

UCL Statistics for Data Sets with Non-Detects

User Selected Options

Date/Time of Computation	ProUCL 5.16/19/17 5:13:20 PM
From File	ProUCLinput_53-001(a)_0-10.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Acetone

General Statistics

Total Number of Observations	28	Number of Distinct Observations	25
		Number of Missing Observations	24
Number of Detects	8	Number of Non-Detects	20
Number of Distinct Detects	8	Number of Distinct Non-Detects	17
Minimum Detect	0.00894	Minimum Non-Detect	0.0052
Maximum Detect	0.0226	Maximum Non-Detect	0.024
Variance Detects	2.0061E-5	Percent Non-Detects	71.43%
Mean Detects	0.0119	SD Detects	0.00448
Median Detects	0.0105	CV Detects	0.378
Skewness Detects	2.492	Kurtosis Detects	6.568
Mean of Logged Detects	-4.48	SD of Logged Detects	0.299

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.643	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.818	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.372	Lilliefors GOF Test
5% Lilliefors Critical Value	0.283	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	0.00733	KM Standard Error of Mean	8.3556E-4
KM SD	0.00391	95% KM (BCA) UCL	0.00884
95% KM (t) UCL	0.00875	95% KM (Percentile Bootstrap) UCL	0.00881
95% KM (z) UCL	0.00871	95% KM Bootstrap t UCL	0.00916
90% KM Chebyshev UCL	0.00984	95% KM Chebyshev UCL	0.011
97.5% KM Chebyshev UCL	0.0125	99% KM Chebyshev UCL	0.0156

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.056	Anderson-Darling GOF Test
5% A-D Critical Value	0.715	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.331	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.294	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	11.12	k star (bias corrected MLE)	7.036
Theta hat (MLE)	0.00107	Theta star (bias corrected MLE)	0.00169
nu hat (MLE)	178	nu star (bias corrected)	112.6
Mean (detects)	0.0119		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.00894	Mean	0.0105
Maximum	0.0226	Median	0.01
SD	0.00244	CV	0.231
k hat (MLE)	31.26	k star (bias corrected MLE)	27.94
Theta hat (MLE)	3.3686E-4	Theta star (bias corrected MLE)	3.7697E-4
nu hat (MLE)	1751	nu star (bias corrected)	1565
Adjusted Level of Significance (β)	0.0404		
Approximate Chi Square Value (N/A, α)	1474	Adjusted Chi Square Value (N/A, β)	1468
95% Gamma Approximate UCL (use when $n \geq 50$)	0.0112	95% Gamma Adjusted UCL (use when $n \geq 50$)	0.0112

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.00733	SD (KM)	0.00391
Variance (KM)	1.5272E-5	SE of Mean (KM)	8.3556E-4
k hat (KM)	3.52	k star (KM)	3.166
nu hat (KM)	197.1	nu star (KM)	177.3
theta hat (KM)	0.00208	theta star (KM)	0.00232
80% gamma percentile (KM)	0.0104	90% gamma percentile (KM)	0.0129
95% gamma percentile (KM)	0.0152	99% gamma percentile (KM)	0.0201

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (177.31, α)	147.5	Adjusted Chi Square Value (177.31, β)	145.8
95% Gamma Approximate KM-UCL (use when $n \geq 50$)	0.00881	95% Gamma Adjusted KM-UCL (use when $n \geq 50$)	0.00891

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.738	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.818	Detected Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.31	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.283	Detected Data Not Lognormal at 5% Significance Level	

Detected Data Not Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.00667	Mean in Log Scale	-5.136
SD in Original Scale	0.00411	SD in Log Scale	0.469
95% t UCL (assumes normality of ROS data)	0.00799	95% Percentile Bootstrap UCL	0.00807
95% BCA Bootstrap UCL	0.00845	95% Bootstrap t UCL	0.00874
95% H-UCL (Log ROS)	0.00781		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-5.01	KM Geo Mean	0.00667
KM SD (logged)	0.396	95% Critical H Value (KM-Log)	1.864
KM Standard Error of Mean (logged)	0.0847	95% H-UCL (KM -Log)	0.00832
KM SD (logged)	0.396	95% Critical H Value (KM-Log)	1.864
KM Standard Error of Mean (logged)	0.0847		

DL/2 Statistics**DL/2 Normal****DL/2 Log-Transformed**

Mean in Original Scale	0.00632	Mean in Log Scale	-5.336
SD in Original Scale	0.00507	SD in Log Scale	0.728
95% t UCL (Assumes normality)	0.00796	95% H-Stat UCL	0.00848

