JEDEC STANDARD

LOGNORMAL ANALYSIS OF UNCENSORED DATA AND OF SINGLY RIGHT-CENSORED DATA UTILIZING THE PERSSON AND ROOTZEN METHOD

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Foreword

This standard is intended for use by those involved with reliability, lifetime estimation or failure data analysis. This standard enables the user to estimate the parameters of a two parameter lognormal distribution from complete or singly right-censored independent failure data. The methods described were chosen because they can be easily done with a calculator or spreadsheet and are as accurate as more complex iterative techniques for the cases described.

Interferences or issues that can complicate and/or invalidate the analysis are discussed. One section discusses analysis of failure data where all units from within the sample have a known failure time. Another section discusses analysis of failure data for the case where the life experiment was stopped and the failure times for the surviving unis are not known. Graphical presentation is discussed and sample calculations are presented in several annexes.

Introduction

Analysis of reliability experiments depends extensively on failure statistics and commonly used failure distribution is the normal distribution after natural logarithms of the failure times have been calculated. Lognormal distributions and the associated statistics are used by analysts working in semiconductor reliability to interpret and communicate results from failure experiments. Unfortunately, many individuals who lack a sufficient background in statistical methods are using the techniques; errors in usage and interpretation are abundant.

This document was written to provide a very basic set of tools for determining the parameters of the lognormal distribution for cases where sophisticated tools or expertise do not exist. The techniques handle a majority of the experimental cases experienced by contributors. The step-by-step standard and annexes are intended to instruct and to help ensure proper analysis.

STANDARD FOR LOGNORMAL ANALYSIS OF UNCENSORED DATA AND OF SINGLY RIGHT-CENSORED DATA UTILIZING THE PERSSON AND ROOTZEN METHOD

(From JEDEC Board Ballot JCB-17-28, formulated under the cognizance of the JC-14.2 Committee on Wafer-Level Reliability)

1 Scope

1.1 Intent

This standard enables the user to estimate the parameters of a two-parameter lognormal distribution from complete or singly right-censored independent data samples.
Specifically, this standard is intended for analyzing failure-time (t_f) data obtained from a stress test of a sample of units when the natural logarithm of the failure-time ($\ln t_f$) follow a normal distribution.
This standard is not intended to describe techniques used to determine how well the failure data fits a lognormal distribution. However, if points lie along a straight line for plots generated in section 8 the lognormal distribution estimators will describe the points along the line.

1.2 Results

The results of the analysis provide bias-corrected sample estimates for the median time-to-failure (t_{50}), mean of the $\ln t_f$ values ($\ln t_{50}$), and the standard deviation (σ) of the $\ln t_f$ value of the lognormal distribution. Additionally, confidence intervals are provided for complete data samples (no censoring). These are all obtained from the failure time values (t_f)

1.3 Complete data case

This standard may be used to analyze complete data where the failure-time data for the entire sample population is known and used. The analysis uses the most efficient estimators for obtaining estimates of the two primary parameters (t_{50}, σ) of the distribution.

1.4 Right-censored case

This standard may be used to analyze singly right-censored (Type II censored) data where the test has been stopped before all the parts have failed. The analysis uses the Persson and Rootzen Estimators [1] corrected for bias [2, 3]. These estimators can be calculated with a hand calculator and are as accurate as more complex estimators.

1.5 Other methods

This standard does not preclude the use of other estimators for determining a lognormal distribution, as long as the method has been shown to provide results similar to those obtained by this standard. For example, Maximum Likelihood Estimators are widely used, have desirable properties and are acceptable when bias is removed. However, these estimators are difficult to obtain without computerized iterative techniques, are subject to similar, if not identical bias and many software tools do not remove this bias.

1.6 Normal distribution

This standard can also be used to estimate the parameters of a normal distribution from complete and right-censored data samples. Raw data is used without taking the natural logarithm. The mean and standard deviation can be used without modification.

2 Normative references

T. Persson and H. Rootzen, “Simple and highly efficient estimators for a Type-I censored normal sample”, *Biometrika*, Vol. 64, 1977, pp.123.

3 Terms, definitions, and symbols

3.1 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

bias (statistical): The difference between the mean (or expectation) of an estimator, T, and the true value, θ, of a parameter: E(T) – θ.

censored data: The set of data for the portion of the stressed samples that had stressing discontinued prior to the originally intended end of the test stress.

NOTE This is also known as singly right censored data.

complete data: All available data from all units in the stress test, including those in the failure set.

confidence interval: An interval of the form (A, B) where A and B are the confidence limits calculated from sample statistics such that $P(A \leq \theta \leq B) = 1 - \alpha$ (where α is the probability of error) is a confidence interval.

NOTE With repeated sampling, at least $100(1 - \alpha)\%$ of the similarly constructed intervals will contain the true population parameter θ.

failure set: The subset of the sample that fails the defined test criterion during the stress time.

3 Terms, definitions, and symbols (cont'd)

lognormal distribution: A distribution in which for some value a, ln $(X - a)$ has a normal (Gaussian) distribution with a mean μ and variance σ^2.

NOTE If the parent population does not follow a lognormal distribution, this standard should not be used.

sample: A subset of units from a homogeneous parent population that has undergone stress testing.

NOTE 1 This subset of the population is assumed to retain the characteristics of the parent population from which it was taken. NOTE 2 Failure data from the units in this subset are used to determine distribution parameter estimates of the parent population.

unit: A single test structure from which one failure time observation is possible.

3.2 Symbols

N: The number of units in the sample.

t_f: The failure time observation of a unit from the sample.

$$\text{Fail time } t_f = \exp\left[\frac{\ln(t_{\text{last good}}) + \ln(t_{\text{first fail}})}{2}\right]$$

$$- \text{ OR } - \qquad (1)$$

$$= \sqrt{t_{\text{last good}}\, t_{\text{first fail}}}$$

where:

$t_{\text{last good}}$: The last time duration the unit was known to be good
$t_{\text{first fail}}$: The time duration the unit was known to have failed

$t_{\text{f-cen}}$: The censor time of a unit from the population. The censor time may or may not be the time that another part is known to have failed.

σ: The real (unknown) standard deviation or shape parameter of the lognormal parent distribution.

s: The sample estimate of the standard deviation of the lognormal parent distribution, calculated from logarithms of the observed failure times.

t_{50}: The real (unknown) median-time-to-fail (MTTF) of the parent distribution.

t_{50s}: The sample estimate of the MTTF of the parent distribution, calculated from the logarithms of observed failure times.

α: The maximum probability of error that is acceptable when making decisions.

4 Summary of Techniques

4.1 Complete data

For complete sample data sets (i.e., sets consisting of the complete population of the sample) the standard deviation of the parent population distribution is based on the standard deviation of the ln(t_f) values, corrected for bias. The t_{50s} is determined from the exponential of the mean of the ln(t_f) values. The confidence intervals for the mean and the standard deviation of the population are obtained through the use of Student's t-distribution and the chi-square (χ^2) distribution, respectively.

4.2 Singly censored data

For censored sample data sets, s and t_{50s} are the Persson and Rootzen estimators corrected for bias. These are easily calculated estimators; however, confidence intervals are not available. The censoring time is the time the test was stopped (a unit may or may not have failed at this time).

4.3 Information required

Parties to the test must have t_f, $t_{f\text{-cen}}$ (if used), and desired $1 - \alpha$ confidence level (α error) values at hand to calculate parameter estimates.

