Reliability Prediction Terms

Definitions for Ten Commonly Used Reliability Prediction Terms

Of the many tools available for performing reliability analysis, one of the most fundamental and widely accepted tools used early in the design process is reliability prediction analysis. The primary goals of a reliability prediction are to provide an upfront estimate of a product's reliability and identify problem areas for correction, elimination, or mitigation. Reliability predictions are generally begun during the early design phase of a product lifecycle and then updated as the design matures.

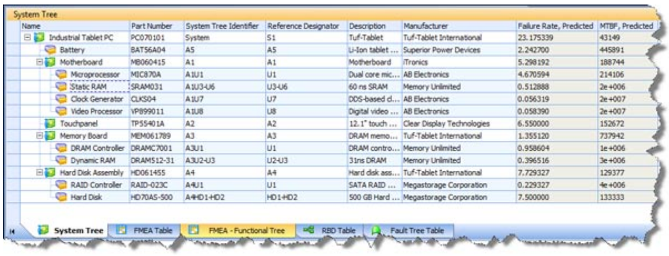
On the input side, the analyst defines the system and its components along with various data parameters which affect reliability. With this information, resulting failure rates (average failures over a time range), MTBF (mean time between failures), and various other reliability metrics can be computed. These computations are done using any one, or a combination of, globally accepted standards for reliability prediction analysis.

To better understand how to use and apply reliability prediction analysis, it is important to learn some of the key terms used in this reliability engineering methodology. This reference document covers some of the key terms that you need to know.

1. System

In basic terms, a system refers to an interdependent group of items which together perform a function. A complete system includes all equipment, related facilities, material, software, services, and personnel required for operation. When used in reliability prediction analysis, a system refers to the electronic, mechanical, and electro-mechanical components of a product. The term "system," for reliability prediction purposes, typically refers to the hardware components that comprise a product. However, at the discretion of the analyst, software that is part of the operation of the system may also be included.

A system is usually defined in a hierarchical manner. An example of a system would be a laptop computer, composed of a power supply, motherboard, graphics card, display screen, keyboard, etc. This could then be further broken down into sublevels, and then further down until the system is broken down into individual parts or components. For example, the components of the motherboard may be a microprocessor, memory chips, and various other integrated circuits. The number of levels between the topmost "system" and the lowest level components is dependent on the system itself and how the analyst wants to break down the system for analysis. Alternatively, in some cases, analysts may decide not to break the system down to the component level, but to some higher subassembly level. For example, this would be applicable for a system integrator who purchases assemblies from a vendor and does not need to consider a complete parts level breakdown of these COTS (commercial off-the-shelf) units.



System Tree

Name	Part Number	System Tree Identifier	Reference Designator	Description	Manufacturer	Failure Rate, Predicted	MTBF, Predicted
Industrial Tablet PC	PC070101	System	S1	Tuf-Tablet	Tuf-Tablet International	23.175339	43149
Battery	BAT56A04	A5	A5	Li-Ion tablet ...	Superior Power Devices	2.242700	445891
Motherboard	MB060415	A1	A1	Motherboard	iTronics	5.298192	188744
Microprocessor	MIC870A	A1U1	U1	Dual core mic...	AB Electronics	4.670594	214106
Static RAM	SRAM031	A1U3-U6	U3-U6	60 ns SRAM	Memory Unlimited	0.512888	2e+006
Clock Generator	CLKS04	A1U7	U7	DDS-based d...	AB Electronics	0.056319	2e+007
Video Processor	VP899011	A1U8	U8	Digital video ...	AB Electronics	0.058390	2e+007
Touchpanel	TP55401A	A2	A2	12.1" touch ...	Clear Display Technologies	6.550000	152672
Memory Board	MEM061789	A3	A3	DRAM memo...	Tuf-Tablet International	1.355120	737942
DRAM Controller	DRAMC7001	A3U1	U1	DRAM contro...	Memory Unlimited	0.958604	1e+006
Dynamic RAM	DRAM512-31	A3U2-U3	U2-U3	31ns DRAM	Memory Unlimited	0.396516	3e+006
Hard Disk Assembly	HD061455	A4	A4	Hard disk ass...	Tuf-Tablet International	7.729327	129377
RAID Controller	RAID-023C	A4U1	U1	SATA RAID ...	Megastorage Corporation	0.229327	4e+006
Hard Disk	HD70AS-500	A4HD1-HD2	HD1-HD2	500 GB Hard ...	Megastorage Corporation	7.500000	133333

A *System* is a hierarchical breakdown of all assemblies, subassemblies, components, and parts which comprise your product.

