigma_{wiel} = \frac{F.Y}{b\,m} c_v c_o c_\beta = \frac{2755 \times 2{,}23}{24 \times 0{,}65} \times 1{,}27 \times 1 \times 0{,}9 = 450$ kg/cm²

U staal op staal $= 1510 \sqrt{\text{kg/cm}^2}$

$\sigma_c = U \sqrt{\frac{F.c_v}{b.d_1} \cdot \cos^2\beta \; \frac{i+1}{i}}$

$\sigma_{c_{rondsel}} = 1510 \sqrt{\frac{2755 \times 1{,}27}{24 \times 15{,}6} \cdot (0{,}9781)^2 \cdot \frac{4{,}625+1}{4{,}625}} = 4980$ kg/

2C60 $n = 1500$ omw/min $\quad \sigma_c = 5620$ kg/cm² (Tab 2–4–1

2C45 $\quad \sigma_c = 4860$

t.w.k 2A3_110 Spec (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

2e overbrenging $^{106}/_{23}$ ($m = 10$, $\beta = 5^\circ$)

$$X_1 = \frac{+3,6}{m} = \frac{+3,6}{10} = +0,36$$

$$z_{n_1} = \frac{23}{(\cos 5)^3} = \frac{23}{0,9962^3} = 23,26$$

$\Big\}\ Y_1 \approx 2,35$

$$X_2 = \frac{-0,8}{m} = \frac{-0,8}{10} = -0,08$$

$$z_{n_2} = \frac{106}{(\cos 5)^3} = \frac{106}{0,9962^3} = 107,2$$

$\Big\}\ Y_2 \approx 2,2$

$$Stc_1 \approx z_1 . m = 23 \times 10 = 230\ mm = 23\ cm$$

$$P_t = \frac{99.373\ kgcm}{\frac{23}{2}\ cm} = 8641\ kg$$

$$v = \frac{\pi\ 0,23\ [m] \times 324}{60} = 3,9\ m/sec$$

$$c_v = \sqrt{\frac{5,6 + \sqrt{3,9}}{5,6}} = \sqrt{1,35} = 1,16 \qquad c_o = 1$$

$$c_\beta = 1 - \frac{\beta}{120} = 1 - \frac{5}{120} = 0,958$$

$$\sigma_{rondsel} = \frac{F\,Y}{b\,m}\, c_v\, c_o\, c_\beta = \frac{8641 \times 2,35}{37 \times 1} \times 1,16 \times 1 \times 0,958 = 611\ kg/cm^2$$

mat. rondsel 2C 60 $\rightarrow \sigma_{sprong} = 1140\ kg/cm^2$ (Tab 2-1-1

" tandwiel 2C 45 1015

U staal op staal $= 1510 \sqrt{kg/cm^2}$

$$\sigma_c = U \sqrt{\frac{F . c_v}{b\, d_1} \cos^2\beta\ \frac{i+1}{i}}$$

$$\sigma_{c_{rondsel}} = 1510 \sqrt{\frac{8641 \times 1,16}{37 \times 23}\ 0,9962^2\ \frac{4,6+1}{4,6}} = 5696\ kg/cm^2$$

2C 60 $n = 324$ omw/min. $\sigma_c = 5620\ kg/cm^2$

C 45 $\sigma_c = 4860$

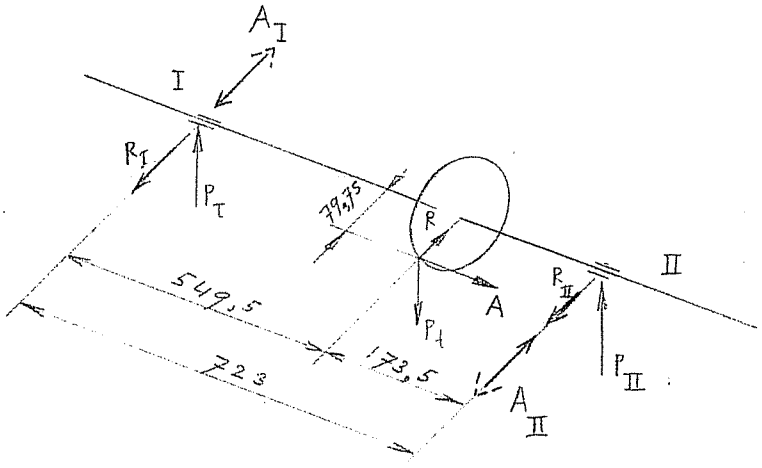
t.w.k 2A3-110 Spec (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Ingaande as hoofdmotor (zie tek. C3678/.

$P_t = 2755$ kg

$A = P_t \cdot tg\beta = 2755\, tg12^\circ = 2755 \times 0{,}212 = 584$ kg

$R = P_t \frac{tg\alpha}{\cos\beta} = \,\text{"}\, \frac{tg20^\circ}{\cos 12} = 2755 \times \frac{0{,}364}{0{,}978} = 1025$ kg



$r_{gem\ rondsel} = \frac{159{,}5}{2} = 79{,}75$ mm

$\frac{173{,}5}{723} \approx 0{,}24$ $\qquad$ $\frac{549{,}5}{723} \approx 0{,}76$

Opm.: Bij noodmotordraaien wordt de as ongunstiger belast

$P_I = 0{,}24 \times 2755$ kg $= 661$ kg
$P_{II} = 0{,}76 \times 2755$ kg $= 2094$ kg
} vertikaal

Horizontaal

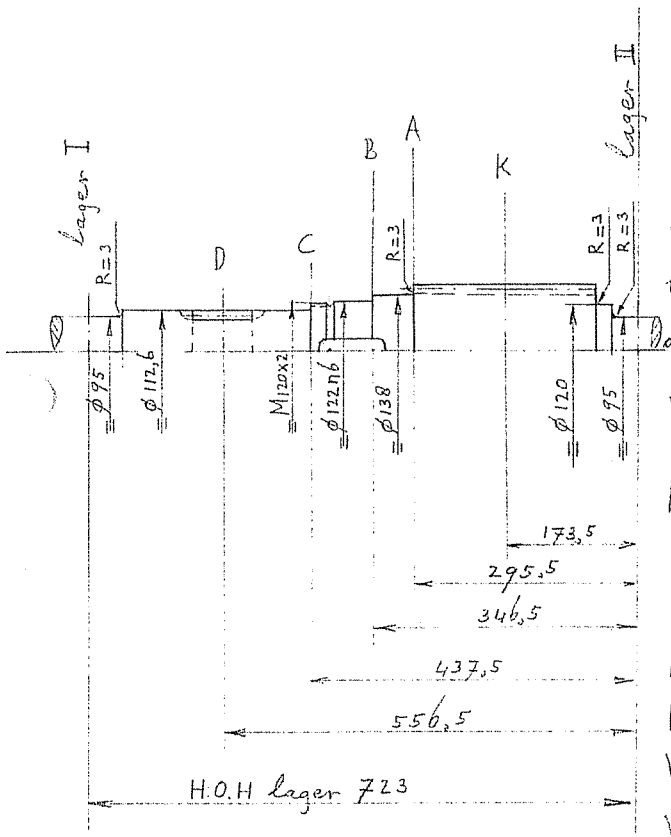
$|A_I| = |A_{II}| = \frac{584\,kg \times 7{,}975\,cm}{72{,}3} = 64$ kg

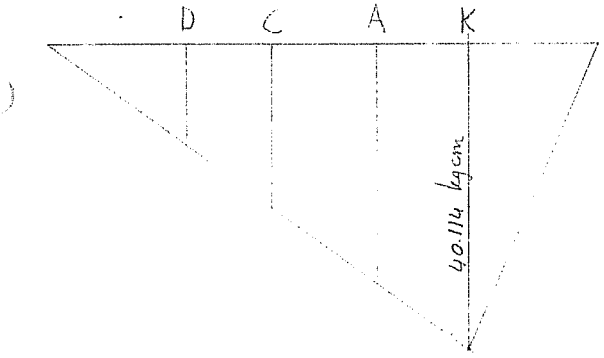
$R_I = 0{,}24 \times 1025$ kg $= 246$ kg
$R_{II} = 0{,}76 \times 1025$ kg $= 779$ "

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$$Res_I = \sqrt{(R_I + A_I)^2 + P_I^2} = \sqrt{(246 + 64)^2 + 661^2} = 730 \text{ kg}$$
$$Res_{II} = \sqrt{(R_{II} + A_{II})^2 + P_{II}^2} = \sqrt{(779 + 64)^2 + 2094^2} = 2257 \text{ kg}$$

Opm.: $R_I + A_I$ en $R_{II} + A_{II}$ zo ongunstig mogelijk genomen





afstand van lager II tot: (Tek C 3678/1)

rechterkant rondsel = $67/2 + 18 + 244 = 295{,}5$ mm

linkerkant los tandwiel = $67/2 + 18 + 244 + 51 = 346{,}5$ mm

overgang draad M120x2/as = $346{,}5 + 64 + 27 = 437{,}5$ „

enkelgangige worm = $437{,}5 + 79 + 40 = 556{,}5$ „

hart rondsel = $67/2 + 18 + \frac{244}{2} = 173{,}5$ „

$M_{A\,res} = 730 \text{ kg } (72{,}3 - 29{,}55) \text{ cm} = 31.208$ kgcm

$M_{B\,res} = 730 \text{ kg } (72{,}3 - 34{,}65) \text{ cm} = 27.485$ „

$M_{C\,res} = 730 \text{ kg } (72{,}3 - 43{,}75) \text{ cm} = 20.842$ „

$M_{D\,res} = 730 \text{ kg } (72{,}3 - 55{,}65) \text{ cm} = 12.155$ „

$M_{K\,res} = 730 \text{ kg } (72{,}3 - 17{,}35) \text{ cm} = 40.114$ „

$W_{b\,A} = 0{,}1 \times 13{,}8^3 = 263 \text{ cm}^3$ | $W_{w\,A} = 2 \times 263 = 526$ cm

$W_{b\,B} = 0{,}1 \times 12{,}2^3 = 182$ „ | $W_{w\,B} = 2 \times 182 = 363$ „

$W_{b\,C} = 0{,}1 \times 11{,}26^3 = 143$ „ | $W_{w\,C} = 2 \times 143 = 286$ „

worm DP9 1GR hell. h. 1°31' drukh. 15°

(1GR = 1 groef, enkelgangig)

$m_{ax} = d_1 \operatorname{tg} \gamma = 106{,}96 \operatorname{tg} 1°31' = 106{,}96 \times 0{,}0265 = 2{,}834$ mm

neem aan $h_v = 1{,}25\ m_{ax}$

$d_{voet} = stc - 2 \times 1{,}25\ m_{ax} = 106{,}96 - 2{,}5 \times 2{,}834 = 99{,}875$ mm

$W_{b\,D} = 0{,}1 \times 9{,}98^3 = 100 \text{ cm}^3$ | $W_{w\,D} = 2 \times 100 = 200 \text{ cm}^3$

$d_{voet\,rondsel} = d_{kopc.} - 2 \times 2{,}25\,m = 177 - 4{,}5 \times 6{,}5 = 147{,}75$ mm

$W_{b\,rondsel} = 0{,}1 \times 14{,}775^3 = 323 \text{ cm}^3$ | $W_{w\,rondsel} = 2 \times 323 = 645 \text{ cm}^3$

t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

. Ingaande as (door hoofdmotor aangedreven
volgs geval 2

$$\sigma_v = \sqrt{(\beta\sigma)^2 + 3(\beta_\tau \cdot \tau)^2} \leq \bar{\sigma}$$

tussenas en uitgaande as geval 3

$$\sigma_v = \sqrt{(\beta\sigma)^2 + 3(\alpha\beta_\tau \cdot \tau)^2} \leq \bar{\sigma}$$

$$\sigma_v = \sqrt{(1{,}0\sigma)^2 + 3(0{,}73\,\tau)^2} \leq 635 \text{ kg/cm}^2 \text{ voor } z < 60$$

$\sigma_A = \frac{31.208 \text{ kgcm}}{263 \text{ cm}^3} = 119 \text{ kg/cm}^2$	$\tau_A = \frac{21.486 \text{ kgcm}}{526 \text{ cm}^3} = 41 \text{ kg/cm}^2$
$\sigma_B = \frac{27.485 \text{ kgcm}}{182 \text{ cm}^3} = 151$ "	$\tau_B = \frac{21.486 \text{ kgcm}}{363 \text{ cm}^3} = 59$ "
$\sigma_C = \frac{20.842 \text{ kgcm}}{143 \text{ cm}^3} = 146$ "	$\tau_C = \frac{21.486 \text{ kgcm}}{286 \text{ cm}^3} = 75$ "
$\sigma_D = \frac{12.155 \text{ kgcm}}{100 \text{ cm}^3} = 122$ "	$\tau_D = \frac{21.486 \text{ kgcm}}{200 \text{ cm}^3} = 107$ "
$\sigma_K = \frac{40.114 \text{ kgcm}}{323 \text{ cm}^3} = 124$ "	$\tau_K = \frac{21.486 \text{ kgcm}}{645 \text{ cm}^3} = 33$ "

$$\sigma_{v_A} = \sqrt{119^2 + 3(0{,}73 \times 41)^2} = 130 \text{ kg/cm}^2$$

$$\sigma_{v_B} = \sqrt{151^2 + 3(0{,}73 \times 59)^2} = 157 \text{ "}$$

$$\sigma_{v_B} = \sqrt{(1{,}00 \times 151)^2 + 3(1{,}29 \times 59)^2} = 200 \text{ "}$$

$$\sigma_{v_C} = \sqrt{146^2 + 3(0{,}73 \times 75)^2} = 174 \text{ "}$$

$$\sigma_{v_D} = \sqrt{(1{,}00 \times 122)^2 + 3(0{,}73 \times 107)^2} = 182 \text{ "}$$

$$\sigma_{v_K} = \sqrt{(1{,}00 \times 124)^2 + 3(1{,}00 \times 33)^2} = 137 \text{ "}$$

voor astap zie blz. 14 onder

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

punt A

$$t = \frac{D-d}{2} = \frac{177-138}{2} = 19{,}5 \text{ mm}$$

$$\left.\begin{aligned} \frac{f}{t} &= \frac{3}{19{,}5} = 0{,}153 \\ \frac{t}{D} &= \frac{19{,}5}{177} = 0{,}11 \end{aligned}\right\} \; f/t > 0{,}14$$

punt B

$$t = \frac{138-122}{2} = 8 \text{ mm}$$

$$\left.\begin{aligned} \frac{t}{D} &= \frac{8}{138} = 0{,}058 \\ \frac{f}{t} &= \frac{4}{8} = 0{,}5 \end{aligned}\right\} \; f/t > 0{,}44$$

punt C

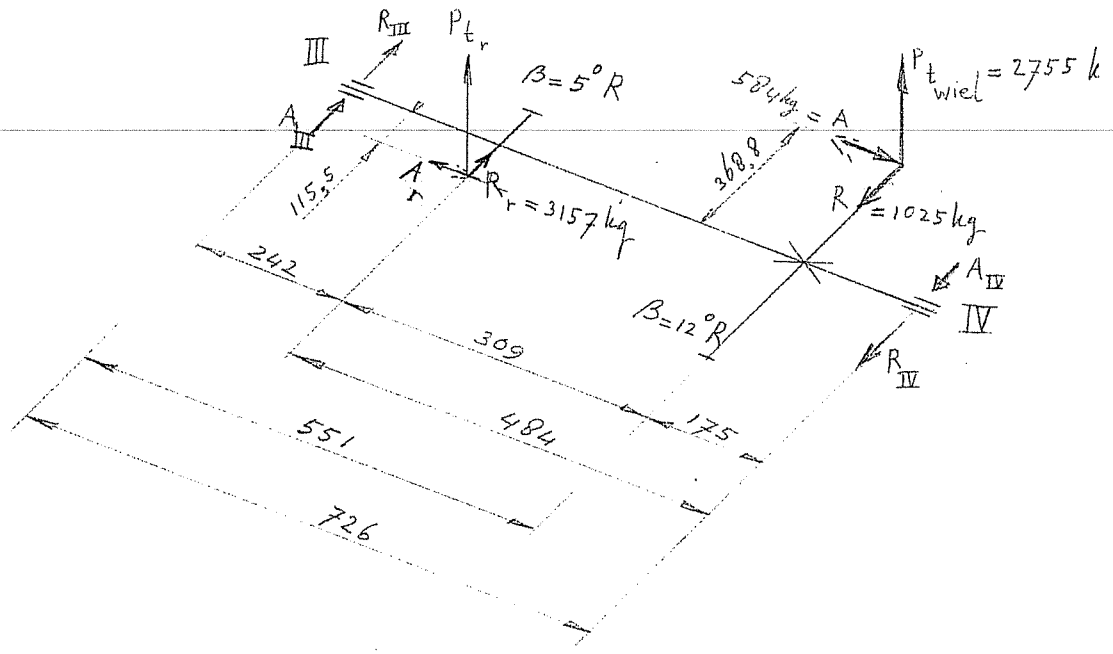
$$t = \frac{120-112{,}6}{2} = 3{,}7$$

Neem $f = 3$

$$\left.\begin{aligned} \frac{t}{D} &= \frac{3{,}7}{120} = 0{,}308 \\ \frac{f}{t} &= \frac{3}{3{,}7} = 0{,}81 \end{aligned}\right\} \; f/t > 0{,}54$$

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Tussenas hoofdmotor gedeelte



$P_{t_r} = 8641$ kg

$A_r = P_{t_r} \operatorname{tg}\beta = 8641 \times \operatorname{tg} 5^\circ = 8641 \times 0{,}0875 = 756$ kg

$R_r = 8641 \times \frac{\operatorname{tg} 20}{\cos 5^\circ} = 8641 \times \frac{0{,}364}{0{,}9962} = 3157$ kg

$\frac{484}{726} = 0{,}666$ $\qquad$ $\frac{175}{726} = 0{,}241$

$\frac{242}{726} = 0{,}333$ $\qquad$ $\frac{551}{726} = 0{,}759$

$0{,}999 \approx 1$ $\qquad$ $1{,}000$

Vertikaal

$P_{III} = 0{,}666 \times 8641 + 0{,}241 \times 2755 = 6419$ kg

$P_{IV} = 0{,}333 \times 8641 + 0{,}759 \times 2755 = 4968$ kg

horizontaal

$R_{III} = 0{,}666 \times 3157 - 0{,}241 \times 1025 = 1856$ kg

$R_{IV} = 0{,}333 \times 3157 - 0{,}759 \times 1025 = 273$ kg

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$$|A_{III}| = |A_{IV}| = \frac{756 \times 11{,}55 + 584 \times 36{,}88}{72{,}6} = 417 \text{ kg}$$

$$R_{III} + A_{III} = 1856 + 417 = 2273 \text{ kg}$$

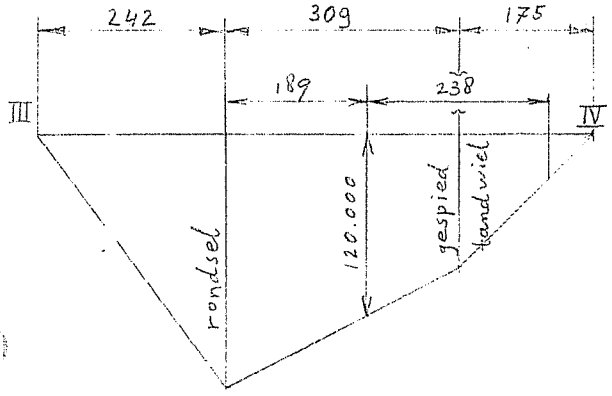
$$R_{IV} + A_{IV} = 273 + 417 = 690 \text{ kg}$$

samengesteld

$$Res_{III} = \sqrt{6419^2 + 2273^2} = 6810 \text{ kg}$$
$$Res_{IV} = \sqrt{4968^2 + 690^2} = 5016 \text{ kg}$$

} liggen niet in zelfde vlak

$$|Asc_{tot}| = 756 - 584 = 172 \text{ kg}$$



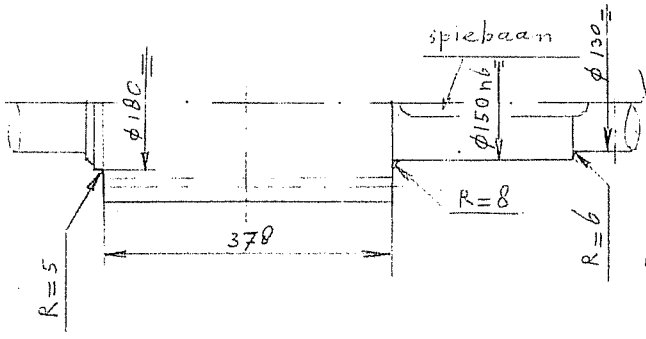
$M_{t.p.v.\ rondsel} = 6810 \text{ kg} \times 24{,}2 \text{ cm} = 164.802 \text{ kgcm}$

$M_{t\,p.v\ tandwiel} = 5016 \text{ kg} \times 17{,}5 \text{ cm} = 87\,780$ "

$M_{t.p.v\ schouder} \approx 120.000$ kgcm (opgemeten uit $r = 8$ niet exact $M_{res\ vlak}$)

voetcirkel rondsel $\approx$ kopc. $- 2 \times 2{,}25$ m

$\approx 258 - 4{,}5 \times 10 = 213$ mm



$W_{b\ rondsel} = 0{,}1 \times 21{,}3^3 = 966 \text{ cm}^3$ $\quad W_w = 2 \times 966 = 1933 \text{ cm}^3$

$W_{b\ as} = 0{,}1 \times 15^3 = 338$ " $\quad W_w = 2 \times 338 = 675$ "

$D_{kopc} = D = 258$ mm, $d_{as\ rondsel} = 150$ mm, $\rho = 8$

$$t = \frac{Stc - d}{2} = \frac{231 - 150}{2} = 40{,}5 \text{ mm}$$

$$\frac{t}{Stc} = \frac{40{,}5}{231} = 0{,}175$$

$$\frac{\rho}{t} = \frac{8}{40{,}5} = 0{,}198$$

$\rho/t < 0{,}23$ $\therefore \rho = 10$ mm

(R = 5 en R = 8 te klein)

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$$\sigma_{t.p.v.\ rondsel} = \frac{16480\ kgcm}{966\ cm^3} = 171\ kg/cm^2$$

$$\sigma_{b\,t.p.v.\ tandwiel} = \frac{87780\ kgcm}{338\ cm^3} = 260\ ,,$$

$$\sigma_{b\,t.pl\ v.\ schouder} = \frac{120.000\ kgcm}{338\ cm^3} = 355\ ,,$$

$$\tau_{w\,t.pl.v.\ rondsel} = \frac{99.373\ kgcm}{1933\ cm^3} = 51\ kg/cm^2$$

$$\tau_{w.t.pl.v.\ spiegas\text{-}gedeelte} = \frac{99.373\ kgcm}{675\ cm^3} = 147\ ,,$$

$$\sigma_v = \sqrt{(\beta.\sigma)^2 + 3(\alpha\beta_\tau.\tau)^2} \leq \bar{\sigma}_{2\,c60}^{\,wissel} \qquad C60 \equiv St_j$$

$$\sqrt{(1.\sigma)^2 + 3(0{,}415\,\tau)^2} \leq 635\ kg/cm^2$$

$$\sigma_{v\,t.p.v.rondsel} = \sqrt{171^2 + 3(0{,}415 \times 51)^2} = 175\ kg/cm^2$$

$$\sigma_{v\,t.p.v.\ gespied\ tandwiel\ geval\ I} = \sqrt{260^2 + 3(0{,}73 \times 147)^2} = 320\ ,,$$

$$,,\ geval\ II = \sqrt{(1{,}3 \times 260)^2 + 3(0{,}74 \times 147)^2} = 387\ ,,$$