5 Inferences

5.1 Distribution

If the parent population does not follow a lognormal distribution, this standard should not be used. The distribution fit can be evaluated as described in section 8. If many of the raw t_f values do not lie along the prediction line determined by the parameters estimated, this may suggest that the parent population was not lognormal. Other techniques are also available [4.5]. Care must be taken with analysis under these circumstances.

5.2 Parent populations

Lack of homogeneity can occur when there are two or more parent populations contained in the sample, or the units in the sample are not treated alike before or during the stress. As above, a plot (see clause 8) of failure times may provide evidence of more than on parent population.

5.3 Frequency of readout

If the failure time is not accurately known, the parameter estimates will be in error. Parties to the test should agree on the frequency of readout for the test, understanding that more frequent readouts will provide more accurate failure times.

5.4 Bias correction for censored data

The factor used to correct bias in parameter estimates from censored data are determined assuming that a failure occurred at the censor time. If units are removed some time after the last failure occurred, the corrections for bias are less accurate. The significant of any error depends upon the time difference (t_{diff}) between the last failure and the censor time. The magnitude of the error may be investigated as described in the following sections.

5.4.1 Small t_{diff}

When t_{diff} is small relative to the time when the next failure is anticipated, compare calculated estimates to estimates determined with censoring time se to the last failure time.

5.4.2 Large t_{diff}

When t_{diff} is large relative to the time when the next failure is anticipated, compare the calculated estimates to estimates determined assuming a unit failed at the censoring time.

5.5 Independence

Lack of independence can occur when two or more failure times are related or are linked by some effect or event. An example is a power surge causing several parts to fail simultaneously.

5.6 Greater than 90% censoring with right censoring

The bias removal techniques for singly right-censored data use in section 7 have only been checked for accuracy with less than 90% censoring [3]. It has not been proven that the technique is valid for more censoring and should be used with caution.

6 Procedure for complete sample data

6.1 Mean and median

Calculate the unbiased sample estimate, $\ln(t_{50s})$, of the mean of the log failure distribution and the sample estimate, t_{50s}, of the median of the failure time distribution.

$$\ln(t_{50s}) = \langle t_f \rangle = \frac{1}{N}\sum_{i=1}^{N} \ln(t_f) \tag{2}$$

then,

$$t_{50s} = \exp[\ln t_{50s}] \tag{3}$$

6.2 Standard deviation

Calculate the biased and unbiased estimates of the standard deviation of the lognormal failure set.

$$s_{\text{biased}} = \sqrt{\frac{\sum_{i=1}^{N}(\ln t_{\text{fi}} - (\ln t_{\text{f}})^2}{N-1}} \tag{4}$$

then,

$$s = s_{\text{biased}} = \left[1 + \frac{1}{4\,(N-1)}\right] s_{\text{biased}} \tag{5}$$

6.3 Confidence interval for the mean

Calculate the $100(1 - \alpha)\%$ confidence interval for the median of the failure set t_{50}.

6.3.1 t-value

Find the t-value corresponding to an upper tail probability of $\alpha/2$ for Student's t-distribution with $N - 1$ degrees of freedom $t[\alpha/2, N - 1]$, from Table C.1 or equivalent.

6.3.2 Limits

Calculate the lower and upper limits of the 100(1 – α) % confidence interval for the median of the time distribution, [LCL(t_{50}), UCL(t_{50})] using the following:

$$\mathrm{LCL}(t_{50}) = \exp\left(\ln_{50s}\left[t[1-\frac{\alpha}{2}; N-1\cdot\frac{s_{\mathrm{biased}}}{\sqrt{N}}\right]\right) \tag{6}$$

then,

$$\mathrm{UCL}(t_{50}) = \exp\left(\ln_{50s}\left[t[1-\frac{\alpha}{2}; N-1\cdot\frac{s_{\mathrm{biased}}}{\sqrt{N}}\right]\right) \tag{7}$$

Where s_{biased} is from (4).

6.4 Confidence interval for the standard deviation

Calculate the 100(1 – α) % confidence interval for σ of the log failure set.

6.4.1 Chi-square

Find the 1 – α/2 and the α/2 percentiles of the chi-squared distributions with N – 1 degrees of freedom (χ[1 – α/2; N – 1], χ^2[α/2; N – 1]) from Table C.2A, Table C.2B, or equivalent.

6.4.2 Limits

Calculate the lower and upper limits of the 100(1 – α)% confidence intervals (LCL(σ), UCL(σ)] from the following equations:

$$\mathrm{LCL}(\sigma) = s_{\mathrm{biased}}\sqrt{\frac{N-1}{\chi^2\left[1-\frac{\alpha}{2}; N-1\right]}} \tag{8}$$

$$\mathrm{UCL}(\sigma) = s_{\mathrm{biased}}\sqrt{\frac{N-1}{\chi^2\left[\frac{\alpha}{2}; N-1\right]}} \tag{9}$$

7 Persson-Rootzen procedure for singly right-censored data [1,2,3]

7.1 Calculate intermediate terms

7.1.1 Standard normal value, z_o

Determine the standard normal value, z_o that corresponds to the (1 – *K*/*N*) percentile of the standard normal distribution, where *N* equals the total number of part on test and *K* equals the number of parts (from sample size *N*) that failed during test. Use Table C.3 or equivalent.

7.1.2 α_{PR}

$$\alpha_{\mathrm{PR}} = \frac{N}{K\sqrt{2\pi}} \exp\left[\ln\frac{z_o^2}{2}\right] \tag{10}$$

7.1.3 Censor time, C_R

$$\mathrm{C_R} = \ln(t_{\mathrm{f-cen}}) \tag{11}$$

7.1.4 M

$$\mathrm{M} = \langle\ln(t_{\mathrm{f}})\rangle = \frac{1}{K}\sum_{i=1}^{K}\ln(t_{\mathrm{fi}}) \tag{12}$$

7.1.5 StdDev

$$\mathrm{StdDev} = \sqrt{\frac{\sum_{i-1}^{K}(\ln(t_{\mathrm{fi}}) - \ln(t_{\mathrm{f}}))^2}{K-1}} \tag{13}$$

7.1.6 s_{RML}

$$\mathrm{s_{RML}} = \frac{1}{2}\left[z_0(\mathrm{C_R} - \mathrm{M}) + \sqrt{z_o(\mathrm{C_R} - \mathrm{M})^2 + 4\left[(\mathrm{C_R} - \mathrm{M})^2 + (\tfrac{K-1}{K})\mathrm{StdDev}^2\right]}\right] \tag{14}$$

7.2 Standard deviation

Calculate the biased and unbiased estimates of standard deviation.

7.2.1 $s_{PR\ biased}$

Calculate the biased sample estimate, $s_{PR\ BIASED}$, of the standard deviation of the censored log failure population from the following equation:

$$s_{PR\ biased} = \sqrt{\frac{(K-1)\mathrm{StdDe\ v}^2}{K} + \alpha_{PR}(\alpha_{PR} - z_o)s^2_{RML}} \tag{15}$$

7.2.1 s

Calculate the unbiased estimate, s, of the standard deviation of the censored log failure set from the following equation:

$$s = s_{PR\ unbiased} = \left(\frac{K}{K-1}\right)\left(\frac{1.8N+5}{1.8N+6}\right) \tag{16}$$

7.3 Mean and median

Calculate the biased and unbiased estimates of the mean of the log failure set.

