

WEIBULL PLOT

PURPOSE

Generates a Weibull plot.

DESCRIPTION

A Weibull plot is a graphical data analysis technique for determining if a 2-parameter (location $t_0 = 0$) Weibull distribution provides a good distributional model for the data. A good distributional fit is indicated by linearity in the Weibull plot. It consists of:

Vertical axis = cumulative percent occurred (in a $\log_e(\log_e(1/(1-p)))$ scale where $p = (i-.3)/(n+.4)$);

Horizontal axis = failure time (in a \log_{10} scale).

For the general (3-parameter) Weibull distribution, the cumulative distribution function $F(t)$, the density function $f(t)$, and the percent point function $G(p)$ are (respectively):

$$\begin{aligned} F(t) = p &= 1 - \exp(-z^{\text{beta}}) \\ f(t) &= (\text{beta}/\text{nu}) * z^{(\text{beta}-1)} * \exp(-z^{\text{beta}}) \\ G(p) = t &= t_0 + \text{nu} * (\log_e(1/(1-p)))^{(1/\text{beta})} \end{aligned}$$

with

$$z = (t-t_0)/\text{nu}$$

Namewise,

t_0 = location parameter (smallest allowable t);
 nu = scale parameter (= "characteristic life", note that $t_0+\text{nu}$ falls at the 63.2% point irrespective of beta);
 beta = shape parameter (specifies the member of the Weibull family).

For the 2-parameter ($t_0 = 0$) Weibull distribution, simplifications occur and so the percent point function $G(p)$ reduces to:

$$G(p) = t = \text{nu} * (\log_e(1/(1-p)))^{(1/\text{beta})}$$

which by rearrangement becomes

$$\begin{aligned} \log_e(\log_e(1/(1-p))) &= \text{beta} * \log_e(G(p)/\text{nu}) \\ \log_e(\log_e(1/(1-p))) &= \text{beta} * \log_e(t/\text{nu}) \\ \log_e(\log_e(1/(1-p))) &= -\text{beta} * \log_e(\text{nu}) + \text{beta} * \log_e(t) \end{aligned}$$

After a minor adjustment to take $\log_e(t)$ to $\log_{10}(t)$, this last expression defines the resulting Weibull plot. That is, the left side appears vertically on the Weibull plot and the right side appears horizontally.

If the data follows a 2-parameter distribution, then the plot will be near-linear and the slope of the plot will be identically beta (the shape parameter). For the Weibull plot, both beta and eta are estimated (behind the scenes) by least squares.

In addition to the raw data, three other lines are drawn on the plot:

1. A fitted line to the raw data;
2. A horizontal line at the 63.2% point;
3. A vertical line at the intersection point of the fitted line and the 63.2% line.

SYNTAX 1

WEIBULL PLOT <y> <SUBSET/EXCEPT/FOR qualification>

where <y> is the response variable (e.g., days to failure);

and where the <SUBSET/EXCEPT/FOR qualification> is optional.

SYNTAX 2

WEIBULL PLOT <y> <tag> <SUBSET/EXCEPT/FOR qualification>

where <y> is the response variable (e.g., days to failure);

<tag> is a 0 or 1 indicator variable where 1 indicates that the item failed by the failure mode of interest and 0 indicates that the item failed but by some other failure mode which is not of interest;

and where the <SUBSET/EXCEPT/FOR qualification> is optional.

EXAMPLES

WEIBULL PLOT Y

WEIBULL PLOT Y TAG

WEIBULL PLOT Y SUBSET MATERIAL 4
 WEIBULL PLOT Y TAG SUBSET MATERIAL 5 SUBSET PROCESS 3

NOTE 1

The value of beta indicates the current status of the failures:

```
beta . hazard function . failure type
.....
< 1 . decreasing . infant mortality
1 . constant . exponential
> 1 . increasing . old-age wear out
```

NOTE 2

The following parameters are automatically produced by DATAPLOT when using the WEIBULL PLOT command:

```
ETA = estimated "characteristic life"
BETA = estimated shape parameter
SDETA = estimated standard deviation of eta
SDBETA = estimated standard deviation of beta
BPT1 = estimated 0.1% point of failure times
BPT5 = estimated 0.5% point of failure times
B1 = estimated 1% point of failure times
B5 = estimated 5% point of failure times
B10 = estimated 10% point of failure times
B20 = estimated 20% point of failure times
B50 = estimated 50% point of failure times
B80 = estimated 80% point of failure times
B90 = estimated 90% point of failure times
B95 = estimated 95% point of failure times
B99 = estimated 99% point of failure times
B995 = estimated 99.5% point of failure times
B999 = estimated 99.9% point of failure times
```

NOTE 3

The attributes of the 4 lines on the Weibull plot can be specified via the LINES and CHARACTER commands (along with their attribute setting commands).

DEFAULT

None

SYNONYMS

None

RELATED COMMANDS

```
CHARACTERS = Sets the type for plot characters.
LINES = Sets the type for plot lines.
WEIBULL PPCC PLOT = Generates a Weibull probability plot correlation coefficient plot.
WEIBULL PROBABILITY PLOT = Generates a (fixed GAMMA) Weibull probability plot.
NORMAL PLOT = Generates a Normal plot.
HISTOGRAM = Generates a histogram.
BOX PLOT = Generates a box plot.
PLOT = Generates a data or function plot.
```

APPLICATIONS

Reliability and Life Testing

IMPLEMENTATION DATE

88/2

```
PROGRAM 1  
SKIP 25  
READ HAHN.DAT MILES TAG  
LINE SOLID DASH DOT DOT  
TITLE AUTOMATIC  
WEIBULL PLOT MILES TAG SUBSET TAG = 1
```