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	0.00875	KM H-UCL	0.00832
95% KM (BCA) UCL	0.00884		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Aroclor-1254**General Statistics**

Total Number of Observations	52	Number of Distinct Observations	33
Number of Detects	15	Number of Non-Detects	37
Number of Distinct Detects	15	Number of Distinct Non-Detects	18
Minimum Detect	0.0031	Minimum Non-Detect	0.00351
Maximum Detect	3.74	Maximum Non-Detect	0.04
Variance Detects	1.524	Percent Non-Detects	71.15%
Mean Detects	0.635	SD Detects	1.234
Median Detects	0.0372	CV Detects	1.944
Skewness Detects	2.217	Kurtosis Detects	3.75
Mean of Logged Detects	-2.657	SD of Logged Detects	2.435

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.565	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.881	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.321	Lilliefors GOF Test
5% Lilliefors Critical Value	0.22	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	0.187	KM Standard Error of Mean	0.101
KM SD	0.701	95% KM (BCA) UCL	0.381
95% KM (t) UCL	0.356	95% KM (Percentile Bootstrap) UCL	0.346
95% KM (z) UCL	0.353	95% KM Bootstrap t UCL	0.947
90% KM Chebyshev UCL	0.489	95% KM Chebyshev UCL	0.626
97.5% KM Chebyshev UCL	0.816	99% KM Chebyshev UCL	1.189

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.88	Anderson-Darling GOF Test
5% A-D Critical Value	0.833	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.214	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.24	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level**Gamma Statistics on Detected Data Only**

k hat (MLE)	0.311	k star (bias corrected MLE)	0.293
Theta hat (MLE)	2.04	Theta star (bias corrected MLE)	2.164
nu hat (MLE)	9.336	nu star (bias corrected)	8.802
Mean (detects)	0.635		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.0031	Mean	0.19
Maximum	3.74	Median	0.01
SD	0.707	CV	3.717
k hat (MLE)	0.291	k star (bias corrected MLE)	0.287
Theta hat (MLE)	0.654	Theta star (bias corrected MLE)	0.663
nu hat (MLE)	30.24	nu star (bias corrected)	29.83
Adjusted Level of Significance (β)	0.0454		
Approximate Chi Square Value (29.83, α)	18.36	Adjusted Chi Square Value (29.83, β)	18.1
95% Gamma Approximate UCL (use when $n \geq 50$)	0.309	95% Gamma Adjusted UCL (use when $n \geq 50$)	0.314

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.187	SD (KM)	0.701
Variance (KM)	0.492	SE of Mean (KM)	0.101
k hat (KM)	0.0712	k star (KM)	0.08
nu hat (KM)	7.409	nu star (KM)	8.315
theta hat (KM)	2.627	theta star (KM)	2.341
80% gamma percentile (KM)	0.089	90% gamma percentile (KM)	0.444
95% gamma percentile (KM)	1.088	99% gamma percentile (KM)	3.315

Gamma Kaplan-Meier (KM) Statistics			
Approximate Chi Square Value (8.32, α)	2.919	Adjusted Chi Square Value (8.32, β)	2.828
95% Gamma Approximate KM-UCL (use when n \geq 100)	0.533	95% Gamma Adjusted KM-UCL (use when n \geq 100)	0.55

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.911	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.881	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.157	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.22	Detected Data appear Lognormal at 5% Significance Level	

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.186	Mean in Log Scale	-5.451
SD in Original Scale	0.708	SD in Log Scale	2.544
95% t UCL (assumes normality of ROS data)	0.351	95% Percentile Bootstrap UCL	0.359
95% BCA Bootstrap UCL	0.455	95% Bootstrap t UCL	0.928
95% H-UCL (Log ROS)	0.518		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-4.631	KM Geo Mean	0.00975
KM SD (logged)	1.852	95% Critical H Value (KM-Log)	3.372
KM Standard Error of Mean (logged)	0.288	95% H-UCL (KM -Log)	0.13
KM SD (logged)	1.852	95% Critical H Value (KM-Log)	3.372
KM Standard Error of Mean (logged)	0.288		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.193	Mean in Log Scale	-3.986
SD in Original Scale	0.706	SD in Log Scale	1.737
95% t UCL (Assumes normality)	0.358	95% H-Stat UCL	0.184

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Gamma Distributed at 5% Significance Level

Suggested UCL to Use

95% KM Approximate Gamma UCL	0.533
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When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test