7.3.1 ln ($t_{50s\ PR\ biased}$)

Calculate the unbiased estimate, *s*, of the standard deviation of the censored log failure set from the following equation:

$$\ln\left(t_{50s_{PR\ biased}}\right) = [\mathrm{M} + \alpha_{PR}\, s_{RML}] \tag{17}$$

7.3.2 ln (t_{50s})

Calculate the unbiased estimate, ln t_{50s}, of mean of the censored log failure set from the following equation:

$$\ln(t_{50s}) = \ln\left(t_{50sPR\ biased}\right)\left[\left[\frac{0.98}{K} + \frac{0.068N}{K^2} - \frac{1.15}{N}\right] s_{PR\ unbiased}\right] \tag{18}$$

7.3.3 t_{50s}

Calculate the estimate, t_{50s}, of median of the failure time population from the following equation:

$$t_{50s} = \exp[\ln(t_{50s})] \tag{19}$$

8 Data graphing and presentation

Use this section to generate graphs of raw fail times and fitted distributions. It is the intent of this section to provide graphs that fully describe the data gathered and any analysis results from the data set.

8.1 Prepare raw fail times for graphing

8.1.1 Rank order fails

Rank order log fail times (ln t_{fi}), with i – 1 being the shortest fail time, i – 2 the 2nd fail time, etc.

8.1.2 Probabilities

Assign failure probabilities to each t_{fi} [5]:

$$P(t_{fi}) = \left[\frac{i-0.3}{N+0.4}\right] \tag{20}$$

8.1.3 Z-values

Determine the standard normal Z-value that corresponds to each failure probability (area). Use Table C.3 or equivalent.

8.1.4 Graph raw data

Graph Z-value versus ln t_{fi} for each failure time. Include symbol used in a key with a label. Label two Z-axes, on with failure probability values and on with Z values. Label the ln t_{fi} axis with time values.

8.1.5 Graph fitted lognormal distribution

Graph the following line using available t_{50s} and s values:

$$Z = \left[\frac{(\ln t - t_{50s})}{s}\right] \tag{21}$$

Include fitted line and description in graph key. If the t_{fi} data belong to a lognormal distribution, they will fall along the line.

9 Reporting

9.1 Minimum data reporting

As a minimum, the following information should be reported: (t_{50s})

- estimate for median-time-to fail (t_{50s});
- estimate for standard deviation of log distribution (s);
- number of samples, failures, and censored units.

9.2 Optional reporting

Report the following for engineering and/or internal improvement:

- items listed in 9.1;
- raw fail data and censor time (if any);
- confidence intervals (if available);
- techniques used to produce estimators;
- state whether estimators are biased or unbiased;
- provide log-normal graph containing raw data an estimated distribution line as described in section 8.

Annex A (informative) Non-censored data example

This example uses the failure set data in columns 2 & 3 of Table C.4, following the Instructions in section 6 to calculate the complete data estimates of the parameters of the parent population.

A.1 ln t_f

Calculate the natural logarithm for each failure time ln t_f (Table C.4, column 4).

A.2 Mean, Median and Standard Deviation

Calculate the unbiased estimate of ln t_{50s} and the estimate of t_{50s} as in 6.1. Use ln t_f's from column 4 of Table C.4.

ln t_{50s} = 2.5679
t_{50s} = 13.039

Calculate biased and unbiased estimates of the standard deviation, σ, of the lognormal failure set using 6.2.

s_{biased} = 0.91502
s = 0.92646

A.3 Confidence intervals

A.3.1 Mean and median

Calculate the 100(1 – α) % = 95% (α = 0.05) confidence interval around the mean of the long failure times and median failure time as in 6.3

Calculate p = 1 – α/2 = 1 – 0.05/2= 0.975

Determine the value of the p-th percentile of the Student's t-distribution with $N - 1$ degrees of freedom (see Table C.1 or equivalent).

t[p; N – 1] – t [0.975; 20] = 2.086

Calculate the upper and lower confidence limits around the median of the failure times as in 6.3.2.

LCL(t_{50}) = 8.597
UCL(t_{50}) = 19.775

A.3.2 Standard deviation

Calculate the 100(1 – α) % = 95% (α = 0.05) confidence interval around the standard deviation of the failure times as in 6.4.
Find the 1 – α/2 = 0.975 and α/2 = 0.024 percentiles of the chi-squared distribution with $N - 1$ degrees of freedom from Table C.2a and Table C.2b.

$\chi^2\ [\alpha/2; N-1] = \chi^2\ [0.025; 20] = 9.571$
$\chi^2\ [1-\alpha/2; N-1] = \chi^2\ [0.0975; 20] = 34.170$

Calculate the lower and upper limits of the 95% confidence interval [LCL(σ), ULC(σ)] from the equations in 6.4.2:

LCL(σ) = 0.7000
ULC(σ) = 1.3213

A.3.3 Plots

Make a plot of data and results as in 8. See Figure C.1.

Annex B (informative) Singly right-censored data example

Using failure set data in columns 2 & 3 of Table C.5, this annex follows the instruction in section 7 to calculate the singly right-censored data parameter estimates based upon the parent population. Data in Table C.5 is the same as Table C.4, but the test is treaded as if it were censored at time = 30 s such that the last 5 failure times are only known to be greater than time = 30 s.

B.1 ln t_f

Calculate the natural logarithm of each failure time, ln t_f (see column 4 in Table C.5).

B.2 Intermediate terms

Calculate $(1 - K/N = 1 - 16/21) = 0.238$

where $N = 21$ (total parts on test) and $K = 16$ (number of parts that failed before the test was stopped).

Determine the term z_o from Table C.3a or equivalent:

$z_o = -0.7128$

Calculate term α_{PR} as in 7.1.2

$\alpha_{PR} = 0.40625$

Calculate the ln (censor-time), term C_r as in 7.1.3

$C_r = 3.4012$

Calculate term M as in 7.1.4

M = 2.1924

Calculate term StdDev as in 7.1.5

StdDev = 0.67911

Calculate term S_{RML} as in 7.1.6

$s_{RML} = 1.0113$

B.3 Standard deviation

Calculate the biased and unbiased estimates of standard deviation as in 7.2.

Calculate the based sample estimate, $s_{PR\ biased}$, of the standard deviation of the censored log failure set as in 7.2.1.

$s_{PR\ biased} = 0.94717$

Calculate the unbiased estimate, s, of the standard deviation of the censored log failure set as in 7.2.2.

s = 0.98725

B.4 Mean and median

Calculate the biased and unbiased estimates of the mean of the log failure set as in 7.3.

Calculate the biased estimate, ln ($t_{50s\ PR\ biased}$), of the mean of the log failure set as in 7.3.1.

$\ln (t_{50s\ PR\ biased}) = 2.6032$

Calculate the unbiased estimate, ln t_{50s}, of the mean of the log failure set as in 7.3.2.

$\ln t_{50s} = 2.6151$

Calculate the estimate, t_{50s}, of the median of the failure set as in 7.3.3.

$t_{50s} = 13.669$

B.5 Plots

Make plot of data and results as in 8. See also Annex C and Figure C.2.

Annex C (informative) Data graphing example for singly right-censored data

This annex will illustrated the means of generating a graph of raw fail times and the fitted distribution for censored data. The example data is from Annex B.

C.1 Prepare data as in 8.1

Rank order log fail times, ln t_{fi}, with i = 1 being the shortest fail time, i = 2 the 2nd fail time *etc*., as in column 1 of Table C.5.

