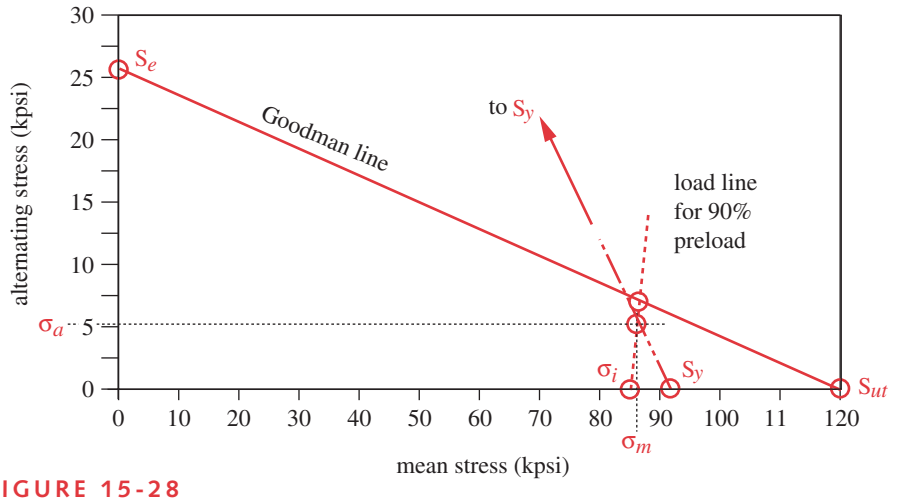

FIGURE 15-28

Modified-Goodman Diagram for Example 15-3

12 The static bolt stress after initial local yielding and the yielding safety factor are:

$$\sigma_s = \frac{F_{bolt}}{A_t} = \frac{4102}{0.045\,36} = 78\,227 \text{ psi} \qquad N_y = \frac{S_y}{\sigma_b} = \frac{92\,000}{78\,227} = 1.18 \qquad (k)$$

13 The preload required to obtain these safety factors is

$$F_i = 0.90 S_p A_t = 0.90(85\,000)(0.052\,431) \cong 4011 \text{ lb} \qquad (l)$$

14 The safety factor against joint separation is found from equation 15.14*d*:

$$N_{separation} = \frac{F_i}{P(1-C)} = \frac{4011}{1000(1-0.090\,56)} = 4.4 \qquad (m)$$

15 The fatigue and separation safety factors are acceptable. The yielding safety factor is low but is nevertheless acceptable, since the bolt is being deliberately preloaded to a level close to its yield strength.

16 The model was solved for the range of possible preloads from zero to 100% of proof strength and the safety factors plotted versus percent preload. The results are shown in Figure 15-29. The fatigue and separation safety factors are < 1 below 20% preload, at which point the preload becomes effective at keeping the joint closed. The fatigue safety factor remains essentially constant as preload is increased above the 20% threshold, but the safety factor against joint separation increases linearly with increasing preload. To protect the bolted joint against possible overloads, it is desirable to use the largest preload that will not yield the bolt when tightened. In this example, preloading to 90% of the bolt's proof strength gives an overload margin of $N_{separation} = 4.4$ at *A*, with an 18% reserve against yielding during preloading ($N_y = 1.18$ at *C*), along with a safety factor against fatigue failure of $N_f = 1.38$ at *B*.

17 The recommended design is then a 5/16-18 UNC-2A, grade 5.2 bolt, 2.5 in long, preloaded to 90% of proof strength with a force of 4011 lb. Note that this one, small, preloaded bolt will support a half-ton of fluctuating load! The files EX15-03 can be found on the book's website.