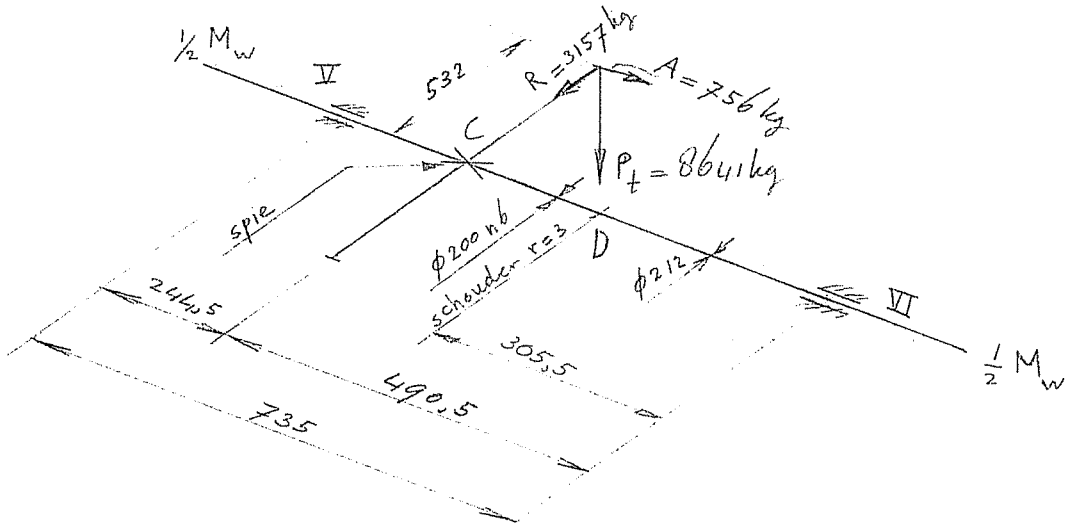
$$\sigma_{v\,t.p.v.\ schouder\ R=8} = \sqrt{355^2 + 3(0{,}415 \times 147)^2} = 370\ ,,$$

Uitgaande as (hoofdmotorgedeelte)

De uitgaande as heeft 2 astapuitgangen

$$\frac{490{,}5}{735} = 0{,}667 \qquad \frac{244{,}5}{735} = 0{,}333$$

t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt



vertikaal

$P_V = 0{,}667 \times 8641 \text{ kg} = 5764 \text{ kg}$

$P_{VI} = 0{,}333 \times 8641 \text{ kg} = 2877 \text{ kg}$

horizontaal

$R_V = 0{,}667 \times 3157 \text{ kg} = 2106 \text{ kg}$

$R_{VI} = 0{,}333 \times 3157 \text{ ,,} = 1051 \text{ kg}$

$|A_V| = |A_{VI}| = \frac{756 \text{ kg} \times 53{,}2 \text{ cm}}{73{,}5 \text{ cm}} = 547 \text{ kg}$

$(R_V + A_V)_{max} = 2106 + 547 = 2653 \text{ kg}$

$(R_{VI} + A_{VI})_{max} = 1051 + 547 = 1598 \text{ ,,}$

samengesteld

$Res_V = \sqrt{5764^2 + 2653^2} = 6345 \text{ kg}$

$Res_{VI} = \sqrt{2877^2 + 1598^2} = 3291 \text{ kg}$

$M_{bC} = 6345 \text{ kg} \times 24{,}45 \text{ cm} = 155.135 \text{ kgcm}$

$M_{bC} = 3291 \text{ ,,} \times 49{,}05 \text{ ,,} = 161.424 \text{ kgcm}$

$M_{bt.p.v.\ schouder\ r=3} = 3291 \text{ kg} \times 30{,}55 \text{ cm} = 100.540 \text{ kgcm}$

t. w. k. 2 A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$W_{b\ \text{recht van D}} = 0{,}1 \times 21{,}2^3 = 953\ cm^3$

$W_{b\ \text{links van D}} = 0{,}1 \times 20^3 = 800\ ,,$

$W_{b\ c} = 0{,}1 \times 20^3 = 800\ ,,$

$W_{w\ \text{rechts van D}} = 2 \times 953 = 1906\ cm^3$

$W_{w\ \text{links van D}} = 2 \times 800 = 1600\ ,,$

$W_{w\ c} = 2 \times 800 = 1600\ ,,$

$D = 212\ mm\ ,\ d = 200\ ,\ r = 3$

$t = \frac{D-d}{2} = \frac{212-200}{2} = 6\ mm$

$\frac{t}{D} = \frac{6}{212} = 0{,}028$

$\frac{f}{t} = \frac{3}{6} = 0{,}5$

$\rho/t = 0{,}5$

$\sigma_{b\ \text{rechts van D}} = \frac{100.540\ kgcm}{953\ cm^3} = 105\ kg/cm^2$

$\sigma_{b\ \text{links van D}} = \frac{100.540\ kgcm}{800\ cm^3} = 126\ ,,$

$\sigma_{b\ c} = \frac{161.424\ kgcm}{800\ cm^3} = 202\ ,,$

$M_{w\ \text{as t.pl v. tandwiel}} = 1/1\ M_w = 457.115\ kgcm$

$M_{w\ \text{as } \phi 212} = \frac{1}{2} M_w = \frac{1}{2} \times 457\,115 = 228.558\ kgcm$

$\tau_{w\ \text{rechts van D}} = \frac{228.558\ kgcm}{1906\ cm^3} = 120\ kg/cm^2$

$\tau_{w\ \text{links van D}} = \frac{457.115\ kgcm}{1600\ cm^3} = 286\ ,,$

$\tau_{w\ c} = \frac{457\,115\ kgcm}{1600\ cm^3} = 286\ ,,$

t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Mat. uitgaande as 2C35

trekvastheid C 35 = 50 $\frac{kg}{mm^2}$ (Tab 2-4-1)

$\sigma_{50\ kg/mm^2}$ wisselspanning = 500 kg/cm^2 (Tab 2-1-

naaf of lager op as (aan omtrek) $\beta = 1{,}21$ en

$\alpha\beta_t = 0{,}68$ voor 50 kg/mm^2

as met spie aan (in grond spie) $\beta = 1{,}00$

$\alpha\beta_t = 0{,}73$

$$\sigma_v = \sqrt{(\beta\sigma)^2 + 3(\alpha\beta_\tau \tau)^2}$$

$$\sigma_{v\ \text{rechts van D}} = \sqrt{(1{,}0 \times 105)^2 + 3(0{,}415 \times 120)^2} = 136\ kg/cm^2$$

$$\sigma_{v\ \text{links van D}} = \sqrt{(1{,}0 \times 126)^2 + 3(0{,}415 \times 286)^2} = 241\ ,,$$

$$\sigma_{v\ C\ \text{aan omtrek}} = \sqrt{(1{,}21 \times 202)^2 + 3(0{,}68 \times 286)^2} = 416\ ,,$$

$$\sigma_{v\ C\ \text{in spiegraaf}} = \sqrt{(1{,}00 \times 202)^2 + 3(0{,}73 \times 286)^2} = 414\ ,,$$

voor astapuiteinde zie blz 15

Astapuiteinden (tek C 3678)

ingaande as (hoofdmotorgedeelte)

$\phi\ 85 \rightarrow W_w = 0{,}2 \times 8{,}5^3 = 123\ cm^3$

mat. as 2C60 overeen St 70 $\rightarrow \sigma = 635\ kg/cm^2$

$$\tau_w = \frac{M_w}{W_w} = \frac{21486\ kgcm}{123\ cm^3} = 175\ kg/cm^2$$

$\beta_{\tau\ \text{groeven}} = 0{,}73$ $\beta_{\tau\ \text{as met spiebaan}} = 1{,}29$

$\sigma_v = \beta_\tau \cdot \tau \cdot \sqrt{3}$

$\sigma_v = 0{,}73 \times 175\ \sqrt{3} = 221\ kg/cm^2$

$\sigma_v = 1{,}29 \times 175\ \sqrt{3} = 391\ ,,$

t.w.k. 2 A 3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Uitgaande as (hoofdmotorgedeelte)

ϕ 180 → $W_w = 0{,}2 \times 18^3 = 1166\ cm^3$

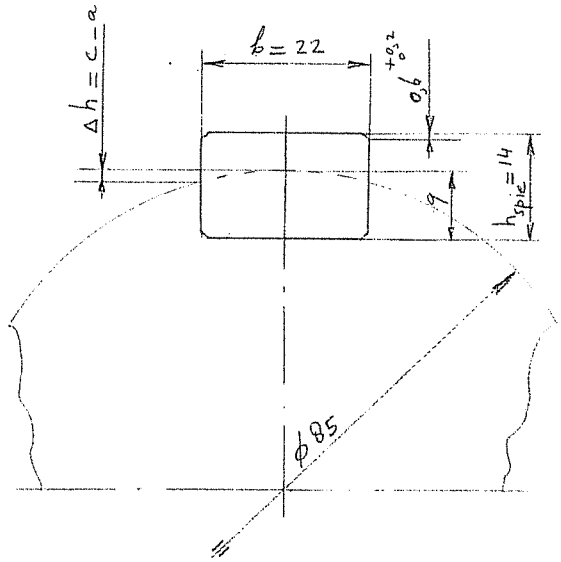
$\frac{1}{2} M_w = 228.558$ kgcm (zie blz 1)

$\tau_w = \frac{228.558\ kgcm}{1166\ cm^3} = 196\ kg/cm^2$

$\sigma_v = 0{,}73 \times 196\sqrt{3} = 248\ kg/cm^2$

$\sigma_v = 1{,}29 \times 196\sqrt{3} = 438$ "

mat 2 C 35 $\sigma_B = 50\ kg/mm^2 \rightarrow \sigma_{spr.} = 885\ kg/cm^2$



Inlegspieën

ingaande as

astep ϕ85 mb (hoofdmotor)

$P_{spie} = \frac{21.486\ kgcm}{\frac{8,5}{2}\ cm} = 5056\ kg$

$b_{spie} = 22$ mm → $h_{spie} = 14$ mm
spiefafschuining $= 0{,}6^{+0,2}_{0}$ } NEN 243

spiediepte in as in hart gemeten 9 mm

$\Delta h = R - \sqrt{R^2 - \left(\frac{1}{2}b\right)^2} = 42{,}5 - \sqrt{42{,}5^2 - 11^2} = 1{,}448\ 2$ mm

$l_{spie} = 130 - 22 = 108$ mm

$F_{spie\ op\ naaf} = (14 - 9 - 0{,}8 + 1{,}448)\ 108 = 5{,}648 \times 108 = 610$ mm

$\sigma_{o\ naaf} = \frac{5.056}{6{,}1} = 830\ kg/cm^2$ (Naaf Cij $\sigma_o = 500\ kg/cm^2$)

$F_{spie\ op\ as} = (9 - 0{,}8 - 1{,}448)\ 108 = 6{,}752 \times 108 = 729\ mm^2$

$\sigma_{o\ as} = \frac{5.056}{7{,}29} = 693\ kg/cm^2$

spie op tussenas ϕ150 mb

$P_{spie} = \frac{99.373\ kgcm}{\frac{15}{2}\ cm} = 13.250\ kg$

t.w.k. 2A3-110 Spec. (Hoofdmotor gedeelte) Nieuwe Schutsluis Weurt.

$b_{spie} = 36\ mm \rightarrow h_{spie} = 20\ mm$
$spiefafschuining = 1\ ^{+0,2}_{0}$ } NEN 2431

spiediepte in as in hart gemeten = 10 mm

$\Delta h = 75 - \sqrt{75^2 - 18^2} = 2,192\ mm$

$l_{spie\ werkzaam} = 250 - \frac{36}{2} - 18 = 214\ mm$

$F_{spie\ op\ naaf} = (20 - 10 - 1,2 + 2,192)214 = 10,992 \times 214 = 2352\ mm^2$

$\sigma_{o\ naaf} = \frac{13.250\ kg}{23,52\ cm^2} = 563\ \frac{kg}{cm^2}$ (naaf GG 20 $\rightarrow \sigma_o = 500\ kg/cm^2$

$F_{spie\ op\ as} = (10 - 1,2 - 2,192)214 = 6,608 \times 214 = 1414\ mm^2$

$\sigma_{o\ as} = \frac{13250\ kg}{14,14\ cm^2} = 937\ kg/mm^2$

Spie voor tandwiel uitgaande as ϕ200

$P_{spie} = \frac{457.115\ kgcm}{\frac{20}{2}\ cm} = 45712\ kg$

$b_{spie} = 45\ mm \rightarrow h_{spie} = 25\ mm$
$spiefafschuining = 1\ ^{+0,2}_{0}$ } NEN 2431

spiediepte in as in hart gemeten = 12,5 mm

Opm.: spiediepte minder diep dan normaal

$l_{spie\ werkzaam} = 386 - \frac{45}{2} - 22,5 = 341\ mm$

$\Delta h = 100 - \sqrt{100^2 - 22,5^2} = 2,564\ mm$

$F_{spie\ naaf} = (25 - 12,5 - 1,2 + 2,564)341 = 13,86 \times 341 = 4728\ mm^2$

$\sigma_{o\ naaf} = \frac{45.712}{47,27} = 967\ kg/cm^2$

$F_{spie\ op\ as} = (12,5 - 1,2 - 2,564)341 = 8,736 \times 341 = 2979\ mm^2$

$\sigma_{o\ as} = \frac{45.712}{29,79} = 1534\ kg/cm^2$

Spie astap ϕ180

$P_{spie} = \frac{\frac{1}{2} M_w}{r_{as}} = \frac{228.558}{\frac{18}{2}} = 25395\ kg$

t.w.k. 2 A 3_ 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$b_{spie} = 45$ mm $\rightarrow$ $h_{spie} = 25$ mm
spieafschuining $= 1^{+0,2}_{0}$ } NEN 2431

spiediepte in as in hart gemeten $= 15$ mm

$\Delta h = 90 - \sqrt{90^2 - 22,5^2} = 2,857$ mm

$\ell_{spie\ werkzaam} = 220 - 45 = 175$ mm

$F_{spie\ op\ naaf} = (25 - 15 - 1,2 + 2,857)\,175 = 11,657 \times 175 = 2040$ mm^2

$\sigma_{0\ naaf} = \frac{25.395}{20,4} = 1245$ kg/cm^2 (naaf van staal $\sigma_0 = 900$ kg/cm^2

$F_{spie\ op\ as} = (15 - 1,2 - 2,857)\,175 = 1915$ mm^2

$\sigma_{0\ as} = \frac{25.395}{19,15} = 1326$ kg/cm^2 ($\sigma_0 = 900$ kg/cm^2

Lagers van hoofmotorgedeelte
(bij hoofdmotordraaien.) Tek no 1142

ingaande as
2 rijig tonlager nr 22319 $95 \times 200 \times 67$
$C_{dyn} = 45,5$ t , $C_{stat} = 40,5$ t

tussen as
2 rijig tonlager nr 22226 $130 \times 230 \times 64$
$C_{dyn} = 49$ t , $C_{stat.} = 45,5$ t

uitgaande as
2 rijig tonlager nr 23038 $190 \times 290 \times 75$
$C_{dyn} = 67$ t , $C_{stat.} = 73,5$ t

Opm : draaggetallen vlgs SKF

Neem voor L_h gemakshalve 25000 ipv 24000

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

· Ingaande as

$n = 1500$ omw/min (blz. 1)
$F_r = 2257$ kg (blz. 6)
$F_{ax} = 584$ kg (blz 5

$\frac{F_a}{F_r} = \frac{584}{2257} = 0,26 \leq e = 0,5$

$X = 1 \quad Y = 1,9$

$P = 1 \times 2257 + 1,9 \times 584 = 3367$ kg

$\frac{C}{P} \approx 10$ voor $L_H = 24000$ en $n = 1500$

$C = 10 \times 3367$ kg $= 33.670$ kg $< C_{dyn} = 45.500$ kg

statisch

$Y_o = 1,8$

$P_o = F_r + Y_o F_a = 2257 + 1,8 \times 584 = 3308$ kg

$V = \frac{40.500}{3308} = 12,24 > 2,25$

aanloopfactor 1,5 motor koppel

$V_{stat\ nom.\ koppel} = 1,5 \times 1,5 = 2,25$

Lager voldoet

tussenas

$n = 324$ omw/min (blz 1)
$F_r = 6810$ kg } blz. 10
$F_{ax} = 172$ kg }

$\frac{F_a}{F_r} = \frac{172}{6810} = 0,025 < e = 0,26$

t.w.k. 2A3 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$X = 1 \qquad Y = 2,6$

$P = 1 \times 6810 + 2,6 \times 172 = 7257 \text{ kg}$

$\frac{C}{P} \approx 6,36$ VOOR $L_H = 24000$ EN $n = 324$

$C = 6,36 \times 7257 = 46.156 \text{ kg} < C_{dyn} = 49000 \text{ k}$

statisch

$Y_o = 2,5$

$P_o = F_r + Y_o F_a = 6810 + 2,5 \times 172 = 7240 \text{ kg}$

$V = \frac{45.500}{7240} = 6,28 > 2,25$

Lager voldoet

Uitgaande as

$n = 70$ omw/min. (blz. 1

$F_r = 6345 \text{ kg}$ } blz. 12

$F_{ax} = 756 \text{ kg}$ }

$\frac{F_{ax}}{F_r} = \frac{756 \text{ kg}}{6345 \text{ kg}} = 0,119 < 0,23 = e$

$X = 1 \qquad Y = 2,9$

$P = 1 \times 6345 + 2,9 \times 756 = 8537 \text{ kg}$

$\frac{C}{P} \approx 3,9$ VOOR $L_H = 24000$ EN $n = 70$

$C = 3,9 \times 8537 = 33296 \text{ kg} < C_{dyn} = 73.500 \text{ kg}$

statisch

$Y_o = 2,8$

$P_o = F_r + Y_o F_a = 6345 + 2,8 \times 756 = 8462 \text{ kg}$

$V = \frac{73.500}{8462} = 8,69 > 2,25$

Lager voldoet

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Dekselbouten (hoofdmotorgedeelte)

ingaande as

6 x M12 kwal. 8.8 pos. 96 van stuklijst

$F_{ax} = 584$ kg

$P_{per\ bout} = \frac{584}{6} = 97$ kg

$F_{k\ M12} = 0{,}718$ cm²

$\sigma_t = \frac{97}{0{,}718} = 136$ kg/cm²

$\bar{\sigma} = 560$ kg/cm²

tussenas

6 x M16 kwal 8.8 pos. 97 van stuklijst

$F_{ax} = 172$ kg

$P_{per\ bout} = \frac{172}{6} = 29$ kg

$F_{k\ M16} = 1{,}37$ cm³

$\sigma_t = \frac{29}{1{,}37} = 21$ kg/cm²

uitgaande as

6 x M16 kwal. 8.8 pos. 97 van stuklijst

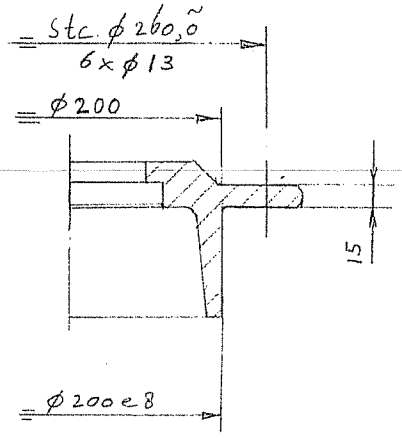
$F_{ax} = 756$ kg

$P_{per\ bout} = \frac{756}{6} = 126$ kg

$\sigma_t = \frac{126\ kg.}{1{,}37\ cm^2} = 92$ kg/cm²

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe schutsluis Weurt

Spanning in deksels

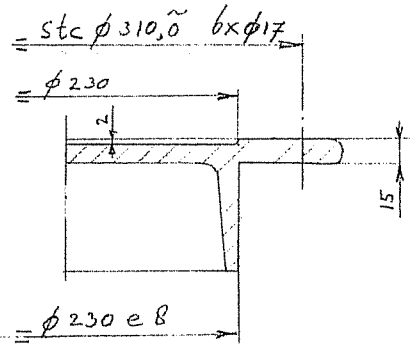


deksel ingaande as (simmerring 95-120-7)
zie tek Norm 110 I

$$\sigma_b = \frac{\frac{1}{2} P_{bout}}{\frac{1}{6} \delta^2} = \frac{\frac{1}{2} \cdot 97}{\frac{1}{6} 1{,}5^2} = 129 \text{ kg/cm}^2$$

$$\sigma = \frac{M}{W} = \frac{Pe}{\frac{\pi d \delta^2}{6}} = \frac{584 \text{ kg} \times 3 \text{ cm}}{\frac{\pi 20 \times 1{,}5^2}{6} \text{ cm}^3} = \frac{1752}{23{,}55} = 74 \text{ kg/cm}^2$$

Mat. G.G. 20 → $\bar{\sigma}$ = 270 kg/cm²

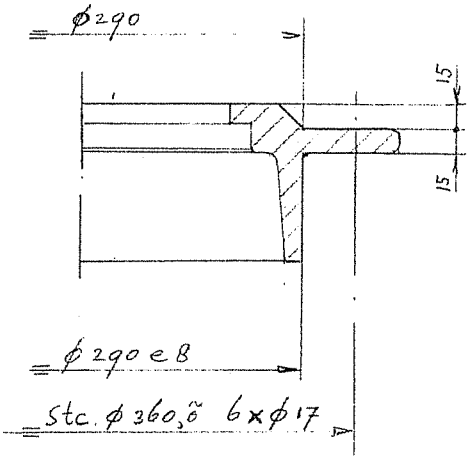


deksel tussen as
zie tek. Norm 128 A

$$\sigma_b = 3 \frac{P_{bout}}{\delta^2} = \frac{3 \times 29}{(1{,}5-0{,}2)^2} = 52 \text{ kg/cm}^2$$

$$\sigma = \frac{17^2 \times 4}{\frac{\pi 23 \times (1{,}5-0{,}2)^2}{6}} = \frac{688}{20{,}3} = 34 \text{ kg/cm}^2$$

Mat. G.G 20 ∴ $\bar{\sigma}$ = 270 kg/cm²



deksel uitgaande as (simmerring 190-220-15)
zie tek Norm 140 I

$$\sigma_b = \frac{3 \times 126 \text{ kg}}{1{,}5^2 \text{ cm}^2} = 168 \text{ kg/cm}^2$$

