virtually always a useful preliminary to more detailed statistical analysis. The two methods will be discussed in more detail in the following subsections.

8.3.1 GRAPHICAL METHODS

The basic idea of graphical methods is the use of special probability plotting papers in which the cumulative distribution function (cdf) or the cumulative hazard can be plotted as a straight line for the particular distribution being studied. Since a straight line has two parameters (slope and intercept), two parameters of the distribution can be determined. Thus, reliability data can be evaluated quickly, without a detailed knowledge of the statistical mathematics being necessary. This facilitates analysis and presentation of data.

Graphical curve fitting techniques and special probability plotting papers have been developed for all of the distributions commonly associated with reliability analysis (Refs. 4, 5).

Ranking of Data

Probability graph papers are based upon plots of the variable of interest against the cumulative percentage probability. The data therefore need to be ordered, and the cumulative probability calculated. For reliability work, the data is ordered from the smallest to largest; this is referred to as order statistics. For example, consider the data on times to failure of 20 items (Table 8.3.1-1). For the first failure, the cumulative proportion is 1/20 or 5%. For the second, the cumulative proportion is 2/20 or 10%, and so on to 20/20 or 100% for the 20th failure. However, for probability plotting, it is better to make an adjustment to allow for the fact that each failure represents a point on a distribution. Thus, considering that the whole population of 20 items represent a sample, the times by which 5, 10 ... 100% will have failed in several samples of 20 will be randomly distributed. However, the data in Table 8.3.1-1 show a bias, in that the first failure is shown much further from the zero cumulative percentage point than is the last from 100% (in fact it coincides). To overcome this, and thus to improve the accuracy of the estimation, mean or median ranking of cumulative percentages is used for probability plotting. Mean ranking is used for symmetrical distributions, e.g., normal; median ranking is used for skewed distributions, e.g., Weibull.

The usual method for mean ranking is to use (n + 1) in the denominator, instead of n, when calculating the cumulative percentage position. Thus in Table 8.3.1-1 the cumulative percentages (mean ranks) would be:

$$\frac{100}{20 + 1} = 5$$

$$\frac{200}{20 + 1} = 10$$

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$$\frac{2000}{20 + 1}$$