Assign failure probabilities to each ln t_{fi}, as in 8.1.2. See column 5 of Table C.5.

Determine the standard normal Z-value that corresponds to each failure probability. Use Tables C.3a, b or equivalent. See column 6 of Table C.5 for results.

C.2 Graph raw data (see Figure C.2)

Graph Z-value versus ln t_{fi} for each failure time. Include symbol used in a key.

Label left axis with failure probability values, right axis with normal Z values, and bottom axis with time values. Determine standard normal Z-values for probability scale (0.01, 0.1, 0.3, 0.5, 0.7, 0.9, 0.99 for example) from Tables C.3a, b or equivalent.

C.3 Censored data points

Graph a line at right angles to the time scale at the censor time = 30 s and provide a message stating 5 units were censored at 30 s. Include a censoring message in graph key.

C.4 Graph fitted lognormal distribution

Graph the following line using Annex B, t_{50s}, and s values:

$$Z = [\ \ln t - \ln t_{50s}\ ] / s = [\ \ln t - \ln (13.67)\ ] / 0.9873$$

Include the fitted line and description in a graph key. Include t_{50s}, s, and "Persson-Rootzen unbiased" in the graph key.

Table C.1 — Percent points of Student's t – t [P; df]. [6]

df	P=0.8	P=0.9	P=0.95	P=0.975	P=0.99	P=0.995
1	1.376	3.078	6.314	12.706	31.821	63.657
2	1.061	1.886	2.920	4.303	6.965	9.925
3	0.978	1.638	2.353	3.182	4.541	5.841
4	0.941	1.533	2.132	2.776	3.747	4.604
5	0.920	1.476	2.015	2.571	3.365	4.032
6	0.906	1.440	1.943	2.447	3.143	3.707
7	0.896	1.415	1.895	2.365	2.998	3.499
8	0.889	1.397	1.860	2.306	2.896	3.355
9	0.883	1.383	1.833	2.262	2.821	3.250
10	0.879	1.372	1.812	2.228	2.764	3.169
11	0.876	1.363	1.796	2.201	2.718	3.106
12	0.873	1.356	1.782	2.179	2.681	3.055
13	0.870	1.350	1.771	2.160	2.650	3.012
14	0.868	1.345	1.761	2.145	2.624	2.977
15	0.866	1.341	1.753	2.131	2.602	2.947
16	0.865	1.337	1.746	2.120	2.583	2.921
17	0.863	1.333	1.740	2.110	2.567	2.898
18	0.862	1.330	1.734	2.101	2.552	2.878
19	0.861	1.328	1.729	2.093	2.539	2.861
20	0.860	1.325	1.725	2.086	2.528	2.845
21	0.859	1.323	1.721	2.080	2.518	2.831
22	0.858	1.321	1.717	2.074	2.508	2.819
23	0.858	1.319	1.714	2.069	2.500	2.807
24	0.857	1.318	1.711	2.064	2.492	2.797
25	0.856	1.316	1.708	2.060	2.485	2.787
26	0.856	1.315	1.706	2.056	2.479	2.779
27	0.855	1.314	1.703	2.052	2.473	2.771
28	0.855	1.313	1.701	2.048	2.467	2.763
29	0.854	1.311	1.699	2.045	2.462	2.756
30	0.854	1.310	1.697	2.042	2.457	2.750
31	0.853	1.309	1.696	2.040	2.453	2.744
32	0.853	1.309	1.694	2.037	2.449	2.738
33	0.853	1.308	1.692	2.035	2.445	2.733
34	0.852	1.307	1.691	2.032	2.441	2.728
35	0.852	1.306	1.690	2.030	2.438	2.724
36	0.852	1.306	1.688	2.028	2.434	2.719
37	0.851	1.305	1.687	2.026	2.431	2.715
38	0.851	1.304	1.686	2.024	2.429	2.712
39	0.851	1.304	1.685	2.023	2.426	2.708
40	0.851	1.303	1.684	2.021	2.423	2.704
42	0.850	1.302	1.682	2.018	2.418	2.698
44	0.850	1.301	1.680	2.015	2.414	2.692
46	0.850	1.300	1.679	2.013	2.410	2.687
48	0.849	1.299	1.677	2.011	2.407	2.682
50	0.849	1.299	1.676	2.009	2.403	2.678
55	0.848	1.297	1.673	2.004	2.396	2.668
60	0.848	1.296	1.671	2.000	2.390	2.660
70	0.847	1.294	1.667	1.994	2.381	2.648
80	0.846	1.292	1.664	1.990	2.374	2.639
100	0.845	1.290	1.660	1.984	2.364	2.626

Table C.2A — Left handed Chi-square percent points – χ2 [P; df]. [6]

df	P=0.005	P=0.025	P=0.05	P=0.1
1	0.000	0.001	0.004	0.016
2	0.010	0.051	0.103	0.211
3	0.072	0.216	0.352	0.584
4	0.207	0.484	0.711	1.064
5	0.412	0.831	1.145	1.610
6	0.676	1.237	1.635	2.204
7	0.989	1.690	2.167	2.833
8	1.344	2.180	2.733	3.490
9	1.735	2.700	3.325	4.168
10	2.156	3.247	3.940	4.865
11	2.603	3.816	4.575	5.578
12	3.074	4.404	5.226	6.304
13	3.565	5.009	5.892	7.042
14	4.075	5.629	6.571	7.790
15	4.601	6.262	7.261	8.547
16	5.142	6.908	7.962	9.312
17	5.697	7.564	8.672	10.085
18	6.265	8.231	9.390	10.865
19	6.844	8.907	10.117	11.651
20	7.434	9.591	10.851	12.443
21	8.034	10.283	11.591	13.240
22	8.643	10.982	12.338	14.041
23	9.260	11.689	13.091	14.848
24	9.886	12.401	13.848	15.659
25	10.520	13.120	14.611	16.473
26	11.160	13.844	15.379	17.292
27	11.808	14.573	16.151	18.114
28	12.461	15.308	16.928	18.939
29	13.121	16.047	17.708	19.768
30	13.787	16.791	18.493	20.599
31	14.458	17.539	19.281	21.434
32	15.134	18.291	20.072	22.271
33	15.815	19.047	20.867	23.110
34	16.501	19.806	21.664	23.952
35	17.192	20.569	22.465	24.797
36	17.887	21.336	23.269	25.643
37	18.586	22.106	24.075	26.492
38	19.289	22.878	24.884	27.343
39	19.996	23.654	25.695	28.196
40	20.707	24.433	26.509	29.051
42	22.138	25.999	28.144	30.765
44	23.584	27.575	29.787	32.487
46	25.041	29.160	31.439	34.215
48	26.511	30.755	33.098	35.949
50	27.991	32.357	34.764	37.689
55	31.735	36.398	38.958	42.060
60	35.534	40.482	43.188	46.459
70	43.275	48.758	51.739	55.329
80	51.172	57.153	60.391	64.278
100	67.328	74.222	77.929	82.358

