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Statistical Model Calibration of Lifetime Models with Failure and Censored Life Testing Data

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Abstract

The physics-based modeling approach helps assess a lifetime distribution of electronic products, predict potential safety risks, and calculate warranty and maintenance costs. Statistical model calibration can be used to build a high fidelity model. However, the adoption of a probabilistic physics-based modeling approach by the industry is still slow. We identified two challenges. First, the probabilistic modeling approach typically relies on Monte Carlo simulation in calculating the life distribution, which is time-consuming and computationally-expensive. Second, accelerated life testing commonly produces censoring data. In order words, tests can be terminated before failing all the samples. Information of time-to-failure is not available for some samples. To overcome the challenges, in this study, we propose a novel model calibration approach that is based on the eigenvector dimensional reduction (EDR) method, which is known to be an efficient algorithm for uncertainty propagation when multiple unknown variables exist. Uncertainty in multiple variables of the damage model for solder joints is propagated by the EDR. The response of the damage model is compared to the experimental data. Then, the discrepancy between the simulation and the experimental data is quantified using the likelihood function, which is modified to incorporate the information of censored data as well as failure data. The distributions of the unknown variables are optimized until the likelihood metric is minimized. An example of chip resistor assemblies with solder fatigue failure is employed to demonstrate the effectiveness of the proposed approach.