SAS/QC® Software: Changes and Enhancements, Release 8.1

The Power to Know™

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Chapter 1

The SHEWHART Procedure

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Chapter 1
The SHEWHART Procedure

SYNTAX

BOXSTYLE=*POINTSSCHEMATIC*

specifies a schematic box chart that is overlaid with points plotting all observations in the subgroups. This box style combines the POINTS and SCHEMATIC box styles. This option is available in the BOXCHART statement.

MRRESTART
MRRESTART=*value*

causes the moving range computation on the IRCHART to be restarted when a missing value is encountered. Without the MRRESTART option, a missing value is simply skipped, and the moving range for the next non-missing subgroup is computed using the most recent previous non-missing value. MRRESTART restarts the moving range computation, so only the observations after the missing value are used in subsequent moving range computations. MRRESTART restarts the moving range computation on any missing value; you can also specify MRRESTART=value to restart only on a particular missing value. For example, MRRESTART=R will restart the computation only when the missing value ".R" is encountered. This option is available in the IRCHART statement.

TESTRESET=*variable*
TESTRESET=*value*

allows tests for special causes to be reset in a primary chart. The specified variable must be a character variable of length 8, or length 16 if customized tests are requested. The variable values have the same format as those of the _TESTS_ variable in a TABLE= data set. A test that is flagged by the TESTRESET= value for a given subgroup is reset starting with that subgroup. That means that a positive result for the test can include the given subgroup only if it is the first subgroup in the pattern. For example, the value "12345678" for the TESTRESET= variable will reset all standard tests for special causes. This option is available in all chart statements.

TEST2RESET=*variable*
TEST2RESET=*value*

allows tests for special causes to be reset in a secondary chart. The specified variable must be a character variable of length 8, or length 16 if customized tests are requested. The variable values have the same format as those of the _TESTS_ variable in a TABLE= data set. A test that is flagged by the TEST2RESET= value for a given subgroup is reset starting with that subgroup. That means a positive result for the test can include the given subgroup only if it is the first subgroup in the pattern. For example, the value "12345678" for the TEST2RESET= variable will reset all standard tests for special causes. This option is available with the MRCHART, RCHART, SCHART, XRCHART, and XSCHART statements.

Chapter 2
The TRELIABILITY Procedure

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Chapter 2
The TRELIABILITY Procedure

Overview

The TRELIABILITY procedure is an experimental version of the RELIABILITY procedure. The following are the major changes and enhancements available in the TRELIABILITY procedure:

- You can specify the logarithm of the distribution scale parameter as a function of explanatory variables in regression models.
- You can construct simultaneous confidence bands on probability plots.
- The default confidence intervals on probability plots are pointwise aymptotic normal parametric intervals on cumulative failure probability. The default intervals in PROC RELIABILITY are pointwise parametric intervals on distribution percentiles.
- Multiple overlaying symbols on plots are labeled with the count of points instead of being jittered as in PROC RELIABILITY.
- You can plot non-linear relationships on relation plots.
- You can construct relation plots with two independent variables.

Syntax

The following statements and statement options are available in the TRELIABILITY procedure in addition to the statements and options in the RELIABILITY procedure.

LOGSCALE Statement

LOGSCALE <*effect-list*> < **/** *options* >**;**

LOGSCALE is a new statement in the TRELIABILITY procedure. You use the LOGSCALE statement to model the logarithm of the distribution scale parameter as a function of explanatory variables. A MODEL statement must be present to specify the model for the distribution location parameter. *effect-list* is a list of variables in the input data set representing the values of the independent variables in the model for each observation, and combinations of variables representing interaction terms. It can contain any variables or combination of variables in the input data set. It can contain the same variables as the MODEL statement, or it can contain different variables. The variables in the *effect-list* can be any combination of indicator variables named in a CLASS statement and continuous variables. The coefficients of the explanatory variables are estimated by maximum likelihood.

The following *options* are available for the LOGSCALE statement.

Table 2.1. LOGSCALE Statement Options

Option	**Option Description**
INITIAL=*number list*	specifies initial values for log-scale regression parameters other than the location, or intercept term
INTERCEPT=*number* < INTINIT >	specifies initial or fixed value of the intercept parameter, depending on whether INTINIT is present

MCFPLOT Statement

The following options are new or can take additional values.