When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

General Statistics

Total Number of Observations	52	Number of Distinct Observations	39
Number of Detects	28	Number of Non-Detects	24
Number of Distinct Detects	27	Number of Distinct Non-Detects	13
Minimum Detect	0.0013	Minimum Non-Detect	0.00355
Maximum Detect	3.84	Maximum Non-Detect	0.13
Variance Detects	0.616	Percent Non-Detects	46.15%
Mean Detects	0.336	SD Detects	0.785
Median Detects	0.0646	CV Detects	2.334
Skewness Detects	3.719	Kurtosis Detects	15.37
Mean of Logged Detects	-2.867	SD of Logged Detects	2.009

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.473	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.924	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.362	Lilliefors GOF Test
5% Lilliefors Critical Value	0.164	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	0.185	KM Standard Error of Mean	0.0831
KM SD	0.589	95% KM (BCA) UCL	0.353
95% KM (t) UCL	0.325	95% KM (Percentile Bootstrap) UCL	0.335
95% KM (z) UCL	0.322	95% KM Bootstrap t UCL	0.567
90% KM Chebyshev UCL	0.435	95% KM Chebyshev UCL	0.548
97.5% KM Chebyshev UCL	0.704	99% KM Chebyshev UCL	1.012

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.283	Anderson-Darling GOF Test
5% A-D Critical Value	0.838	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.199	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.178	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.374	k star (bias corrected MLE)	0.358
Theta hat (MLE)	0.899	Theta star (bias corrected MLE)	0.94
nu hat (MLE)	20.96	nu star (bias corrected)	20.04
Mean (detects)	0.336		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.0013	Mean	0.186
Maximum	3.84	Median	0.01
SD	0.594	CV	3.2
k hat (MLE)	0.34	k star (bias corrected MLE)	0.333
Theta hat (MLE)	0.546	Theta star (bias corrected MLE)	0.557
nu hat (MLE)	35.38	nu star (bias corrected)	34.67
Adjusted Level of Significance (β)	0.0454		
Approximate Chi Square Value (34.67, α)	22.2	Adjusted Chi Square Value (34.67, β)	21.92
95% Gamma Approximate UCL (use when $n \geq 50$)	0.29	95% Gamma Adjusted UCL (use when $n \geq 50$)	0.294
Estimates of Gamma Parameters using KM Estimates			
Mean (KM)	0.185	SD (KM)	0.589
Variance (KM)	0.346	SE of Mean (KM)	0.0831
k hat (KM)	0.0991	k star (KM)	0.106
nu hat (KM)	10.31	nu star (KM)	11.05
theta hat (KM)	1.87	theta star (KM)	1.745
80% gamma percentile (KM)	0.14	90% gamma percentile (KM)	0.505
95% gamma percentile (KM)	1.071	99% gamma percentile (KM)	2.856
Gamma Kaplan-Meier (KM) Statistics			
Approximate Chi Square Value (11.05, α)	4.606	Adjusted Chi Square Value (11.05, β)	4.487
95% Gamma Approximate KM-UCL (use when $n \geq 50$)	0.444	95% Gamma Adjusted KM-UCL (use when $n \geq 50$)	0.456
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.982	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.924	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0737	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.164	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	0.184	Mean in Log Scale	-4.04
SD in Original Scale	0.595	SD in Log Scale	2.069
95% t UCL (assumes normality of ROS data)	0.323	95% Percentile Bootstrap UCL	0.332
95% BCA Bootstrap UCL	0.415	95% Bootstrap t UCL	0.526
95% H-UCL (Log ROS)	0.433		
Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution			
KM Mean (logged)	-3.979	KM Geo Mean	0.0187
KM SD (logged)	2.018	95% Critical H Value (KM-Log)	3.598
KM Standard Error of Mean (logged)	0.323	95% H-UCL (KM -Log)	0.396
KM SD (logged)	2.018	95% Critical H Value (KM-Log)	3.598
KM Standard Error of Mean (logged)	0.323		
DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.189	Mean in Log Scale	-3.536

SD in Original Scale	0.593	SD in Log Scale	1.754
95% t UCL (Assumes normality)	0.327	95% H-Stat UCL	0.301

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Lognormal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (Chebyshev) UCL	0.548
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Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. Recommendations are based upon data size, data distribution, and skewness. These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Chromium

General Statistics

Total Number of Observations	28	Number of Distinct Observations	25
		Number of Missing Observations	24
Minimum	1.44	Mean	10.81
Maximum	93.1	Median	5.905
SD	17.29	Std. Error of Mean	3.268
Coefficient of Variation	1.6	Skewness	4.305

