A Survey of the Currently Available Reliability Prediction Models

Reliability Prediction Models: The Current Landscape of Choices

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What Is a Reliability Prediction Model?

Reliability engineers use Reliability Prediction Models to evaluate the failure rate or MTBF of a series system based on the components of the system. The Prediction Model provides mathematical equations that determine the predicted failure rate by assigning a variety of parameters to the components. In the failure rate calculation for each part type, the Prediction Model generally uses the same factors (environment, temperature, quality, and electrical stress), although these factors are weighted differently in each Prediction Model.

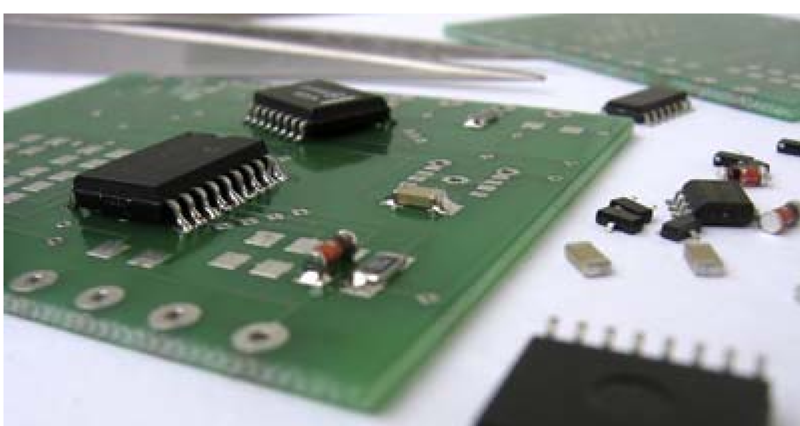
All of the Prediction Models include the primary component types: Integrated Circuits, Transistors, Diodes, Resistors, and Capacitors. However, the predicted failure rate of these core part types will vary depending on the Prediction Model used, because each standard uses different data sources to construct the equations for the component models.

Types of Reliability Prediction Analyses

Within a Reliability Prediction Model there may be two types of analyses – the Parts Count Analysis and the Part Stress Analysis.

The Parts Count Analysis is generally used in the early design stage of a project when exact parts and part parameters have not yet been identified. This Analysis type uses generic failure rates for various part types given an operating environment and temperature and then multiplies them by a quality factor.

The models for the Part Stress Analysis are much more detailed and are typically used later in the development stage when most of the components and operating conditions have been identified. The engineer must have detailed information for each component in a design to determine the parameters needed to perform a Part Stress Analysis. In a Part Stress Analysis, temperature and electrical stress become important factors in predicting the part failure rate.



When the components and operating conditions are identified, a more

detailed Part Stress Analysis can be performed.

Available Prediction Models

You can choose from a number of different Prediction Models when performing a Reliability Prediction Analysis of your system. Here are a few of the more popular Prediction Models currently used worldwide.

MIL-HDBK-217

MIL-HDBK-217, The Military Handbook *Reliability Prediction of Electronic Equipment*, created by the United States Department of Defense, is one of the original prediction standards designed to provide models for various types of electronic devices. This Model allows you to perform both a Part Stress Analysis and a Parts Count Analysis and is widely used by the defense industry and by commercial companies throughout the world.

MIL-HDBK-217 supports the five most commonly used environments in the telecom industry (Ground Fixed Controlled, Ground Fixed Uncontrolled, Ground Mobile, Airborne Commercial, and Space) plus additional choices useful in the military environment. The latest version is MIL-HDBK-217 (Revision F Notice 2).

$$\lambda_p = \lambda_b \pi_T \pi_P \pi_S \pi_Q \pi_E \text{ Failures / } 10^6 \text{ Hours}$$

The equation for the failure rate (λ_p) of a resistor as defined in MIL-HDBK-217.