Table C.2B — Right handed Chi-square percent points – $\chi 2$ [P; df]. Source [6]

df	P=0.9	P=0.95	P=0.975	P=0.995
1	2.706	3.841	5.024	7.879
2	4.605	5.991	7.378	10.597
3	6.251	7.815	9.348	12.838
4	7.779	9.488	11.143	14.860
5	9.236	11.070	12.832	16.750
6	10.645	12.592	14.449	18.548
7	12.017	14.067	16.013	20.278
8	13.362	15.507	17.535	21.955
9	14.684	16.919	19.023	23.589
10	15.987	18.307	20.483	25.188
11	17.275	19.675	21.920	26.757
12	18.549	21.026	23.337	28.300
13	19.812	22.362	24.736	29.819
14	21.064	23.685	26.119	31.319
15	22.307	24.996	27.488	32.801
16	23.542	26.296	28.845	34.267
17	24.769	27.587	30.191	35.718
18	25.989	28.869	31.526	37.156
19	27.204	30.144	32.852	38.582
20	28.412	31.410	34.170	39.997
21	29.615	32.671	35.479	41.401
22	30.813	33.924	36.781	42.796
23	32.007	35.172	38.076	44.181
24	33.196	36.415	39.364	45.559
25	34.382	37.652	40.646	46.928
26	35.563	38.885	41.923	48.290
27	36.741	40.113	43.195	49.645
28	37.916	41.337	44.461	50.993
29	39.087	42.557	45.722	52.336
30	40.256	43.773	46.979	53.672
31	41.422	44.985	48.232	55.003
32	42.585	46.194	49.480	56.328
33	43.745	47.400	50.725	57.648
34	44.903	48.602	51.966	58.964
35	46.059	49.802	53.203	60.275
36	47.212	50.998	54.437	61.581
37	48.363	52.192	55.668	62.883
38	49.513	53.384	56.896	64.181
39	50.660	54.572	58.120	65.476
40	51.805	55.758	59.342	66.766
42	54.090	58.124	61.777	69.336
44	56.369	60.481	64.201	71.893
46	58.641	62.830	66.617	74.437
48	60.907	65.171	69.023	76.969
50	63.167	67.505	71.420	79.490
55	68.796	73.311	77.380	85.749
60	74.397	79.082	83.298	91.952
70	85.527	90.531	95.023	104.215
80	96.578	101.879	106.629	116.321
100	118.498	124.342	129.561	140.169

Table C.3A — Normal percent points, Z [P = 0.001-0.499]. [6]

P	P+.000	P+.001	P+.002	P+.003	P+.004	P+.005	P+.006	P+.007	P+.008	P+.009
0.00	--	-3.0902	-2.8782	-2.7478	-2.6521	-2.5758	-2.5121	-2.4573	-2.4089	-2.3656
0.01	-2.3263	-2.2904	-2.2571	-2.2262	-2.1973	-2.1701	-2.1444	-2.1201	-2.0969	-2.0749
0.02	-2.0537	-2.0335	-2.0141	-1.9954	-1.9774	-1.9600	-1.9431	-1.9268	-1.9110	-1.8957
0.03	-1.8808	-1.8663	-1.8522	-1.8384	-1.8250	-1.8119	-1.7991	-1.7866	-1.7744	-1.7624
0.04	-1.7507	-1.7392	-1.7279	-1.7169	-1.7060	-1.6954	-1.6849	-1.6747	-1.6646	-1.6546
0.05	-1.6449	-1.6352	-1.6258	-1.6164	-1.6072	-1.5982	-1.5893	-1.5805	-1.5718	-1.5632
0.06	-1.5548	-1.5464	-1.5382	-1.5301	-1.5220	-1.5141	-1.5063	-1.4985	-1.4909	-1.4833
0.07	-1.4758	-1.4684	-1.4611	-1.4538	-1.4466	-1.4395	-1.4325	-1.4255	-1.4187	-1.4118
0.08	-1.4051	-1.3984	-1.3917	-1.3852	-1.3787	-1.3722	-1.3658	-1.3595	-1.3532	-1.3469
0.09	-1.3408	-1.3346	-1.3285	-1.3225	-1.3165	-1.3106	-1.3047	-1.2988	-1.2930	-1.2873
0.10	-1.2816	-1.2759	-1.2702	-1.2646	-1.2591	-1.2536	-1.2481	-1.2426	-1.2372	-1.2319
0.11	-1.2265	-1.2212	-1.2160	-1.2107	-1.2055	-1.2004	-1.1952	-1.1901	-1.1850	-1.1800
0.12	-1.1750	-1.1700	-1.1650	-1.1601	-1.1552	-1.1503	-1.1455	-1.1407	-1.1359	-1.1311
0.13	-1.1264	-1.1217	-1.1170	-1.1123	-1.1077	-1.1031	-1.0985	-1.0939	-1.0893	-1.0848
0.14	-1.0803	-1.0758	-1.0714	-1.0669	-1.0625	-1.0581	-1.0537	-1.0494	-1.0451	-1.0407
0.15	-1.0364	-1.0322	-1.0279	-1.0237	-1.0194	-1.0152	-1.0110	-1.0069	-1.0027	-0.9986
0.16	-0.9945	-0.9904	-0.9863	-0.9822	-0.9782	-0.9741	-0.9701	-0.9661	-0.9621	-0.9581
0.17	-0.9542	-0.9502	-0.9463	-0.9424	-0.9385	-0.9346	-0.9307	-0.9269	-0.9230	-0.9192
0.18	-0.9154	-0.9116	-0.9078	-0.9040	-0.9002	-0.8965	-0.8927	-0.8890	-0.8853	-0.8816
0.19	-0.8779	-0.8742	-0.8705	-0.8669	-0.8633	-0.8596	-0.8560	-0.8524	-0.8488	-0.8452
0.20	-0.8416	-0.8381	-0.8345	-0.8310	-0.8274	-0.8239	-0.8204	-0.8169	-0.8134	-0.8099
0.21	-0.8064	-0.8030	-0.7995	-0.7961	-0.7926	-0.7892	-0.7858	-0.7824	-0.7790	-0.7756
0.22	-0.7722	-0.7688	-0.7655	-0.7621	-0.7588	-0.7554	-0.7521	-0.7488	-0.7454	-0.7421
0.23	-0.7388	-0.7356	-0.7323	-0.7290	-0.7257	-0.7225	-0.7192	-0.7160	-0.7128	-0.7095
0.24	-0.7063	-0.7031	-0.6999	-0.6967	-0.6935	-0.6903	-0.6871	-0.6840	-0.6808	-0.6776
0.25	-0.6745	-0.6713	-0.6682	-0.6651	-0.6620	-0.6588	-0.6557	-0.6526	-0.6495	-0.6464
0.26	-0.6433	-0.6403	-0.6372	-0.6341	-0.6311	-0.6280	-0.6250	-0.6219	-0.6189	-0.6158
0.27	-0.6128	-0.6098	-0.6068	-0.6038	-0.6008	-0.5978	-0.5948	-0.5918	-0.5888	-0.5858
0.28	-0.5828	-0.5799	-0.5769	-0.5740	-0.5710	-0.5681	-0.5651	-0.5622	-0.5592	-0.5563
0.29	-0.5534	-0.5505	-0.5476	-0.5446	-0.5417	-0.5388	-0.5359	-0.5330	-0.5302	-0.5273
0.30	-0.5244	-0.5215	-0.5187	-0.5158	-0.5129	-0.5101	-0.5072	-0.5044	-0.5015	-0.4987
0.31	-0.4959	-0.4930	-0.4902	-0.4874	-0.4845	-0.4817	-0.4789	-0.4761	-0.4733	-0.4705
0.32	-0.4677	-0.4649	-0.4621	-0.4593	-0.4565	-0.4538	-0.4510	-0.4482	-0.4454	-0.4427
0.33	-0.4399	-0.4372	-0.4344	-0.4316	-0.4289	-0.4261	-0.4234	-0.4207	-0.4179	-0.4152
0.34	-0.4125	-0.4097	-0.4070	-0.4043	-0.4016	-0.3989	-0.3961	-0.3934	-0.3907	-0.3880
0.35	-0.3853	-0.3826	-0.3799	-0.3772	-0.3745	-0.3719	-0.3692	-0.3665	-0.3638	-0.3611
0.36	-0.3585	-0.3558	-0.3531	-0.3505	-0.3478	-0.3451	-0.3425	-0.3398	-0.3372	-0.3345
0.37	-0.3319	-0.3292	-0.3266	-0.3239	-0.3213	-0.3186	-0.3160	-0.3134	-0.3107	-0.3081
0.38	-0.3055	-0.3029	-0.3002	-0.2976	-0.2950	-0.2924	-0.2898	-0.2871	-0.2845	-0.2819
0.39	-0.2793	-0.2767	-0.2741	-0.2715	-0.2689	-0.2663	-0.2637	-0.2611	-0.2585	-0.2559
0.40	-0.2533	-0.2508	-0.2482	-0.2456	-0.2430	-0.2404	-0.2378	-0.2353	-0.2327	-0.2301
0.41	-0.2275	-0.2250	-0.2224	-0.2198	-0.2173	-0.2147	-0.2121	-0.2096	-0.2070	-0.2045
0.42	-0.2019	-0.1993	-0.1968	-0.1942	-0.1917	-0.1891	-0.1866	-0.1840	-0.1815	-0.1789
0.43	-0.1764	-0.1738	-0.1713	-0.1687	-0.1662	-0.1637	-0.1611	-0.1586	-0.1560	-0.1535
0.44	-0.1510	-0.1484	-0.1459	-0.1434	-0.1408	-0.1383	-0.1358	-0.1332	-0.1307	-0.1282
0.45	-0.1257	-0.1231	-0.1206	-0.1181	-0.1156	-0.1130	-0.1105	-0.1080	-0.1055	-0.1030
0.46	-0.1004	-0.0979	-0.0954	-0.0929	-0.0904	-0.0878	-0.0853	-0.0828	-0.0803	-0.0778
0.47	-0.0753	-0.0728	-0.0702	-0.0677	-0.0652	-0.0627	-0.0602	-0.0577	-0.0552	-0.0527
0.48	-0.0502	-0.0476	-0.0451	-0.0426	-0.0401	-0.0376	-0.0351	-0.0326	-0.0301	-0.0276
0.49	-0.0251	-0.0226	-0.0201	-0.0175	-0.0150	-0.0125	-0.0100	-0.0075	-0.0050	-0.0025