Table 2.2. MCFPLOT Statement Options

Option	**Option Description**
PLOTSYMBOL=*symbol* | (*symbol list*)	symbols representing events in an MCF plot
PLOTCOLOR=*color* | (*color list*)	colors of symbols representing events in an MCF plot

MODEL Statement

The following are new options in the MODEL statement.

Table 2.3. New MODEL Statement Options

Option	**Option Description**
RELATION=ARRHENIUS | ARRHENIUS2 | POWER | LOGISTIC RELATION=(ARRHENIUS | ARRHENIUS2 | POWER LOGISTIC < , > ARRHENIUS | ARRHENIUS2 | POWER | LOGISTIC)	the *logistic* function, defined as $T(x) = \log\left(\frac{x}{1-x}\right)$, has been added as an optional transformation of the independent variable in a regression model. The logistic transformation is useful when the variable is naturally between 0 and 1. Values of 0, 1, and values outside 0 and 1 are treated as missing values.

PROBPLOT Statement

The following options are new or can take additional values.

Table 2.4. PROBPLOT Statement Options

Option	Option Description
CFIT=*color* | (*color list*)	color for fit lines and confidence curves in a probability plot
LFIT=*linetype* | (*linetype list)*)	line styles for fit lines and confidence curves in a probability plot. The *linetype list* is a list of numbers from 1 to 46 representing different linetypes, and can be separated by blanks or commas or can be a list in the form n_1 to n_2 <by n_3 >.
NOPPOS	suppresses plotting of symbols for failures in a probability plot
NPINTERVALS=POINTWIASE | SIMULTANEOUS	type of nonparametric confidence interval displayed in a probability plot
PINTERVALS=PROBABILITY | PERCENTILES | LIKELIHOOD	type of parametric pointwise confidence interval displayed in a probability plot. The default type is PROBABILITY, pointwise confidence intervals on cumulative failure probability.
PPOSSYMBOL=*symbol* | (*symbol list*)	symbols representing failures on a probability plot
PPOSCOLOR=*color* | (*color list*)	colors of symbols representing failures on a probability plot
SHOWMULTIPLES	display the count for multiple overlaying symbols

RELATIONPLOT Statement

The following options are new or can take additional values.

Table 2.5. RELATIONPLOT Statement Options

Option	Option Description
CFIT=*color* | (*color list*)	color for fit lines and confidence curves in a probability plot
CPLOTFIT=*color* | (*color list*)	colors for percentile lines
FITTYPE=	specifies method of estimating distribution parameters
LSYX	-least squares fit to the probability plot. The probability axis is the dependent variable.
| LSXY	-least squares fit to the probability plot. The lifetime axis is the dependent variable.
| MLE	-maximum likelihood (default)

Table 2.5. RELATIONPLOT Statement Options (continued)

<table>
<tr><th>Option</th><th>Option Description</th></tr>
<tr><td>| MODEL</td><td>-use the fit from the preceding MODEL statement</td></tr>
<tr><td>| NONE</td><td>-no fit is computed</td></tr>
<tr><td>| REGRESSION</td><td>-use the fit from the preceding MODEL statement. Non-linear relations and percentiles from models using two independent variables can be plotted.</td></tr>
<tr><td>| WEIBAYES</td><td>-Weibayes method</td></tr>
<tr><td>LFIT=linetype | (linetype list))</td><td>line styles for fit lines and confidence curves in a probability plot. The linetype list is a list of numbers from 1 to 46 representing different linetypes, and can be separated by blanks or commas or can be a list in the form n_1 to n_2 $<$by $n_3 >$.</td></tr>
<tr><td>LPLOTFIT=linetype | (linetype list))</td><td>line styles for percentile lines. linetype list is a list of numbers representing different linetypes, and can be separated by blanks or commas or can be a list in the form n_1 to n_2 $<$by $n_3 >$.</td></tr>
<tr><td>NOPPOS</td><td>suppresses plotting of symbols for failures in a probability plot</td></tr>
<tr><td>PINTERVALS=PROBABILITY |
PERCENTILES |
LIKELIHOOD</td><td>type of parametric pointwise confidence interval displayed in a probability plot. The default type is PROBABILITY, pointwise confidence intervals on cumulative failure probability.</td></tr>
<tr><td>RCENCOLOR=color | (color list)</td><td>colors for the symbols representing uncensored, right censored, and left censored observations in a relation plot</td></tr>
<tr><td>RCENSYMBOL=symbol | (symbol list)</td><td>symbols representing right censored and left censored observations in a relation plot. The symbol is one of the symbol names (plus, star, square, diamond, triangle, hash, paw, point, dot, circle) or a letter (A–Z).</td></tr>
<tr><td>RELATION=ARRHENIUS |
ARRHENIUS2 |
POWER |
LOGISTIC)</td><td>the logistic function, defined as $T(x) = \log\left(\frac{x}{1-x}\right)$, has been added as an optional transformation of the stress axis. The logistic transformation is useful when the variable is naturally between 0 and 1. Values of 0, 1, and values outside 0 and 1 are not valid.</td></tr>
<tr><td>SHOWMULTIPLES</td><td>display the count for multiple overlaying symbols</td></tr>
</table>

