UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.16/19/17 4:51:49 PM
From File	ProUCLinput_20-003(b)_0-10.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Perchlorate

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
Number of Detects	6	Number of Non-Detects	6
Number of Distinct Detects	6	Number of Distinct Non-Detects	6
Minimum Detect	6.1200E-4	Minimum Non-Detect	0.00206
Maximum Detect	0.0071	Maximum Non-Detect	0.00235
Variance Detects	5.6416E-6	Percent Non-Detects	50%
Mean Detects	0.00254	SD Detects	0.00238
Median Detects	0.00163	CV Detects	0.935
Skewness Detects	1.878	Kurtosis Detects	3.662
Mean of Logged Detects	-6.282	SD of Logged Detects	0.836

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.782	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.788	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.311	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.325	Detected Data appear Normal at 5% Significance Level	

Detected Data appear Approximate Normal at 5% Significance Level

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

KM Mean	0.00191	KM Standard Error of Mean	5.5308E-4
KM SD	0.00169	95% KM (BCA) UCL	0.00284
95% KM (t) UCL	0.0029	95% KM (Percentile Bootstrap) UCL	0.00278
95% KM (z) UCL	0.00282	95% KM Bootstrap t UCL	0.00395
90% KM Chebyshev UCL	0.00356	95% KM Chebyshev UCL	0.00432
97.5% KM Chebyshev UCL	0.00536	99% KM Chebyshev UCL	0.00741

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.355	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.706	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.273	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.337	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	1.78	k star (bias corrected MLE)	1.001

Theta hat (MLE)	0.00143	Theta star (bias corrected MLE)	0.00254
nu hat (MLE)	21.36	nu star (bias corrected)	12.01
Mean (detects)	0.00254		

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	6.1200E-4	Mean	0.00627
Maximum	0.01	Median	0.00855
SD	0.00421	CV	0.672
k hat (MLE)	1.49	k star (bias corrected MLE)	1.173
Theta hat (MLE)	0.00421	Theta star (bias corrected MLE)	0.00534
nu hat (MLE)	35.77	nu star (bias corrected)	28.16
Adjusted Level of Significance (β)	0.029		
Approximate Chi Square Value (28.16, α)	17.05	Adjusted Chi Square Value (28.16, β)	15.74
95% Gamma Approximate UCL (use when n>=50)	0.0104	95% Gamma Adjusted UCL (use when n<5(	0.0112

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.00191	SD (KM)	0.00169
Variance (KM)	2.8410E-6	SE of Mean (KM)	5.5308E-4
k hat (KM)	1.278	k star (KM)	1.014
nu hat (KM)	30.67	nu star (KM)	24.34
theta hat (KM)	0.00149	theta star (KM)	0.00188
80% gamma percentile (KM)	0.00306	90% gamma percentile (KM)	0.00437
95% gamma percentile (KM)	0.00568	99% gamma percentile (KM)	0.00871

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (24.34, α)	14.1	Adjusted Chi Square Value (24.34, β)	12.93
95% Gamma Approximate KM-UCL (use when n>=50)	0.00329	95% Gamma Adjusted KM-UCL (use whe	0.00359

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.968	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.788	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.223	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.325	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	0.00188	Mean in Log Scale	-6.496
SD in Original Scale	0.00174	SD in Log Scale	0.607
95% t UCL (assumes normality of ROS data)	0.00278	95% Percentile Bootstrap UCL	0.00277
95% BCA Bootstrap UCL	0.00327	95% Bootstrap t UCL	0.00635
95% H-UCL (Log ROS)	0.00275		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-6.51	KM Geo Mean	0.00149
KM SD (logged)	0.651	95% Critical H Value (KM-Log)	2.342
KM Standard Error of Mean (logged)	0.25	95% H-UCL (KM -Log)	0.00291
KM SD (logged)	0.651	95% Critical H Value (KM-Log)	2.342
KM Standard Error of Mean (logged)	0.25		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.00181	Mean in Log Scale	-6.553
SD in Original Scale	0.00177	SD in Log Scale	0.632
95% t UCL (Assumes normality)	0.00273	95% H-Stat UCL	0.00271

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

Nonparametric Distribution Free UCL Statistics
Detected Data appear Approximate Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	0.0029

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.

