Both methods are unacceptable for the design of critical components. Each presumes apriori an acceptable level or given mortality for the design. As such, the customer system mortality is much higher, being proportional to the product of all subcomponent mortalities.

In critical component/product design probabilistic and deterministic designs can still be employed yet testing is imperative as the goal is component removal prior to failure. In turbomachines, a critical component such as a turbine disc represents an infinite source of energy to a mobile product such as an airplane, ship, submarine, automobile and a catastrophic source of energy to a stationary powerplant. One can not afford to have a component failure; it must be removed before it fails. This represents a different mind set. It says, no failures are the only acceptable mode. There is no acceptable or fixed level of risk.

Now on the Weibull plot, figure 1, a vertical line is the goal; every component fails at the same time or number of cycles. In reality these plots have fitted slopes not much different unity (Weibull Slope=1 ->exponential; 2->Rayleigh;3.57->normal distributions). As such, the dispersion is large; a few failures at time t_1 with progressive number of failures over a very large range with time. While this is acceptable practice to the community, there is no differentiation between graceful/benign and catastrophic failures.

Still looking more carefully at the data on the Weibull plot there seems to exist a region of no failures followed by a rapid rise or jump (vertical line) in failures. Design of critical components must be within this incubation region and the component removed prior to the "jump". This jump point will be related to the initial crack from a fault in the material, yet unless the component characteristic length is very small or the material ultra fracture sensitive, the effect of this crack will not be detectable. However with time these defects progress, become measurable and continued loading leads to the jump seen in the Weibull plot.

Tallian (1962) delineated such a Weibull locus for bearings and a summary of efforts to define this "jump point" are shown in figure 2, taken from Takata et al. (1985) and found in Zaretsky (1992). For Weibull statistics of bearings, the jump point is related to the L_{10} life by a reliability factor.

$$Ln = a_1 L_{10}$$

where $a_1 = 0.053$ for reliabilities greater than 99.9%, p 70, table 10.2 (Zaretsky (1997)).
In reality, the data present a series of jumps as noted in figure 1. Extrapolating these data to the equivalent 99.9% reliability provides a higher than predicted life. This is good and bad. Good to have more life and bad because you have to test to determine the "incipient jump."

In practice a conservative design could substitute for lack of knowing the jump point. For example, for bearings Zaretsky et al. (2000) found the Lundberg and Palmgren theory is the most conservative and maybe even the least accurate of several lifing theories e.g. Zaretsky , Harris. Still that conservative theory may be the best available for deterministic critical component (bearing) design.

Design of critical components will also require good probabilistic materials data as well as design methods coupled with that test data and engineering know how to delineate the "jump".

Conclusions

Critical components must be removed from service prior to the initial jump seen on the Weibull plot. Effective critical component design will require probabilistic data bases and validated probabilistic design codes. To date neither are available.

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Figure 1. Critical Component Design Criteria Based on Rolling-element Fatigue Life of AISI 52100 Steel