Table 2.5. RELATIONPLOT Statement Options (continued)

Option	**Option Description**
variable=number list	allows plots of percentiles from a regression model when two independent variables are used in a MODEL statement *effect list*. The FIT=REGRESSION option must be used with this option. Percentile plots are created for each value of the independent *variable* in the *number list*. *number list* is a list of numeric values separated by blanks or commas, or in the form of a list n_1 to n_2 <by n_3 >.

Examples

The examples in this section illustrate some of the new features in the TRELIABILITY procedure.

Regression Model With Non-Constant Scale

Nelson (1990, p. 272) and Meeker and Escobar (1998, p. 439) analyzed data from a strain-controlled fatigue test on 26 specimens of a type of superalloy. The following SAS statements create a SAS data set containing for each specimen the level of pseudo-stress (PSTRESS), the number of cycles (in thousands) (KCYCLES) until failure or removal from the test, and a variable to indicate whether a specimen failed (F) or was right censored (C) (STATUS):

```
data alloy;
   input pstress kcycles status$ @@;
   cen = ( status = ’C’ );
   datalines;
80.3  211.629  F    99.8   43.331  F
80.6  200.027  F   100.1   12.076  F
80.8   57.923  C   100.5   13.181  F
84.3  155.000  F   113.0   18.067  F
85.2   13.949  F   114.8   21.300  F
85.6  112.968  C   116.4   15.616  F
85.8  152.680  F   118.0   13.030  F
86.4  156.725  F   118.4    8.489  F
86.7  138.114  C   118.6   12.434  F
87.2   56.723  F   120.4    9.750  F
87.3  121.075  F   142.5   11.865  F
89.7  122.372  C   144.5    6.705  F
91.3  112.002  F   145.9    5.733  F
;
run;
```

The following statements use PROC TRELIABILITY to fit a Weibull regression model with the number of cycles to failure as the response variable. The data set=RESIDS contains standardized residuals created with the ODS OUTPUT statement. The MODEL statement specifies a model quadratic in the log of pseudo-stress for the extreme value location parameter. The quadratic model in pseudo-stress PSTRESS is specified in the MODEL statement, and the RELATION=POW option specifies the log transformation be applied to PSTRESS in the MODEL statement and the LOGSCALE statement. The LOGSCALE statement specifies the log of the scale parameter as a linear function of the log of PSTRESS. The RPLOT statement specifies a plot of the data and the fitted regresion model versus the variable PSTRESS. The FIT=REGRESSION option specifies plotting the regression model fitted with the preceding MODEL statement. The RELATION=POW option specifies using a log stress axis. The PLOTFIT option specifies plotting the 10th, 50th, and 90th percentiles of the regression model at each stress level. The SLOWER, SUPPER, and LUPPER options control limits on the stress and lifetime axes:

```
ods output ModObstats = Resids;
proc treliability data = alloy;
   distribution Weibull;
   model kcycles*cen(1) = pstress pstress*pstress / relation = pow;
   logscale pstress;
   rplot kcycles*cen(1) = pstress /  fit=regression
                                     relation = pow
                                     plotfit  10 50 90
                                     slower=60 supper=160
                                     lupper=500;

   label pstress = "Pseudo-Stress";
   label kcycles = "Thousands of Cycles";
run;
```

Figure 2.1 displays the parameter estimates from the fitted regression model. Parameter estimates for both the model for the location parameter and the scale paramater models are shown. Standard errors and confidence limits for all parameter estimates are included.