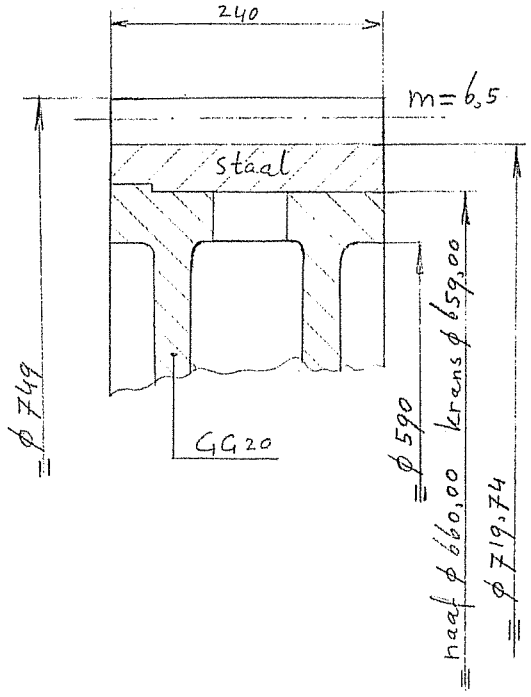
$$\sigma = \frac{756 \times 3{,}5}{\frac{\pi \times 29 \times 1{,}5^2}{6}} = \frac{2646}{34} = 77 \text{ kg/cm}^2$$

Mat. G.G 20 → $\bar{\sigma}$ = 270 kg/cm²

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Krimpverbinding tandwiel op tussenas

zie tek C 36Z8/1



Buiten dia ϕ 749,0 mm
tandhoogte 14,63 mm
voetcirkel $= 749 - 2 \times 14{,}63 = 719{,}74 = d_u$

$$\alpha_1 = \left(\frac{d_u}{d_i}\right)^2 = \left(\frac{719{,}74}{660}\right)^2 = 1{,}09^2 = 1{,}19$$

$$\alpha_2 = \left(\frac{660}{590}\right)^2 = 1{,}12^2 = 1{,}25$$

$E_{st} = 2{,}1.10^6$ kg/cm² (mat 2 C 45) $\quad \mu_{st} = 0{,}3$
$E_{GG20} = 1{,}2.10^6$ " (Tab 3-1-4) $\quad \mu_{Gij} = 0{,}24$

$$\beta_1 = \frac{\alpha_1 + 1}{\alpha_1 - 1} + \mu_1 = \frac{2{,}19}{0{,}19} + 0{,}3 = 11{,}5 + 0{,}3 = 11{,}8$$

$$\beta_2 = \frac{\alpha_2 + 1}{\alpha_2 - 1} - \mu_2 = \frac{2{,}25}{0{,}25} - 0{,}24 = 9 - 0{,}24 = 8{,}76$$

$$\Delta d_1 = 11{,}8 \frac{pd}{E_1}$$

$$\Delta d_2 = 8{,}8 \frac{pd}{E_2}$$

$$\Sigma \Delta d = pd \left(\frac{11{,}8}{E_1} + \frac{8{,}8}{E_2}\right) = \frac{pd}{E_1}\left(11{,}8 + 8{,}8 \frac{E_1}{E_2}\right)$$

$$p = \frac{\Sigma \Delta d \cdot E_1}{d\left(11{,}8 + 8{,}8 \frac{E_1}{E_2}\right)}$$

passing
krans ϕ 659,50 ± 0,005
naaf ϕ 660,00 ± 0,005

(Opm.: Toleranties vlgs stuklijst)

nom. neg. speling $= 659{,}5 - 660 = 0{,}5$ mm

$\Delta d_{max} = 0{,}5 + 2 \times 0{,}005 = 0{,}510$ mm

$\Delta d_{min} = 0{,}5 - 2 \times 0{,}005 = 0{,}490$ "

$11{,}8 + 8{,}8 \frac{E_1}{E_2} = 11{,}8 + 8{,}8 \frac{2{,}1 \cdot 10^6}{1{,}2 \cdot 10^6} = 27{,}2$

$p = \frac{\Sigma \Delta d \cdot E_1}{d \cdot 27{,}2}$

$p_{max} = \frac{0{,}510}{660} \cdot \frac{2100}{27{,}2} = 0{,}060\ t/cm^2$

$p_{min} = \frac{0{,}490}{660} \cdot \frac{2100}{27{,}2} = 0{,}057$ "

$\sigma_{t\ tandkrans} = p \frac{\alpha_1 + 1}{\alpha_1 - 1}$

" $_{max} = 60 \times 11{,}5 = 690\ kg/cm^2$

" $_{min} = 57 \times 11{,}5 = 656$ "

$\sigma_{gietijzeren\ velgrand} = -p \frac{\alpha_2 + 1}{\alpha_2 - 1}$

" $= -60 \times 9 = -540\ kg/cm^2$

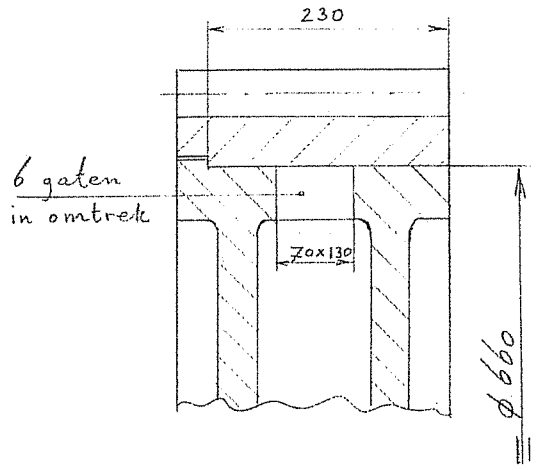
" $= -57 \times 9 = -513$ "

$\sigma_{B_t\ C_1C_120} = 20\ kg/mm^2$

$\sigma_{B_d} = 2\sigma_{B_t} = 2 \times 20 = 40\ kg/mm^2$

$\sigma_d = \frac{4000}{2{,}5} = 1600\ kg/cm^2$

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt



Wrijving tussen velg en tandkrans
(tussenas) ($m = 6,5$)
wrijvingcoeff. $\mu' = 0,15$

Draagvlak tussen krans en velg
$\pi . 66 \times 23 - 6(7 \times 13) = 4221\ cm^2$

$N = 4221\ cm^2 \times 0,057 \frac{t}{cm^2} = 240\ t$

$W = fN = 0,15 \times 240\ t = 36\ t$
$M_{wrijv.} = 36\ t \times \frac{66}{2}\ cm = 1188\ tcm$
$M_{nom.} = 99.373\ kgcm$ (=ie blz 3)

$v = \frac{1188\ tcm}{99,4\ tcm} = 12$

dus wrijving groot genoeg om moment over te brengen

tandkransdikte
bandagedicke $\frac{h}{m} = 4,5 - 5,5$ (Konstruktion 19(1967) Heft 2

$m = 6,5$
$h_{min} = 4,5 \times 6,5 = 29,25\ mm$
$h_{max} = 5,5 \times 6,5 = 35,75\ "$

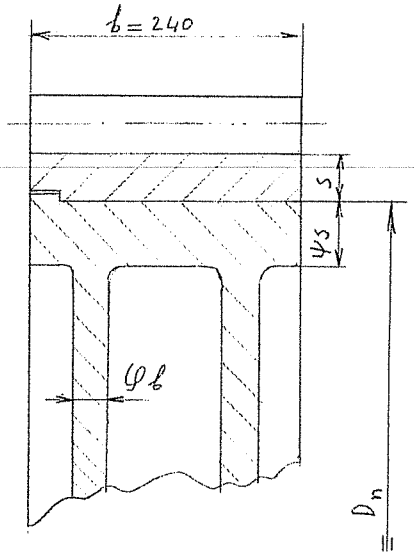
$\frac{1}{2}$ voetcirkel $= \frac{719,74}{2} = 359,87\ mm$

$\delta_{tandkrans} = 359,87 - 330 = 29,87\ mm$

δ vlgs Konstruktion niet te dun

t.w.k. 2A3-110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Afmetingen tandwiel op tussenas (vlgs Donkersloot bl 57)



$D_n \approx 660 \rightarrow s \approx 28$ mm

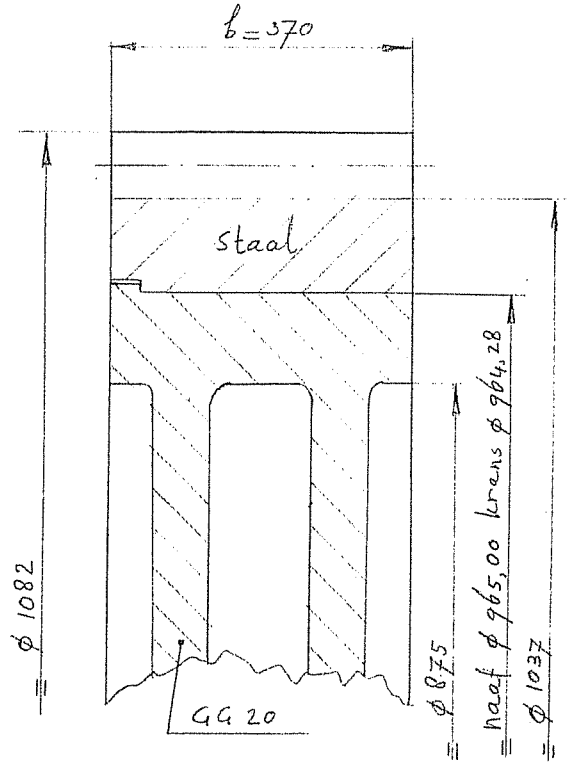
$\frac{D_n}{b} = \frac{660}{240} \approx 2{,}75 \rightarrow \psi = 1{,}18$ en $\varphi = 0{,}0935$

$\psi s = 1{,}18 \times 28$ mm $= 33$ mm

$\varphi b = 0{,}0935 \times 240$ mm $= 22{,}4$ mm

Krimpverbinding tandwiel op uitgaande as

zie tek. C 3678/2



Buiten dia ϕ 1082,0

tandhoogte = 22,5 mm

voetcirkel = 1082 − 2×22,5 = 1037 mm

$\alpha_1 = \left(\frac{d_u}{d_i}\right)^2 = \left(\frac{1037}{964{,}28}\right)^2 = 1{,}157$

$\alpha_2 = \left(\frac{965}{875}\right)^2 = 1{,}216$

$\frac{\alpha_1 + 1}{\alpha_1 - 1} = \frac{1{,}157 + 1}{1{,}157 - 1} = 13{,}74$

$\frac{\alpha_2 + 1}{\alpha_2 - 1} = \frac{1{,}216 + 1}{1{,}216 - 1} = 10{,}247$

$E_{staal} = 2{,}1 \cdot 10^6$ kg/cm² (mat 2C 45) $\quad \mu_{st} = 0{,}3$

$E_{GG\,20} = 1{,}2 \cdot 10^6$ " (Tab 3-1-4) $\quad \mu_{Gij} = 0{,}21$

t.w.k. 2 A3 – 110 Spec (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$$\beta_1 = \frac{\alpha_1+1}{\alpha_1-1} + \mu_1 = 13,74 + 0,3 = 14,04$$

$$\beta_2 = \frac{\alpha_2+1}{\alpha_2-1} - \mu_2 = 10,247 - 0,24 = 10,007$$

$$\Delta d_1 = 14,04 \frac{pd}{E_1}$$

$$\Delta d_2 = 10 \frac{pd}{E_2}$$

$$\sum \Delta d = pd \left(\frac{14}{E_1} + \frac{10}{E_2} \right)$$

$$\text{"} = \frac{pd}{E_1} \left(14 + 10 \frac{E_1}{E_2} \right)$$

$$p = \frac{\sum \Delta d \, E_1}{d \left(14 + 10 \frac{E_1}{E_2} \right)}$$

$$\left(14 + 10 \frac{E_1}{E_2} \right) = 14 + 10 \frac{2,1}{1,2} = 31,5$$

$$p = \frac{\sum \Delta d \, E_1}{d \, 31,5}$$

passing

krans ϕ 964,28 $\pm$ 0,005

naaf ϕ 965 $\pm$ 0,005

(tolerantres vlgs stuklijst)

nom. neg. speling = 964,28 – 965 = – 0,72 mm

$$\Delta d_{max} = 0,72 + 2 \times 0,005 = 0,73 \text{ mm}$$

$$\Delta d_{min} = 0,72 - 2 \times 0,005 = 0,71 \text{ "}$$

$$p_{max} = \frac{0,73}{965} \cdot \frac{2100 \text{ t/cm}^2}{31,5} = 0,050 \text{ kg/cm}^2$$

$$p_{min} = \frac{0,72}{965} \cdot \frac{2100 \text{ "}}{31,5} = 0,0497 \text{ "}$$

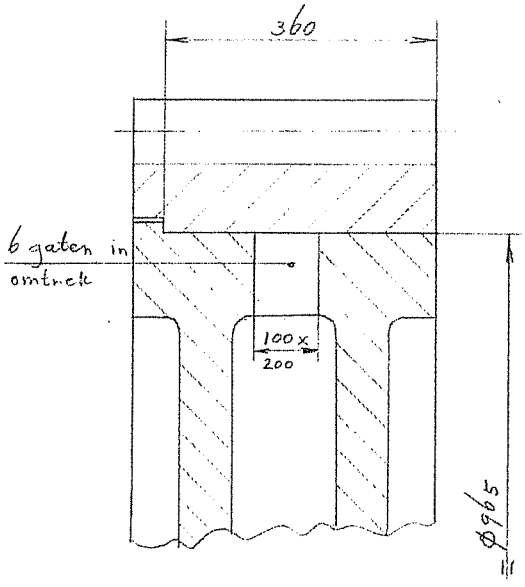
t.w.k. 2 A 3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$$\sigma_{t\ tandkrans} = p\ \frac{\alpha_1+1}{\alpha_1-1}$$

$$\sigma_{max} = 50\ kg/cm^2 \times 13{,}74 = 687\ kg/cm^2$$

$$\sigma_{\substack{gietijzeren\\velgrand}} = -p\ \frac{\alpha_2+1}{\alpha_2-1}$$

$$= -50\ \frac{kg}{cm^2} \times 10{,}247 = -512\ kg/cm^2$$



Wrijving tussen velg en tandkrans
(uitgaande as) (m = 10)

wrijvingscoëff. $\mu' = 0{,}15$

Draagvlak tussen krans en velg

$\pi\ 96{,}5 \times 36 - 6 \times 10 \times 20 = 9708\ cm^2$

$N_{min} = p_{min} F = 50\ kg/cm^2 \times 9708\ cm^2 = 485.418\ kg \approx 485$

$W_{min} = f_{min} . N = 0{,}15 \times 485\ t = 73\ t$

$M_{wrijv.} = 73\ t \times \frac{96{,}5}{2}\ cm = 3513\ tcm$

$M_{nom.} = 457\ tcm$

$V = \frac{3513}{457} = 7{,}69$

dus wrijving groot genoeg om moment over te brengen

tandkransdikte

bandagedicke $\frac{h}{m} = 4{,}5 - 5{,}5$ (Konstruktion 19 (1967) Heft 2

$m = 10$

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

$h_{min} = 4,5 \times 10 = 45$ mm
$h_{max} = 5,5 \times 10 = 55$ mm

$\frac{1}{2}$ voetcirkel $= \frac{1037}{2} = 518,5$

$\delta_{tandkrans} = 518,5 - \frac{965}{2} = 36$ mm

δ vlgs Konstruction te dun

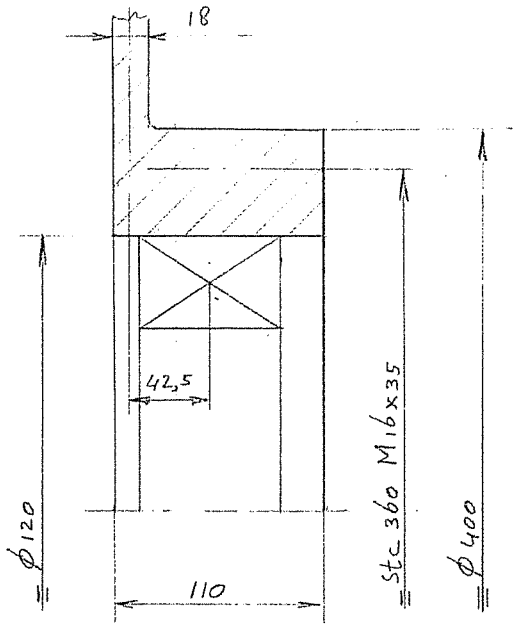
Afmetingen tandwiel op uitgaande as
(vlgs Donkersloot bl 57)

$D_h \approx 965 \rightarrow s = 38$

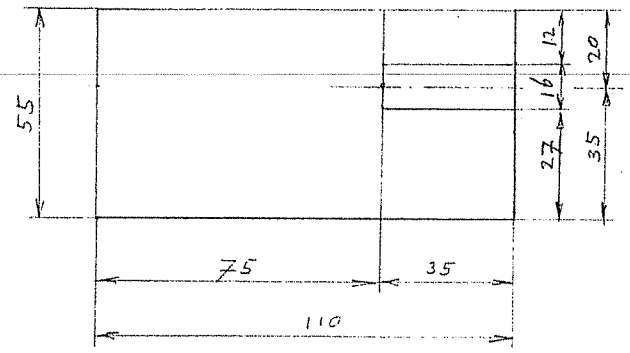
$\frac{D_h}{b} = \frac{965}{370} \approx 2,6 \rightarrow \psi \approx 1,2$ en $\varphi \approx 0,091$

$\psi s = 1,2 \times 38$ mm $= 45,6$ mm
$\psi b = 0,091 \times 370$ mm $= 33,67$ mm
zie fig blz. 25

Lagerpot uitgaande as (hoofdmotor bel.



t.w.k. 2 A 3 - 110 Spec (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt



$J_{\text{over boutgat}} = \Sigma \frac{1}{3} lt^3$

$= \frac{1}{3}\left(3,5 \times 2,7^3 + 7,5 \times 5,5^3 + 3,5 \times 1,2^3\right)$

$= 441\ cm^4$

$J_{\text{zonder boutgat}} = \frac{1}{3} 11 \times 5,5^3 = 610\ cm^4$
verzwakking

$P_{\text{lager vert.}} = 5764\ kg$

$P_{\text{per zijde}} = \frac{5764}{2}\ kg = 2882\ kg = 2,9\ t$ (geld voor pot

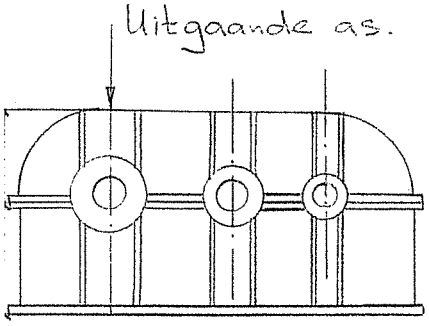
$M_w = M_b = P_{\text{per zijde}} \cdot a = 2,9\ t \times 4,25\ cm = 12,3\ tcm$

$\tau_w = \frac{M_w \cdot \delta}{J}$

$\tau_{w_{max}} = \frac{12,3}{441} \times 5,5 = 0,154\ t/cm^2$

Bij max. motorkoppel $1,5 \times 0,154\ t/cm^2 = 0,231\ t/cm^2$
Mat. onderkast en bovenkast GG 25
τ_w voor ringvormig $\approx (0,8 \ldots 1)\ \sigma_t$

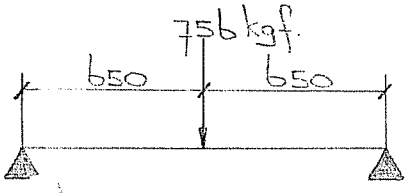
t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe schutsluis Weurt 1.



Berekening deksel tandwielkast.

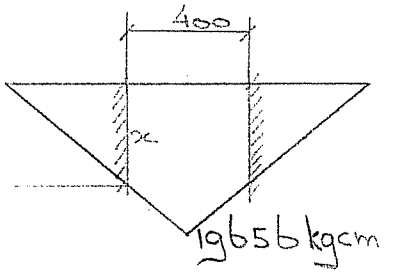
T p.u. uitgaande as $T_V = 5764$ kgf.
$T_H = 756$ kgf.

Moment door horizontale kracht.



$M_b = 0{,}8 \times 756 \times 1/4 \times 130 = \underline{19656}$ kgcm.

Moment wordt opgenomen door twee bouten



$2 \times T_{bout} \times 5{,}6 = 19656$

$T_{bout} = \underline{1755}$ kgf.

Extra kracht t.g.v. vertikale belasting

$T_{bout} = \frac{5764}{2} = \underline{2882}$ kgf.

$x : 19656 = 450 : 650$

$\underline{x = 13608}$ kgcm

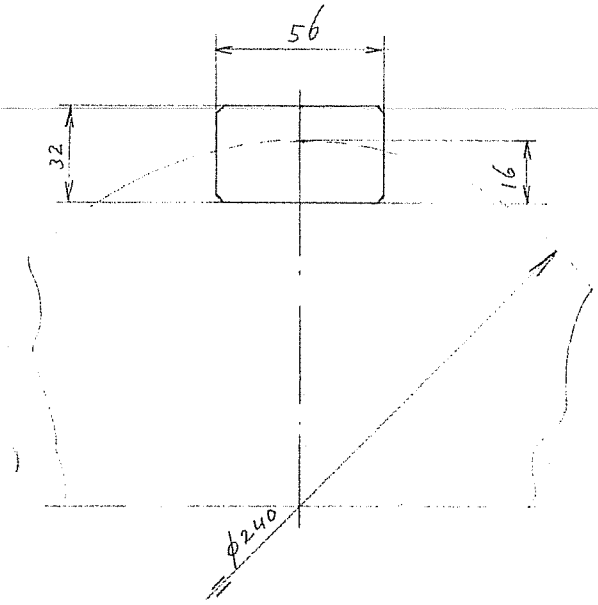
$T_{bout\ totaal} = 1755 + 2882 = \underline{4637}$ kgf.