Table C.3B — Normal percent points, z [P = 0.5-0.999]. Source [6]

P	P+.000	P+.001	P+.002	P+.003	P+.004	P+.005	P+.006	P+.007	P+.008	P+.009
0.50	0.0000	0.0025	0.0050	0.0075	0.0100	0.0125	0.0150	0.0175	0.0201	0.0226
0.51	0.0251	0.0276	0.0301	0.0326	0.0351	0.0376	0.0401	0.0426	0.0451	0.0476
0.52	0.0502	0.0527	0.0552	0.0577	0.0602	0.0627	0.0652	0.0677	0.0702	0.0728
0.53	0.0753	0.0778	0.0803	0.0828	0.0853	0.0878	0.0904	0.0929	0.0954	0.0979
0.54	0.1004	0.1030	0.1055	0.1080	0.1105	0.1130	0.1156	0.1181	0.1206	0.1231
0.55	0.1257	0.1282	0.1307	0.1332	0.1358	0.1383	0.1408	0.1434	0.1459	0.1484
0.56	0.1510	0.1535	0.1560	0.1586	0.1611	0.1637	0.1662	0.1687	0.1713	0.1738
0.57	0.1764	0.1789	0.1815	0.1840	0.1866	0.1891	0.1917	0.1942	0.1968	0.1993
0.58	0.2019	0.2045	0.2070	0.2096	0.2121	0.2147	0.2173	0.2198	0.2224	0.2250
0.59	0.2275	0.2301	0.2327	0.2353	0.2378	0.2404	0.2430	0.2456	0.2482	0.2508
0.60	0.2533	0.2559	0.2585	0.2611	0.2637	0.2663	0.2689	0.2715	0.2741	0.2767
0.61	0.2793	0.2819	0.2845	0.2871	0.2898	0.2924	0.2950	0.2976	0.3002	0.3029
0.62	0.3055	0.3081	0.3107	0.3134	0.3160	0.3186	0.3213	0.3239	0.3266	0.3292
0.63	0.3319	0.3345	0.3372	0.3398	0.3425	0.3451	0.3478	0.3505	0.3531	0.3558
0.64	0.3585	0.3611	0.3638	0.3665	0.3692	0.3719	0.3745	0.3772	0.3799	0.3826
0.65	0.3853	0.3880	0.3907	0.3934	0.3961	0.3989	0.4016	0.4043	0.4070	0.4097
0.66	0.4125	0.4152	0.4179	0.4207	0.4234	0.4261	0.4289	0.4316	0.4344	0.4372
0.67	0.4399	0.4427	0.4454	0.4482	0.4510	0.4538	0.4565	0.4593	0.4621	0.4649
0.68	0.4677	0.4705	0.4733	0.4761	0.4789	0.4817	0.4845	0.4874	0.4902	0.4930
0.69	0.4959	0.4987	0.5015	0.5044	0.5072	0.5101	0.5129	0.5158	0.5187	0.5215
0.70	0.5244	0.5273	0.5302	0.5330	0.5359	0.5388	0.5417	0.5446	0.5476	0.5505
0.71	0.5534	0.5563	0.5592	0.5622	0.5651	0.5681	0.5710	0.5740	0.5769	0.5799
0.72	0.5828	0.5858	0.5888	0.5918	0.5948	0.5978	0.6008	0.6038	0.6068	0.6098
0.73	0.6128	0.6158	0.6189	0.6219	0.6250	0.6280	0.6311	0.6341	0.6372	0.6403
0.74	0.6433	0.6464	0.6495	0.6526	0.6557	0.6588	0.6620	0.6651	0.6682	0.6713
0.75	0.6745	0.6776	0.6808	0.6840	0.6871	0.6903	0.6935	0.6967	0.6999	0.7031
0.76	0.7063	0.7095	0.7128	0.7160	0.7192	0.7225	0.7257	0.7290	0.7323	0.7356
0.77	0.7388	0.7421	0.7454	0.7488	0.7521	0.7554	0.7588	0.7621	0.7655	0.7688
0.78	0.7722	0.7756	0.7790	0.7824	0.7858	0.7892	0.7926	0.7961	0.7995	0.8030
0.79	0.8064	0.8099	0.8134	0.8169	0.8204	0.8239	0.8274	0.8310	0.8345	0.8381
0.80	0.8416	0.8452	0.8488	0.8524	0.8560	0.8596	0.8633	0.8669	0.8705	0.8742
0.81	0.8779	0.8816	0.8853	0.8890	0.8927	0.8965	0.9002	0.9040	0.9078	0.9116
0.82	0.9154	0.9192	0.9230	0.9269	0.9307	0.9346	0.9385	0.9424	0.9463	0.9502
0.83	0.9542	0.9581	0.9621	0.9661	0.9701	0.9741	0.9782	0.9822	0.9863	0.9904
0.84	0.9945	0.9986	1.0027	1.0069	1.0110	1.0152	1.0194	1.0237	1.0279	1.0322
0.85	1.0364	1.0407	1.0451	1.0494	1.0537	1.0581	1.0625	1.0669	1.0714	1.0758
0.86	1.0803	1.0848	1.0893	1.0939	1.0985	1.1031	1.1077	1.1123	1.1170	1.1217
0.87	1.1264	1.1311	1.1359	1.1407	1.1455	1.1503	1.1552	1.1601	1.1650	1.1700
0.88	1.1750	1.1800	1.1850	1.1901	1.1952	1.2004	1.2055	1.2107	1.2160	1.2212
0.89	1.2265	1.2319	1.2372	1.2426	1.2481	1.2536	1.2591	1.2646	1.2702	1.2759
0.90	1.2816	1.2873	1.2930	1.2988	1.3047	1.3106	1.3165	1.3225	1.3285	1.3346
0.91	1.3408	1.3469	1.3532	1.3595	1.3658	1.3722	1.3787	1.3852	1.3917	1.3984
0.92	1.4051	1.4118	1.4187	1.4255	1.4325	1.4395	1.4466	1.4538	1.4611	1.4684
0.93	1.4758	1.4833	1.4909	1.4985	1.5063	1.5141	1.5220	1.5301	1.5382	1.5464
0.94	1.5548	1.5632	1.5718	1.5805	1.5893	1.5982	1.6072	1.6164	1.6258	1.6352
0.95	1.6449	1.6546	1.6646	1.6747	1.6849	1.6954	1.7060	1.7169	1.7279	1.7392
0.96	1.7507	1.7624	1.7744	1.7866	1.7991	1.8119	1.8250	1.8384	1.8522	1.8663
0.97	1.8808	1.8957	1.9110	1.9268	1.9431	1.9600	1.9774	1.9954	2.0141	2.0335
0.98	2.0537	2.0749	2.0969	2.1201	2.1444	2.1701	2.1973	2.2262	2.2571	2.2904
0.99	2.3263	2.3656	2.4089	2.4573	2.5121	2.5758	2.6521	2.7478	2.8782	3.0902