The RELIABILITY Procedure

Weibull Parameter Estimates

Parameter	Estimate	Standard Error	Asymptotic Normal 95% Confidence Limits Lower	Upper
Intercept	243.1681	58.0666	129.3596	356.9766
pstress	-96.5240	24.7075	-144.9498	-48.0983
pstress*pstress	9.6653	2.6247	4.5210	14.8095

Log-Scale Parameter Estimates

Parameter	Estimate	Standard Error	Asymptotic Normal 95% Confidence Limits Lower	Upper
Intercept	4.4666	4.0724	-3.5152	12.4485
pstress	-1.1757	0.8731	-2.8870	0.5355

Figure 2.1. Parameter Estimates for Fitted Regression Model

Figure 2.2 displays the plot of the data and fitted regression model.

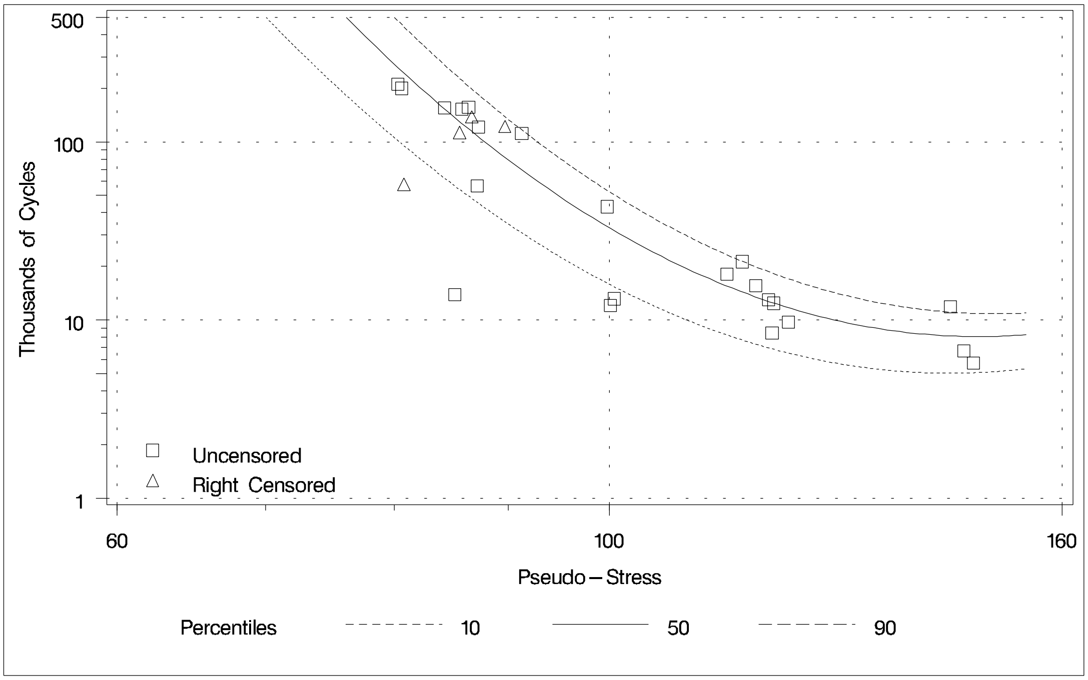

Figure 2.2. Superalloy Fatigue Data with Fitted Regression Model

The following SAS statements create an extreme values probability plot of standardized residuals from the regression model shown in Figure 2.3:

```
proc treliability data = Resids;
   distribution ev;
   pplot sresid*cen(1) / nofit;
run;
```