2. Components/Parts

The term component can take on various meanings. However, when used in reliability prediction analyses, the terms component, or part, typically are used to refer to the lowest level electronic device level – an electronic part such as a resistor, capacitor, or transistor. This usage is based on the fact that prediction standards provide failure rate equations for parts. For example, the equation for a prediction standard for a resistor looks like this:

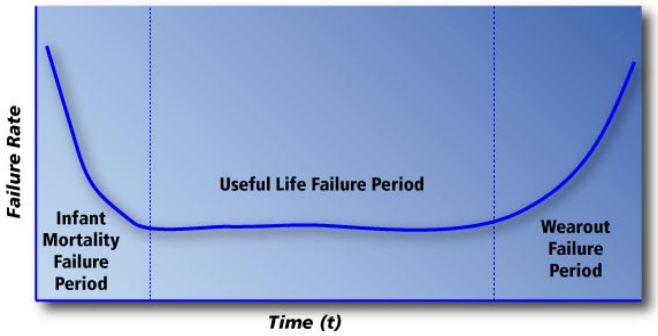
$$\lambda_p = \lambda_b \pi_T \pi_P \pi_S \pi_Q \pi_E \text{ failures per million hours}$$

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

When performing prediction analyses, the lowest level of a system is the "part" level.

3. Bathtub Curve

When considering the failure rate of any item over its lifetime, the graph of the failure rate over time takes on a "U" shape. Because the two ends are sharp and the center is broad, this curve is commonly referred to as the bathtub curve.



The graph of the failure rate of a system over its lifetime, commonly known as the bathtub curve.

The bathtub curve is divided into three general regions. The initial region is when the device is newly in operation. In this timeframe, devices experience what is referred to as infant mortality: failures resulting early in life due to manufacturing defects or other startup issues. Over time, infant mortalities decrease and the failure rate becomes more constant as the device enters the long useful life region of the curve. Lastly, as the device matures, the effects of wearout failures begin to be seen, as noted in the wearout portion of the curve.

4. Infant Mortality Failure Period

Infant mortalities, or early life failures, of products are most commonly due to manufacturing defects, design flaws, installation errors, or incorrect startup procedures. For example, manufacturing defects that may cause an early life failure include poor joints and connections, damaged components, dirt and contamination, and assembly errors.

To reduce infant mortality failures, manufacturers can improve design specifications or production processes. Testing, such as stress screening tests, can be used to identify defects that could lead to failures. These defects are analyzed and corrective actions are taken to remove the root cause of these defects. Testing can also be used to remove defective devices from the supply chain. This process, known as burn-in, is a stress test used to exercise the device, induce an infant mortality failure, and eliminate the defective device before it enters service.

5. Useful Life Failure Period

During the useful life period, the infant mortality failure rate has greatly decreased, and the wearout failure rate is not yet significant. Some failures may still arise from manufacturing defects or premature wearout; however the majority of failures during the useful life of a device are caused by various factors, most significantly, stresses to which the device is subjected. Examples of stresses encountered include temperature, voltage, and environmental factors.

In this timeframe, failure rates are essentially constant. The useful life failure period is the period of most interest from a reliability prediction standpoint. Reliability prediction analysis results compute the predicted failure rates of a system when it is operating in the useful life region of the lifecycle.

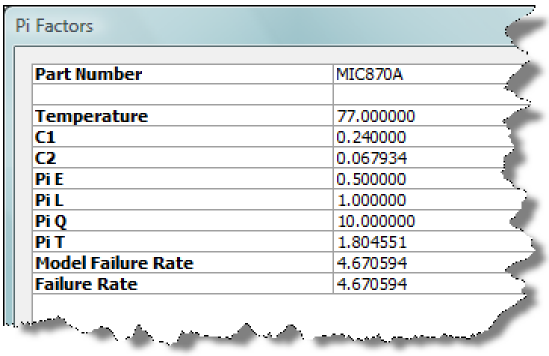
6. Wearout Failure Period

Towards the end of its lifecycle, a device typically experiences failures resulting primarily from the deterioration due to prolonged exposure to operating and environmental stresses. Physical effects of deterioration may include insulation breakdown, wear or fatigue, corrosion, and oxidation. During the wearout failure period, the failure rate increases more rapidly as time goes on.