Bout M30 - 8.8

$\sigma_t = \frac{4637}{4{,}953} = \underline{936}$ kgf/cm² ($\bar{\sigma} = 560$ kgf/cm²)

* Bouten M30 wijzigen in bouten M36 - 8.8

t.w.k. 2A3_110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt



Uitgaande as spie tandwiel (wijziging)

· ϕ 200 → $\frac{t}{h} = \frac{12,5}{25} = 0,5$ → $t = 0,5\,h$

ϕ 240 → $b = 56$
$h = 32\ ^{+0,4}_{0}$
$s = 1,6$
$t_1 = 20$
} vlgs NEN 2430

$t = 0,5 \times 32 = 16$ mm

Houdt voor spiediepte 16 mm aan

$\Delta t = R - \sqrt{R^2 - (\frac{1}{2}b)^2} = 120 - \sqrt{120^2 - 28^2} = 3,312$ mm

$l_{w\ spie} = 386 - \frac{56}{2} - \frac{56}{2} = 330$ mm

$h_{werkz\ naaf} = 32 - 16 + 3,312 - 2 = 17,312$ mm
$h_{werk\ as} = 16 - 3,312 - 2 = 10,688$ "

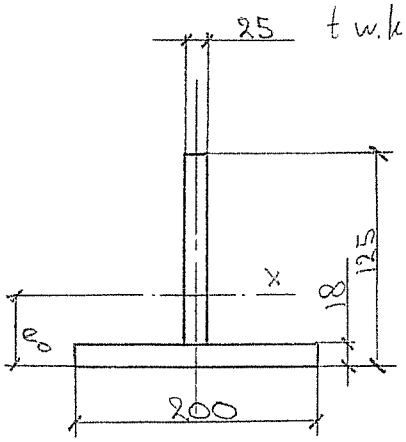
$F_{werkz\ naaf} = 330 \times 17,312 = 5713$ mm²
$F_{werkz\ as} = 330 \times 10,688 = 3527$ "

$P_{spie} = \frac{457.115\ kgcm}{12\ cm} = 38.093$ kg (η verwaarloosd)

$\sigma_{o\ op\ naaf\ GG} = \frac{38.093\ kg}{57,13\ cm^2} = 667\ kg/cm^2 > 500\ kg/cm^2$

$\sigma_{o\ op\ as} = \frac{38.093\ kg}{35,27\ cm^2} = 1080$ "

Opm.: bij noodmotor draaien wordt de vlakte-druk nog ca 3% groter



t.w.k. 2 A3 - 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt 2

Berekening ruggen. Mat. deksel GG25

$F_1 = 10,7 \times 2,5 = 26,75 cm^2$ $\quad S_1 = 26,75 \times 7,15 = 191,3 c$

$F_2 = 20 \times 1,8 = 36 cm^2$ $\quad S_2 = 36 \times 0,9 = 32,4 c$

$\Sigma F = 62,75 cm^2$ $\quad \Sigma S = 223,7 c$

$$e_o = \frac{223,7}{62,75} = 3,56 cm$$

$$I_{x-x} = 1/12 . 2,5 . 10,7^3 + 26,75 \times 3,59^2 + 1/12 . 20 . 1,8^3 + 36 \times 2,66^2 =$$

$$= 864 cm^4$$

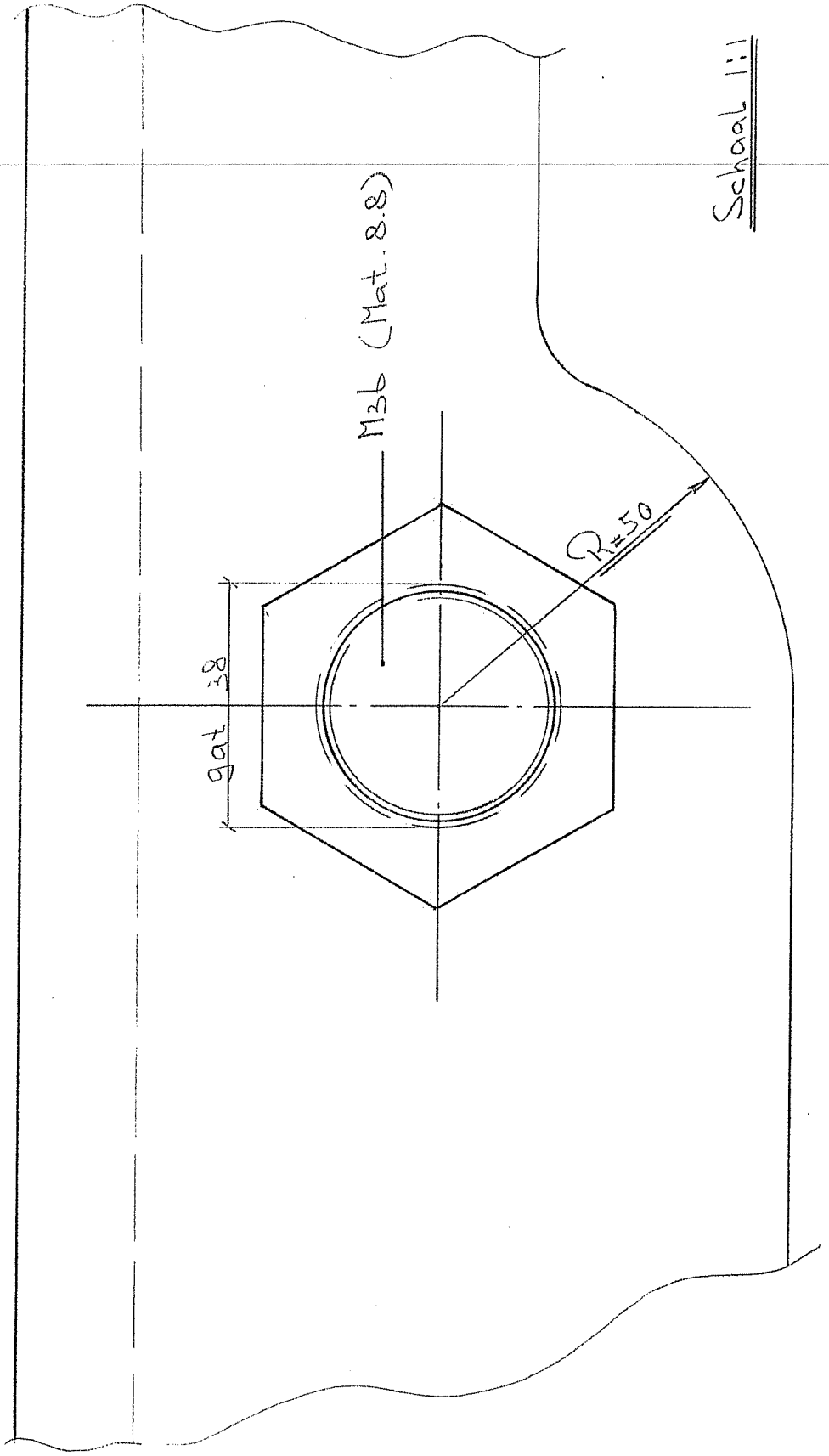
$$W_o = \frac{864}{3,56} = 243 cm^3 \qquad W_b = \frac{864}{8,94} = 97 cm^3$$

$$\sigma_{b_{max}} = \frac{13608}{97} = 140 \ kgf/cm^2$$

$$\tau = \frac{756/2}{10,7 \times 2,5} = 28 \ kgf/cm^2$$

$$\sigma_v = \sqrt{140^2 + 3.28^2} = 148 \ kgf/cm^2 \quad (\bar{\sigma} = 315 \ kgf/cm^2)$$

t.w.k. 2 A 3 - 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

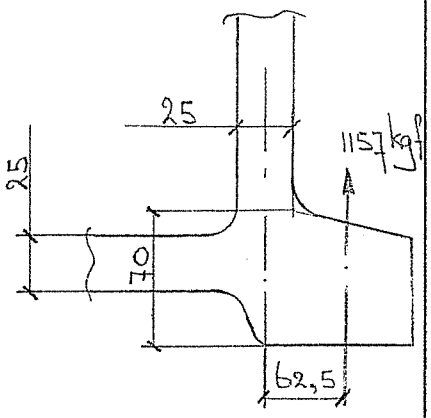


Tandwielkast Weurt.

Bouteruitzicht M30 in M36

t.w.k. 2A3 – 110 Spec. (Hoofdmotorgedeelte) Nieuwe Schutsluis Weurt

Berekening voetplaat tandwielkast.



$T_{bout} = 1157\ kgf$ Materiaal GG 25

$M_b = 1157 \times 6{,}25 = 7231\ kgfcm$

$\sigma_b = \frac{7231}{\frac{1}{6}.b.7^2}$ $b = 155\ mm$

$\sigma_b = \frac{7231}{\frac{1}{6}.15{,}5.7^2} = \underline{57}\ kgf/cm^2$

$\tau = \frac{1157}{7 \times 15{,}5} = \underline{11}\ kgf/cm^2$

$\sigma_v = \sqrt{57^2 + 3.11^2} = \underline{60}\ kgf/cm^2$ $\bar{\sigma} = \underline{315}\ kgf/cm^2$

Berekening zijplaat en onderplaat van 25 mm

$\sigma_b = \frac{7231/2}{\frac{1}{6}.15{,}5 \times 2{,}5^2} = \underline{224}\ kgf/cm^2$

$\tau = \frac{1157/2}{15{,}5 \times 2{,}5} = \underline{15}\ kgf/cm^2$

$\sigma_v = \sqrt{224^2 + 3.15^2} = \underline{226}\ kgf/cm^2$ ($\bar{\sigma} = 315\ kgf/cm^2$)

NIEUWE SCHUTSLUIS TE WEURT.

8. BEREKENING TANDWIELKAST 2A3-110 Spec.

(NOODMOTORGEDEELTE).

OPMERKING OVER DE SPANNINGEN IN DE ONDERDELEN VAN DE HOOFDAANDRIJVING

DE TORSIESPANNINGEN EN DE TANDSPANNINGEN ZIJN IN TEGENSTELLING TOT DIE VAN DE HOOFDAANDRIJVING BESCHOUWD ALS WISSEL-SPANNINGEN.
DIT IS GEBASEERD OP HET FEIT DAT BIJ AANLOPEN OF REMMEN HET TEKEN VAN HET KOPPEL ZOWEL POSITIEF ALS NEGATIEF KAN ZIJN.
DE EINDRENDE SPANNINGEN TREDEN OP TIJDENS NORMAAL BEWEGEN.
BIJ AANLOPEN EN REMMEN ZIJN DEZE SPANNINGEN ECHTER HOGER.
DE OPTREDENDE BELASTINGSFACTOREN ZIJN DAN:

$G.D^2$ MOTOR = $40\ Kg\,m^2$
$G.D^2$ KOPPELREMSCHIJF = $16\ Kg\,m^2$
$G.D^2$ REMSCHIJF = $10\ Kg\,m^2$
$G.D^2$ DOOR GEREED. $\simeq 0$
$\Sigma G.D^2 = 66\ Kg\,m^2$

1e MAAL HOOFDMOTORAS : $i = 15$
$\Sigma G.D^2$ GER. $= 66/15^2 = 0{,}293\ Kg\,m^2$
$G.D^2$ MOTOR $= 0{,}90\ Kg\,m^2$

$\alpha_1 = \frac{0{,}293}{0{,}90+0{,}293} = 0{,}246$ $\qquad \alpha_2 = 1-\alpha_1 = 0{,}754.$

GEREDUCEERD MOMENT NAAR DE HOOFDMOTORAS :
$M = 22129\ Kg\,cm$ (NOMINAAL)
AANLOOPFACTOR : 1,5

BENODIGD MOTORKOPPEL VOOR HET BEWEGEN VAN DE DELEN INCLUSIEF INVLOED VAN VERSNELLINGSKRACHTEN :
$M = 1{,}5 \cdot 22129\ Kg\,cm$

1 BELASTINGSFACTOR BIJ BEGIN AANLOPEN VAN HOOFDMOTOR

$$\varphi_1 = \frac{22129 \cdot 1{,}5 \cdot 2 \cdot 0{,}246 + 1{,}5 \cdot 22129\,(1-2 \cdot 0{,}246)}{22129} = 1{,}32$$

2 BEL. FACT. TIJDENS AANLOPEN

$$\varphi_2 = \frac{22129 \cdot 1,0 \cdot 0,246 + 18936\,(1 - 0,246)}{22129} = 1,08$$

3 BEL. FACT BIJ BEGIN REMMEN (REMMOMENT 26000 kgf/cm. ÉÉN REM)

MOMENT DOOR DEUR GEWICHT: $M \approx 1592 \cdot 9,9 \cdot 0,25 / 0,269 = 13322$ kgf/cm

FACTOR VOOR HET SNEL INVALLEN VAN DE REM: 1,5

$$\varphi_3 = \frac{(26000 \cdot 1,50 + 13322)\, 0,754}{22129} = 1,79$$

4 BEL. FACTOR TIJDENS REMMEN:

$$\varphi_4 = \frac{(26000 + 13322) \cdot 0,754}{22129} = 1,34$$

VERWACHT MAG WORDEN DAT DE NOODAANDRIJVING NIET VAAK GEBRUIKT ZAL WORDEN, DERHALVE WORDT $\varphi_4 = 1,34$ ALS MAATGEVEND BESCHOUWD

RESUMÉ VAN DE TE HOGE SPANNINGEN IN DE ONDERDELEN VAN DE HOOFDAANDRIJVING.

1 TANDEM CONISCHE OVERBRENGING

CONTACTSPANNINGEN BIJ NORMALE BELASTING:

σ_c = 8520 Kg/cm² $\quad \sigma_{RONDSEL}$ = 8900 Kg/cm²

σ_{WIEL} = 5620 "

LEVENSDUUR WIEL CA 52 UUR OF CA 44 OPENINGEN.

SPANNINGEN IN TANDVOET:

RONDSEL: σ = 1193 Kg/cm² NORMAAL

σ = 1,34 . 1193 = 1589 Kg/cm² TIJDENS REMMEN.

DE SPANNINGEN DIE TIJDENS REMMEN OPTREDEN ZIJN AFWISSELEND POSITIEF EN NEGATIEF.

MAT. 42 CR MO 4: σ_{WISSEL} = 670 Kg/cm²

WIEL: σ = 1035 Kg/cm² NORMAAL

σ = 1,34 1035 = 1387 Kg/cm² TIJDENS REMMEN.

2 L 60: σ = 635 Kg/cm²

2 TANDEM RECHTE OVERBRENGING.

CONTACT SPANNINGEN BIJ NORMALE BELASTING:

σ_c = 7149 Kg/cm² $\quad \sigma_{RONDSEL}$ = 5620 Kg/cm²

σ_{WIEL} = 5250 "

SPANNINGEN IN TANDVOET:

RONDSEL: σ = 948 Kg/cm² NORMAAL

σ = 1,34 . 948 = 1270 Kg/cm² TIJDENS REMMEN

2 L 60: σ_D = 635 Kg/cm²

WIEL: σ = 984 Kg/cm² NORMAAL

σ = 1,34 . 984 = 1319 Kg/cm² TIJDENS REMMEN.

2 L 46: σ_D = 570 Kg/cm²

3 EERSTE TUSSENAS

DE SPANNINGEN IN DE AS VANAF RONDSEL TOT HET CONISCHE WIEL VARIËREN VAN 670 TOT 925 Kgf/cm² (NORMAAL)

TOENS REKENEN WIJ DE SPANNINGEN:

$$\sigma = 1{,}34 \cdot 925 = \underline{1240\ Kgf/cm^2}$$

$$2/3 : \quad \bar{\sigma}_0 = \underline{500\ Kgf/cm^2}$$

4 SPIEVERBINDING TANGENTIEEL OP INGAANDE HOOFDMOTOR-AS.

VLAKTEDRUK SPIE: $\sigma_d = 1023\ Kgf/cm^2$

$$\sigma_w = 1{,}34 \cdot 1023 = 1371\ Kgf/cm^2$$

$$\bar{\sigma}_d = 900\ Kgf/cm^2$$

1e Wijziging t.w.k. 2 A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

Gewijzigde kon. overbrenging 51/10

$d_{m_1} = 58$

$P_o = \frac{1472 \text{ kgcm}}{5{,}8 \text{ cm}} = 508 \text{ kg}$

$v = \frac{\pi \cdot 0{,}058 \times 1460}{60} = 4{,}43 \text{ m/sec}$

$c_v = \sqrt{\frac{5{,}6 + \sqrt{4{,}43}}{5{,}6}} = 1{,}17$

$i = \frac{51}{10} = 5{,}1$

$\sigma_c = 1{,}2 \times 1510 \sqrt{\frac{508 \times 1{,}17}{4{,}7 \times 5{,}8} \times \cos^2 33 \times \cos 9{,}5^\circ \times \frac{5{,}1^2 + 1}{5{,}1^2}}$

$\quad = 1812 \sqrt{21{,}8 \times 0{,}7033 \times 0{,}986 \times 1{,}038} = 7179 \text{ kg/cm}^2 > 5620 \text{ kg/cm}^2$

$\sigma_{42\,CrMo4} \approx 8900 \text{ kg/cm}^2 \quad \sigma_{2C60} = 5620 \text{ kg/cm}^2$

$z_{n_1} = \frac{10}{\cos^3 33 \times \cos 9{,}5^\circ} = 17{,}18 \rightarrow Y_1 = 3{,}08$

$z_{n_2} = \frac{66}{\cos^3 33 \times \cos 83{,}5^\circ} = 988 \rightarrow Y_2 = 2{,}11$

$\sigma_{rondsel} = \frac{508 \times 3{,}08}{4{,}7 \times 0{,}45} \times 1{,}17 \times 1 = 866 \text{ kg/cm}^2$

$\sigma_{wiel} = \frac{508 \times 2{,}11}{4{,}7 \times 0{,}45} \times 1{,}17 \times 1 = 593$ "

tijdens remmen:

$\sigma_{rondsel} = 1{,}34 \times 866 = 1160 \text{ kg/cm}^2 \quad \sigma = 670 \text{ kg/cm}^2$

$\sigma_{wiel} = 1{,}34 \times 593 = 795$ " $\quad \sigma = 635$ "

dus spanningen te hoog

1e Wijziging t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

2e overbrenging noodmotor 77/26

$\sigma_{b\,rondsel} = 948$ kg/cm² } zie blz 4
$\sigma_{b\,wiel} = 984$ " }

mat. overbrenging gewijzigd
mat. rondsel 42 CrMo4 → $\bar{\sigma}_{wissel}$ = 670 kg/cm²
" wiel 2 C 60 → $\bar{\sigma}_{wissel}$ = 635 kg/cm²

$\sigma_c = 7149$ kg/cm² (zie blz 4)

$\bar{\sigma}_{c\ 2C60} = 5620$ kg/cm²

tijdens remmen:
$\sigma_{b\,rondsel} = 1{,}34 \times 948 = 1270$ kg/cm²

$\sigma_{b\,wiel} = 1{,}34 \times 984 = 1319$ "

spanningen te hoog

spie tandwiel (z = 77 m = 5) niet gewijzigd
$\sigma_o = 1023$ kg/cm²
tijdens remmen = $1{,}34 \times 1023 = 1371$ kg/cm²
$\bar{\sigma}_o = 900$ kg/cm²

1e Wijziging t.w.k. 2A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weur

Spanning (1e tussenas noodmotor, mat 2C35)

zie blz. 11

Gewijzigde W

$W_{b\,schuift} = 0{,}1 \times 8{,}0^3 = 51{,}2\ cm^3$

$W_{b\,kon.wiel} = 0{,}1 \times 8{,}2^3 = 55{,}13$ "

$W_{w\,schuift\,w} = 2 \times 51{,}2 = 102{,}4\ cm^3$

$W_{w\,kon\,w} = 2 \times 55{,}13 = 110{,}27$ "

$\sigma_{b\,schuift\,w} = \frac{31.463}{51{,}2} = 615\ kg/mm^2$

$\sigma_{b\,konwiel} = \frac{28.627}{55{,}13} = 519$ "

$\tau_{w\,schuift.w} = \frac{7476}{102{,}4} = 73$ "

$\tau_{w\,kon.w.} = \frac{7476}{110{,}27} = 68$ "

Mat. as gewijzigd in 2C60 $\rightarrow \sigma_B = 70\ kg/mm^2$

$\sigma_{wissel} = 635\ kg/cm^2$

$\sigma_{v\,schuiftandw.} = \sqrt{(1{,}21 \times 615)^2 + 3(1{,}21 \times 73)^2} = 760\ kg/cm^2$

$\sigma_{v\,schuiftandw} = \sqrt{(1{,}00 \times 615)^2 + 3(1{,}29 \times 73)^2} = 636$ "

$\sigma_{v\,kon.wiel} = \sqrt{(1{,}21 \times 519)^2 + 3(1{,}21 \times 68)^2} = 644\ kg/cm^2$

$\sigma_{v\,kon.wiel} = \sqrt{(1{,}00 \times 519)^2 + 3(1{,}29 \times 68)^2} = 541$ "

tijdens remmen $\sigma_{v\,max} = 1{,}34 \times 760 = 1018\ kg/cm^2$

spanningen in de as te hoog

Tandwielkast 2A3 110 spec Nieuwe Schutsluis Weurt

Noodmotor

$N = 30$ PK $\quad n = 1460$ omw/min.