Table C.4 — Non-censored data example, JC-14.2 round robin.

Rank - i	Time (s)	Censor Type	ln(Time)	(i-.3)/(N+.4)	Normal - z
1	2.97	Valid Data	1.0886	0.0330	-1.8384
2	3.35	Valid Data	1.2090	0.0790	-1.4118
3	3.46	Valid Data	1.2413	0.1260	-1.1455
4	4.18	Valid Data	1.4303	0.1730	-0.9424
5	6.21	Valid Data	1.8262	0.2200	-0.7722
6	6.71	Valid Data	1.9036	0.2660	-0.6250
7	9.18	Valid Data	2.2170	0.3130	-0.4874
8	9.23	Valid Data	2.2225	0.3600	-0.3585
9	9.50	Valid Data	2.2513	0.4070	-0.2353
10	11.03	Valid Data	2.4006	0.4530	-0.1181
11	15.81	Valid Data	2.7606	0.5000	0.0000
12	15.92	Valid Data	2.7676	0.5470	0.1181
13	16.70	Valid Data	2.8154	0.5930	0.2353
14	17.42	Valid Data	2.8576	0.6400	0.3585
15	17.96	Valid Data	2.8881	0.6870	0.4874
16	24.50	Valid Data	3.1987	0.7340	0.6250
17	32.13	Valid Data	3.4698	0.7800	0.7722
18	32.30	Valid Data	3.4751	0.8270	0.9424
19	43.56	Valid Data	3.7741	0.8740	1.1455
20	57.56	Valid Data	4.0528	0.9210	1.4118
21	58.92	Valid Data	4.0762	0.9670	1.8384

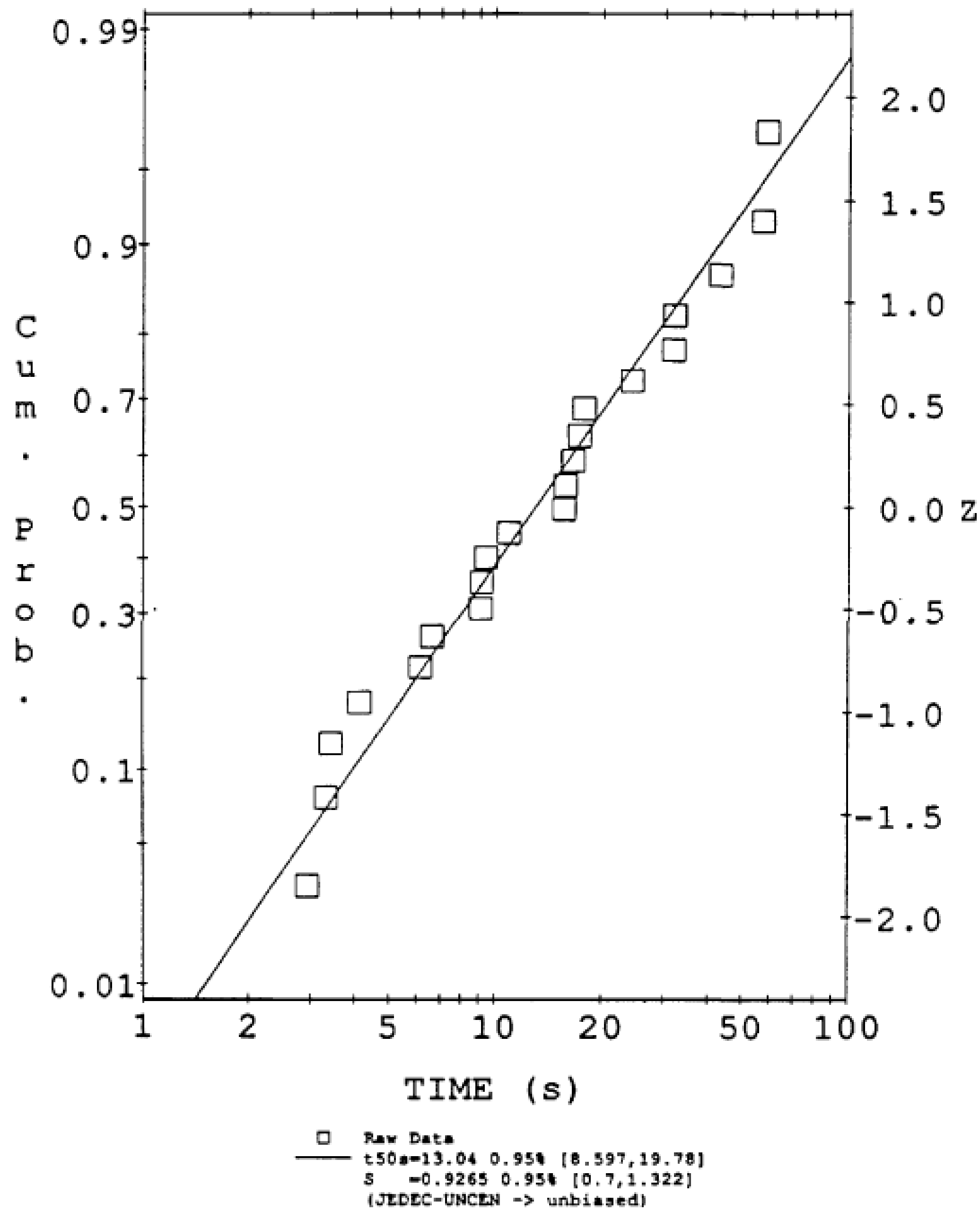

Figure C.1 — Non-censored data example, JC-14.2 round robin

Table C.5 — Singly right-censored data example, JC-14.2 round robin.