To reduce wearout failures, maintenance plans are generally put into place. Maintenance policies can involve many processes, such as replacing aged components, performing preventive maintenance actions to keep units in good working order, or monitoring system performance for signs of wear.

7. Prediction Standards

A prediction standard is an established and accepted methodology for computing reliability metrics. Over the years, many prediction analysis standards have been developed by the military and commercial companies across the world for many types of electronic and mechanical components. Prediction standards use mathematical reliability models derived from the statistical analysis of accumulated test or field failure data. Typically, a base failure rate for a particular part type is multiplied by a set of factors, called pi factors, which account for operating stresses which affect failure rate, such as environment, temperature, quality, and electrical stress.


Pi Factors

Part Number	MIC870A
Temperature	77.000000
C1	0.240000
C2	0.067934
Pi E	0.500000
Pi L	1.000000
Pi Q	10.000000
Pi T	1.804551
Model Failure Rate	4.670594
Failure Rate	4.670594

Prediction standards are used to compute component failure rates based on pi factors, or factors which affect the part's failure rate.

Well-known and commonly used prediction standards include:

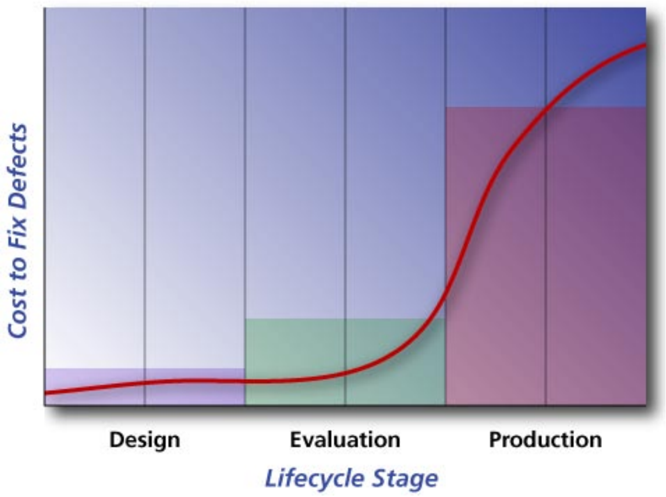
- MIL-HDBK-217
- Telcordia
- PRISM
- 217Plus
- RDF 2000
- HRD5
- IEC TR 62380
- NSWC-98/LE1 Mechanical
- China GJB/z 299
- Siemens SN29500

There are various factors to consider when selecting a prediction standard to employ.

8. Parts Count Analysis

Parts count analysis is used to obtain a very early indication of overall system reliability. Typically performed early on, before detailed system and component information is available, parts count analysis relies on some basic system information for determining system failure rate: the number of total parts (i.e., the parts count), a general failure rate of the components based on average operating stresses, and the operating environment.

Not all prediction standards support a parts count analysis. However, the advantages of looking at reliability early on in design are clear: changes to design are easy at this point, and the cost effectiveness of changing a design early in the process versus after deployment is widely known and documented. Parts count predictions can be an important part of Design for Reliability principles.

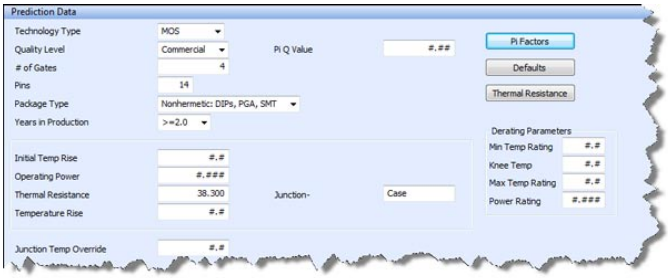


Adopting Design for Reliability principles allows you to correct problems when they can be fixed most cost effectively — early in the design process.

