

## A Bathtub Curve from Nonparametric Model

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**Abstract :** This paper presents a nonparametric method to obtain the hazard rate “Bathtub curve” for power system components. The model is a mixture of the three known phases of a component life, the decreasing failure rate (DFR), the constant failure rate (CFR) and the increasing failure rate (IFR) represented by three parametric Weibull models. The parameters are obtained from a simultaneous fitting process of the model to the Kernel nonparametric hazard rate curve. From the Weibull parameters and failure rate curves the useful lifetime and the characteristic lifetime were defined. To demonstrate the model the historic time-to-failure of distribution transformers were used as an example. The resulted “Bathtub curve” shows the failure rate for the equipment lifetime which can be applied in economic and replacement decision models.

**Keywords :** bathtub curve, failure analysis, lifetime estimation, parameter estimation, Weibull distribution

**Conference Title :** ICENE 2014 : International Conference on Electrical and Nuclear Engineering

**Conference Location :** Venice, Italy

**Conference Dates :** June 19-20, 2014