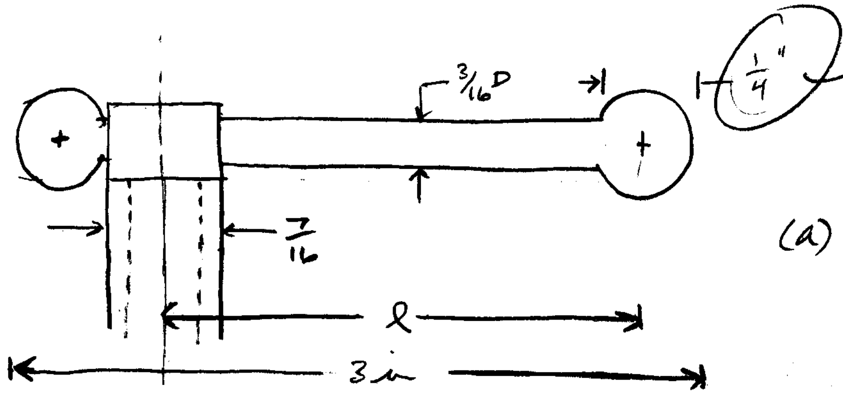
8.7)



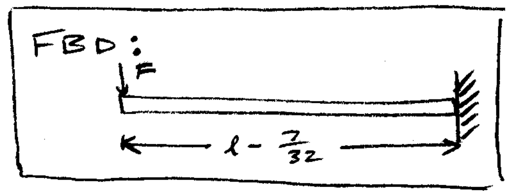
(a) FIND TORQUE NECESSARY TO CAUSE PERMANENT DEFORMATION IN HANDLE.

$\therefore\ \ell = 3'' - \frac{7}{32}'' - \frac{1}{8}'' - \frac{1}{4}'' = 2.41''$

and $T = 2.41\,F$

CALCULATE F:

$M = \left(\ell - \frac{7}{32}\right)F$ $\longrightarrow$



$= 2.19\,F$

DUE TO PLASTIC DEFORMATION

$\sigma = S_y = \frac{Mc}{I} = \frac{32M}{\pi d^3} = \frac{32(2.19)F}{\pi(.1875)^3} = 48000$

$F = 14.18$ lb.

$\therefore\ \boxed{T = 2.41(14.18) = 34.2\ \text{lb-in}}$

(b) WHAT CLAMPING FORCE WILL THE TORQUE FROM PART (a) CAUSE? $f_c = .075$

EQ 8-5 : $\alpha = 60°$, $\lambda = 1/14 = .0714$ (From Table 8.2)

$d_m = d - .649519P = \frac{7}{16} - .649519\left(\frac{1}{14}\right) = .391$ in

$p = \frac{1}{14}$ in.

$$F = \left(\frac{\pi d_m - f\lambda\sec\alpha}{\lambda + \pi f d_m \sec\alpha}\right)\left(\frac{2T}{d_m}\right)$$

$$= \left[\frac{\pi(.391) - .075(.0714)(2)}{(.0714) + \pi(.075)(.391)2}\right]\left(\frac{2(34.2)}{.391}\right)$$

$$= \boxed{833.2\ \text{lbs.}}$$

(c) COLUMN IS ONE END FIXED, OTHER END PIVOTED. BASE DECISION ON MEAN DIAMETER.

$C = 1.2 \quad D = .391 \text{ in.} \quad E = 30 \times 10^6 \text{ psi} \quad l = 4.1875 \text{ in}$

USE EQUATION:

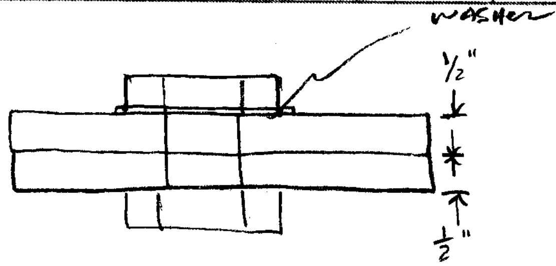
$$P = \frac{C\pi E I}{l^2} \quad \text{where} \quad I = \frac{\pi d^4}{64}$$

$$= 1.15 \times 10^{-3} \text{ in}^4$$

$$\cong 7400 \text{ lbs.}$$

(d) possible stresses in clamp itself and THE THREADS.

8.11)



(a) WHAT IS THE LENGTH OF THE THREAD L_T ?

$L_T = 2D + \frac{1}{4} = 2(.5) + .25 = 1.25$ in. (TABLE 8-7)

(b) WHAT IS LENGTH OF GRIP L_G ?

$L_g = .5 + .5 + .109 = 1.109$ in.

(c) WHAT IS HEIGHT H OF NUT ?

(TABLE E-31) $H = \frac{7}{16} = .4375$ in.

(d) IS BOLT LONG ENOUGH ?

$L_g + H = 1.109 + .4375 = 1.5465$ in

BOLT IS 1.75" ∴ IT IS LONG ENOUGH.

(e) WHAT IS LENGTH OF SHANK AND THREADED portions OF BOLT w/IN GRIP ?

