SPUR GEAR BENDING

Based on ANSI/AGMA 2001-D04 (U.S. customary units)

$$d_P = \frac{N_P}{P_d}$$

$$V = \frac{\pi d n}{12}$$

$$W^t = \frac{33\,000\text{ H}}{V}$$

Gear bending stress equation Eq. (14–15)

$$\sigma = W^t K_o K_v K_s \frac{P_d}{F} \frac{K_m K_B}{J}$$

- W^t: from the equation above
- K_o: Table below
- K_v: Eq. (14–27)
- K_s: 1 [or Eq. (a), Sec. 14–10]
- K_m: Eq. (14–30)
- K_B: Eq. (14–40)
- J: Fig. 14–6

Gear bending endurance strength equation Eq. (14–17)

$$\sigma_{\text{all}} = \frac{S_t}{S_F} \frac{Y_N}{K_T K_R}$$

- S_t: ${}_{0.99}(S_t)_{10^7}$ Tables 14–3, 14–4
- Y_N: Fig. 14–14
- K_T: 1 if $T < 250°$F
- K_R: Table 14–10, Eq. (14–38)

Bending factor of safety Eq. (14–41)

$$S_F = \frac{S_t Y_N/(K_T K_R)}{\sigma}$$

Remember to compare S_F with S_H^2 when deciding whether bending or wear is the threat to function. For crowned gears compare S_F with S_H^3.

Table of Overload Factors, K_o

	Driven Machine		
Power source	Uniform	Moderate shock	Heavy shock
Uniform	1.00	1.25	1.75
Light shock	1.25	1.50	2.00
Medium shock	1.50	1.75	2.25

SPUR GEAR WEAR

Based on ANSI/AGMA 2001-D04 (U.S. customary units)

$$d_P = \frac{N_P}{P_d}$$

$$V = \frac{\pi d n}{12}$$

$$W^t = \frac{33\,000\ \mathrm{H}}{V}$$

Gear contact stress equation Eq. (14–16)

$$\sigma_c = C_p \left(W^t K_o K_v K_s \frac{K_m}{d_P F} \frac{C_f}{I} \right)^{1/2}$$

- C_p: Eq. (14–13), Table 14–8
- W^t: from the equation above
- K_o: Table below
- K_v: Eq. (14–27)
- K_s: 1 [or Eq. (a), Sec. 14–10]
- K_m: Eq. (14–30)
- C_f: 1
- I: Eq. (14–23)

Gear contact endurance strength Eq. (14–18)

$$\sigma_{c,\text{all}} = \frac{S_c Z_N C_H}{S_H K_T K_R}$$

- S_c: $_{0.99}(S_c)_{10^7}$ Tables 14–6, 14–7
- Z_N: Fig. 14–15
- C_H: Section 14–12, gear only
- K_T: 1 if $T < 250°$F
- K_R: Table 14–10, Eq. (14–38)

Wear factor of safety Eq. (14–42)

$$S_H = \frac{S_c Z_N C_H / (K_T K_R)}{\sigma_c}$$

- C_H: Gear only

Remember to compare S_F with S_H^2 when deciding whether bending or wear is the threat to function. For crowned gears compare S_F with S_H^3.

Table of Overload Factors, K_o

	Driven Machine		
Power source	Uniform	Moderate shock	Heavy shock
Uniform	1.00	1.25	1.75
Light shock	1.25	1.50	2.00
Medium shock	1.50	1.75	2.25

EQUATIONS (continued)

Tensile forces in bolts

$$P = \frac{P_{total}}{N} = P_b + P_m$$

$$F_b = F_i + P_b$$

$$F_i = 0.75\,F_p = 0.75\,A_t\,S_p \text{ (re-used fasteners)}$$

$$F_i = 0.75\,F_p = 0.9\,A_t\,S_p \text{ (permanent fasteners)}$$

$$T = K\,F_i\,d$$

Joint stiffness constant

$$C = \frac{k_b}{k_m + k_b}$$

Member stiffness (when the entire joint is made of the same material)

$$\frac{k_m}{E\,d} = A\exp\left(B\,d/l\right)$$

Table 8–8 Stiffness Parameters of Various Member Materials[†]

