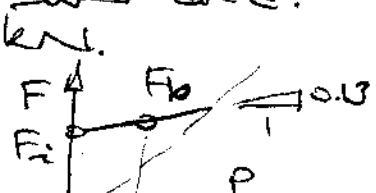
a) Bolt (shaft) $k_b = \frac{AE}{L} = 5 \times \frac{\pi}{4} \times 12^2 \times 207/340 = 344$ kN/mm
Joint – only the cylinder is compliant. Assume its compressed length is 320 mm
$k_j = \frac{\pi}{4}(120^2 - 100^2) \times 207/320 = 2240$ kN/mm
$C = k_b/(k_b + k_j) = 344/(344 + 2240) = 0.13$.

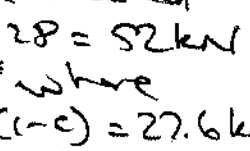
b) For 1 bolt, $F_p = A_s S_p = 84.3 \times 380 = 32$ kN
$F_i = 0.75 F_p = 0.75 \times 32 = 24$ kN.
External load per bolt due to fluid pressure acting over internal end area:
$P = \frac{1}{5} \text{ of } \frac{\pi}{4} \times 100^2 \times 4 = 6.28$ kN.
So $F_b = F_i = 24$ kN
$F_b = F_i + CP = 24 + 0.13 \times 6.28$
$= 24.8$ kN



$\therefore \sigma = \frac{1}{2}(24 + 24.8)/A_s = 24.4/84.3$
$= 289$ MPa.
$\sigma_a = \frac{1}{2}(24.8 - 24)/A_s = 0.4/84.3 = 4.7$ MPa

c) $S_u = 500$ MPa
$S_e' = (0.55 - 0.088 \times 0.5)\,0.5 = 253$ MPa (Landgraf)
$S_e = S_e'/K_f = 253/2.2 = 115$ MPa (rolled threads).

d) Applying (6b) $\times A_s$ for one bolt:
$F_i/S_u + n \cdot \frac{1}{2} CP (1/S_u + 1/S_e) = A_s$
$\therefore n = \frac{84.3 - 24 \times 10^3/500}{\frac{1}{2} \times 0.13 \times 6.28 (1/500 + 1/115) \times 10^3} = 8.3$
(or use $\bar{\sigma}, \tilde{\sigma}$ above on Goodman line).
BUT – this implies that the pressure load per bolt cannot increase to $8.3 \times 6.28 = 52$ kN whereas separation occurs at P^* where
$F_i = F_i - (1-C)P = 0$ i.e. $P^* = F_i/(1-C) = 27.6$ kN
So the 8.3 safety factor only applies if sealing is not affected by separation, by e.g. O-ring :–



Static failure when nP, the static load

If nP is the static failure load ($P = 6.28$ kN above) then, as above.
$F_b = F_i + nCP$
$= 24 + 0.13 \times 6.28 n$ $\delta = F_p$ @ failure
$\therefore n = (32 - 24)/0.13 \times 6.28 = 9.8$.