Failure Data Review and Statistical Analysis

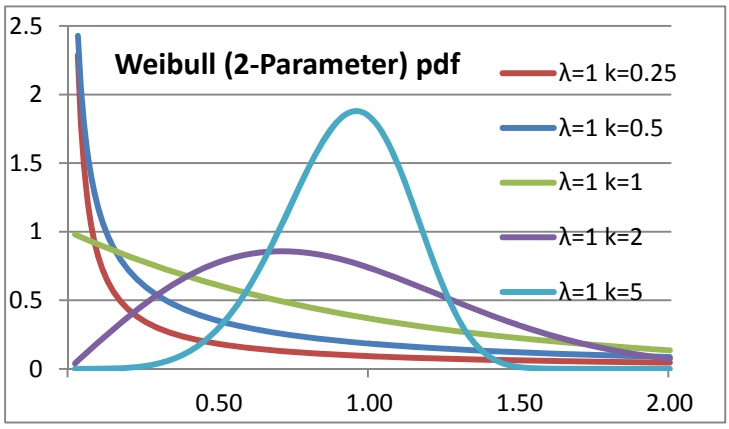
What is it?

Failure data review and statistical analysis, is an important tool, widely used in the manufacturing and engineering industries, for the development of new products/components and for the improvement of existing products/components.

Failure analysis can be used to identify trends and isolate probable causes of breakdowns. It can be used to identify manufacturing and design problems and predict future failure occurrences, and/or improve the performance of the component.

The failure data review process uses collected operational experience data to perform analysis of observed failures. Failures can be categorised by cause and failure mode to help identify patterns in the data. Statistical distributions can be used to model the product/component lifetime, thus providing a summary of the operational experience, which can be used as an input to more complex models such as those used in Reliability, Availability, Maintainability and Safety (RAMS) studies.

Predictions are made about the life-time of a particular component/product in a population by fitting a statistical distribution from a representative sample. Once a parameterised distribution has been fitted, various reliability characteristics are implied, such as instantaneous failure probability, mean lifetime, mean time between failures (MTBF) and lifetime variance.



There are several statistical distributions which can be used to model lifetimes. The choice of distribution depends on a number of factors, including type of common failure modes, extent of operating experience, simplicity and goodness-of-fit requirements and software restrictions. An example of a simple distribution is the exponential distribution. This constant failure model is ideal for modelling the flat section of the bathtub curve. A more complex distribution such as Weibull is better suited to lifetime distributions (modelling wear-in and wear-out periods).

Why is it important?

Statistical analysis is a vital first step to produce parameter estimates that can be used within a larger study, such as RAMS or Quantitative Risk Assessment (QRA)/Probabilistic Safety Assessment (PSA).

Other purposes include:

- To highlight features of the design which represent a significant risk of failure; this may lead to a revision of the product specification.

- A standalone analysis of failure data can be used to provide evidence of a system meeting a particular level of reliability. The analysis can be used as evidence that industry specific standards are being met, such as those used for Rail (EN-50126/8/9), Petrochemical (ISO 14224), or Defence (DEF STAN 00-40 series).
- To provide inputs to other studies, such as design reviews and evaluations, cost-benefit analysis, life cycle costing, maintenance support, logistics studies and safety analyses.
- To ascertain whether production methods have adversely affected reliability.

What we do

CRA has considerable experience in analysing component failures for hazardous industries. In particular CRA is a leader in the analysis of failure data in the UK nuclear industry.

- Review and analyse operating experience for component failures. This includes allocation for different failure types and degradation assessment.
- Access trusted generic industry databases to assign failure rates/probabilities to components.
- Model component lifetimes using statistical distributions such as exponential, gamma and Weibull distributions.
- Analyse time series data for evidence of trends.
- Deriving common cause failure probabilities from operating experience for various components. Common cause failure is often a limiting factor in the reliability of a system. This involves categorising events according to fault degradation level to increase the amount of data used to derive probability values.
- Use Bayesian Inference to derive failure rates/probabilities from different datasets.

Our work

CRA has extensive experience in analysing component failure data. This work has included:

- Numerous component reliability reviews for UK nuclear power stations. This entails reviewing industry data for appropriate sources of reliability values, analysing operating experience in order to identify component failures, performing Bayesian analysis to establish prior and posterior failure distributions and reviewing the posterior distribution against the source data to ensure that a suitable source has been used.
- Application of empirical Bayes theorem and pooling of data across categories to produce better estimates of low frequency precursors in the UK Rail Safety Risk Model.
- We have developed common cause failure methodologies, tailored to the needs of industry and offer training courses on this subject.