Uranium-235/236

General Statistics

Total Number of Observations	12	Number of Distinct Observations	12
Number of Detects	11	Number of Non-Detects	1
Number of Distinct Detects	11	Number of Distinct Non-Detects	1
Minimum Detect	0.0583	Minimum Non-Detect	0.0485
Maximum Detect	0.223	Maximum Non-Detect	0.0485
Variance Detects	0.0029	Percent Non-Detects	8.333%
Mean Detects	0.0959	SD Detects	0.0539
Median Detects	0.0755	CV Detects	0.562
Skewness Detects	1.815	Kurtosis Detects	2.483
Mean of Logged Detects	-2.452	SD of Logged Detects	0.45

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.718	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.327	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.251	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	0.0919	KM Standard Error of Mean	0.0154
KM SD	0.0509	95% KM (BCA) UCL	0.12
95% KM (t) UCL	0.12	95% KM (Percentile Bootstrap) UCL	0.117
95% KM (z) UCL	0.117	95% KM Bootstrap t UCL	0.169
90% KM Chebyshev UCL	0.138	95% KM Chebyshev UCL	0.159
97.5% KM Chebyshev UCL	0.188	99% KM Chebyshev UCL	0.245

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.08	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.732	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.297	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.256	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)	4.832	k star (bias corrected MLE)	3.575
Theta hat (MLE)	0.0198	Theta star (bias corrected MLE)	0.0268
nu hat (MLE)	106.3	nu star (bias corrected)	78.65
Mean (detects)	0.0959		

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	0.01	Mean	0.0887
Maximum	0.223	Median	0.0715
SD	0.057	CV	0.643
k hat (MLE)	2.548	k star (bias corrected MLE)	1.966
Theta hat (MLE)	0.0348	Theta star (bias corrected MLE)	0.0451
nu hat (MLE)	61.15	nu star (bias corrected)	47.19
Adjusted Level of Significance (β)	0.029		
Approximate Chi Square Value (47.19, α)	32.43	Adjusted Chi Square Value (47.19, β)	30.57
95% Gamma Approximate UCL (use when n>=50)	0.129	95% Gamma Adjusted UCL (use when n<5(	0.137

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.0919	SD (KM)	0.0509
Variance (KM)	0.00259	SE of Mean (KM)	0.0154
k hat (KM)	3.262	k star (KM)	2.502
nu hat (KM)	78.3	nu star (KM)	60.06
theta hat (KM)	0.0282	theta star (KM)	0.0367
80% gamma percentile (KM)	0.134	90% gamma percentile (KM)	0.17
95% gamma percentile (KM)	0.203	99% gamma percentile (KM)	0.277

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (60.06, α)	43.24	Adjusted Chi Square Value (60.06, β)	41.07
95% Gamma Approximate KM-UCL (use when n>=50)	0.128	95% Gamma Adjusted KM-UCL (use whe	0.134

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.811	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Detected Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.269	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.251	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	0.0904	Mean in Log Scale	-2.538
SD in Original Scale	0.0547	SD in Log Scale	0.524
95% t UCL (assumes normality of ROS data)	0.119	95% Percentile Bootstrap UCL	0.118
95% BCA Bootstrap UCL	0.123	95% Bootstrap t UCL	0.155
95% H-UCL (Log ROS)	0.128		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-2.5	KM Geo Mean	0.0821
KM SD (logged)	0.441	95% Critical H Value (KM-Log)	2.071
KM Standard Error of Mean (logged)	0.133	95% H-UCL (KM -Log)	0.119
KM SD (logged)	0.441	95% Critical H Value (KM-Log)	2.071
KM Standard Error of Mean (logged)	0.133		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.0899	Mean in Log Scale	-2.557
SD in Original Scale	0.0554	SD in Log Scale	0.564
95% t UCL (Assumes normality)	0.119	95% H-Stat UCL	0.133

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	0.12	KM H-UCL	0.119
95% KM (BCA) UCL	0.12		

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.