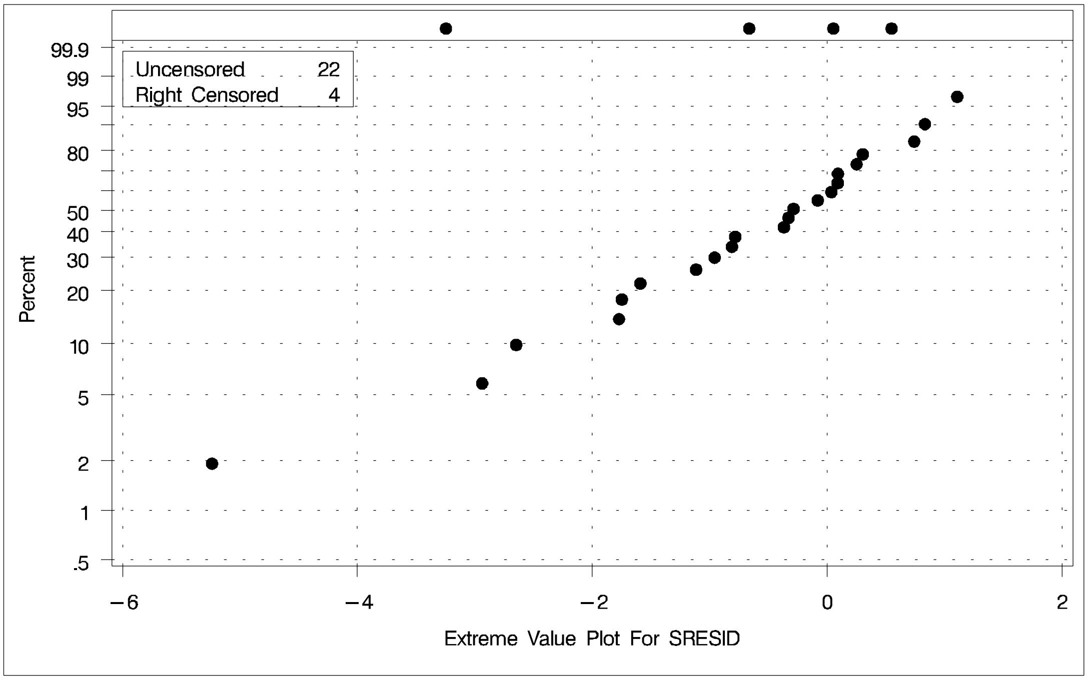

Figure 2.3. Residuals for Superalloy Fatigue Data Regression Model

Regression Model With Two Independent Variables

Meeker and Escobar (1998, p. 447) analyze data from an accelerated test on the lifetimes of glass capacitors as a function of operating voltage and temperature. The following SAS statements create a SAS data set containing the data. There are four lifetimes for each of eight combinations and four censored observations after the fourth failure for each combination:

```
data glass;
   input Temp Voltage @;
   do i = 1 to 4;
      Cen = 0;
      input Hours @;
      output;
   end;
   do i = 1 to 4;
      Cen = 1;
      output;
   end;
   datalines;
170 200  439  904  1092  1105
170 250  572  690   904  1090
170 300  315  315   439   628
170 350  258  258   347   588
180 200  959 1065  1065  1087
180 250  216  315   455   473
180 300  241  315   332   380
180 350  241  241   435   455
;
```

The following statements use PROC TRELIABILITY to analyze the capacitor data. The MODEL statement fits a regression model with TEMP and VOLTAGE as independent variables. Parameter estimates from the fitted regression model are shown in Figure 2.4. An interaction term between TEMP and VOLTAGE is included. The PPLOT statement creates a Weibull probability plot shown in Figure 2.5 with all temperature-voltage combinations overlaid on the same plot. The regression model fit is also plotted. The RPLOT statement creates the plot shown in Figure 2.6 of the data and Weibull distribution percentiles from the regression model as a function of voltage for values of temperature of 150, 170, and 180:

```
proc treliability data = glass;
   distribution Weibull;
   model Hours*Cen(1) = temp voltage temp * voltage;

   pplot Hours*Cen(1) = ( temp voltage ) / fit = model
                                           overlay
                                           noconf
                                           lupper = 2000
                                           lfit = ( 1 to 8 );

   rplot Hours*Cen(1) = voltage / fit = regression
                                  plotfit
                                  temp = 150, 170, 180;
run;
```

The RELIABILITY Procedure

Weibull Parameter Estimates

Parameter	Estimate	Standard Error	Asymptotic Normal 95% Confidence Limits Lower	Upper
Intercept	9.4135	10.5402	-11.2449	30.0719
Temp	-0.0062	0.0598	-0.1235	0.1110
Voltage	0.0086	0.0374	-0.0648	0.0820
Temp*Voltage	-0.0001	0.0002	-0.0005	0.0003
EV Scale	0.3624	0.0553	0.2687	0.4887
Weibull Shape	2.7593	0.4210	2.0461	3.7209

