# ENDURANCE LIMIT MODIFYING FACTORS

FOR A REAL PART, THE MEASURED ENDURANCE LIMIT MUST BE MODIFIED TO REFLECT A REAL PART OPERATING IN A REAL ENVIRONMENT. THIS CAN BE ACCOMPLISHED THROUGH MARIN'S EQUATION, WHICH IS WRITTEN AS

$$S_e = k_a k_b k_c k_d k_e S_e'$$

WHERE $k_a$ = SURFACE FACTOR
$k_b$ = SIZE FACTOR
$k_c$ = LOAD FACTOR
$k_d$ = TEMPERATURE FACTOR
$k_e$ = RELIABILITY FACTOR

} MARIN FACTORS

$S_e'$ = ROTARY-BEAM TEST SPECIMEN ENDURANCE LIMIT
$S_e$ = ENDURANCE LIMIT AT THE CRITICAL LOCATION OF A MACHINE PART IN THE GEOMETRY AND CONDITION OF USE

## SURFACE FACTOR, $k_a$

ACCOUNTS FOR INCREASED SUSCEPTIBILITY TO FATIGUE WHEN SURFACE FINISHES ARE ROUGH.

$$k_a = a S_{ut}^b$$

, WHERE a AND b ARE CURVE FIT PARAMETERS THAT DEPEND ON YOUR SURFACE FINISH (i.e. GROUND, MACHINED, HOT-ROLLED, AS-FORGED)

## SIZE FACTOR, $k_b$

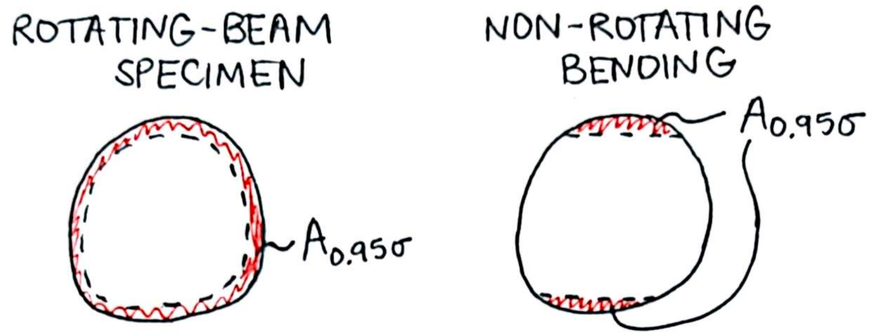
ACCOUNTS FOR LARGER NUMBER OF POTENTIAL FATIGUE INITIATION SITES AS PARTS INCREASE IN SIZE.

FOR BENDING OR TORSION:

$$k_b = \begin{cases} (d/0.3)^{-0.107} = 0.879d^{-0.107} & 0.3 \le d \le 2 \text{ in} \\ 0.91d^{-0.157} & 2 < d \le 10 \text{ in} \\ (d/7.62)^{-0.107} = 1.24d^{-0.107} & 7.62 \le d \le 51 \text{ mm} \\ 1.51d^{-0.157} & 51 < d \le 254 \text{ mm} \end{cases}$$

FOR AXIAL, $k_b = 1$

THESE EQUATIONS FOR $k_b$ ASSUME A ROUND ROTATING SPECIMEN IN BENDING OR TORSION. FOR OTHER SCENARIOS, WE NEED TO FIND AN EQUIVALENT DIAMETER TO USE. THE EQUIVALENT DIAMETER, $d_e$ IS FOUND BY EQUATING THE VOLUME OF MATERIAL STRESSED AT AND ABOVE 95% OF THE MAXIMUM STRESS TO THE SAME VOLUME IN THE ROTATING-BEAM SPECIMEN.




SEE TABLE 6-3 IN SHIGLEY FOR EFFECTIVE DIAMETERS OF VARIOUS GEOMETRIES

## LOAD FACTOR, $k_c$

ACCOUNTS FOR DIFFERENT STRESS DISTRIBUTIONS IN BENDING VS. AXIAL VS. TORSIONAL LOADING, AND DIFFERENT STRENGTH VALUES IN SHEAR VS. NORMAL.

$$k_c = \begin{cases} 1 & \text{BENDING} \\ 0.85 & \text{AXIAL} \\ 0.59 & \text{TORSION} \end{cases}$$

## TEMPERATURE FACTOR, $k_d$

ACCOUNTS FOR CHANGES IN STRENGTH AND DUCTILITY WITH CHANGES IN TEMPERATURE.

- IF YOU HAVE $S_e'$ AT THE OPERATING TEMPERATURE FOR YOUR PART, USE THAT AND LET $k_d = 1$.
- IF YOU HAVE $S_e'$ AT ROOM TEMPERATURE AND NEED TO ADJUST FOR THE OPERATING TEMPERATURE, USE

$$k_d = S_T / S_{RT}$$

WHERE $S_T$ AND $S_{RT}$ ARE THE ULTIMATE STRENGTHS AT OPERATING TEMPERATURE AND ROOM TEMPERATURE, RESPECTIVELY.

FOR STEELS,

$$S_T/S_{RT} = 0.98 + 0.35(10^{-4})T_F - 6.3(10^{-7})T_F^2 \qquad 70°F \le T_F \le 1000°F$$

$$S_T/S_{RT} = 0.99 + 0.59(10^{-4})T_C - 2.1(10^{-6})T_C^2 \qquad 20°C \le T_C \le 550°C$$

- IF YOU ONLY HAVE $S_{RT}$, USE THE ABOVE TO ESTIMATE $S_T$ AND THEN LET $S_e' = 0.5 S_T$ (FOR $S_T \le 200$ ksi) WITH $k_d = 1$.

## RELIABILITY FACTOR, $k_e$

ADJUSTS ENDURANCE LIMIT ESTIMATE TO CAUSE FEWER DATA POINTS TO LIE BELOW THE ESTIMATED VALUE.

$$k_e = 1 - 0.08\, z_\alpha$$

WHERE $z_\alpha$ IS TRANSFORMATION VARIATE FOR A NORMAL DISTRIBUTION.

$$z_\alpha = \frac{x - \mu_x}{\hat{\sigma}_x}$$

AND VALUES FOR ANY DESIRED RELIABILITY CAN BE DETERMINED FROM TABLES IN SHIGLEY (TABLE A-20 AND/OR TABLE 6-4).

## MISCELLANEOUS EFFECTS

ANY NUMBER OF ADDITIONAL FACTORS COULD BE INCLUDED AS ADDITIONAL MULTIPLIERS IN THE MARIN EQUATION ($k_f$, $k_g$, etc.). A FEW EFFECTS THAT MAY WARRANT AN ADDITIONAL MARIN FACTOR ARE LISTED BELOW:

- RESIDUAL STRESSES
- DIRECTIONAL CHARACTERISTICS
- CORROSION
- ELECTROLYTIC PLATING
- METAL SPRAYING
- CYCLIC FREQUENCY
- FRETTAGE CORROSION