Normal GOF Test

Shapiro Wilk Test Statistic	0.476	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.924	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.325	Lilliefors GOF Test
5% Lilliefors Critical Value	0.164	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	16.37	95% Adjusted-CLT UCL (Chen-1995)	19.02
		95% Modified-t UCL (Johnson-1978)	16.82

Gamma GOF Test

A-D Test Statistic	1.29	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.771	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.184	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.17	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.109	k star (bias corrected MLE)	1.014
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Theta hat (MLE)	9.74	Theta star (bias corrected MLE)	10.65
nu hat (MLE)	62.13	nu star (bias corrected)	56.81
MLE Mean (bias corrected)	10.81	MLE Sd (bias corrected)	10.73
		Approximate Chi Square Value (0.05)	40.48
Adjusted Level of Significance	0.0404	Adjusted Chi Square Value	39.63

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when $n \geq$	15.16	95% Adjusted Gamma UCL (use when	15.49
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Lognormal GOF Test

Shapiro Wilk Test Statistic	0.957	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.924	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.102	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.164	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.365	Mean of logged Data	1.866
Maximum of Logged Data	4.534	SD of logged Data	0.92

Assuming Lognormal Distribution

95% H-UCL	14.98	90% Chebyshev (MVUE) UCL	15.34
95% Chebyshev (MVUE) UCL	17.91	97.5% Chebyshev (MVUE) UCL	21.48
99% Chebyshev (MVUE) UCL	28.49		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	16.18	95% Jackknife UCL	16.37
95% Standard Bootstrap UCL	15.87	95% Bootstrap-t UCL	27.1
95% Hall's Bootstrap UCL	36.58	95% Percentile Bootstrap UCL	16.63
95% BCA Bootstrap UCL	20.17		
90% Chebyshev(Mean, Sd) UCL	20.61	95% Chebyshev(Mean, Sd) UCL	25.05
97.5% Chebyshev(Mean, Sd) UCL	31.22	99% Chebyshev(Mean, Sd) UCL	43.33

Suggested UCL to Use

95% H-UCL	14.98
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Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

ProUCL computes and outputs H-statistic based UCLs for historical reasons only.

H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.

It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.

Copper

General Statistics

Total Number of Observations	28	Number of Distinct Observations	28
		Number of Missing Observations	24
Minimum	1.25	Mean	5.516
Maximum	12.8	Median	5.265
SD	2.533	Std. Error of Mean	0.479
Coefficient of Variation	0.459	Skewness	0.702

Normal GOF Test

Shapiro Wilk Test Statistic	0.958	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.924	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.107	Lilliefors GOF Test
5% Lilliefors Critical Value	0.164	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	6.331	95% Adjusted-CLT UCL (Chen-1995)	6.371
		95% Modified-t UCL (Johnson-1978)	6.342

Gamma GOF Test

A-D Test Statistic	0.282	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.749	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0883	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.166	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	4.539	k star (bias corrected MLE)	4.076
Theta hat (MLE)	1.215	Theta star (bias corrected MLE)	1.353
nu hat (MLE)	254.2	nu star (bias corrected)	228.3
MLE Mean (bias corrected)	5.516	MLE Sd (bias corrected)	2.732
		Approximate Chi Square Value (0.05)	194.3
Adjusted Level of Significance	0.0404	Adjusted Chi Square Value	192.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when $n \geq$	6.481	95% Adjusted Gamma UCL (use when	6.546
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Lognormal GOF Test

Shapiro Wilk Test Statistic	0.953	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.924	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.109	Lilliefors Lognormal GOF Test

5% Lilliefors Critical Value 0.164 Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.223	Mean of logged Data	1.593
Maximum of Logged Data	2.549	SD of logged Data	0.516

Assuming Lognormal Distribution

95% H-UCL	6.824	90% Chebyshev (MVUE) UCL	7.299
95% Chebyshev (MVUE) UCL	8.073	97.5% Chebyshev (MVUE) UCL	9.148
99% Chebyshev (MVUE) UCL	11.26		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	6.303	95% Jackknife UCL	6.331
95% Standard Bootstrap UCL	6.293	95% Bootstrap-t UCL	6.374
95% Hall's Bootstrap UCL	6.391	95% Percentile Bootstrap UCL	6.29
95% BCA Bootstrap UCL	6.331		
90% Chebyshev(Mean, Sd) UCL	6.952	95% Chebyshev(Mean, Sd) UCL	7.602
97.5% Chebyshev(Mean, Sd) UCL	8.505	99% Chebyshev(Mean, Sd) UCL	10.28

