ARP Bolt Fatigue

This bolt is a good display of the noticeable difference between the fatigue crack surface and the final fracture surface. Also notice that the crack started on the inside of the bolt and propagated toward the surface until final fracture occurred.

Endurance limit:

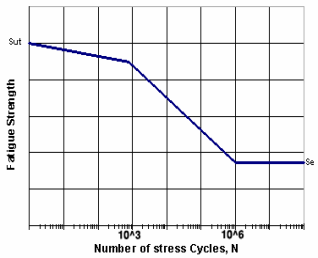
ENGLISH	$S'_e = 0.504 S_{ut}$ ksi	$S_{ut} \le 200$ ksi
	$S'_e = 100$ ksi	$S_{ut} > 200$ ksi
METRIC	$S'_e = 0.504 S_{ut}$ MPa	$S_{ut} \le 1400$ MPa
	$S'_e = 700$ MPa	$S_{ut} > 1400$ MPa

Modified endurance limit:

$$S_e := k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot S_{eprime}$$

Modifying factors:

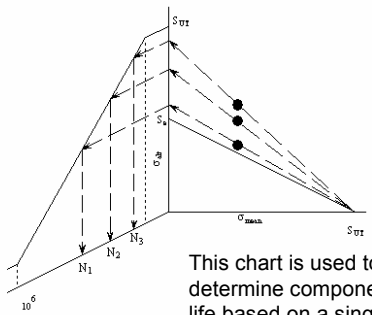
k_a	Surface Condition	$k_a = a \cdot S_{ut}^b$	Eq. 7-14 Table 7-4
k_b	Size	$k_b = 1$ Axial Loading $k_b = \left(\frac{d}{0.3}\right)^{-0.1133}$ $0.11 \le d \le 2$ in $k_b = \left(\frac{d}{7.62}\right)^{-0.1133}$ $2.79 \le d \le 51$ mm * k_b ranges from 0.60 to 0.75 for larger sizes in bending or torsion.	Eq. 7-15
k_c	Loading	$k_c = 0.923$ Axial $S_{ut} \le 220$ ksi (1520 MPa) $k_c = 1$ Axial $S_{ut} > 220$ ksi (1520 MPa) $k_c = 1$ Bending $k_c = 0.577$ Torsion and Shear	Eq. 7-22
k_d	Temperature	$k_d = \frac{S_T}{S_{RT}}$	Eq. 7-23 Table 7-5
k_e	Misc. effects	$k_e = \frac{1}{K_f}$	Eq. 7-24



Above is an S-N Diagram.

This bolt displays microvoid coalescence which is attributed to interfacial cracking between inclusions and the surrounding material matrix. This is usually a high energy process that occurs at high crack growth rates.

Pictured is a bent connecting rod, this is an example of the strength and endurance for which ARP connecting rod bolts are designed.



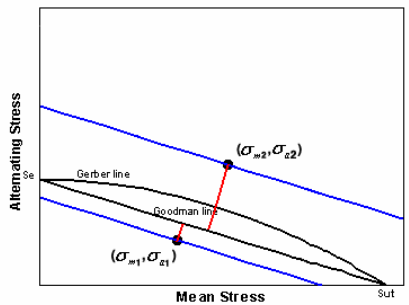
This chart is used to determine component life based on a single loading mode and different alternating stress magnitudes.

$$N = \left(\frac{\sigma_a}{a}\right)^{\frac{1}{b}}$$

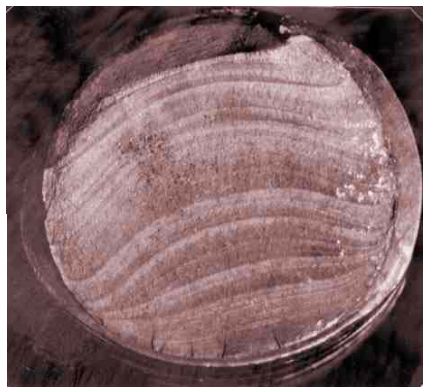
- $a = \frac{(0.9 \cdot S_{ut})^2}{S_e}$
- $b = -\frac{1}{3}\log\left(\frac{0.9 \cdot S_{ut}}{S_e}\right)$

Mean and alternating stresses:

$$\sigma_m := \frac{\sigma_{max} + \sigma_{min}}{2} \qquad \sigma_a := \frac{\sigma_{max} - \sigma_{min}}{2}$$



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



The picture above is a good example of beach mark formations which are indicative of cyclic fatigue failure. If a powerful enough microscope were used, the individual striations would be visible on each beach mark.