Overbrengingen en toerentallen

$i_1 = 66/13 = 5{,}08$ $\quad n_{1e\ tussenas} = 1460/5{,}08 = 287$ omw/mi

$i_2 = 77/26 = 2{,}96$ $\quad n_{2e\ "} = 287/2{,}96 = 97$ "

$i_3 = 111/24 = 4{,}625$ $\quad n_{3e\ "} = 97/4{,}625 = 21$ "

$i_4 = 106/23 = 4{,}6$ $\quad n_{uitg.\ as} = 21/4{,}6 = 4{,}6$ "

$i_{tot} = 5{,}08 \times 2{,}96 \times 4{,}625 \times 4{,}6 = 320{,}48$

Aswringmomenten

$M_{ingaande\ as} = 71620 \times \frac{30}{1460} = 1472$ kgcm

$M_{1e\ tussen\ as} = 5{,}08 \times 1472 = 7476$ "

$M_{2e\ tussenas} = 2{,}96 \times 7476 = 22.129$ *) " (ing. as hoofdmotor)

$M_{3e\ tussen\ as} = 4{,}625 \times 22.129 = 102.346$ "

$M_{uitg.\ as} = 4{,}6 \times 102.346 = 470.791$ " (dit moment wordt aan beide zijde afgegeven dus per astap $\frac{1}{2} M_w = 235.396$ kgcm

*) Dit koppel komt overeen met het motorkoppel van de hoofdmotor

1e (konische) overbrenging.

pignonwiel $z_1 = 13$

kroonwiel $z_2 = 66$

$m_n = 3{,}5$

$m_o = 4{,}85$

$\alpha = 20^\circ$

kegelrondselhoek $\delta_1 = 9^\circ 30'$ $\quad \cos \delta_1 = 0{,}9863$

tandbreedte $b = 35$

gem. spiraalhoek $\beta_m = 34^\circ$ $\quad \cos 34^\circ = 0{,}829$

Stc. wiel $d_{stc\ 2} = 320$

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Stc. gem rondsel $d_{m_1} = 56$

Mat. rondselas 42 Cr Mo 4
" tandwiel 2 C 60

$$P_o = \frac{1472 \text{ kgcm}}{\frac{5,6}{2} \text{ cm}} = 526 \text{ kg}$$

$$P_{a.} = \frac{P_o}{\cos \beta_m} \left(tg \alpha_{nm} \sin \varphi_1 - \sin \beta_m \cdot \cos \varphi_1 \right)$$ form 81 Van Hattum

$$P_a = \frac{526}{\cos 34} \left(tg 20 \cdot \sin 9^\circ 30' - \sin 34^\circ \cdot \cos 9^\circ 30' \right)$$

$$P_a = \frac{526}{0,829} \left(0,364 \times 0,165 - 0,5592 \times 0,9863 \right)$$

$$P_a = 634 \left(0,06 - 0,5515 \right) = -312 \text{ kg}$$

$$P_a' = 634 \left(0,06 + 0,5515 \right) = +388 \text{ kg}$$

$$P_r = \frac{P_o}{\cos \beta_m} \left(tg \alpha_{nm} \cdot \cos \varphi_1 + \sin \beta_m \cdot \sin \varphi_1 \right)$$ form. 82

$$P_r = \frac{526}{0,829} \left(0,364 \times 0,9863 + 0,5592 \times 0,165 \right)$$

$$P_r = 634 \left(0,359 + 0,092 \right) = 286 \text{ kg}$$

$$P_r' = 634 \left(0,359 - 0,092 \right) = 169 \text{ kg}$$

$$v_{stc.\,gem.} = \frac{\pi \; 0,056 \,[m] \times 1460}{60} = 4,28 \text{ m/sec}$$

$$c_v = \sqrt{\frac{5,6 + \sqrt{4,28}}{5,6}} = 1,17$$

$$U = 1510 \sqrt{kg/cm^2}$$

t.w.k. 2A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$$\sigma_c = 1{,}2\ 4 \sqrt{\frac{F c_v}{b\, d_m} \cdot \cos^2\beta_m \cdot \cos\varphi \ \frac{i^2+1}{i^2}}$$

$$\sigma_c = 1{,}2 \times 1510 \sqrt{\frac{526 \times 1{,}17}{3{,}5 \times 5{,}6} \times 0{,}829^2 \times 0{,}9863 \ \frac{5{,}08^2+1}{5{,}08^2}} = 8520 \ \text{kg/cm}^2$$

$n_1 = 1460$ omw./min : mat 42 CrMo 4 $\bar{\sigma}_c = 5860$ kg/cm²
echter voor geringe afmetingen zoals dit rondsel
$\bar{\sigma}_c = 8900$ kg/cm²

$n_2 = 287$ omw./min : mat 2 C 60 $\bar{\sigma}_c = 5620$ kg/cm²
Levensduur wordt nu ca 52 uur
Dit komt overeen met 44 openingen.

$$z_n = \frac{z}{\cos^3\beta_m \cdot \cos\delta}$$

$$z_{n_1} = \frac{13}{0{,}829^3 \times 0{,}9863} = 23 \rightarrow Y_1 = 2{,}78$$

$$z_{n_2} = \frac{66}{0{,}829^3 \times 0{,}165} = 702 \rightarrow Y_2 = 2{,}06$$

$$\sigma = \frac{F\, Y_n}{b\, m_n} c_v \cdot c_o \qquad (c_o = 1 \quad c_v = 1{,}17)$$

$$\sigma_{\text{rondsel}} = \frac{526 \times 2{,}78}{3{,}5 \times 0{,}35} \cdot 1{,}17 \times 1 = 1193 \ \text{kg/cm}^2$$

$$\sigma_{\text{wiel}} = \frac{526 \times 2{,}06}{3{,}5 \times 0{,}35} \cdot 1{,}17 \times 1 = 1035 \ ,,$$

mat. rondsel 42 CrMo 4 $\rightarrow \bar{\sigma}_{\text{wissel smeedst}}$ ($\sigma_B = 75$ kg/cm²) = 670 kg/cm²

,, tandwiel 2 C 60 $\rightarrow \bar{\sigma}_{\text{wissel smeedst}}$ ($\sigma_B = 70$ kg/cm²) = 635 ,

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2e overbrenging noodmotor 77/26 m = 5 β = 0

$X_1 = \frac{+2,5}{m} = \frac{+2,5}{5} = +0,5$ $\quad z_1 = 26$ $\Big\} Y_1 \approx 2,175$ $\qquad X_2 = 0$ $\quad z_2 = 77$ $\Big\} Y_2 \approx$

$Stc_1 = 13$ cm $\qquad Stc_2 = 38,5$ cm

$P_t = \frac{7.476 \text{ kgcm}}{\frac{13}{2} \text{ cm}} = 1150$ kg

$v = \frac{\pi \; 0,13 \times 287}{60} = 1,95$ m/sec

$c_v = \frac{5,6 + V1,95}{5,6} = 1,25$

$c_o = 1$

$\sigma_{b\,\text{rondsel}} = \frac{FY}{b.m} . c_v . c_o = \frac{1150 \times 2,175}{6,6 \times 0,5} . 1,25 \times 1 = 948$ kg/cm²

$\sigma_{b\,\text{wiel}} = \frac{1150 \times 2,26}{6,6 \times 0,5} 1,25 \times 1 = 984$ kg/cm²

mat rondsel 2C 60 → $\bar{\sigma}_{\text{wissel smeedst.}} \sigma_B = 70$ kg/mm² $= 635$ kg/cm²

" tandwiel 2C 45 → $\bar{\sigma}_{\text{wissel smeedst}} \sigma_B = 60$ " $= 570$ "

staal op staal $U = 1510$ kg/cm²

$\sigma_c = U \sqrt{\frac{F.c_v}{b.d_1} \cdot \frac{i+1}{i}}$

$\sigma_{c\,\text{rondsel}} = 1510 \sqrt{\frac{1150 \times 1,25}{6,6 \times 13} . \frac{2,96+1}{2,96}} = 7149$ kg/cm²

$n_{as\,C60} = 287$ omw/min $\qquad \bar{\sigma}_c = 5620$ kg/cm²

$n_{as\,C45} = 97$ " $\qquad \bar{\sigma}_c = 5250$ "

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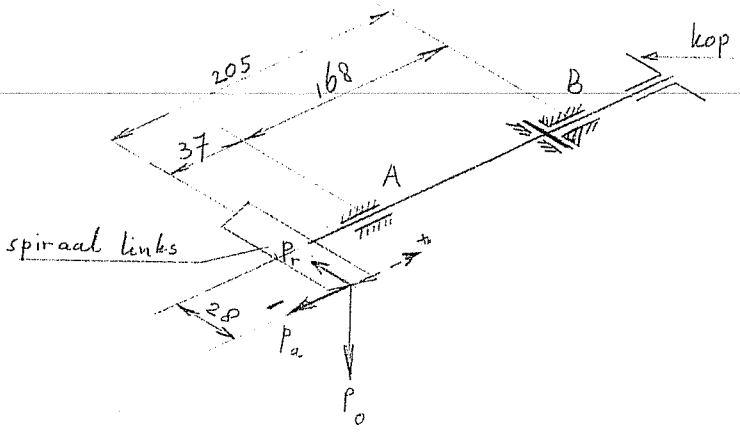
Ingaande as noodmotor



$P_o = 526$ kg

geval I $\quad P_a = -312$ kg en $P_r = 286$ kg

geval II $\quad P'_a = +388$ kg en $P'_r = 169$ kg

Opm.: as staat in wezen vertikaal.

$\frac{20,5}{16,8} = 1,22 \qquad \frac{3,7}{16,8} = \frac{1}{4,54} \qquad \frac{2,8}{16,8} = \frac{1}{6}$

$R_{A\ t.g.v.\ P_o} = 526 \text{ kg} \times 1,22 = 642$ kg

$R_{B\ t.g.v.\ P_o} = 526 \text{ kg} \times \frac{1}{4,54} = 116$ kg

geval I

$R_{A\ t.g.v.\ P_r} = 286 \times 1,22 = 349$ kg

$R_{B\ t.g.v.\ P_r} = 286 \times \frac{1}{4,54} = 63$ kg.

$\left|R_{A\ t.g.v.\ P_a}\right| = \left|R_{B\ t.g.v.\ P_a}\right| = 312 \times \frac{1}{6} = 52$ kg

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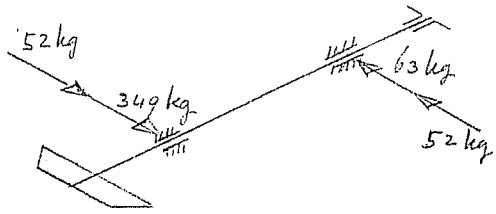
geval II

$R_{A\ t.g.v\ P_r} = 169 \times 1{,}22 = 206$ kg

$R_{B\ t.g.v\ P_r} = 169 \times \frac{1}{4{,}54} = 37$ kg

$|R_{A\ t.g.v.P_a}| = |R_{B\ t.g.v.\ P_a}| = 388 \times \frac{1}{6} = 65$ kg

geval I



$R_{A\ P_r + P_a} = 349 + 52 = 401$ kg

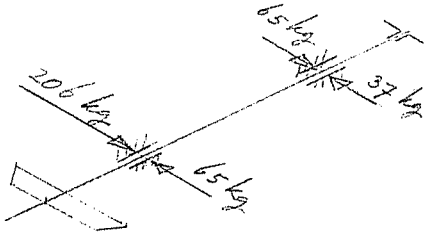
$R_{B\ P_r + P_a} = 63 + 52 = 115$ "

$R_{A\ res} = \sqrt{401^2 + 642^2} = 757$ kg

$R_{B\ res} = \sqrt{115^2 + 116^2} = 163$ kg

$R_{ax\ lager\ B} = 312$ kg ($EG_{as + \frac{1}{2}\ kopp.}$ verwaarloosd)

geval II



$R_{A\ P_r + P_a} = 206 - 65 = 141$ kg

$R_{B\ P_r + P_a} = 37 - 65 = 28$ kg

$R_{A\ res} = \sqrt{141^2 + 642^2} = 657$ kg

$R_{B\ res} = \sqrt{28^2 + 116^2} = 119$ kg

$R_{ax\ lager\ B} = 388$ kg ($EG_{as + \frac{1}{2}\ kopp.}$ verwaarloosd)

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Spanning in ingaande as noodmotor

$M_{b_{A\,res}} = R_{B_{res}} \times$ lagerafstand

$= 163\ kg \times 16{,}8\ cm = 2738\ kgcm$

$W_b = 0{,}1 \times 5{,}5^3 = 16{,}64\ cm^3$

$W_w = 2\,W_b = 2 \times 33\ cm^3$

$\sigma_b = \frac{2738\ kgcm}{16{,}6\ cm^3} = 165\ kg/cm^2$

$M_w = 1472\ kgcm$ (zie blz. 1)

$\tau_w = \frac{M_w}{W_w} = \frac{1472\ kgcm}{33\ cm^3} = 44\ kg/cm^2$

mat. kon. Rondstaas 42 Cr Mo 4

$\sigma_{B\,42\,CrMo4} = 75\ kg/mm^2$ (Tab 2-4-1)

$\sigma_{t\ as\ in\ buig\text{-}en\ wringgedeelte} = \sigma_{wissel} = 670\ kg/cm^2$ (Tab 2-1-1)

remschijf op ingaande as hoofdmotor.

Assen tussen remschijf en noodmotor vlgs geval 2

$\sigma_v = \sqrt{(\beta\sigma)^2 + 3(\beta_T \cdot T)^2} \leq 670\ kg/cm^2$

voor lager op as $\beta = \beta_T = 1{,}44$ voor $\sigma_B = 75\ kg/mm^2$

$\sigma_v = \sqrt{(1{,}44 \times 165)^2 + 3(1{,}44 \times 44)^2} = 262\ kg/cm^2$

schouder $R = 2$ voor kogellager

$D = 64 \quad d = 55 \quad r = 2$

$t = \frac{64 - 55}{2} = 4{,}5\ mm$

$\frac{t}{D} = \frac{4{,}5}{64} = 0{,}0703 \rightarrow \frac{f}{t} > 0{,}17$

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$\frac{\rho}{t} = \frac{2}{4,5} = 0,444 > 0,17$ R voldoet

<u>astap ϕ 48 k 6 voor tandboog kopp.</u>

$W_{w_{astap}} = 0,2 \times 4,8^3 = 22\ cm^3$

$\tau_w = \frac{M_w}{W_w} = \frac{1472}{22} = 67\ kg/cm^2$

$\beta_{T_{spiebaan}} = 1,29$

$\sigma_v = \beta\, \tau\, V_3$

$\sigma_v = 1,29 \times 67 \sqrt{3} = 150\ kg/cm^2$

$\bar{\sigma}_{wissel} = 670\ kg/cm^2$

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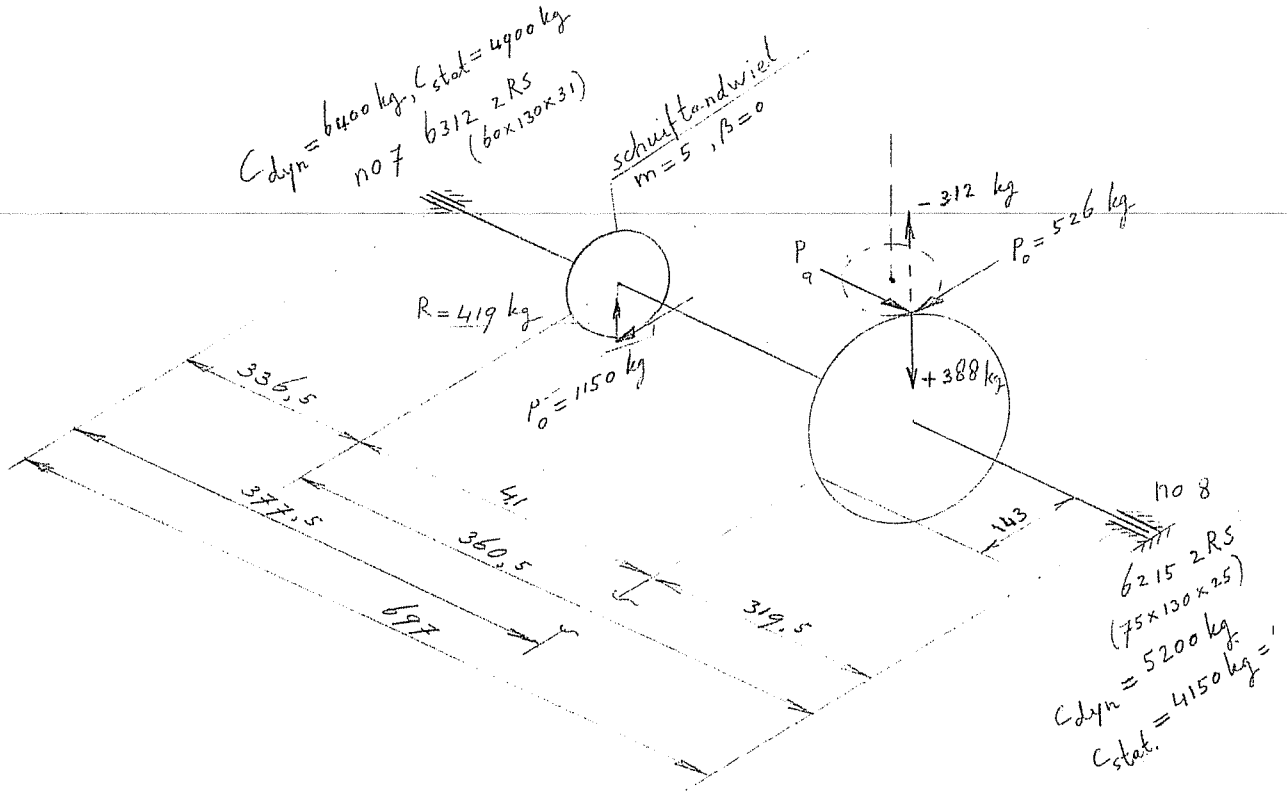
1e tussenas noodmotor



$\frac{360.^5}{697} = 0,517$ $\quad\quad$ $\frac{319,^5}{697} = 0,458$

$\frac{336,5}{697} = 0,483$ $\quad\quad$ $\frac{377,5}{697} = 0,542$

$\frac{143}{697} = 0,205$

$P_o = 526$ kg (kon wiel)

geval I : $P_a = +286$ kg en $P_r = +312$ kg

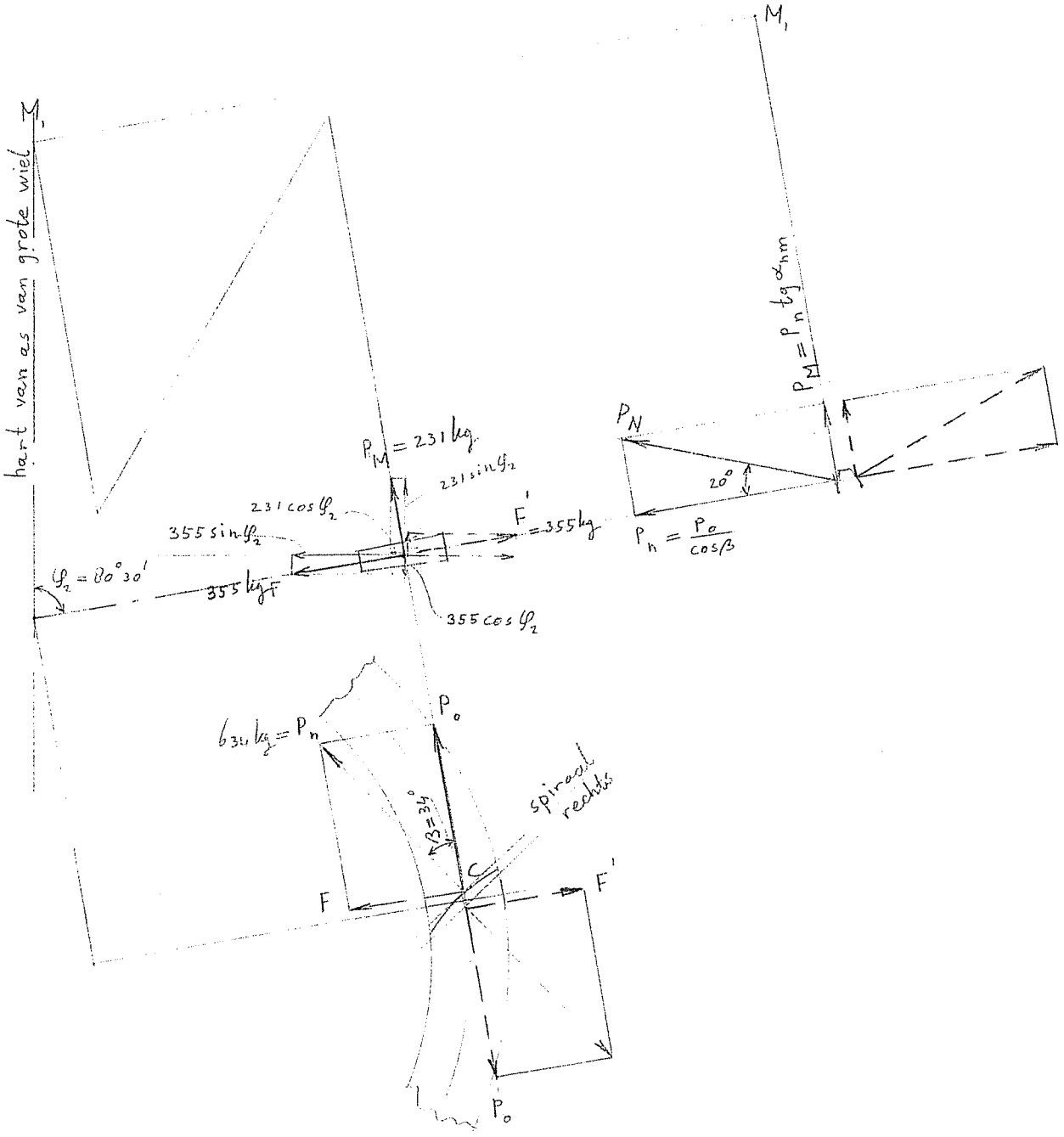
geval II : $P_a = +169$ kg en $P_r = +388$ kg

recht tandwiel ($m = 5$) $\beta = 0$

$P_o = 1150$ kg (zie blz 4)

$R = P_t \frac{tg\alpha}{\cos\beta} = 1150 \frac{tg\,20}{\cos 0} = 1150 \times \frac{0,364}{1} = 419$ kg

t.w.k 2A3_110 Spec (Noodmotorgedeelte) Nieuwe schutsluis Weurt.



$tg\,20° = 0{,}364$ $\quad \beta = 34° \quad \sin\beta = 0{,}5592 \quad \cos\beta = 0{,}829$

$\varphi_2 = 80°\,30' \quad \sin\varphi_2 = 0{,}9863 \quad \cos\varphi_2 = 0{,}165$

$P_n = \frac{P_o}{\cos\beta} = \frac{526}{0{,}829} = 634$ kg

$P_M = P_n\ tg\,\alpha_{nm} = 634 \times 0{,}364 = 231$ kg

$CF = P_o\ tg\,\beta = 526 \times 0{,}6745 = 355$ kg

axiaal :	$231 \sin\varphi_2 = 228$ kg	$355 \cos\varphi_2 = 59$ kg
radiaal :	$231 \cos\varphi_2 = 38$ kg	$355 \sin\varphi_2 = 350$ „

geval I (gestreept)	geval II (getrokken)
$P_{ax} = 228 + 59 = 287$ kg	$P_{ax} = 228 - 59 = 169$ kg
$P_{rad} = 38 - 350 = -312$ kg	$P_{rad} = 38 + 350 = 388$ kg

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

reacties horizontaal (t.g.v. P_o)

no 7 = 1150 × 0,517 + 526 × 0,458 = 595 + 241 = 836 kg

no 8 = 1150 × 0,483 + 526 × 0,542 = 555 + 285 = 840 kg

reacties vertikaal geval I

t.g.v. P_r

no 7 = 419 × 0,517 + 312 × 0,458 = 217 + 143 = 360 kg ↓

no 8 = 419 × 0,483 + 312 × 0,542 = 202 + 169 = 371 kg ↓

t.g.v. P_a

|no 7| = |no 8| = 286 × 0,205 = 59 kg

t.g.v. P_a en P_r

no 7 = +59 ↓ + 360 ↓ = 419 kg ↓

no 8 = −59 ↑ + 371 ↓ = 312 kg ↓

Resulterende reacties geval I

no 7 = $\sqrt{836^2 + 419^2}$ = 935 kg (lager 6312)

no 8 = $\sqrt{840^2 + 312^2}$ = 896 „ (lager 6215)

Axiaalkracht no 7 = 0

Axiaalkracht no 8 = 286 kg

reacties vertikaal geval II

t.g.v. P_r

no 7 = 419 × 0,517 − 388 × 0,458 = 217 − 177 = 40 kg ↓

no 8 = 419 × 0,483 − 388 × 0,542 = 202 − 210 = 8 kg ↑

t.g.v. P_a

|no 7| = |no 8| = 169 × 0,205 = 35 kg

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

t.g.v. P_a en P_r

no 7 = + 35 ↓ + 40 ↓ = 75 kg ↓

no 8 = + 35 ↑ + 8 ↑ = 43 kg ↑

Resulterende reacties geval II

no 7 = $\sqrt{836^2 + 75^2}$ = 839 kg (lager 6312)

no 8 = $\sqrt{840^2 + 43^2}$ = 841 " (" 6215)

Axiaalkracht no 7 = 0

Axiaalkracht no 8 = 169 kg

Spanningen (1e tussenas noodmotor, mat. 2C3 geval I ongunstigst.