Material Used	Poisson Ratio	Elastic Modulus GPa	Elastic Modulus Mpsi	*A*	*B*
Steel	0.291	207	30.0	0.787 15	0.628 73
Aluminum	0.334	71	10.3	0.796 70	0.638 16
Copper	0.326	119	17.3	0.795 68	0.635 53
Gray cast iron	0.211	100	14.5	0.778 71	0.616 16
General expression				0.789 52	0.629 14

Static failure

$$n_p = \frac{S_p}{\sigma_b} = \frac{S_p\,A_t}{CP + F_i}$$

$$n_L = \frac{S_p\,A_t - F_i}{CP}$$

$$n_o = \frac{F_i}{P(1-C)}$$

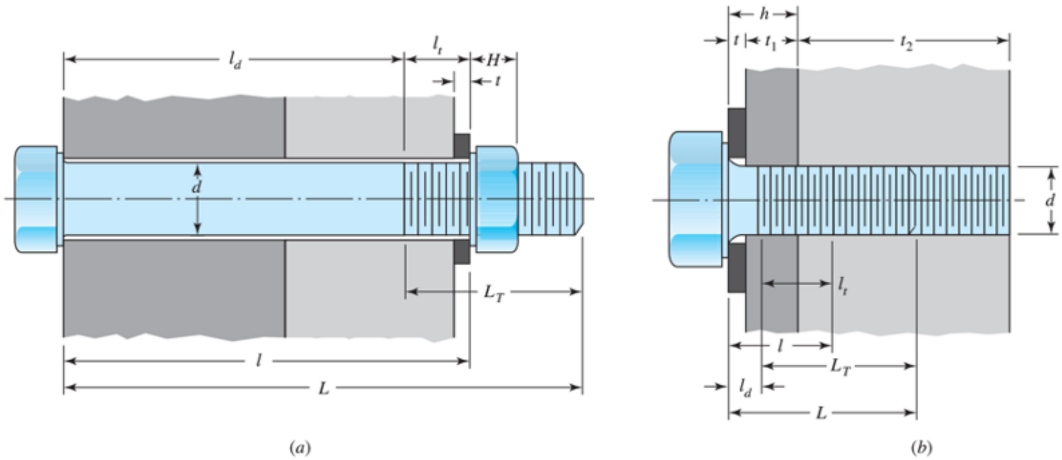
Fatigue failure

$$\sigma_a = \frac{C(P_{max} - P_{min})}{2A_t}$$

$$\sigma_m = \frac{C(P_{max} + P_{min})}{2A_t} + \frac{F_i}{A_t} = \frac{C(P_{max} + P_{min})}{2A_t} + \sigma_i$$

$$n_f = \frac{S_e(S_{ut} - \sigma_i)}{S_{ut}\sigma_a + S_e(\sigma_m - \sigma_i)}$$

Table 8–7 Suggested Procedure for Finding Fastener Stiffness



Given fastener diameter d and pitch p in mm or number of threads per inch

Washer thickness: t from Table A–32 or A–33

Nut thickness [Figure (*a*) only]: H from Table A–31

Grip length:

For Figure (*a*): l = thickness of all material squeezed between face of bolt and face of nut

For Figure (*b*): $l = \begin{cases} h + t_2/2, & t_2 < d \\ h + d/2, & t_2 \geq d \end{cases}$

Fastener length (round up using Table A–17*):

For Figure (*a*): $L > l + H$

For Figure (*b*): $L > h + 1.5d$

Threaded length L_T: Inch series:

$$L_T = \begin{cases} 2d + \frac{1}{4}\text{ in}, & L \leq 6\text{ in} \\ 2d + \frac{1}{2}\text{ in}, & L > 6\text{ in} \end{cases}$$

Metric series:

$$L_T = \begin{cases} 2d + 6\text{ mm}, & L \leq 125\text{ mm}, d \leq 48\text{ mm} \\ 2d + 12\text{ mm}, & 125 < L \leq 200\text{ mm} \\ 2d + 25\text{ mm}, & L > 200\text{ mm} \end{cases}$$

Length of unthreaded portion in grip: $l_d = L - L_T$

Length of threaded portion in grip: $l_t = l - l_d$

Area of unthreaded portion: $A_d = \pi d^2/4$

Area of threaded portion: A_t from Table 8–1 or 8–2

Fastener stiffness: $k_b = \dfrac{A_d A_t E}{A_d l_t + A_t l_d}$