Rank - i	Time (s)	Censor Type	ln(Time)	(i-.3)/(N+.4)	Normal - z
1	2.97	Valid Data	1.0886	0.0330	-1.8384
2	3.35	Valid Data	1.2090	0.0790	-1.4118
3	3.46	Valid Data	1.2413	0.1260	-1.1455
4	4.18	Valid Data	1.4303	0.1730	-0.9424
5	6.21	Valid Data	1.8262	0.2200	-0.7722
6	6.71	Valid Data	1.9036	0.2660	-0.6250
7	9.18	Valid Data	2.2170	0.3130	-0.4874
8	9.23	Valid Data	2.2225	0.3600	-0.3585
9	9.50	Valid Data	2.2513	0.4070	-0.2353
10	11.03	Valid Data	2.4006	0.4530	-0.1181
11	15.81	Valid Data	2.7606	0.5000	0.0000
12	15.92	Valid Data	2.7676	0.5470	0.1181
13	16.70	Valid Data	2.8154	0.5930	0.2353
14	17.42	Valid Data	2.8576	0.6400	0.3585
15	17.96	Valid Data	2.8881	0.6870	0.4874
16	24.50	Valid Data	3.1987	0.7340	0.6250
17	30.00	Right Censor	3.4012	0.7800	
18	30.00	Right Censor	3.4012	0.8270	
19	30.00	Right Censor	3.4012	0.8740	
20	30.00	Right Censor	3.4012	0.9210	
21	30.00	Right Censor	3.4012	0.9670	

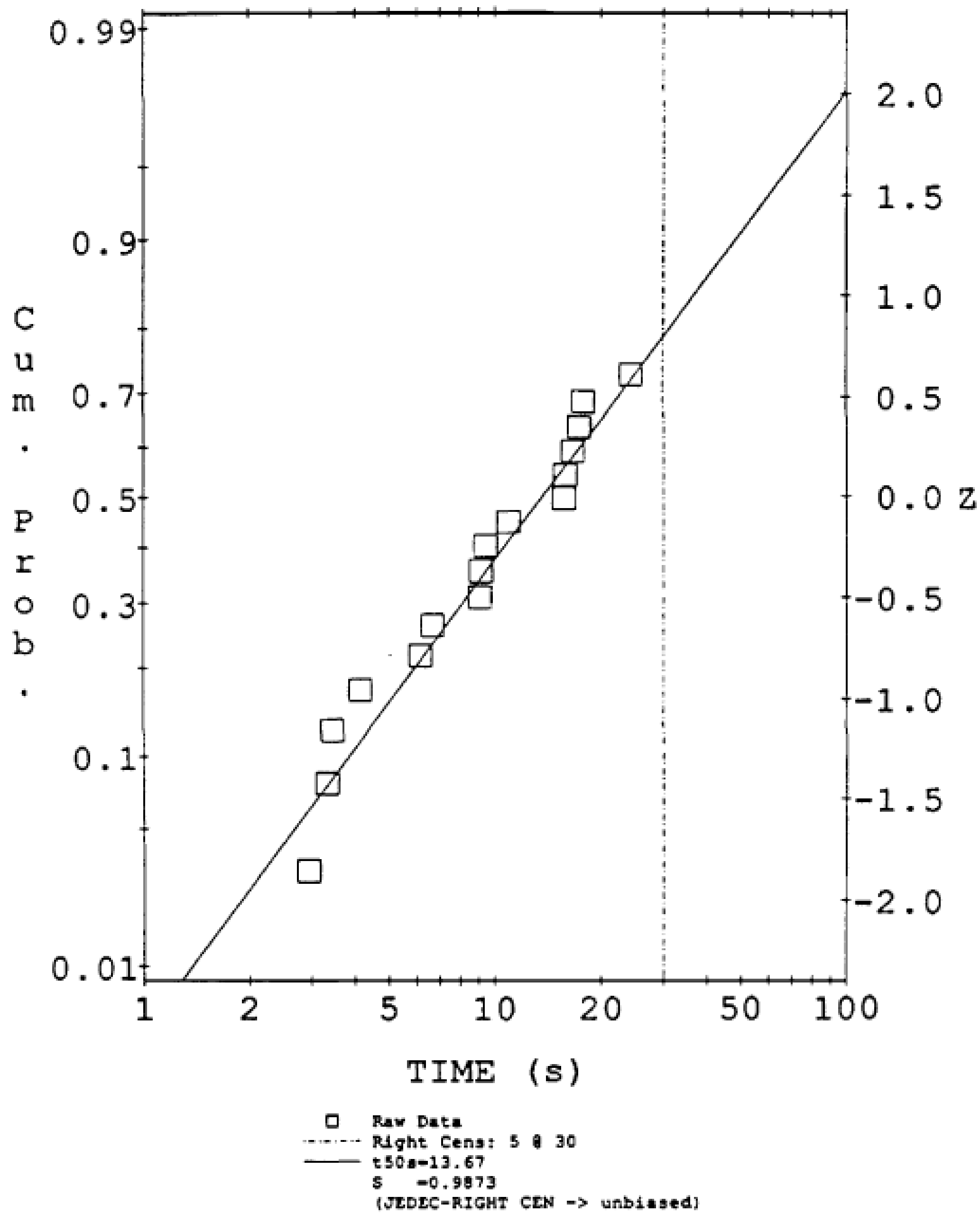

Figure C.2—Non-censored data example, JC-14.2 round robin.

Annex D (informative) Bibliography

1. H. Schafft and J. Lechner, "Analysis of Time to Fail Data", *Presentation at the 1989 Wafer-Level Reliability Workshop*, Lake Tahoe, 1989.

2. J. Lechner, "Estimators for Type-II Censored (Log)Normal Samples", *Transactions on Reliability,* Vol. 40, No. 5, 1991, pp. 547.

3. M. Stephens, "EDF Statistics for Goodness of Fit and Some Comparisons, "*Journal of the American Statistical Association*", Vol. 69, 1974, pp. 730.

4. J. Filliben, "The Probability Plot Correlation Coefficient Test for Normality", *Technometircs*, Vol. 17, 1975, pp. 111.

5. J. Filliben, "Dataplot: An Interactive Hi-Level Language for Graphics, Non-Linear Fitting, Data Analysis and Mathematics", *Computer Graphics*, Vol. 15, 1981, pp. 199.

Annex E (informative) Differences between JESD37A and its predecessor JESD37

This annex briefly describes most of the changes made to entries that appear in this standard, JESD37A, compared to its predecessor, JESD37 (October 1992). If the change to a concept involves any words added or deleted (excluding deletion of accidentally repeated words), it is included. Some punctuation changes are not included.

Clause	Description of change
General	Reaffirmed JESD37 (October 1992) – updated to the new JEDEC template with minor revisions.
3.1	Definitions of terms were edited for format. The definitions for bias, censored date, complete data, and lognormal distribution were revised to better align to JESD88 which post-dated JESD37.

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