$M_{b\,schuift.w.}$ = 935 kg x 33,65 cm = 31.463 kgcm

$M_{b\,kon.w}$ = 896 kg x 31,95 cm = 28 627 "

$W_{b\,schuiftand.w.}$ = $0,1 \times 7,5^3$ = 42 cm^3

$W_{b\,kon.wiel}$ = $0,1 \times 7,6^3$ = 44 "

$W_{w\,schuift\,w}$ = 2 x 42 = 84 cm^3

$W_{w\,kon.w}$ = 2 x 44 = 88 "

$\sigma_{b\,schuift.w.}$ = $\frac{31.463\ kgcm}{42\ cm^3}$ = 749 kg/cm^2

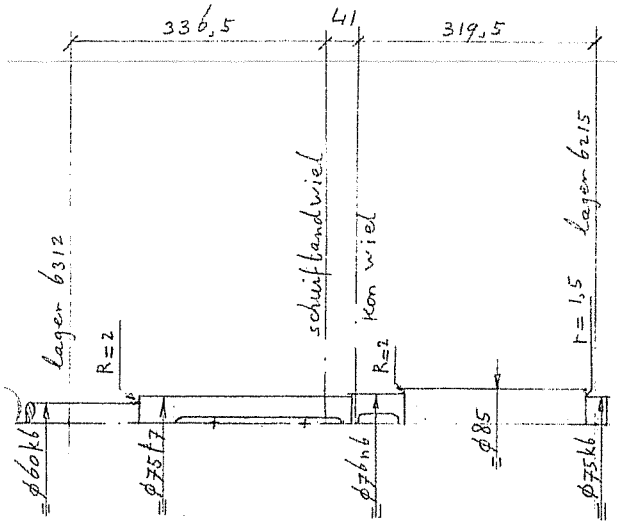
$\sigma_{b\,kon.w}$ = $\frac{28.627\ kgcm}{44\ cm^3}$ = 651 "

M_w = 7476 kgcm

$\tau_{w\,schuift\,w}$ = $\frac{7476\ kgcm}{84\ cm^3}$ = 89 kg/mm^2

$\tau_{w\,kon.w}$ = $\frac{7476}{88}$ = 85 "

t.w.k. 2A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt



mat. 2 C35 $\rightarrow \sigma_B = 50\ kg/mm^2 \rightarrow \bar{\sigma}_{wissel} = 500\ kg/cm^2$

$\beta_{naaf} = \beta\tau_{naaf} = 1{,}21$

$\beta_{spie} = 1{,}00 \qquad \beta\tau_{spie} = 1{,}29$

$\sigma_v = \sqrt{\{\beta\sigma\}^2 + 3\{\beta_\tau\sigma\}^2} \leq \bar{\sigma} = 500\ kg/cm^2$

$\sigma_{v\ schuiftandw.} = \sqrt{(1{,}21 \times 749)^2 + 3(1{,}21 \times 89)^2} = 925\ kg/cm^2$

$\sigma_{v\ schuiftandw} = \sqrt{(1{,}00 \times 749)^2 + 3(1{,}29 \times 89)^2} = 775$ "

$\sigma_{v\ kon.wiel} = \sqrt{(1{,}21 \times 651)^2 + 3(1{,}21 \times 85)^2} = 808$ "

$\sigma_{v\ kon.wiel} = \sqrt{(1{,}00 \times 651)^2 + 3(1{,}29 \times 85)^2} = 678$ "

Opm.: draadgaten M8 voor spiebevestiging geven extra asverzwakking.

Schouder R = 1,5 voor lager 6215 D = 85 d = 75

$t = \frac{D-d}{2} = \frac{85-75}{2} = 5$

$\frac{t}{D} = \frac{5}{85} = 0{,}058 \rightarrow \frac{\rho}{t} > 0{,}19$

$\frac{\rho}{t} = \frac{1{,}5}{5} = 0{,}3 > 0{,}19$

R = 1,5 voldoet

Schouder voor kegelwiel D = 85 d = 76n6 R = 2

$t = \frac{85-76}{2} = 4{,}5$

$\frac{t}{D} = \frac{4{,}5}{85} = 0{,}0529 \rightarrow \frac{\rho}{t}_{\text{bovenste lijn}} > 0{,}46$

t.w.k. 2A3_110 Spec (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$\frac{f}{t} = \frac{2}{4,5} = 0,444 < 0,46$

afronding R = 2 te klein

Schouder voor aanslagbus schuiftandwiel

D = 75 j7 d = 60 k6 r = 2

$t = \frac{75-60}{2} = 7,5$ mm

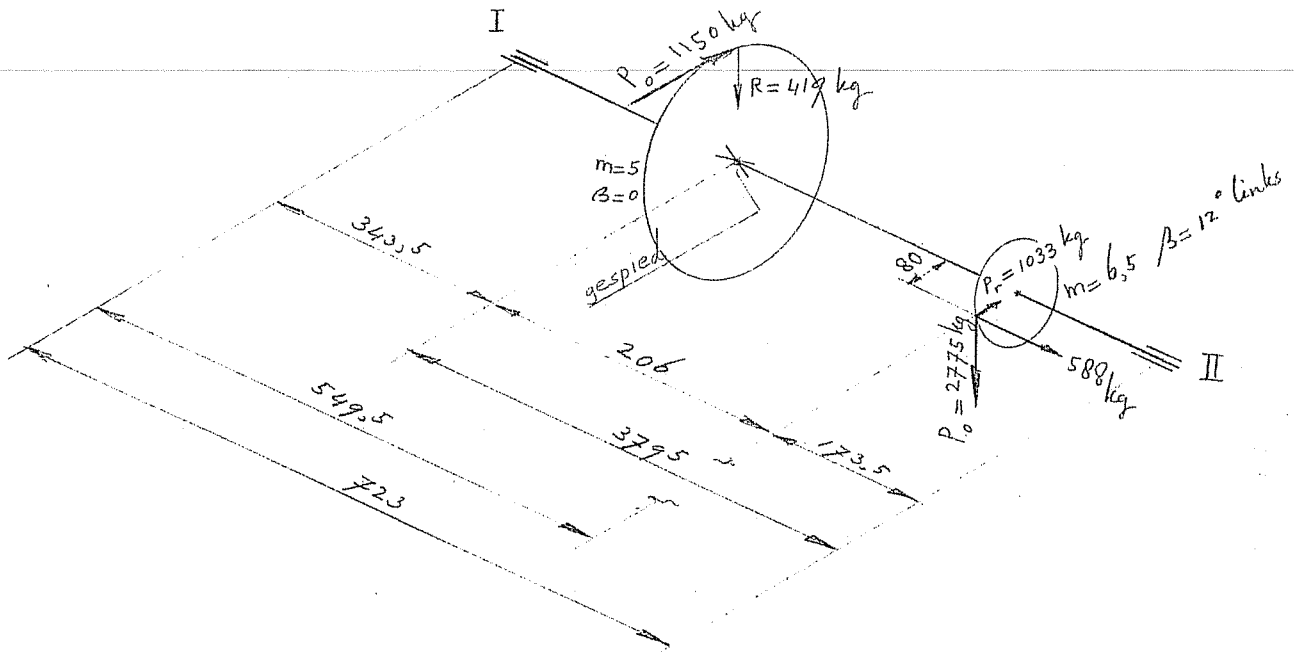
$\frac{t}{D} = \frac{7,5}{75} = 0,1 \rightarrow f/t_{\text{bovenste lijn}} > 0,355$

$\frac{f}{t} = \frac{2}{7,5} = 0,266 < 0,355$

afr r = 2 te klein

t.w.k. 2A3 – 110 Spec (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

2e tussenas (ingaande as hoofdmotor)



$\frac{379,5}{723} = 0,524$ $\qquad$ $\frac{173,5}{723} = 0,240$

$\frac{343,5}{723} = 0,475$ $\qquad$ $\frac{549,5}{723} = 0,76$

$\frac{80}{723} = \frac{1}{9,03}$

tandwiel ($m = 5$)

$P_o = 1150$ kg

$R = 1150 \times 0,364 = 419$ kg

$M_{w\ 2e\ tussenas} = 22.129$ kgcm (zie blz. 1)

rondsel ($m = 6,5$ $\beta = 12$)

$P_o = \frac{22.129 \text{ kgcm}}{\frac{15,95}{2} \text{ cm}} = 2775$ kg

$P_r = P_t \frac{tg\alpha}{\cos\beta} = 2775 \times \frac{0,364}{0,9781} = 1033$ kg

$P_{ax} = P_t \cdot tg\beta = 2775 \times 0,2126 = 588$ kg

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

reacties vertikaal

no I = 419 × 0,524 + 2775 × 0,24 = 219,5 + 666 = 886 kg

no II = 419 × 0,475 + 2775 × 0,76 = 199 + 2109 = 2308 kg

reacties horizontaal

t.g.v. R en P_a

no I = 1150 × 0,524 + 1033 × 0,24 = 603 + 247,9 = 851 kg

no II = 1150 × 0,475 + 1033 × 0,76 = 546 + 785 = 1331 kg

t.g.v. P_a

$|\text{no I}| = |\text{no II}| = 588 \times \frac{1}{9,03} = 65$ kg

t.g.v. R en P_a

no I = 65 + 851 = 916 kg (ongunstigste geval)

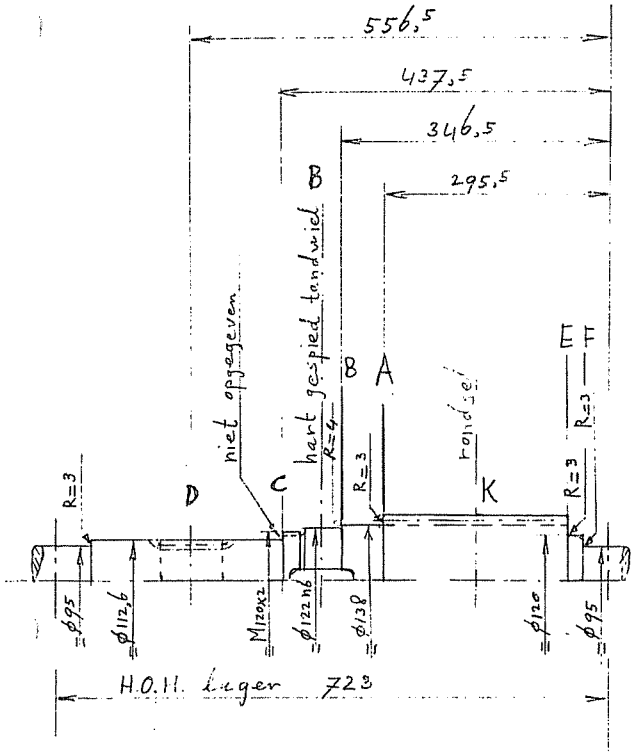
no II = 65 + 1331 = 1396 " (" ")

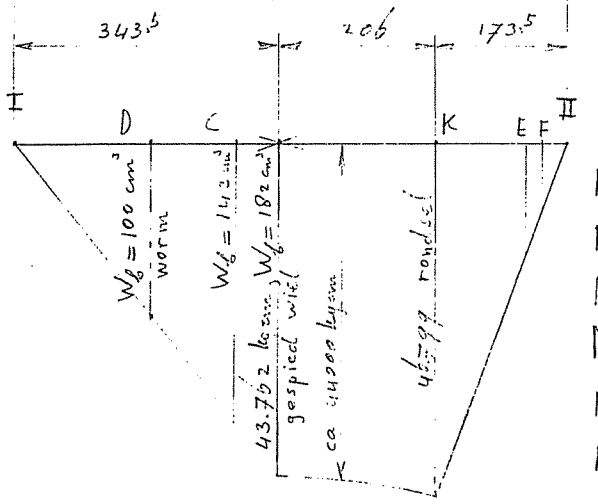
Resulterende reacties

no I = $\sqrt{916^2 + 886^2}$ = 1274 kg

no II = $\sqrt{1396^2 + 2308^2}$ = 2697 kg

P_{axe} = 588 kg





Spanningen in as

mat 2 C60 → σ_B = 70 kg/mm² → $\bar{\sigma}_{wissel}$ = 635 kg/cm²

buigmomenten

$M_{rondsel\ m=6,5}$ = 2697 kg × 17,35 cm = 46.799 kgcm

M_D ≈ 23000 kgcm (opgemeten)

M_C ≈ 37000 " (")

$M_{C\ res}$ = 1274 kg (72,3 – 43,75) cm = 36.373 kgcm

$M_{D\ res}$ = 1274 " (72,3 – 55,65) cm = 21.212 "

$M_{gespied\ tandwiel}$ = 1274 kg × 34,35 cm = 43.762 "

t.w.k. 2A3 - 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Wemeldinge

voor W zie ook blz 6 hoofdmotorberekening

$W_{b_A} = 0{,}1 \times 13{,}8^3 = 263\ cm^3$ $\quad W_{w_A} = 2 \times 263 = 526\ cm^3$

$W_{b_B} = 0{,}1 \times 12{,}2^3 = 182$ „ $\quad W_{w_B} = 363$ „

$W_{b_C} = 0{,}1 \times 11{,}26^3 = 143$ „ $\quad W_{w_C} = 286$ „

$W_{b_D} = 0{,}1 \times 9{,}98^3 = 100$ „ $\quad W_{w_D} = 200$ „

$W_{b_E} = 0{,}1 \times 12^3 = 173$ „ $\quad W_{w_E} = 346$ „

$W_{b_F} = 0{,}1 \times 9{,}5^3 = 86$ „ $\quad W_{w_F} = 171$ „

$W_{b_K} = 323$ „ $\quad W_{w_K} = 645$ „

$\sigma_{b_A} \approx \frac{44000}{263} = 167\ kg/cm^2$ $\quad \tau_{w_A} = \frac{22.129}{526} = 42\ kg/cm^2$

$\sigma_{b_B} \approx \frac{44000}{182} = 242$ „ $\quad \tau_{w_B} = \frac{22.129}{363} = 61$ „

$\sigma_{b_C} \approx \frac{37000}{143} = 259$ „ $\quad \tau_{w_C} = \frac{22.129}{286} = 77$ „

$\sigma_{b_D} \approx \frac{23000}{100} = 230$ „ $\quad \tau_{w_D} = \frac{22.129}{200} = 111$ „

$\sigma_{b_E} \approx \frac{15000}{173} = 87$ „ $\quad \tau_{w_E} = \frac{22.129}{346} = 64$ „

$\sigma_{b_F} \approx \frac{9000}{86} = 105$ „ $\quad \tau_{w_F} = \frac{22.129}{171} = 129$ „

$\sigma_{b_K} \approx \frac{46.799}{323} = 145$ „ $\quad \tau_{w_K} = \frac{22.129}{42} = 527$ „

$$\sigma_v = \sqrt{(\beta\sigma)^2 + 3(\beta_\tau \cdot \tau)^2} \leq 635\ kg/cm^2$$

plaats A :	afronding groef	$\beta = 1{,}00$	$\beta_\tau = 0{,}73$
„ B :	„	1,00	0,73
„ B :	spiebaan	1,00	1,29
„	hart gespiedwiel : naaf	1,39	1,39
„ C :	afrond. gr.	1,00	0,73
„ D :	„ „	1,00	0,73
„ E :	„ „	1,00	0,73
„ F :	„ „	1,00	0,73
„ K :	„ „	1,00	0,73

t.w.k. 2A3 - 110 Spec (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$$\sigma_{v_A} = \sqrt{(1 \times 167)^2 + (0{,}73 \times 42)^2 3} = 175 \text{ kg/cm}^2$$

$$\sigma_{v_{B_{gr.}}} = \sqrt{(1 \times 242)^2 + (0{,}73 \times 61)^2 3} = 254 \text{ "}$$

$$\sigma_{v_{B_{sp.b.}}} = \sqrt{(1 \times 242)^2 + (1{,}29 \times 61)^2 3} = 278 \text{ "}$$

$$\sigma_{v_{wiel}} = \sqrt{(1{,}39 \times 242)^2 + (1{,}39 \times 61)^2 3} = 367 \text{ "}$$

$$\sigma_{v_C} = \sqrt{(1 \times 259)^2 + (0{,}73 \times 77)^2 3} = 277 \text{ "}$$

$$\sigma_{v_D} = \sqrt{(1 \times 230)^2 + (0{,}73 \times 111)^2 3} = 269 \text{ "}$$

$$\sigma_{v_E} = \sqrt{(1 \times 87)^2 + (0{,}73 \times 64)^2 3} = 119 \text{ "}$$

$$\sigma_{v_F} = \sqrt{(1 \times 105)^2 + (0{,}73 \times 129)^2 3} = 194 \text{ "}$$

$$\sigma_{v_K} = \sqrt{(1 \times 145)^2 + (0{,}73 \times 527)^2 3} = 411 \text{ "}$$

t.w.k 2A3_110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

punt A

$$t = \frac{D-d}{2} = \frac{177-138}{2} = 19{,}5 \text{ mm}$$

$$\left.\begin{aligned} \frac{f}{t} &= \frac{3}{19{,}5} = 0{,}153 \\ \frac{t}{D} &= \frac{19{,}5}{177} = 0{,}11 \end{aligned}\right\} \; \rho/t > 0{,}14$$

punt B

$$t = \frac{138-122}{2} = 8 \text{ mm}$$

$$\left.\begin{aligned} \frac{t}{D} &= \frac{8}{138} = 0{,}058 \\ \frac{\rho}{t} &= \frac{4}{8} = 0{,}5 \end{aligned}\right\} \; \rho/t > 0{,}44$$

punt C

$$t = \frac{120-112{,}6}{2} = 3{,}7$$

Neem $\rho = 3$

$$\left.\begin{aligned} \frac{t}{D} &= \frac{3{,}7}{120} = 0{,}0308 \\ \frac{f}{t} &= \frac{3}{3{,}7} = 0{,}81 \end{aligned}\right\} \; \rho/t > 0{,}54$$

t.w.k. 2A3_110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

Lagers konische rondselas

2 lagers 6311 2RS 55 x 120 x 29

$C_{dyn} = 5600$ kg

$C_{stat} = 4250$ " $= C_o$

lager A

geval I ongunstigst.

$F_r = 757$ kg $\quad F_a = 0$

$L_h = \frac{1000.000}{60\,n}\left(\frac{C}{P}\right)^p$ $\quad$ p kogellagers = 3

$L_h = \frac{1000.000}{60 \times 1460}\left(\frac{5600}{757}\right)^3 = 11{,}41 \times 405$

$L_h = 4621$

lager B

geval I

$F_r = 163$ kg $\quad F_a = 312$ kg

$\frac{F_a}{F_r} = \frac{312}{163} = 1{,}9$ $\rightarrow e = 0{,}27 \rightarrow X = 0{,}56 \quad Y = 1{,}6$

$\frac{F_a}{C_o} = \frac{312}{4250} = 0{,}07$

$P = 0{,}56 \times 163 + 1{,}6 \times 312 = 590$ kg.

geval II

$F_r = 119$ kg $\quad F_a = 388$ kg

$\frac{F_a}{F_r} = \frac{388}{199} = 1{,}95$ $\rightarrow e \approx 0{,}28 \quad X = 0{,}56 \quad Y = 1{,}6$

$\frac{F_a}{C_o} = \frac{388}{4250} = 0{,}091$

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$P = 0{,}56 \times 119 + 1{,}6 \times 388 = 687$ kg

geval II ongunstiger

$$L_h = \frac{1000.000}{60\,n}\left(\frac{C}{P}\right)^p$$

$$L_h = \frac{1000.000}{60 \times 1460}\left(\frac{5600}{687}\right)^3 = 6171$$

Opm.: $EG_{a.s}$ + ½ koppeling verwaarloosd.

Statisch

lager A

$$v = \frac{C_o}{P} = \frac{4250}{757} = 5{,}61$$

lager B

$X_s = 1$ $\quad Y_s = 0{,}75$ (Fag, kogellagers)

$P = X_s \cdot F_r + Y_s \cdot F_a$

$P = 1 \times 163 + 0{,}75 \times 312 = 397$ kg

$$v = \frac{C_o}{P} = \frac{4250}{397} = 10{,}7$$

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

Lagers 1e tussenas

lager 6312 punt no 7 (zie fig blz 9)

geval 1 : $F_r = 935$ kg $F_a = 0$

" 2 : $F_r = 839$ " $F_a = 0$

$n_{1e\ tussenas} = 287$ omw./min

$$L_h = \frac{1000.000}{60 \times 287}\left(\frac{C}{P}\right)^3 = 58\left(\frac{6400}{935}\right)^3 = 18.600$$

lager 6215 punt no 8

geval 1	geval 2
$F_r = 896$ kg	$F_r = 841$ kg
$F_a = 286$ kg	$F_a = 169$ "
$\frac{F_a}{C_o} = \frac{286}{4150} = 0{,}068$ $\quad e \approx 0{,}27$	$\frac{F_a}{C_o} = \frac{169}{4150} = 0{,}04$ $\quad e \approx 0{,}24$
$\frac{F_a}{F_r} = \frac{286}{896} = 0{,}319 > e$	$\frac{F_a}{F_r} = \frac{169}{841} = 0{,}201 < e$
$X = 0{,}56$ $\quad Y = 1{,}6$	$X = 1$ $\quad Y = 0$
$P = 0{,}56 \times 896 + 1{,}6 \times 286 = 959$ kg	$P = F_r = 841$ kg

$$L_h = 58\left(\frac{5200}{959}\right)^3 = 9.247$$

statisch

lager 6312 (punt no 7)

$X_s = 1$ $\quad Y_s = 0{,}75$

$P_{geval\ 1} = 935$ kg $\quad\|\quad P_{geval\ 2} = 839$ kg

$$v = \frac{C_o}{P} = \frac{4900}{935} = 5{,}24$$

t.w.k. 2A3 - 110 Spec (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

Lager 6215 (punt no 8)

$X_s = 1 \quad Y_s = 0{,}75$

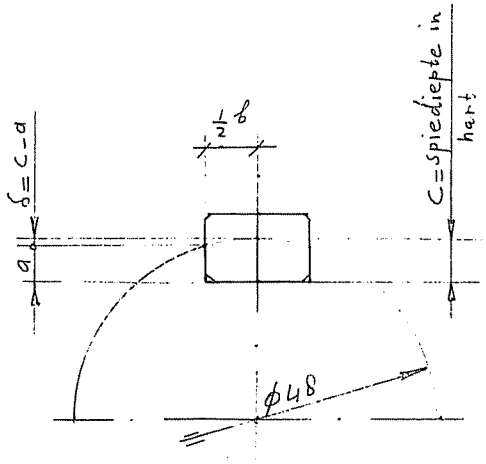
$P_{geval\ 1} = 896 + 0{,}75 \times 286 = 1111\ kg \quad \| \quad P_{geval\ 2} = 841 + 0{,}75 \times 169 = 968$

$$V = \frac{C_o}{P} = \frac{4150}{1111} = 3{,}7$$

Lagers 2e tussenas noodmotor (ingaande as hoofdmotor

Lagerreacties by noodmotordraaien iets hoger als bij hoofdmotordraaien.
Lagers voldoen.

t.w.h. 2A3_110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt



Inlegspieën (noodmotor)

rondselas (tek B 8839/2)

astap ϕ 48 k 6 (spie voor tandboogkoppeling)

$P_{spie} = \frac{1472 \text{ kgcm}}{\frac{4,8}{2} \text{ cm}} = 613 \text{ kg}$

$b_{spie} = 14 \rightarrow h_{spie} = 9$ NEN 2431

spieafsch. $= 0,4\ ^{+0,2}_{0}$

spiediepte in as in hart gem. = 5,5 mm (vlgs tek.)