Telcordia (Bellcore)

The Telcordia Prediction Model (*Reliability Prediction Procedure for Electronic Equipment SR-332*) was developed by AT&T Bell Labs. This Model (previously known as Bellcore) modified the MIL-HDBK-217 Prediction Model to better represent the equipment of the telecommunication industry by adding the ability to take into account burn-in, field, and laboratory test data. Although the Telcordia standard was developed specifically for the telecom industry, it is used to model products in a number of other industries, both military and commercial.

Telcordia offers the ability to perform a Part Stress Analysis and a Parts Count Analysis based on Calculation Methods. Telcordia offers 10 different Calculation Methods designed to account for different information. The Telcordia Prediction Model was designed to calculate the failure rates in FITs (or failures in time). The older versions provide failure rates based on a 90% upper confidence interval value. The newest version, Telcordia Issue 2, contains the predicted failure rate calculation of the mean failure rate of the component with associated standard deviations at the upper confidence levels at any desired level of confidence.

Telcordia Prediction supports only the five most commonly used environments in the telecom industry (Ground Fixed Controlled, Ground Fixed Uncontrolled, Ground Mobile, Airborne Commercial, and Space).

Mechanical Model

The Mechanical Prediction Model was developed by the United States Navy and provides Part Stress Analysis models for various types of mechanical devices. The latest release of the Mechanical Prediction Model is *The Handbook of Reliability Prediction Procedures for Mechanical Equipment (NSWC-98/LE1)*. Examples of some of the mechanical devices that have reliability models are springs, bearings, seals, motors, and brakes. The Mechanical Prediction Model is normally used in both the military industry and commercial companies.

Mechanical components are much more sensitive to stress-related failure mechanisms that result in equipment degradation.

The failure rates of mechanical components differ from those of electronic components in that they are not usually described by a constant failure rate. The Mechanical Model considers many different variables that affect component reliability, including material properties, operating environment, and critical failure modes. The models for mechanical components must take into account stress levels, total operating hours, and total failures, because mechanical components are much more sensitive to impact loading, operating mode, and utilization rate, as well as wear, fatigue, and other stress-related failure mechanisms that result in equipment degradation.

PRISM

The PRISM Prediction Model (*PRISM Reliability Prediction Methodology*) was originally developed by the Reliability Analysis Center (RAC). This Model considers the inherent failure mechanisms of the components of the system. PRISM also allows you to use a number of other factors that affect the reliability, including process grading factors, empirical data from a predecessor system, and Bayesian analysis techniques. In addition, laboratory and field test data can be factored into the analysis using the PRISM model.

PRISM incorporates the NPRD/EPRD database of failure rates, which were obtained by gathering test data of components from various sources. The PRISM Prediction Model was designed to support both military and commercial products.

217Plus

The 217Plus model was developed by the Reliability Information Analysis Center (RIAC), a Department of Defense Information Analysis Center sponsored by the Defense Technical Information Center. The 217Plus Prediction Model is based on the *RIAC-HDBK-217Plus, Handbook of 217Plus Reliability Prediction Models* and is the next generation of the PRISM model, containing twice the number of component models.

The 217Plus Model includes both the Parts Count and Part Stress Analyses and supports process grades, predecessor data, and Bayesian analysis. 217Plus also incorporates the NPRD/EPRD database of failure rates. In addition, laboratory and field test data can be factored into the prediction analysis.

217Plus was designed for the military industry and for commercial companies, and provides 37 environments that are a mix of commercial and military locations.

HRD5

The HRD5 Prediction Model was developed by British Telecommunications and is the fifth issue of the *Handbook of Reliability Data for Electronic Components Used in Telecommunications Systems*. HRD5 was designed for the telecom industry but is often used to model products in other industries.

HRD5 provides simple models requiring fewer data parameters for analysis than some other Prediction Models. The failure rate models allow the effect of different factors to be used, including operating environment and the effect of the junction temperature.

The failure rates shown in the HRD5 model are in FITs and are given as estimates of the upper 60% confidence level values. They are based on data collected from the service performance of equipment installed in primarily inland telecommunication networks.