Figure 2.4. Parameter Estimates for Fitted Regression Model

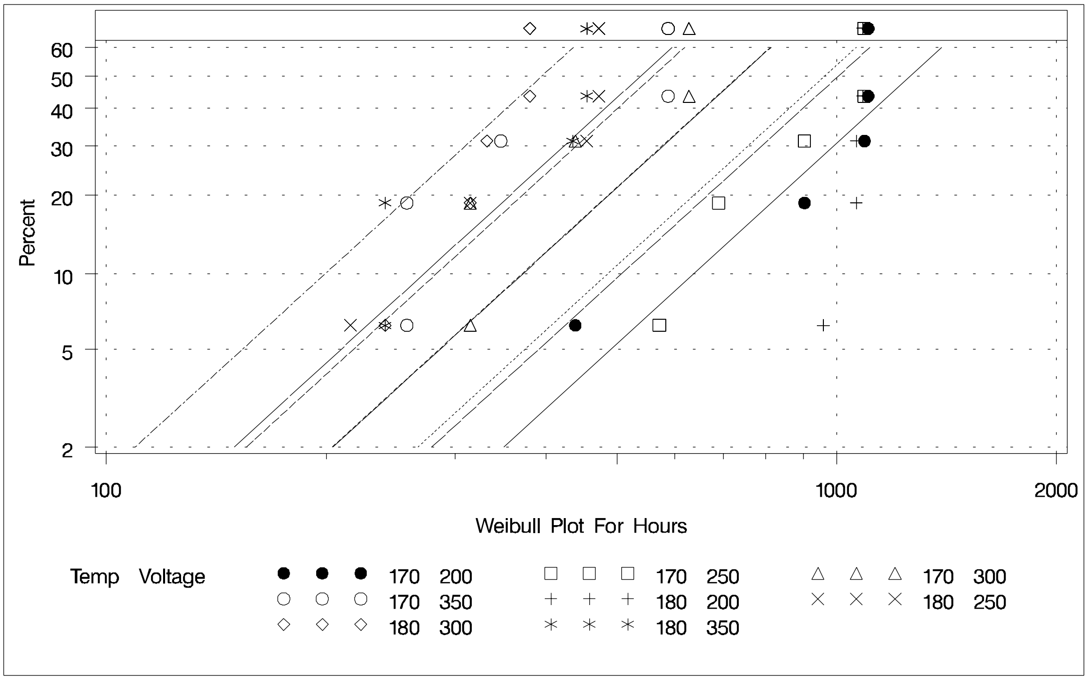

Figure 2.5. Probability Plot for Glass Capacitor Regression Model

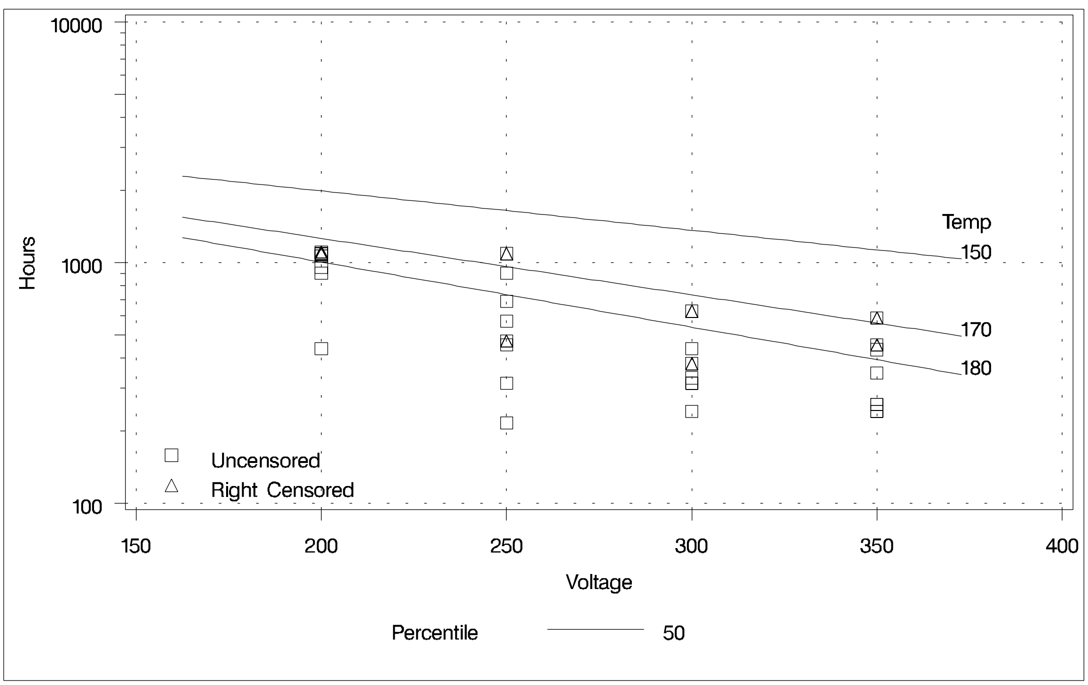

Figure 2.6. Plot of Data and Fitted Weibull Percentiles for Glass Capacitor Regression Model

References

Meeker, W.Q. and Escobar, L.A.(1998), *Statistical Methods for Reliability Data*, New York: John Wiley & Sons.

Nelson, W. (1990), *Accelerated Testing: Statistical Models, Test Plans, and Data Analyses*, New York: John Wiley & Sons.

Chapter 3

The ADX Interface for Design and Analysis of Experiments

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Chapter 3

The ADX Interface for Design and Analysis of Experiments

Overview

The ADX Interface is a point-and-click interface for the design and analysis of experiments. Designed for the desktop environment of PCs and workstations, the Interface is intended primarily for engineers and researchers who require a guided interface for every step in the experimental process.

The ADX Interface has been enhanced in several ways. Mixture designs have been extended to include constraints to restrict the region of experimentation, and analysis of split-plot data is now supported. A simple grid search is available to perform a numerical optimization of response variables, and methods are now available to augment a design. N-way effects plots, 3-D surface plots, and box plots are three new interactive graphical displays available.

Constrained Mixture Designs

Sometimes the nature of a mixture experiment does not allow the researcher to set factor levels freely. Constraints on the factors usually do not allow classical design of experiment analysis. Analysis of constrained mixture designs has been added that uses optimal design techniques. This requires a more delicate analysis than that used in the classical case.

Split-plot Designs

In some situations, complete randomization of the order of runs within a block is not possible. In such cases, a split-plot design is appropriate. Typically in a split-plot design each block is divided into whole plots and each whole plot is divided into subplots (or split-plots). The ADX Interface now allows analysis of split-plot data. However, the split-plot design needs to be created outside the Interface and then imported.

Numerical Optimization