$\delta = R - \sqrt{R^2 - (\frac{1}{2}b)^2} = 24 - \sqrt{24^2 - 7^2} = 24 - 22,9 = 1,04$ mm

spiediepte in as aan kant gem. $= 5,5 - 1 = 4,5$ mm

$l_{spie\ werkzaam} = 90 - 14 = 76$ mm

$h_{spie\ werkz.\ naaf} = 9 - 4,5 - 0,6 = 3,9$ mm

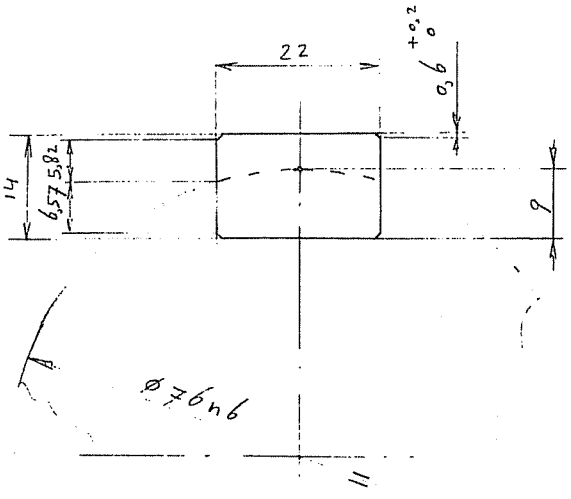
$F_{spie} = 76 \times 3,9 = 296 \text{ mm}^2 = 2,96 \text{ cm}^2$

$\sigma_{o\ tussen\ spie\ en\ naaf} = \frac{613 \text{ kg}}{2,96 \text{ cm}^2} = 207 \text{ kg/cm}^2$

mat. naaf tandboogkopp. 2C 60

" krans " 2C 45

$\bar{\sigma}_o = 900 \text{ kg/cm}^2$



Kegelwiel spieverbinding op 1e tussenas

as ϕ 76 n 6 (zie tek. B 8839/6)

$P_{spie} = \frac{7476 \text{ kgcm}}{\frac{7,6}{2} \text{ cm}} = 1967 \text{ kg}$

$b_{spie} = 22$ mm $\rightarrow h_{spie} = 14$

spieafsch. $= 0,60\ ^{+0,2}_{0}$

diepte spie in hart gem. 9 mm (vlgs tek.)

$\delta = 38 - \sqrt{38^2 - 11^2} = 1,6269331$ mm

t.w.k 2A3_110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$l_{spie\ werkzaam} = 63 - 22 = 41$ mm

$h_{spie\ werk.\ voor\ naaf} = 14 - 9 + 1{,}62 - 0{,}8 = 5{,}82$

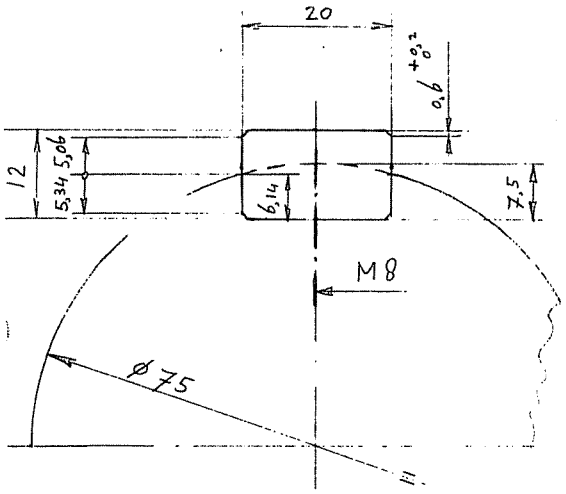
$F_{tussen\ spie\ en\ naaf} = 41 \times 5{,}82 = 238{,}6\ mm^2$

$\sigma_{o\ tussen\ spie\ en\ naaf} = \frac{1967\ kg}{2{,}386\ cm^2} = 824\ kg/cm^2$

Mat. kegelwiel 2C60 $\sigma_o = 900\ kg/cm^2$

$F_{tussen\ spie\ en\ as} = (9 - 1{,}63 - 0{,}8)41 = 6{,}57 \times 41 = 269\ mm^2$

$\sigma_{o\ tussen\ spie\ en\ as} = \frac{1967\ kg}{2{,}69\ cm^2} = 730\ kg/cm^2$



schuiftandwiel 1e tussenas

as Ø75 H7/f7

as met spie tek B 8839/6

rondsel met schuiftandwiel B 8839

$P_{spie} = \frac{7476\ kgcm}{\frac{7,5}{2}\ cm} = 1994\ kg$

$b_{spie} = 20 \rightarrow h_{spie} = 12$ NEN 2432

spieafsch. $= 0{,}6\ ^{+0{,}2}_{0}$

spiediepte in as in hart gem. $= \frac{75-60}{2} = 7{,}5$ mm

$\delta = 37{,}5 - \sqrt{37{,}5^2 - 10^2} = 1{,}3579$ mm

spiediepte in as aan kant gemeten $= 7{,}5 - 1{,}36 = 6{,}14$ mm

$l_{spie\ werkz.} = 180$ mm

$h_{werkzaam\ tussen\ spie\ en\ as} = 12 - 6{,}14 - 0{,}8 = 5{,}06$ mm

$F_{tussen\ spie\ en\ naaf} = 180 \times 5{,}06 = 910{,}8\ mm^2$

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

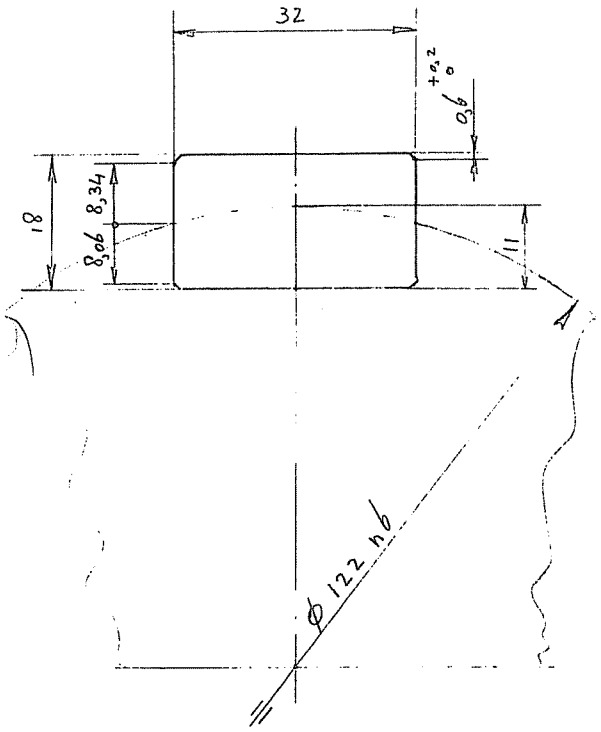
$\sigma_o = \frac{1994\ kg}{9{,}11\ cm^2} = 219\ kg/cm^2$

Opm.: as heeft 2 inlegspieen stel één inlegspie werkzaam.

Mat. schuiftandwiel 2 C60
schuiftandwiel $\bar{z}_{o\ beweeglijk} < \bar{\sigma}_{o\ vast} = 900\ kg/cm^2$

$F_{tussen\ spie\ en\ as} = 180(7{,}5 - 1{,}36 - 0{,}8) = 180 \times 5{,}34 = 961\ mm^2$

$\sigma_{o\ tussen\ spie\ en\ as} = \frac{1994\ kg}{9{,}61\ cm^2} = 207\ kg/cm^2$



Spie van tandwiel m = 5 z = 77

as ϕ 122 h6

$M_w = 22.129\ kg\,cm$ (zie blz. 1)

$P_{spie} = \frac{22.129\ kg\,cm}{\frac{12{,}2}{2}\ cm} = 3628\ kg$

$b_{spie} = 32 \rightarrow h_{spie} = 18$
spiesafsch. $= 0{,}6\ ^{+0{,}2}_{0}$

spiediepte in as in hart gemeten = 11 mm (vlgs tek.)

$\delta = 61 - \sqrt{61^2 - 16^2} = 2{,}1357\ mm$

$h_{werkz.\ tussen\ spie\ en\ naaf} = 18 - 11 + 2{,}14 - 0{,}8 = 8{,}34\ mm$

$l_{spie\ werkz.} = 80 - \frac{32}{2} - 20 = 44\ mm$

$F_{tussen\ spie\ en\ naaf} = 44 \times 8{,}34 = 367\ mm^2$

$\sigma_o = \frac{3628\ kg}{3{,}67\ cm^2} = 989\ kg/cm^2$

t.w.k. 2A3_110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

mat. tandwiel 2C45 $\sigma_0 = 900 \text{ kg/cm}^2$

$h_{\text{werkzaam tussen spie en as}} = 11 - 2{,}14 - 0{,}8 = 8{,}06 \text{ mm}$

$F_{\text{tussen spie en as}} = 8{,}06 \times 44 = 354{,}6 \text{ mm}^2$

$\sigma_{\text{tussen spie en as}} = \frac{3628 \text{ kg}}{3{,}54 \text{ cm}^2} = 1.023 \text{ kg/cm}^2 > \sigma_0 = 900 \text{ kg/cm}^2$

t.w.k. 2A3 – 110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

Lagerpot (pos 41) mat GG 20 (voor lager in rondselas noodmotor

zie tek. B 8839/11

$F = \pi D h = \pi \; 12 \times 0{,}8 = 30{,}1 \; cm^2$

$P_{ax} = -312 \; kg$ of $+388 \; kg$

$\bar{\tau}_D = \frac{388 \; kg}{30{,}1 \; cm^2} = 13 \; kg/cm^2$

Dekselbouten (6 x M 10 Stc. 140)

zie tek. B 8839/11

$P_{per. \; bout} = \frac{388}{6} \; kg = 65 \; kg$

$F_{k \; M10} = 0{,}49 \; cm^2$

$\sigma_t = \frac{65}{0{,}49} = 132 \; kg/cm^2$

Voor deksel zie tek. A 12858/7

$\sigma_{b \; deksel} = \frac{3P}{s^2} = \frac{3 \times 65}{1{,}2^2} = 135 \; kg/cm^2$

mat deksel G.G. 20

Opm. kruip verwaarloosd

Spanning in lagerpot (pos. 41) bouten

Zie tek. B 8839/11

4 bouten M 20 op Stc 260 (bouten diametraal tegenover elkaar

$M_{w \; noodmotor} = 1472 \; kgcm$ (zie blz 1)

$S_{bout} = \frac{1472 \; kgcm}{2 \times 26 \; cm} = 28 \; kg$

Neem aan: afschuiven over F_k

$F_{k \; M20} = 2{,}145 \; cm^2$

t.w.k. 2A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$\tau_D = \frac{28}{2,145} = 13 \text{ kg/cm}^2$

$P_{\text{ax kon. wiel}} = 388 \text{ kg.}$

$T_{\text{per bout}} = \frac{388}{4} \text{ kg} = 97 \text{ kg}$

$\sigma_t = \frac{97 \text{ kg}}{2,145 \text{ cm}^2} = 45 \text{ kg/cm}^2$

$\sigma_i = \sqrt{45^2 + 3 \times 13^2} = 51 \text{ kg/cm}^2$

Tand - koppeling (ingrijpende as op noodmotor)

Aantal tanden 39
Modul 3
Drukhoek 20°
tandbreedte inw. vertanding 30 mm
" uitw. " 26 "
steekcirkel 117
kopc. uitw. vertanding 123
voetc. inw. " 111
kromming R = 80 mm

$h_{k\,\text{tand}_{\text{uitw.}}} = \frac{123-117}{2} = 3 \text{ mm} = \text{modul}$

$h_{k\,\text{tand}_{\text{inw.}}} = \frac{117-110}{2} = 3,5 \text{ mm} = \frac{3,5}{3} \text{ m} = 1,166 \text{ modul}$

kromming $R_{o\ \text{op steekc.}} = 80 - 3 = 77 \text{ mm}$

kromming tandflank $R = \frac{R_o}{\sin 20} = \frac{77}{0,3142} = 225 \text{ mm}$

$M_w = 1472 \text{ kg cm}$ (zie blz. 1)

t.w.k. 2A3-110 Spec. (Noodmotorgedeelte) Nieuwe Schutsluis Weurt

$$P_{tanden} = \frac{M_w}{\frac{Stc}{2}} = \frac{1472 \text{ kgcm}}{\frac{11,7}{2} \text{ cm}} = 252 \text{ kg}$$

$$P_{o\,tand\ 75\%\ werkzaam} = \frac{252}{39} \times \frac{100}{75} = 8,6 \text{ kg}$$

$$P_N = \frac{P_o}{\cos 20} = \frac{8,6}{0,9397} = 9,2 \text{ kg}$$

$$h_{tand\ werkz.} = 3 + 3,5 = 6,5 \text{ mm} = 0,65 \text{ cm}$$

$$\sigma_H = 0,418 \sqrt{\frac{\frac{9,2}{0,65} \times 2.100.000}{22,5}} = 480 \text{ kg/cm}^2$$

$z = 39 \rightarrow Y \approx 2,47$

schat aan. Legbreedte op kopc. uitw. vert. $\approx$ 2 mm

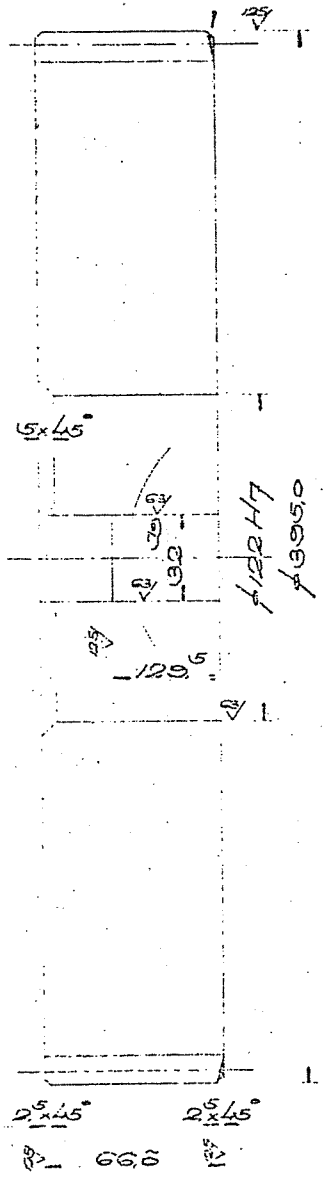
$b_{werkzaam\ op\ voete} = 2 + 2 \times 6,5 = 15 \text{ mm} = 1,5 \text{ cm}$

$$\sigma_b = \frac{P\,Y}{b\,m} = \frac{8,6 \times 2,47}{1,5 \times 0,3} = 47 \text{ kg/cm}^2$$

tandwiel op 2e tussenas

Tanden afronden...

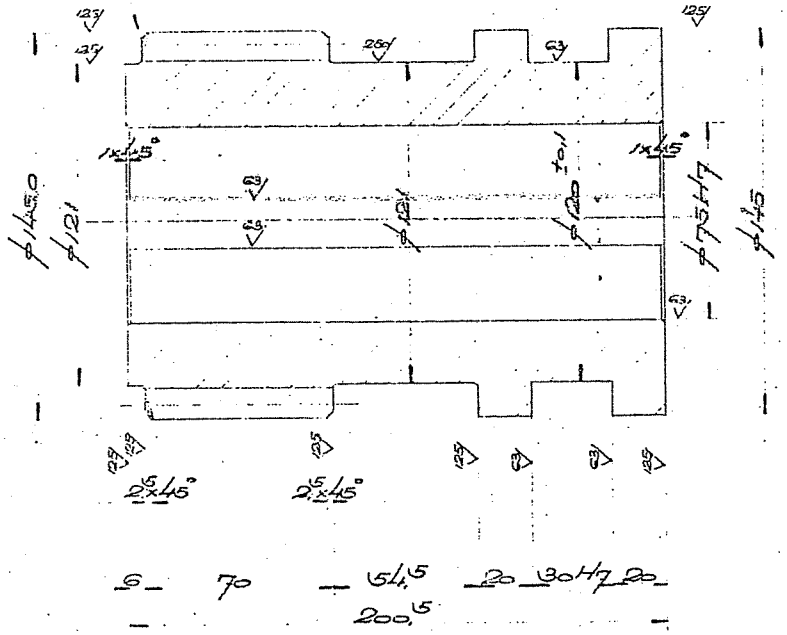
z = 77

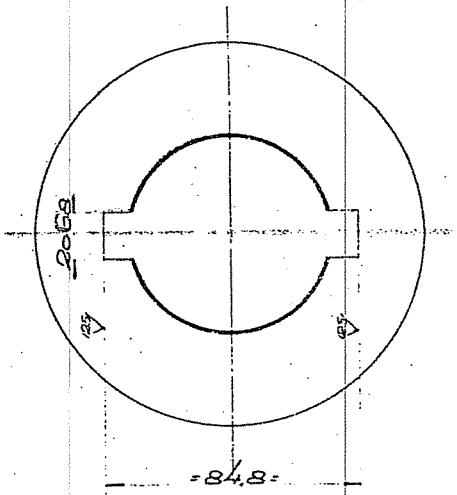


rondsel op 1e tussenas

Tanden afronden...

z = 26





	RONDSEL	WIEL
AANTAL TANDEN	26	77
MODUL	5	
EINGRIFFSWINKEL	20°	
PROFIELVERSCHUIVING	—	—
TANDDIKTE	11,25	
DEELCIRKEL	130	385
BUITENDIAM.	145,0	390,0
[illegible]	+2,5	—
[illegible]	200,0	
[illegible]	4155,103	5'13'25"

ORDER NO.	AANTAL
75-1052	3x

AANTAL	POS.	BENAMING	MATERIAAL	OPMERKING
1	19	Tandwiel	2C45	
1	18	Rondsel	2C60	

GET. H.B. DATUM 2/3-75 OPM. 2A3-110366c. Nieuwe schuifsleutel Keur!

GEC. SCHAAL

(noodmotor)

Rondsel + Tandwiel

AUG. BIERENS & ZN.

TILBURG

WIJZ.

MODEL NO.

TEK. NO. B2939/3

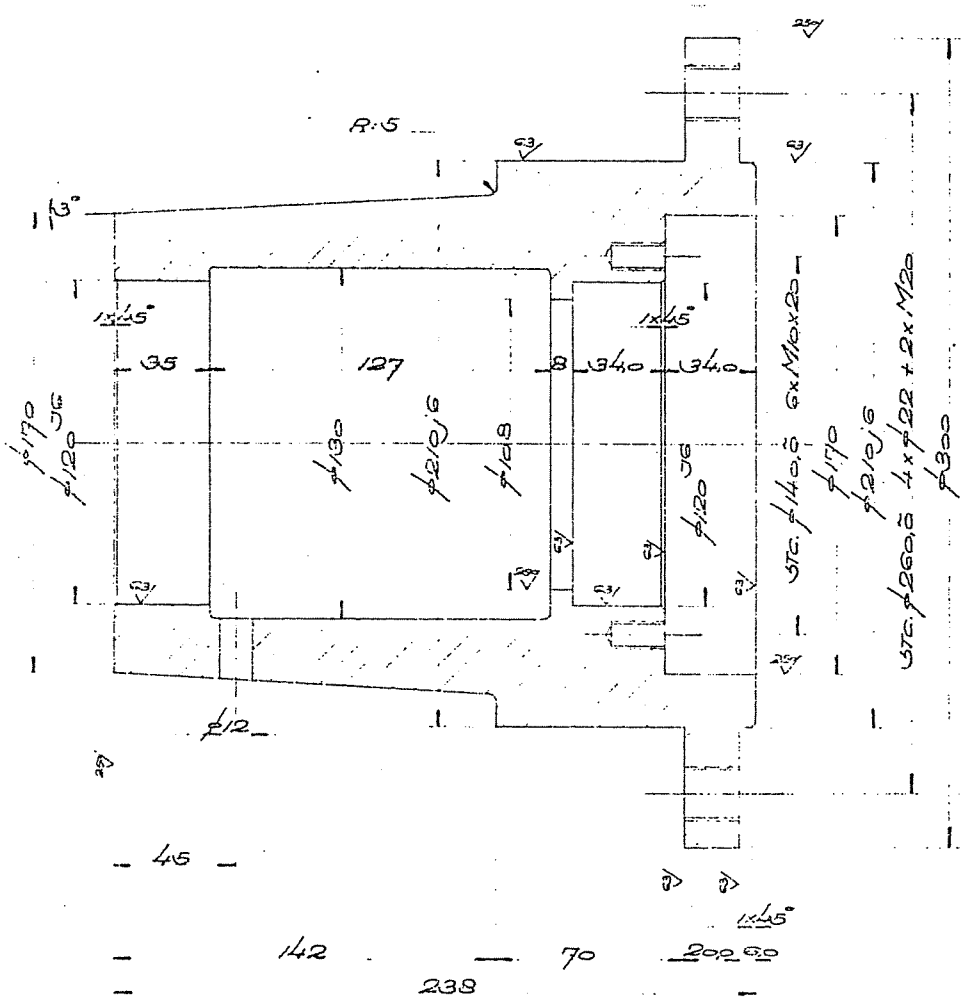
AM. PROJ.