As system design moves further along and more details are available, the parts count analysis is often used as a basis to move into a parts stress analysis.

9. Parts Stress Analysis

Parts stress analysis involves a detailed assessment of a system with all operational, environmental, and device information taken into account. Parts stress analyses involve many steps: defining the system, breaking down the system into component parts, researching data parameters for all component parts, determining operational and other design-specific parameters, and then performing the mathematical analysis. The amount of information needed for a parts stress analysis varies across prediction standards, but typically involves much more than required for a parts count analysis. For example, when doing a parts stress analysis using MIL-HDBK-217 and assessing the failure rate of a single integrated circuit (IC), the data necessary includes:



Parts stress analyses take into account a number of data parameters in order to assess failure rate.

Parts stress analysis is normally used later in the development stage when most of the components and operating conditions have been identified. Parts stress analysis can also support "what-if?" analyses by allowing an analyst to make changes to the prediction model and view the resulting effects of system reliability. For example, the effect of reducing the operating temperatures on certain components may end up significantly reducing failure rate, which would lead to adding heat sinks or fans into a design.

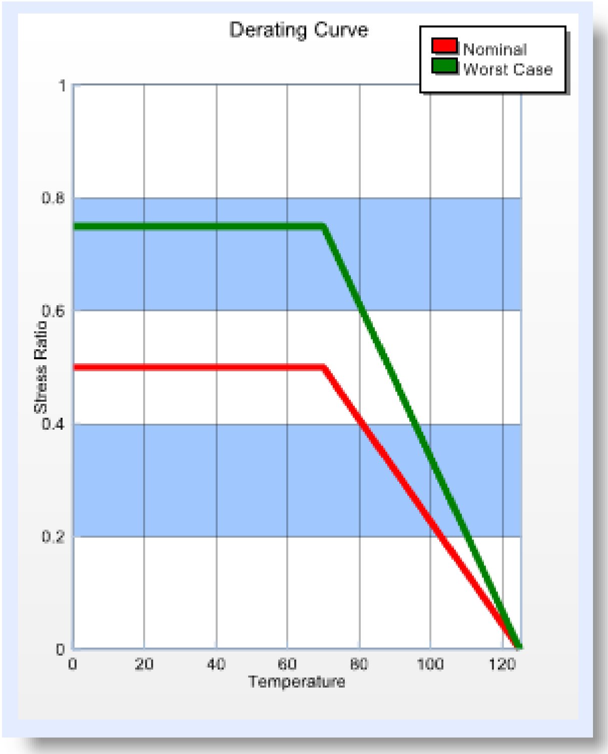
Parts stress analysis also provides failure rate information which may be required to meet contractual requirements, or to satisfy internal reliability objectives.

10. Derating

Derating analysis involves evaluating the stresses applied to components to ensure they are operating within recommended or allowable ranges. The idea behind a derating analysis is that by making sure components are not overstressed, or operating beyond recommended limits, the device will have a lower incidence of failure, as well as have a longer life span.

The results of a derating analysis may be a design modification to reduce the stress level to a particular part, or to replace a highly stressed or overstressed component with a part which has a higher tolerance level. There are various standards used for derating analysis, such as MIL-HDBK-1547, NAVSEA TE000-AB-GTP-010, MIL-STD-975M (NASA), and AS-4613.

In some cases, derating can be defined by an above-or-below cutoff type of evaluation, but for most electronic components, the derating curve must be used to determine if a part is overstressed.



A derating curve is used to determine if a part is overstressed.

Conclusion

These ten terms are some of the many that will aid you in effectively performing reliability prediction analyses. If you would like to learn more about performing reliability prediction, and also discover the best practices for these analyses, you can attend a Relex University Reliability Prediction Best Practices training course. Developed and presented by Relex engineers who have years of experience and widely known expertise in reliability prediction techniques, this course will provide you with the fundamentals you need to effectively set up reliability prediction analyses, analyze results, improve system design, and ultimately increase your system performance. To view a schedule or register for an upcoming Reliability Prediction Best Practices class, visit the Relex Web site.

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.

Learn More

For more information about Relex Reliability Prediction software, please visit **www.relex.com/products/prediction.asp.**