The ADX Interface offers a simple grid search to perform a numerical optimization of response variables. A wizard-style approach is used where the response and optimization objective are first specified. The user then has a choice to enter limits on the non-optimized responses. Later the factor space region where the search is to be focused is specified. The ADX Interface computes the response predictions in that factor space region (for each response variable using the respective predictive model) and then sorts the results based on the response objective.

Design Augmentation

New to the ADX Interface are three methods to augment a design. The user can choose to fold-over a design by adding a new fraction with signs reversed to an existing fractional factorial design to break certain alias links. In some situations where a fold-over design is not optimal, the Interface can search for the minimun runs that can break the specified alias links. Finally, a two-level design can be augmented to a central composite design.

Canonical and Ridge Analysis

Canonical analysis can be performed to determine the shape of the fitted response and determine if the estimated stationary point is a maximum, minimum, or saddle point. This type of analysis can be used to answer the following questions:

- Is the surface shaped like a hill, a valley, a saddle surface, or a flat surface?
- If there is a unique optimum combination of factor values, where is it?
- To which factor or factors are the predicted responses most sensitive?

Ridge analysis can be performed to determine the direction in which further experimentation should be be conducted.

Graphical Displays

Three new graphical displays are avaiable in the ADX Interface. The n-way effect plot allows the experimenter to look in detail at potential 3- and 4-way interactions. These can be viewed from main effect up to 4-way interaction effects using the n-way effect plot. The 3-D surface plot is a representation of the response surface system. The 3-D surface plot can be spun to view the surface from various points by using the spin-control palette available at the top left corner of the plot. Box plots are a popular tool to display the differences in the response distribution between different levels of factors. Not only do the box plots show differences in response mean between different levels, thus suggesting significant main effects, they can also show differences in the data spread.

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