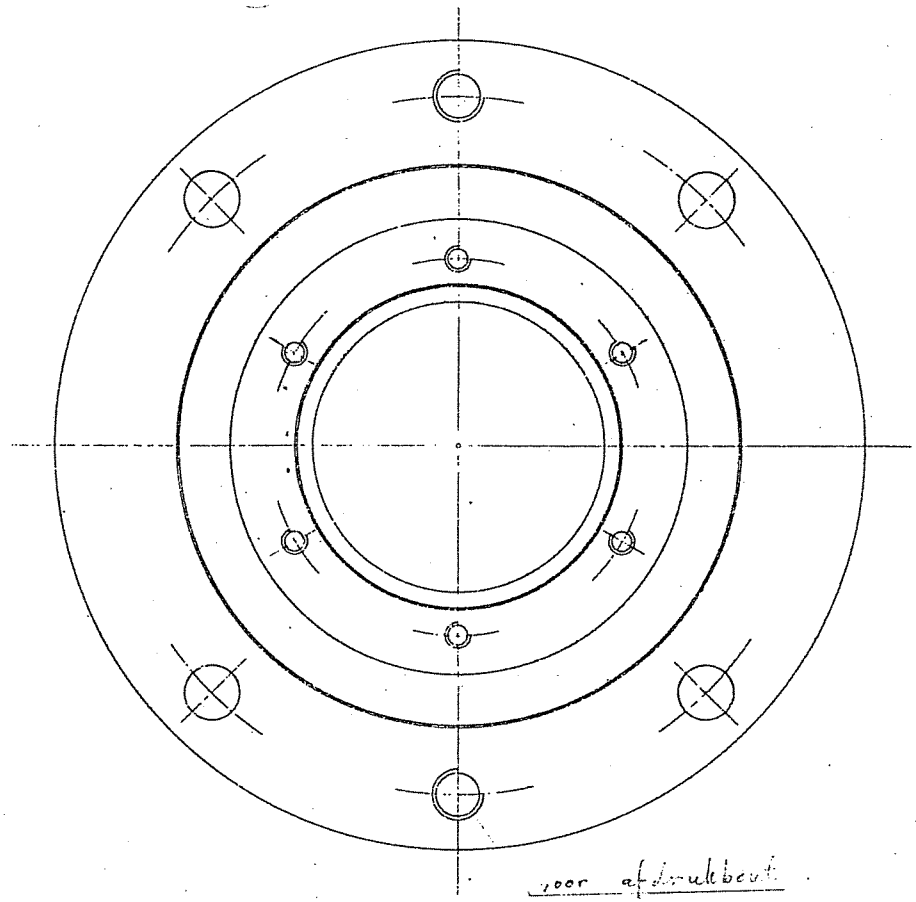
SCHERPE KANTEN BREKEN ½ X 45°

OPPERVLAKTE RUWHEID VLG. NEN 630 ▽ MAX. 32 R_{ll}

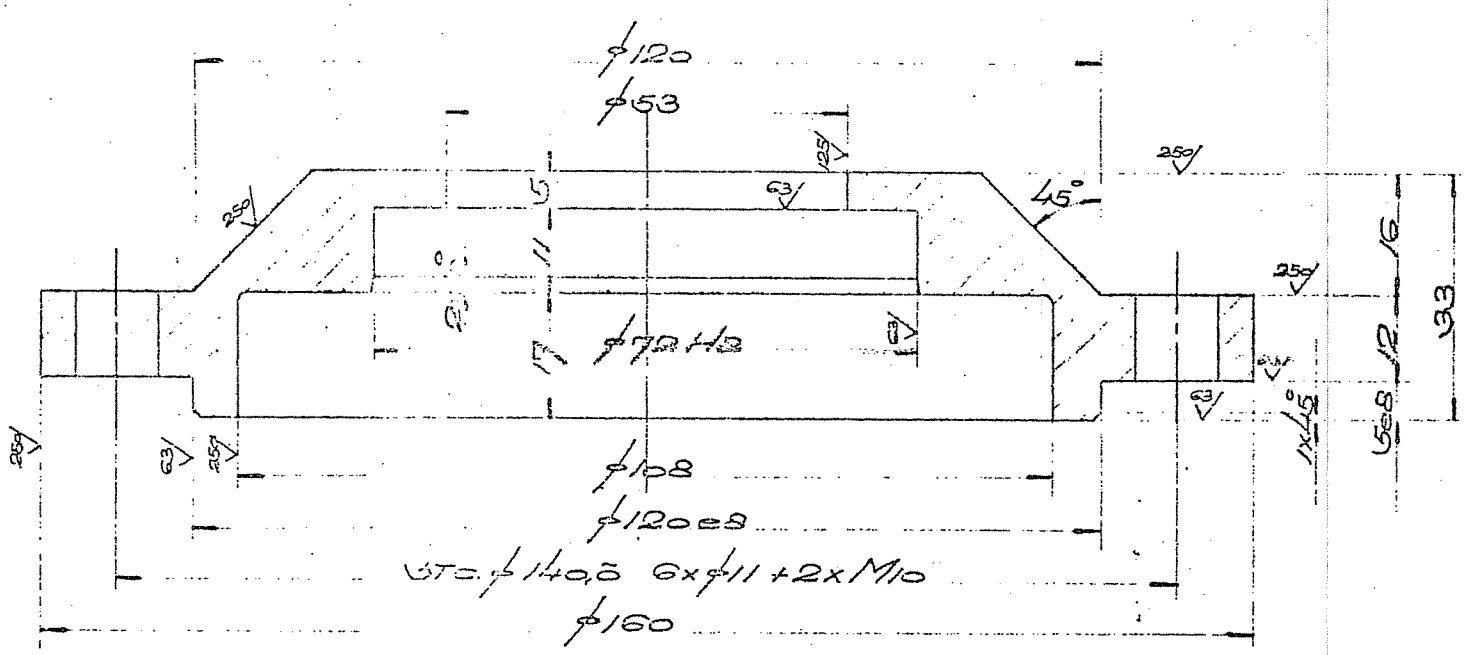
25 = ± 0,5 | 25,6 = ± 0,1 | 25,0 = ± 0,2 | 25,0 = ± 0,05

tek 4

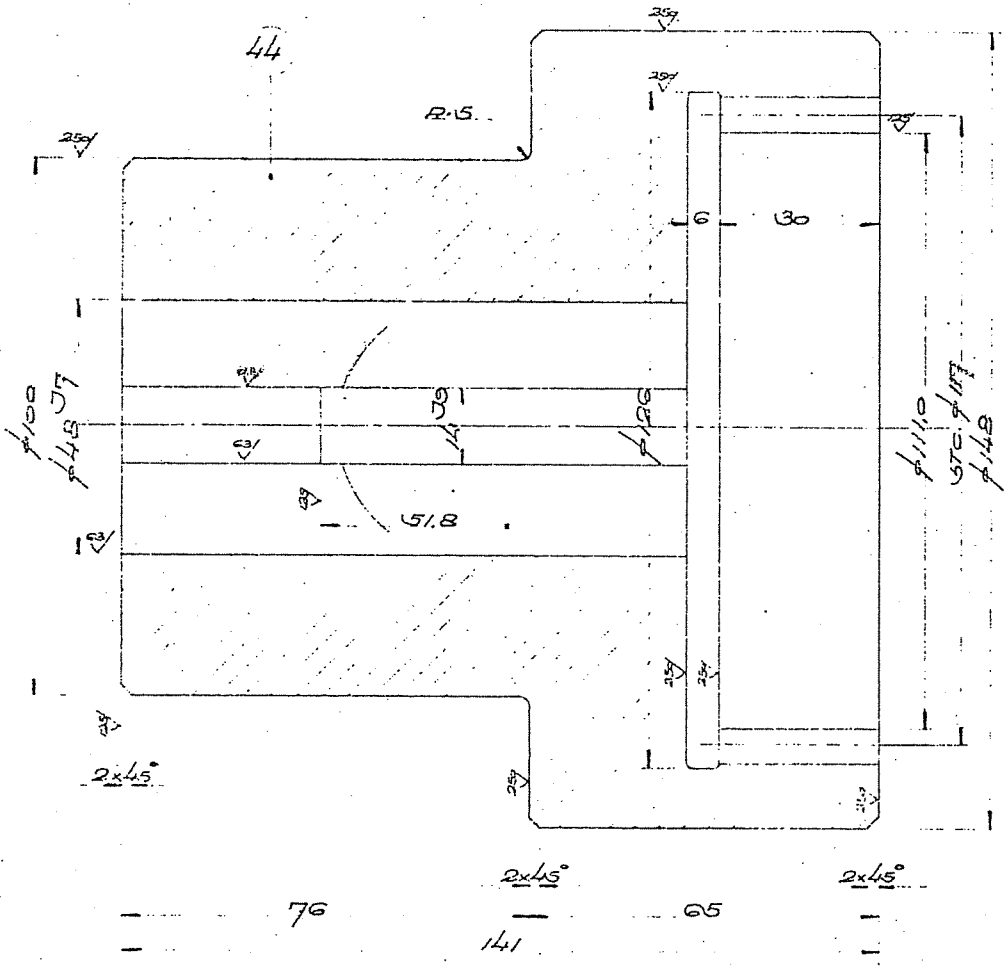


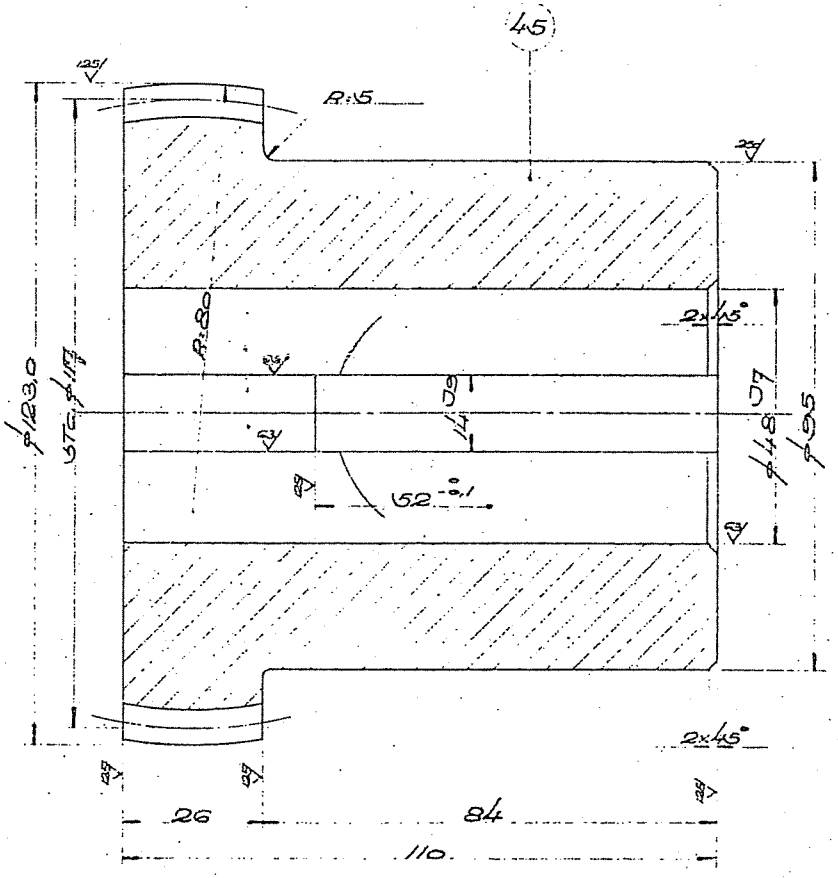


		1	41	Lagerpot	GG20	
		AANTAL	POS.	BENAMING	MATERIAAL	OPMERKING
		GET. H.B.	DATUM 14.75	OPM. 2A3-110 Spec. Nieuwe schuifbus keurt		
		GEC.	SCHAAL:			
		Lagerpot (rondsel las noodmotor				
		AUG. BIERENS & ZN. TILBURG		WIJZ.		
				MODEL NO.		
				TEK. NO. B8839/11	AM. PROJ.	
75-1656	3x	SCHERPE KANTEN BREKEN ½ X 45°		25 = ± 0,5	25,6 = ± 0,1	
ORDER NO	AANTAL	OPPERVLAKTE RUWHEID VLG. NEN 630 ▽ MAX. 32 Rμ		25,6 = ± 0,2	25,0 = ± 0,05	



		1	42	Deksel	GG20
		AAN-TAL	POS.	BENAMING	MATERIAAL / OPMERKING
		GET. H.B.	DATUM 1/4.75	OPM. 2A3-1105pec.	
		GEC.	SCHAAL	Nieuwe schutsluis Weurt	
				Deksel (lagerpot, noodmotor)	
				AUG. BIERENS & ZN. TILBURG	WIJZ.
					MODEL NO.
					TEK. NO. A/2858/7
					AM. PROJ.
75-1556	18x	SCHERPE KANTEN BREKEN ½ X 45°			25 = ± 0,5 / 25,5 = ± 0,1
ORDER NO	AAN-TAL	OPPERVLAKTE RUWHEID VLG. NEN 630 32/= MAX. 32 R/			25,5 = ± 0,2 / 25,0 = ± 0,05





39 Tanden
Modul 3
Drukh. 20°

1	45	Tandkoppelwiel	2C60	
1	44	Tandkoppelhuis	2C45	
AAN-TAL	POS.	BENAMING	MATERIAAL	OPMERKING

GET. H.B. DATUM 4.75 OPM. 2A3-110 Spec.
GEC. SCHAAL : Nieuwe Schuilwijk Weurt

Tandkoppeling (noodmotor)

AUG. BIERENS & ZN.
TILBURG

WIJZ.
MODEL NO.
TEK. NO. B8839/3
AM. PROJ.

35-6x55 3x SCHERPE KANTEN BREKEN ½ X 45°

ORDER NO | AAN-TAL | OPPERVLAKTE RUWHEID VLG. NEN 630 ▽= MAX. 32 Rμ

25 = ± 0,5 | 25,5 = ± 0,1 | 25,5 = ± 0,2 | 25,0 = ± 0,05

NIEUWE SCHUTSLUIS TE WEURT.

9. BEREKENING TURBOFLEXKOPPELING HBS 6700-8X.

De berekening is gemaakt voor type HBS 6700 - 8X

Gekozen is type HBS - 8000 - 8X

De berekende spanningen zullen, bij toepassing van type HBS 8000 - 8X, lager worden, en ongeveer gelijk aan de spanningen volgens deze berekening vermenigvuldigd met de verhouding van de toelaatbare koppels van HBS 6700 - 8X en HBS 8000 - 8X :

Toelaatbare koppels volgens de katalogus :

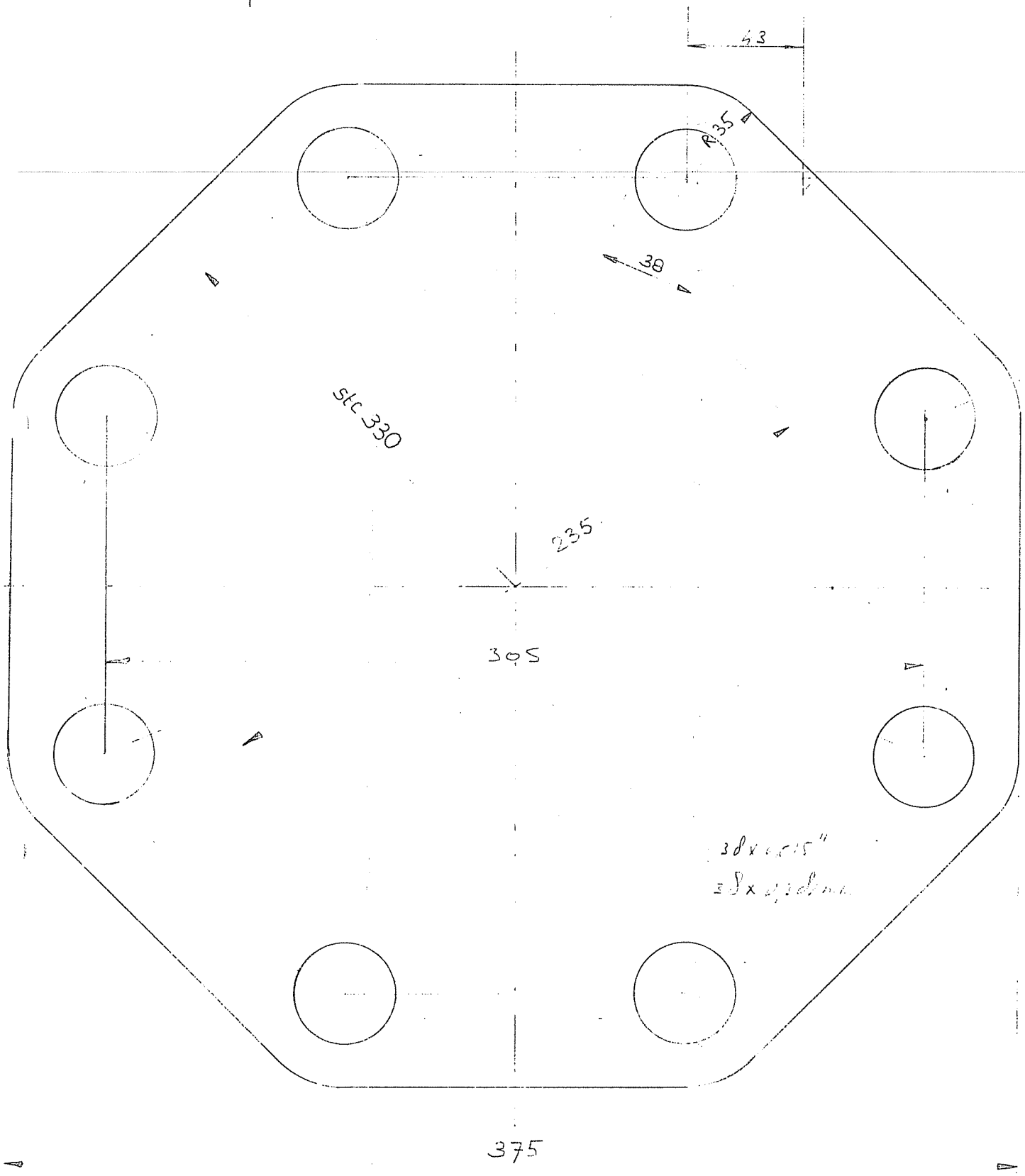
HBS 6700 - 8X : 4871 kgfm
HBS 8000 - 8X : 5816 kgfm

Optredend koppel : 2260 kgfm

De kritieke spanningen in :

	HBS 6700 - 8X	HBS 8000 - 8X		
Lamel	2540	2127	kgf/cm²	($\sigma_b \approx 8500$ kgf/cm
Bout	1994	1670	kgf/cm²	($\sigma_b \approx 8500$ kgf/cm
Flens	1787	1497	kgf/cm²	

Turboflex koppeling HBS 6700 - 8X

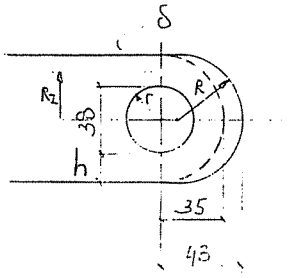


schaal 1 : 2

Turboflex koppeling HBS 6700 - 8X

Lamellen

Berekening van lamel als oog



excentr. $e = 43 - 35 = 8$ mm

$R = 35$ mm

$r = 19$ mm

$$\frac{e}{R-r} = \frac{8}{35-19} = 0,50$$

$$\frac{R-r}{R+r} = \frac{35-19}{35+19} = 0,296$$

k-waarde

$\frac{e}{R-r}$ / $\frac{R-r}{R+r}$	0,30	0,60
0,2	0,132	0,103
0,4	0,125	0,090

Interpolatie: $0,296 - 0,3 \rightarrow x_1 = 0,132 - \frac{0,096}{0,2}(0,132 - 0,105 = 0,12864$

$0,296 - 0,6 \rightarrow x_2 = 0,103 - \frac{0,096}{0,2}(0,103 - 0,090) = 0,0967$

$0,296 - 0,5 \rightarrow x_3 = 0,12864 - \frac{0,2}{0,3}(0,12864 - 0,0967) =$

$x_3 = \underline{K = 0,10738}$

Turboflex koppeling HBS 6700 - 8X

$M_w = 2260$ kgf m

$F_{lamel} = \frac{2260}{2 \cdot 0{,}305} = 3705$ kgf

Uog: $\delta = 38 \cdot 0{,}0381 = 1{,}447$ cm

$h = 3{,}5 - 1{,}9 = 1{,}6$ cm

$A = 1{,}6 \cdot 1{,}447 = 2{,}315$ cm^2

$W = \frac{1}{6} \cdot 1{,}6^2 \cdot 1{,}447 = 0{,}6174$ cm^3

$R_z = \frac{3{,}5 + 1{,}9}{2} = 2{,}7$ cm

$M_i = F \cdot R_z \cdot k = 3705 \cdot 2{,}7 \cdot 0{,}10738 = 1074$ kgf/cm

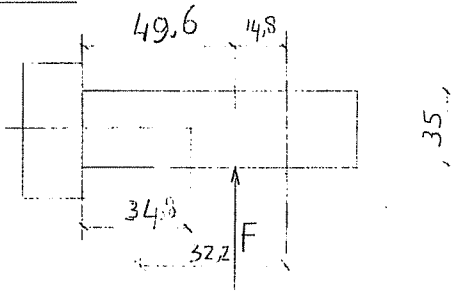
$\sigma_t = \frac{F}{2A} = \frac{3705}{2 \cdot 2{,}315} = 800$ kgf/cm^2

$\sigma_b = \frac{M_b}{W} = \frac{1074}{0{,}6174} = 1740$ kgf/cm^2

$\sigma = \sigma_t + \sigma_b = 800 + 1740 = \underline{2540 \text{ kgf/cm}^2}$

Turboflex koppeling HBS 6700 - 8X

Bout



$d = 1\frac{3}{8}'' = 35\ mm$

$A_b = \frac{\pi}{4} \cdot 3,5^2 = 9,62\ cm^2$

$W_b = \frac{\pi}{32} \cdot 3,5^3 = 4,21\ cm^3$

$\tau_{gem} = \frac{F}{A_b} = \frac{3705}{9,62} = 385\ kg/cm^2$

$M_b = \left(1,48 + \frac{1}{6} \cdot 3,48\right) 3705 = 7632\ kgf\,cm$

$\sigma_b = \frac{M_b}{W_b} = \frac{7632}{4,21} = \underline{1813\ kgf/cm^2}$

spanning in gat:

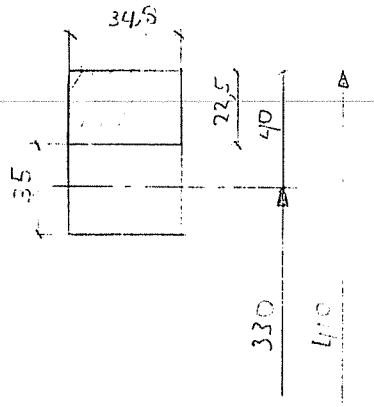
$W = \frac{1}{6} \cdot 3,48^2 \cdot 3,5 = 7,06\ cm^3$

$A = 3,5 \cdot 3,48 = 12,18\ cm^2$

$\sigma = \frac{3705 \cdot 3,2}{7,06} + \frac{3705}{12,18} = \underline{1994\ kg/cm^2}$

Turboflex koppeling HBS 6700 - 8X

Flens



$$W = \frac{1}{6} \cdot 3{,}48^2 \cdot 2{,}25 = 4{,}54 \text{ cm}^3$$

$$M = \frac{3705 \cdot 3{,}22}{2} = 5965 \text{ kgf cm}$$

$$\sigma_b = \frac{5965}{4{,}54} = 1314 \text{ kgf/cm}^2$$

$$\sigma_t = \frac{3705}{3{,}48 \cdot 2{,}25} = 473 \text{ kgf/cm}^2$$

$$\sigma = 1314 + 473 = \underline{1787 \text{ kgf/cm}^2}$$