Suggested UCL to Use

95% Student's-t UCL	6.331
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Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Mercury

General Statistics

Total Number of Observations	28	Number of Distinct Observations	26
		Number of Missing Observations	24
Number of Detects	13	Number of Non-Detects	15
Number of Distinct Detects	13	Number of Distinct Non-Detects	13
Minimum Detect	0.00513	Minimum Non-Detect	0.0109
Maximum Detect	0.16	Maximum Non-Detect	0.12
Variance Detects	0.00186	Percent Non-Detects	53.57%
Mean Detects	0.0299	SD Detects	0.0431
Median Detects	0.0132	CV Detects	1.441
Skewness Detects	2.71	Kurtosis Detects	7.689
Mean of Logged Detects	-4.083	SD of Logged Detects	0.997

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.6	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.866	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.308	Lilliefors GOF Test
5% Lilliefors Critical Value	0.234	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	0.0182	KM Standard Error of Mean	0.00606
KM SD	0.0305	95% KM (BCA) UCL	0.0301
95% KM (t) UCL	0.0286	95% KM (Percentile Bootstrap) UCL	0.0288
95% KM (z) UCL	0.0282	95% KM Bootstrap t UCL	0.0569
90% KM Chebyshev UCL	0.0364	95% KM Chebyshev UCL	0.0447
97.5% KM Chebyshev UCL	0.0561	99% KM Chebyshev UCL	0.0785

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.03	Anderson-Darling GOF Test
5% A-D Critical Value	0.757	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.237	Kolmogorov-Smirnov GOF
5% K-S Critical Value	0.243	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.006	k star (bias corrected MLE)	0.825
Theta hat (MLE)	0.0297	Theta star (bias corrected MLE)	0.0363
nu hat (MLE)	26.15	nu star (bias corrected)	21.45
Mean (detects)	0.0299		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.00513	Mean	0.0192
Maximum	0.16	Median	0.01
SD	0.0305	CV	1.583
k hat (MLE)	1.355	k star (bias corrected MLE)	1.234
Theta hat (MLE)	0.0142	Theta star (bias corrected MLE)	0.0156
nu hat (MLE)	75.89	nu star (bias corrected)	69.09
Adjusted Level of Significance (β)	0.0404		
Approximate Chi Square Value (69.09, α)	50.96	Adjusted Chi Square Value (69.09, β)	49.99
95% Gamma Approximate UCL (use when $n \geq 50$)	0.0261	95% Gamma Adjusted UCL (use when $n \geq 50$)	0.0266

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.0182	SD (KM)	0.0305
Variance (KM)	9.3200E-4	SE of Mean (KM)	0.00606
k hat (KM)	0.357	k star (KM)	0.342

nu hat (KM)	19.97	nu star (KM)	19.17
theta hat (KM)	0.0511	theta star (KM)	0.0533
80% gamma percentile (KM)	0.0288	90% gamma percentile (KM)	0.0528
95% gamma percentile (KM)	0.0799	99% gamma percentile (KM)	0.149

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (19.17, α)	10.24	Adjusted Chi Square Value (19.17, β)	9.835
95% Gamma Approximate KM-UCL (use when n:	0.0341	95% Gamma Adjusted KM-UCL (use wh	0.0355

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.901	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.866	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.181	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.234	Detected Data appear Lognormal at 5% Significance Level	

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.0179	Mean in Log Scale	-4.532
SD in Original Scale	0.031	SD in Log Scale	0.804
95% t UCL (assumes normality of ROS data)	0.0278	95% Percentile Bootstrap UCL	0.0292
95% BCA Bootstrap UCL	0.0335	95% Bootstrap t UCL	0.0567
95% H-UCL (Log ROS)	0.021		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-4.514	KM Geo Mean	0.011
KM SD (logged)	0.799	95% Critical H Value (KM-Log)	2.224
KM Standard Error of Mean (logged)	0.168	95% H-UCL (KM -Log)	0.0212
KM SD (logged)	0.799	95% Critical H Value (KM-Log)	2.224
KM Standard Error of Mean (logged)	0.168		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.0207	Mean in Log Scale	-4.471
SD in Original Scale	0.0325	SD in Log Scale	0.943
95% t UCL (Assumes normality)	0.0311	95% H-Stat UCL	0.0275

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics

Detected Data appear Approximate Gamma Distributed at 5% Significance Level

Suggested UCL to Use

Gamma Adjusted KM-UCL (use when $k \leq 1$ and 1	0.0355
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When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test

When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.