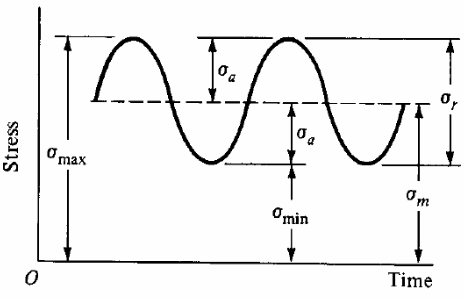
Definitions



Stress Range

$$\sigma_r = \sigma_{max} - \sigma_{min}$$

Alternating Stress

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

Mean Stress

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

Stress Ratio

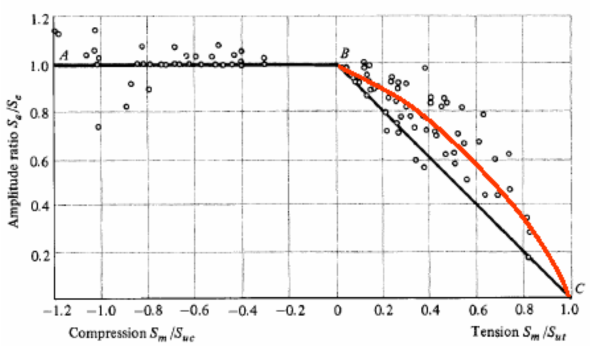
$$R = \frac{\sigma_{min}}{\sigma_{max}}$$

Amplitude Ratio

$$A = \frac{\sigma_a}{\sigma_m}$$

Note that R=-1 for a completely reversed stress state with zero mean stress.

Fluctuating Stress Failure Data

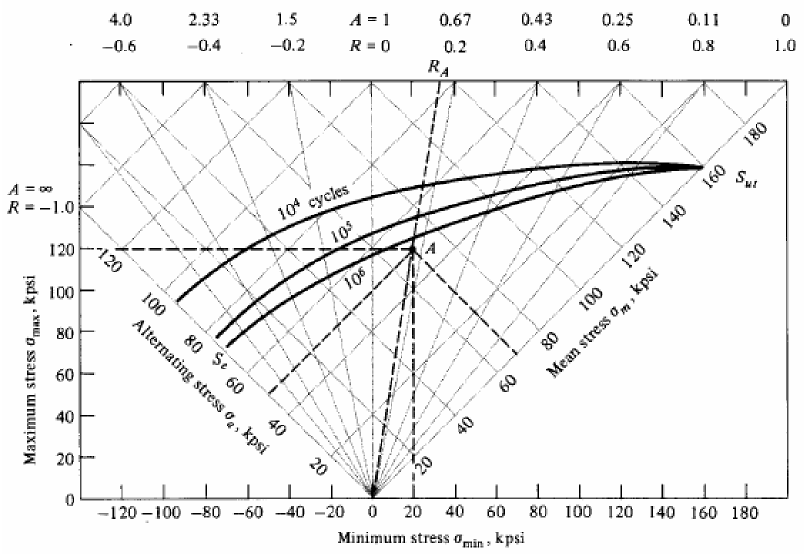


This plot shows the fatigue strength of several steels as a function of mean stress for a constant number of cycles to failure.

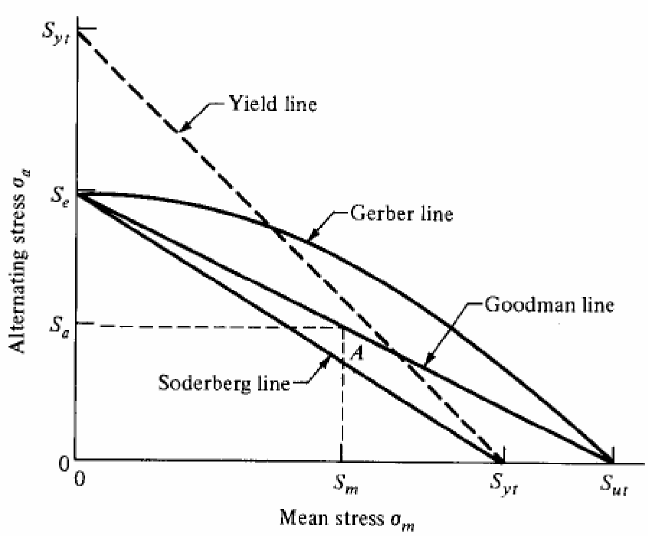
Note that a tensile mean stress results in a significantly lower fatigue strength for a given number of cycles to failure.

Note that a curved line passes through the mean of the data.

Master Fatigue Plot



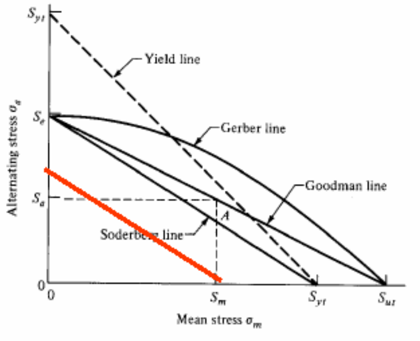
Fluctuating Stress Failure Interaction Curves



Soderberg Interaction Line

$$\frac{S_a}{S_e} + \frac{S_m}{S_{yt}} = 1$$

Any combination of mean and alternating stress that lies on or below the Solderberg line will have infinite life.