$l_s = l_d = L - L_T = 1.75 - 1.25 = .500$ in

$l_T = L_G - l_d = 1.109 - .500 = .609$ in

8-20 BOLT SPACING SHOULD BE SUCH THAT THE NUMBER OF FASTENERS LIES BETWEEN

$$\frac{\pi D_b}{6d} = \frac{\pi 9}{6(0.5)} = 9.42 \text{ bolts}$$

AND

$$\frac{\pi(9)}{3(0.5)} = 18.85 \text{ bolts}$$

WHICH IT DOES. $A_t = 0.1419 \text{ in}^2$, (8-2)

$A_d = 0.7854(0.5)^2 = 0.1964 \text{ in}^2$ (TABLE 8-7)

$L_T = 2d + 0.25 = 2(0.5) + 0.25 = 1.25 \text{ in}$

$L_G = t_1 + t_2 = 0.5 + 0.5 = 1 \text{ in}$

$H = 0.4375 \text{ in}$ (TABLE E-31)

$\ell_d = L - L_T = 1.5 - 1.25 = 0.25 \text{ in}$

$\ell_T = L_G - \ell_d = 1 - 0.25 = 0.75 \text{ in}$

MINIMUM LENGTH BOLT

$L_G + H = 1 + 0.4375 = 1.4375 \text{ in}$

PREFERRED ROUNDING $L = 1.5 \text{ in}$

$$k_b = \frac{0.1964(0.1419)30(10^6)}{0.1964(0.75) + 0.1419(0.25)}$$

$$= 4.574 \text{ Mlb/in}$$

$$k_m = AEd \exp(B\, d/\ell)$$

$$k_m = 30(10^6)0.5(0.78713) \cdot \exp\left(0.62873 \frac{0.5}{1}\right)$$

$$= 16.169 \text{ Mlb/in}$$

$$C = \frac{4.574}{4.574 + 16.169} = 0.220$$

$$F_i = \frac{T}{Kd} = \frac{880}{0.2(0.5)} = \cancel{8800 \text{ lb}} \quad 8000$$

THIS SHOULD BE 800

(MAKE appropriate changes)

$$\xi_1 = \frac{F_i}{S_p A_t} = \frac{8800}{85000(0.1419)}$$

$$= 0.730$$

$$\sigma_i = \frac{F_i}{A_t} = \frac{8800}{0.1419} = 62\,016 \text{ psi}$$

$$\xi_2 = \xi_1 + \frac{CmP}{S_p A_t}$$

Hydrostatic multiple

$$= 0.730 + \frac{0.220(2)(1800)}{85000(0.1419)}$$

Force / Bolt

$$= 0.796$$

$$\sigma_b = \sigma_i + \frac{CmP}{S_p A_t}$$

$$= 62\,016 + \frac{0.220(2)1800}{0.796 - 0.730}$$

$$= 67\,608 \text{ psi}$$

$$n_j = \frac{1 - \xi_1}{\xi_2 - \xi_1} = \frac{1 - 0.730}{0.796 - 0.730} = 4.09$$

$$n_0 = \frac{\xi_1 S_p A_t}{(1-C)mP}$$

$$= \frac{0.730(85000)0.1419}{(1-0.220)2(1800)} = 3.14$$

$$n_p = \frac{1}{\xi_2} = \frac{1}{0.796} = 1.256$$

$$z_2 = \frac{1 - \xi_2}{\xi_1 C_{F_i}} = \frac{1 - 0.796}{0.730(0.09)} = 3.11$$

$$p_f = 1 - \mathrm{CDF}(z_2) = 1 - \mathrm{CDF}(3.11)$$

$$= 1 - (1 - 0.000\,968) = 0.000\,968$$

$$R = 1 - p_f = 1 - 0.000\,968 = 0.999$$

8-20 (CONT.)

$$R_j = (1-p_f)^{N_b} = (1-0.000968)^{10} = 0.990$$

$$p_{f_j} = 1 - R_j = 1 - 0.990 = 0.01$$

NOTE THAT n_j AND n_b ARE LOAD-BASED fos, WHICH MEANS

- THE LOAD (TEST PRESSURE) CAN BE RAISED 4.09-FOLD BEFORE THE STRESS IN THE BOLT EQUALS S_p.
- THE LOAD (TEST PRESSURE) CAN BE RAISED 3.14-FOLD ON THE JOINT BEFORE IT OPENS

NOTE THAT n_p IS A STRESS-BASED fos. THE STRESS IN THE BOLT (67 607 psi) CAN BE INCREASED 1.256-FOLD TO REACH THE PROOF STRENGTH S_p. THIS IS BECAUSE STRESS, WHILE LINEAR WITH LOAD, IS NOT PROPORTIONAL TO LOAD.

THE PROBABILITY THAT ONE OR MORE FASTENERS ARE STRESSED TO PROOF LOAD p_{f_j} IS ONE IN 100 JOINTS.

THE ABOVE SET OF EQUATIONS CAN BE THE BASIS FOR A COMPUTER PROGRAM.