RDF 2000

The RDF 2000 Prediction Model is a French Telecom standard that was developed by the Union Technique de l'Ectricite (UTE). A newer version of the CNET 93 standard, this Model is similar to MIL-HDBK-217 in that it provides a detailed stress analysis. However, it does not include a Parts Count Analysis. The RDF 2000 model is used in the telecom, commercial, and military industries.

RDF 2000 uses cycling profiles and their applicable phases to provide a completely different basis for the reliability analysis. The component failure rate contains a base failure rate multiplied by factors influenced by mission profiles. These mission profiles contain information about operational cycling and thermal variations during various working phases. The phases of the cycling profile that are considered are the on/off working phase, the permanent working phase, and the storage or dormant phase.

IEC 62380

The IEC 62380 Prediction Model (*IEC TR 62380/RDF 2000, Reliability Data Handbook - Universal Model for Reliability Prediction of Electronic Components, PCBs, and Equipment*) was created by the International Electrotechnical Commission in Europe. The IEC 62380 Model was designed for the telecom industry, but is widely used in other industries.

Like RDF 2000, the IEC 62380 Prediction considers cycling profiles and their applicable phases when determining the failure rate. However, the IEC 62380 Prediction defines a new approach to failure rate modeling that utilizes a distinctive method for handling PCBs.

The IEC 62380 Prediction Model was created for the telecommunications industry, but is used in a variety of industries.

GJB/z 299C

The GJB/z 299C Prediction Model, *The Reliability Calculation Model for Electronic Equipment*, is a Chinese standard developed for the Chinese military and is similar to MIL-HDBK-217. You can do both a Parts Count and Part Stress Analysis with the GJB/z 299C model. Although 299C was developed for military applications, it is often used in commercial applications.

The 299C Prediction Model is somewhat unique from other Prediction Models because it contains separate models for components from foreign manufacturers in both the Parts Count and Part Stress Analyses.

Siemens SN29500

The Siemens SN29500 Prediction Model was developed by Siemens AG in Germany and encompasses failure rate Prediction Models for a broad base of components. The SN29500 v1 model consists of several separate Siemens documents that have been packaged together as a standard.

The Siemens SN29500 model is based on IEC 61709, *Electronic Components - Reliability - Reference Conditions for Failure Rates and Stress Models for Conversion*. It provides frequently updated failure rate data at reference conditions, as well as the Parts Count and Part Stress models necessary for reliability predictions. The reference conditions adopted are typical for the majority of applications of components in systems. If operating conditions differ significantly from reference conditions, this model supports converting the failure rate data at the reference conditions to actual operating conditions.

FIDES

The FIDES Prediction Model (*FIDES Guide 2004 Issue, A Reliability Methodology for Electronic Systems*) was designed by the FIDES Group, a consortium of European companies from the aeronautics and defense fields, to apply to all domains using electronics, including the military, commercial industry, and telecommunications.

The FIDES Prediction Model provides models for electrical, electronic, and electromechanical components with consideration of all technological and physical factors. The FIDES Prediction Model considers the mission profile, electrical, mechanical, and thermal overstresses and the failures linked to the development, production, field operation, and maintenance processes.

The FIDES methodology is based on the physics of failure and supported by the analysis of test data, field returns, and existing modeling. This makes it different from traditional prediction methods.

Conclusion

The Prediction Model you choose should be based on a wide array of factors specific to your application. The “best” standard to use depends on your particular situation and requirements. By understanding the underlying similarities and differences between the Prediction Models, you will be able to select the best model for your needs.

Relex Reliability Prediction is a premier out-of-the-box reliability prediction analysis software tool offering all the capabilities you need for efficient reliability prediction analysis. Relex supports all available globally accepted standards for reliability prediction analysis, and offers the ability to combine standards and useful standard-specific features. The comprehensive Prediction Parts Libraries included make prediction analyses immeasurably easier and more efficient by providing instant access to a wide-ranging database of component information. Extensive analysis options, customizable reports and graphs, seamless data integration, and many other features give you the power to improve product design, streamline your system architecture, and produce more reliable products with confidence.