Factor of Safety Format

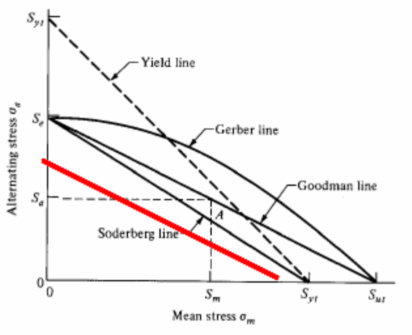
$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{yt}} = \frac{1}{n_f}$$

Note that the fatigue stress concentration factor is applied only to the alternating component.

Goodman Interaction Line

$$\frac{S_a}{S_e} + \frac{S_m}{S_{ut}} = 1$$

Any combination of mean and alternating stress that lies on or below the Goodman line will have infinite life.



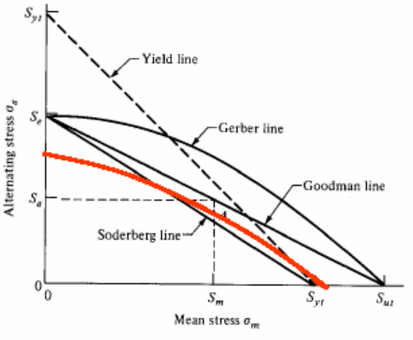
Factor of Safety Format

$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}} = \frac{1}{n_f}$$

Note that the fatigue stress concentration factor is applied only to the alternating component.

Gerber Interaction Line

$$\frac{S_a}{S_e} + \left(\frac{S_m}{S_{ut}}\right)^2 = 1$$



Any combination of mean and alternating stress that lies on or below the Gerber line will have infinite life.

Factor of Safety Format

$$\frac{n_f\,\sigma_a}{S_e} + \left(\frac{n_f\,\sigma_m}{S_{ut}}\right)^2 = 1$$

Note that the fatigue stress concentration factor is applied only to the alternating component.

ASME-elliptic (distortion-energy)

$$\left(\frac{S_a}{S_e}\right)^2 + \left(\frac{S_m}{S_{yt}}\right)^2 = 1$$

Factor of Safety Format

$$\left(\frac{n_f\sigma_a}{S_e}\right)^2 + \left(\frac{n_f\sigma_m}{S_{yt}}\right)^2 = 1$$

Table 7–15

Amplitude and Steady Coordinates of Strength and Important Intersections in First Quadrant for DE-Gerber and Langer Failure Loci

Intersecting Loci	Intersection Coordinates
$\frac{S_a}{S_e} + \left(\frac{S_m}{S_{ut}}\right)^2 = 1$	$S_a = \frac{r^2 S_{ut}^2}{2S_e}\left[-1 + \sqrt{1 + \left(\frac{2S_e}{rS_{ut}}\right)^2}\right]$
Load line $r = \frac{S_a}{S_m}$	$S_m = \frac{S_a}{r}$ **(Point B)**
$\frac{S_a}{S_y} + \frac{S_m}{S_y} = 1$	$S_a = \frac{rS_y}{1+r}$
Load line $r = \frac{S_a}{S_m}$	$S_m = \frac{S_y}{1+r}$ **(Point C)**
$\frac{S_a}{S_e} + \left(\frac{S_m}{S_{ut}}\right)^2 = 1$	$S_m = \frac{S_{ut}^2}{2S_e}\left[1 - \sqrt{1 + \left(\frac{2S_e}{S_{ut}}\right)^2\left(1 - \frac{S_y}{S_e}\right)}\right]$
$\frac{S_a}{S_y} + \frac{S_m}{S_y} = 1$	$S_a = S_y - S_m,\ r_{crit} = S_a/S_m$ **(Point D)**

Fatigue factor of safety

$$n_f = \frac{1}{2}\left(\frac{S_{ut}}{\sigma_m}\right)^2 \frac{\sigma_a}{S_e}\left[-1 + \sqrt{1 + \left(\frac{2\sigma_m S_e}{S_{ut}\sigma_a}\right)^2}\right]$$

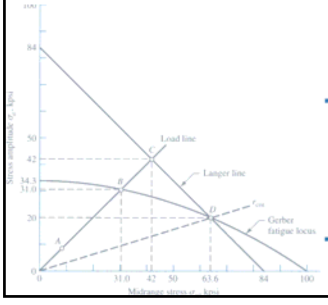


Table 7–16

Amplitude and Steady Coordinates of Strength and Important Intersections in First Quadrant for DE-Elliptic and Langer Failure Loci

Intersecting Loci	Intersection Coordinates
$\left(\frac{S_a}{S_e}\right)^2 + \left(\frac{S_m}{S_y}\right)^2 = 1$	$S_a = \sqrt{\frac{r^2 S_e^2 S_y^2}{S_e^2 + r^2 S_y^2}}$
Load line $r = S_a/S_m$	$S_m = \frac{S_a}{r}$ **(Point B)**
$\frac{S_a}{S_y} + \frac{S_m}{S_y} = 1$	$S_a = \frac{rS_y}{1+r}$
Load line $r = S_a/S_m$	$S_m = \frac{S_y}{1+r}$ **(Point C)**
$\left(\frac{S_a}{S_e}\right)^2 + \left(\frac{S_m}{S_y}\right)^2 = 1$	$S_a = 0,\ \frac{2}{S_y\left(1/S_e^2 + 1/S_y^2\right)}$ **(Point D)**
$\frac{S_a}{S_y} + \frac{S_m}{S_y} = 1$	$S_m = S_y - S_a,\ r_{crit} = S_a/S_m$

Fatigue factor of safety

$$n_f = \sqrt{\frac{1}{(\sigma_a/S_e)^2 + (\sigma_m/S_y)^2}}$$