8-21 IN THIS CASE $m = 1$ OR IT IS REMOVED FROM THE EQUATIONS. THE SOLUTION IS THE SAME AS IN Prob. 8-20 THROUGH STEP $\xi_2 = 0.763$. WE CONTINUE.

$$\sigma_b = \frac{CP}{A_t} + \sigma_i = \frac{0.220(1800)}{0.1419} + 62\,016 = 64\,806 \text{ psi}$$

$$\sigma_a = \frac{CP}{2A_t} = \frac{0.220(1800)}{2(0.1419)} = 1395 \text{ psi}$$

$$\sigma_m = \sigma_a + \sigma_i = 1395 + 62\,016 = 63\,411 \text{ psi}$$

USE DE-GERBER FAILURE LOCUS, EQS. (8-53). THE STRENGTH COMPONENTS ARE

$$S_m = \frac{120^2}{2(18.6)}\left[-1+\sqrt{1+\frac{4(18.6)}{120^2}(18.6+62)}\right] = 73.6 \text{ kpsi}$$

$$S_a = S_m - \sigma_i = 73.6 - 62 = 11.6 \text{ kpsi}$$

$$n_f = \frac{S_a}{\sigma_a} = \frac{11.6}{1.395} = 8.31$$

FROM EQ. (8-57)

$$n_{fo} = \frac{120^2}{2(18.6)}\left[-1+\sqrt{1+\frac{4(18.6)^2}{120^2}}\right]\frac{2(0.1419)}{1.800} = 2.865$$

$$n_p = \frac{1}{\xi_2} = \frac{1}{0.763} = 1.31$$

$$z_2 = \frac{1-\xi_2}{\xi_1 C_{F_i}} = \frac{1-0.763}{0.730(0.09)} = 3.62$$

$$p_f = 0.000\,159$$

$$R_b = 1 - p_f = 1 - 0.000159 = 0.999\,841$$

$$R_j = R_b^{N_b} = 0.999\,841^{10} = 0.9984$$

$$p_{f_j} = 1 - R_j = 1 - 0.9984 = 0.0016$$

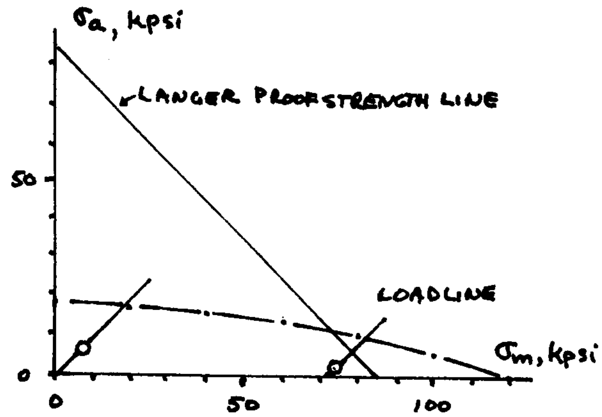
THIS IS ABOUT 2 IN 1000, BETTER THAN IN Prob. 8-20. HOWEVER, IF EACH JOINT IS PRESSURE TESTED, THE OVERPROOF STRESSING IS DONE AND p_{f_j} IS REALLY 0.01.

THE DESIGNER'S FATIGUE DIAGRAM IS USEFUL, AS ALWAYS. THE GERBER FATIGUE FAILURE LOCUS IS GIVEN BY

$$S_a = 18.6\left[1-\left(\frac{S_m}{120}\right)^2\right]$$

S_m	S_a
0	18.6
20	18.1
40	16.5
60	14.0
80	10.3
100	5.7
120	0

8-21 (CONT.)



THE LOAD LINE BEGINS AT ABSCISSA INTERCEPT $\sigma_i = 62$ kpsi AND RISES WITH A SLOPE OF 1. THE OPERATING POINT IS $\sigma_a = 1395$ psi, $\sigma_m = 63\,411$ psi. THE STRENGTH COMPONENTS ARE $S_a = 11.6$ kpsi, $S_m = 73.6$ kpsi AND THE FATIGUE fos IS $n_f = 8.31$.

IF THE INITIAL TENSION FADES, THE LOAD LINE MOVES TO THE LEFT WITH σ_a STAYING CONSTANT AT 1395 psi. THE FACTOR OF SAFETY IN FATIGUE INCREASES SLIGHTLY. IF THE INITIAL TENSION VANISHES, THEN C=1, AND THE BOLT HAS TO CARRY THE EXTERNAL LOAD WITHOUT THE AID OF THE MEMBERS. σ_a MOVES FROM $0.22P/(2A_t)$ TO $(1)P/(2A_t)$, OR FROM 1395 psi TO 6342 psi. THE fos DROPS FROM 8.31 TO 2.865. THIS IS WHY ENGINEERS SPEAK OF PRELOAD AS BENIFICIAL.

NOTICE HOW THE LANGER PROOF STRENGTH LINE TELLS US THAT THE THREAT FROM OVER-PROOFSTRESSING IS LARGER THAN FROM FATIGUE.

8-22 ONE COULD CHOOSE A DESIGN FACTOR GOAL OF $n_f \geq 3$ AN BUILD A TABLE WITH FASTENER SIZE RANGING FROM $\frac{1}{4}$"-20 THROUGH 1"-8 WITH COLUMN HEADINGS