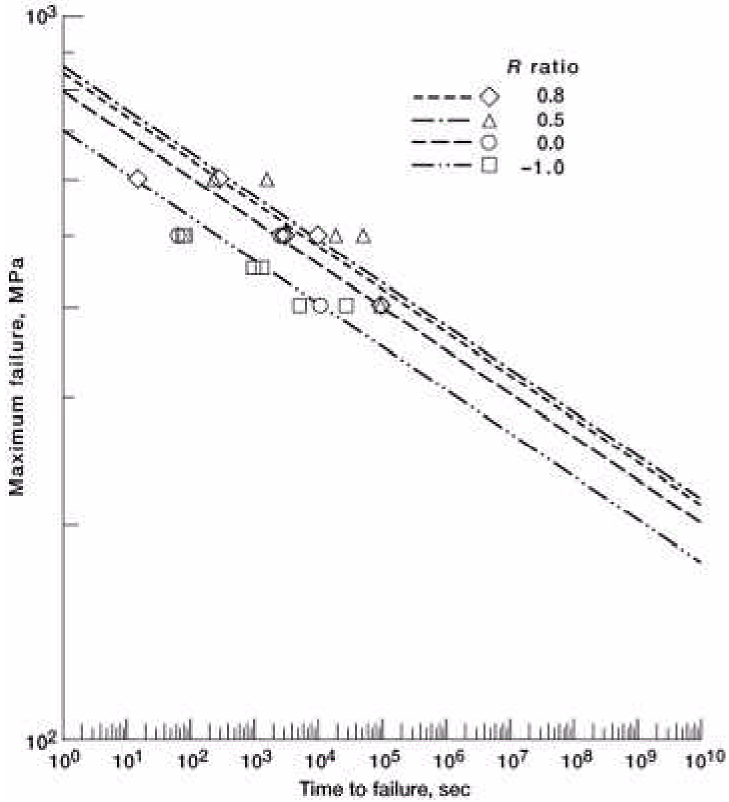
CARES/*Life* Ceramics Durability Evaluation Software Enhanced for Cyclic Fatigue

The CARES/*Life* computer program predicts the probability of a monolithic ceramic component’s failure as a function of time in service. The program has many features and options for materials evaluation and component design. It couples commercial finite element programs--which resolve a component's temperature and stress distribution--to reliability evaluation and fracture mechanics routines for modeling strength-limiting defects. The capability, flexibility, and uniqueness of CARES/*Life* have attracted many users representing a broad range of interests and has resulted in numerous awards for technological achievements and technology transfer.

Recent work with CARES/*Life* was directed at enhancing the program’s capabilities with regards to cyclic fatigue. Only in the last few years have ceramics been recognized to be susceptible to enhanced degradation from cyclic loading. To account for cyclic loads, researchers at the NASA Lewis Research Center developed a crack growth model that combines the Power Law (time-dependent) and the Walker Law (cycle-dependent) crack growth models. This combined model has the characteristics of Power Law behavior (decreased damage) at high R ratios (minimum load/maximum load) and of Walker law behavior (increased damage) at low R ratios. In addition, a parameter estimation methodology for constant-amplitude, steady-state cyclic fatigue experiments was developed using nonlinear least squares and a modified Levenberg-Marquardt algorithm. This methodology is used to give best estimates of parameter values from cyclic fatigue specimen rupture data (usually tensile or flexure bar specimens) for a relatively small number of specimens. Methodology to account for runout data (unfailed specimens over the duration of the experiment) was also included.



Median regression lines for partially stabilized zirconia tensile specimens with various R-ratios (combined law model).

The preceding graph shows an example of this regression technique for tensile specimen data for partially stabilized zirconia. Data for various *R* ratios and their corresponding median regression lines are shown for the combined fatigue law model. Note that at lower *R* ratios (0 and -1) the combined law predicted increased material strength degradation, whereas at higher *R* ratios (0.5 and 0.8) this trend was reversed.

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