Factors that effect fatigue strength:

The **loading on a component effects the fatigue strength of a part**. For example in the rotating beam specimen, an element on the beam "sees" a fully reversed stress state on the top and bottom surfaces of the specimen (for ½ a cycle tension, for ½ a cycle compression). In a bending test, the entire circumference of the beam sees reversed stresses. In these two cases, the fatigue strengths are very close to one another.

However, if an **axial fatigue** test is performed, the entire cross section of the specimen is uniformly stressed. Do you think an axial load would produce fatigue strengths higher or lower than a bending load? Why?

How about **torsion**? Would you guess that a component under pure torsion would have higher or lower fatigue strengths than a component under bending loads?

Size of a part also impacts the fatigue strength. Larger parts fail at lower stresses than smaller parts? Why?

Surface treatments effect fatigue strength. Why would smoother surfaces endure higher stresses for a greater number of stress cycles?

Temperature effects fatigue strength. At high temperatures the endurance limit for steels "disappears"; i.e., the fatigue strength continues to decline after 1000000 cycles.

Reliability effects fatigue strength. What is reliability? If we produce a component using quality control procedures that yields no more than 10 failed parts in 100, then the reliability is 90%. If the requirement is to produce no more than 1 failed part in 100, then the reliability is 99%. Why would fatigue strength be reduced with increased reliability?

Environment effects fatigue strength. It makes perfect sense that the fatigue strength of a component would be higher in a dry, non-corrosive environment than it would be in an environment exposed to salt water for example.

How do we account for all of these factors? Each of the factors below will multiply the endurance limit (S_e) of the material (for example, the endurance limit of most steels is computed to be ½ S_{ut} if $S_{ut} < 200$ ksi; if $S_{ut} \geq 200$ ksi, use an endurance limit of 100 ksi). **The fatigue strength of steel is approximately 0.9Sut at 1000 cycles**. If the machine component is **loaded axially**, then the **fatigue strength at 1000 cycles is approximately 0.75 S_{ut}.**

Loading:

For bending loads using a Marin factor of 1.0
For axial loads use a Marin factor of 0.70
For torsional loads will be handled those using von Mises equivalent stresses

Size effects:

For components with circular cross sections:

if $d \leq 0.3$ inches (8mm)	$k_{size} = 1.0$
$0.3 \leq d \leq 10$ inches	$k_{size} = 0.869d^{(-.097)}$
$8 \text{ mm} \leq d \leq 250 \text{ mm}$	$k_{size} = 1.189d^{(-.097)}$

For parts that are not circular in cross section, an equivalent diameter may be computed using the following :

$$A_{95} = 0.0766d^2$$

$$d_{equiv} = \sqrt{\frac{A_{95}}{0.0766}}$$

Page 284, Shigley and Mischke, gives equivalent diameters for some common cross-sections (solid round, rectangle, c-channel, and I-beam).

Surface treatments

Use a Marin factor computed as follows:

$K_{surface} = A(Sut)^b$

A and b are given on page 283 of Shigley and Mischke, and include ground, machined or cold drawn, hot-rolled, and As-forged surface finishes.

Temperature effects

Use the following Marin factors for temperature (good for steels only!)

$T \leq 450°$ C (840°F)	$K_{temp} = 1.0$
$450°C \leq T \leq 550°C$	$k_{temp} = 1 - 0.0058(T-450°)$
$840°F \leq T \leq 1020°F$	$k_{temp} = 1 - 0.0032(T-840°)$

Reliability

Use the following Marin factors for reliability

50% reliability	$k_{reliab} = 1.000$
90%	$k_{reliab} = 0.897$
99%	$k_{reliab} = 0.814$
99.9%	$k_{reliab} = 0.753$
99.99%	$k_{reliab} = 0.702$
99.999%	$k_{reliab} = 0.659$

Environmental

If a steel is exposed to fresh water begin with an endurance limit of 15 ksi.

Example:

Create an S-N diagram for a steel, axially loaded and define its equations. How many cycles of life can be expected if the alternating stress is 100 M Pa? Assume a reliability of 99.9%

S_{ut} = 600 M Pa
Hot Rolled finish
150 mm square cross-section
Operating in environment of 500°C