

Reliability Activities And Their Impact On Weibull Shapes

Written by Bill Keeter, CMRP, BK Reliability Engineers, Inc.
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There's been a shift in the maintenance and reliability marketplace towards more analytical software that takes predictive maintenance and equipment history data and then provides optimum solutions for a company's assets.

The Weibull distribution is a widely recognized statistical model created by Swedish-born Waloddi Weibull to describe life distributions. Its primary advantage is that it requires very small amounts of data when compared with other forms of statistical analysis. It could be said that the primary job of physical asset managers is to prevent failures. Stated another way, the primary job of physical asset managers is to develop and then analyze data points for improved decision making. A statistical method that is effective using small amounts of data is a very useful tool. There is a direct relationship between maintenance and operating activities performed on equipment and the Weibull shapes that are developed for the equipment. This article discusses basic Weibull shapes, how operating and maintenance activities impact the reliability of equipment and the steps organizations can take to change those shapes to meet the needs of the business for equipment availability.

The bathtub curve

The bathtub curve consists of three distinct regions. Each region contains its own unique values for the Weibull parameters, Eta, Beta, and Gamma. The Weibull parameters provide insight into the failure mechanism that is present. (See Table I.)

What Beta values tell us

Beta values are extremely important because they tell us the failure behavior of the component. Knowledge of the failure behavior will lead us down a certain path when trying to improve overall reliability and availability. This will aid in decisions as to whether to apply preventive or predictive maintenance techniques to the equipment component.

Infant failures

Beta less than one, or infant failure, indicates that there may be a quality issue present among our maintenance, operating or spare parts acquisition programs. There is not a time-based maintenance activity for these types of failures until the root cause or causes of the infant failures are determined. The goal is to eliminate or minimize the high early failure rate represented by the curve.

There is a large laundry list of possible causes of infant failure mechanisms. Table II gives examples of the sources of infant failures. When examining these failure causes, it can readily be seen that there is little benefit from investing in advanced predictive technologies to

prevent infant failures.

High failure rate random failures

Random failures are characterized by a Beta value of approximately one. High failure rate random failures have a shorter than expected, or shorter than desired characteristic life, or Eta. Random failures typically lend themselves to either route-based, or constant condition monitoring, but still may have a greater than desired negative impact on the goals of the organization if the failure rate is too high.

Random failures are usually caused by some outside action that induces failures into the component. The organizational activities listed in table three are some likely sources of higher than expected or desired random failure rates. When examining the failure causes for random failures, it is easy to see that increasing the focus on the preventive maintenance program, particularly the basics, would eliminate many random failures.

Short life wearout failures (early wearout)

Generally, wearout failures lend themselves to some type of time-based replacement or overhaul strategy. While wearout is predictable, it can have a significant negative impact on the goals of the organization if components are not lasting as long as expected or desired. This is the area where a substantial return on investment can be realized when deploying predictive maintenance tools and techniques.

Early wearout is often caused by a lack of understanding of the stresses present in the equipment during the design phase, but there also are organizational activities that can lead to early component wearout. Again, the proper utilization of predictive techniques, such as vibration analysis, thermography, and spectrographic oil analysis can provide significant benefits.

How you know what you have (build-ing Weibull shapes without data)

Many companies do not have the complete data to perform a full Weibull analysis on their failing components. They do, however, have some data from their CMMS/EAM system, their predictive software systems and even information from experienced maintenance and operations personnel who are knowledgeable about what fails—and how. The trick to building Weibull shapes without complete CMMS/EAM system and predictive system data is to learn what questions to ask the maintainers and operators.

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This isn't perfect

The questioning method for building Weibull shapes is not a perfect replacement for a CMMS/EAM system or predictive system data. Still, it does provide a good starting point until an organization is able to build a complete database. The goal should be to eventually develop a database of predictive information that will allow for the development of maintenance tactics and strategies to eliminate undesired failures that keep you from meeting your business goals.

The key things to remember here are that the failure mechanisms present in equipment are a reflection of the maintenance, operating and procurement activities present within your organization. Furthermore, there is a direct link between best maintenance and operating practices and changing the Weibull behavior of your equipment. As an organization develops the preventive and predictive maintenance data necessary to properly analyze, it will progress to using analytical predictive software. The Weibull techniques discussed in this article help provide an understanding of how the analytical software utilizes this data to optimize preventive and predictive maintenance policies and procedures. **MT**

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Table I: Weibull Parameters

Weibull Parameter	Description
Gamma (g) or Location Parameter	Gamma is the location of each section of the Weibull curve. Gamma 3 is particularly important.
Beta (b) or Shape Factor	Beta values are an indicator of the failure behavior of the component. Beta values are a function of the failure mechanism.
Eta (h) or Characteristic Life	Eta gives an estimate of how long components might last after being put into service.

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Table II: Potential Organizational Causes for Infant Failures

Source

Causes

Maintenance Activities

- No or inadequate quality of work control procedures and policies
- Unskilled or untrained maintainers
- No or Poorly written maintenance procedures
- Poor organizational communication
- No focus on precision maintenance
- Inadequate Maintenance Supervision

Operating Activities

- No or inadequate operating procedures, especially start up procedures
- Unskilled or untrained operators
- Inadequate Operations Supervision

Procurement Activities

- Procurement focused solely on price
- No or inadequate quality control procedures for incoming spares, especially custom manufactured
- Parts procured from a wide variety of vendors

Table III. Potential Causes for High Random Failure Rates

Source

Causes

Maintenance Activities

- Lubrication routes not well designed
- Inconsistent torque applied to bolts
- Poor maintenance cleanliness practices
- Inadequate lightning protection

Operating Activities

- Equipment occasionally operated outside its design envelope
- Process upsets created by inadequate quality control of incoming raw materials
- Process upsets created by unskilled or untrained operators

Procurement Activities

- Parts procured from a wide variety of vendors
- Parts specifications not clear

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Table IV. Potential Causes for Early Wearout

Source	Causes
Maintenance Activities	<ul style="list-style-type: none">- Under-Lubrication of bearings- Using Incorrect Lubricant for the Service- Over-Lubrication of bearings- Service intervals too long for:<ul style="list-style-type: none">- Lubrication- Adjustments - Consistent Over Tightening of Belts- Consistent Over-Torquing of Bolts- Using Parts Below Required Specifications
Operating Activities	<ul style="list-style-type: none">- Consistently operating the equipment outside its design envelope
Procurement Activities	<ul style="list-style-type: none">- Purchasing spares below needed specifications

Table V. Some Simple Questions for Determining Weibull Failure Mechanisms

Question	Answer	What The Answer Tells Us
1. How many times have you repaired this particular failure in the last three years?	Three	Information of the mean time to failure
2. If you work on it today, do you know you have to take it out because it may fail again?	Yes	Was it probably an infrequent failure because it may fail again?
3. If you work on it today, do you know you won't have to take it out because it may fail again?	Yes	This is probably a wear-out failure and it is most likely to fail again.
4. If you work on it today, is it likely to fail sometime between now and a future failure?	Yes	This is most likely a random failure and it can be handled.