UCL Statistics for Data Sets with Non-Detects

User Selected	
Date/Time of C	ProUCL 5.16/19/17 5:06:57 PM
From File	ProUCLinput_20-004_0-10.xls
Full Precision	OFF
Confidence Cc	95%
Number of Boc	2000

Barium

General Statistics

Total Number of Observa	11	Number of Distinct Obse	11
		Number of Missing Obse	0
Minimum	62.2	Mean	76.32
Maximum	95.2	Median	74
SD	10.73	Std. Error of Mean	3.236
Coefficient of Variation	0.141	Skewness	0.655

Normal GOF Test

Shapiro Wilk Test Statist	0.937	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical	0.85	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.131	**Lilliefors GOF Test**
5% Lilliefors Critical Valu	0.251	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	82.18	95% Adjusted-CLT UC	82.33
		95% Modified-t UCL (J	82.29

Gamma GOF Test

A-D Test Statistic	0.258	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.728	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.127	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.255	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	57.6	k star (bias corrected ML	41.95
Theta hat (MLE)	1.325	Theta star (bias correcte	1.819
nu hat (MLE)	1267	nu star (bias corrected)	922.9
MLE Mean (bias correcte	76.32	MLE Sd (bias corrected)	11.78
		Approximate Chi Square	853.4
Adjusted Level of Signific	0.0278	Adjusted Chi Square Val	842.5

Assuming Gamma Distribution

95% Approximate Gam	82.53	95% Adjusted Gamma	83.6

Lognormal GOF Test

Shapiro Wilk Test Statist	0.956	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.116	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Valu	0.251	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.13	Mean of logged Data	4.326
Maximum of Logged Dat	4.556	SD of logged Data	0.137

Assuming Lognormal Distribution

95% H-UCL	82.63	90% Chebyshev (MVU	85.81
95% Chebyshev (MVU	90.11	97.5% Chebyshev (MVU	96.08
99% Chebyshev (MVU	107.8		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	81.64	95% Jackknife UCL	82.18
95% Standard Bootstra	81.34	95% Bootstrap-t UCL	83.72
95% Hall's Bootstrap U	84.49	95% Percentile Bootstr	81.73
95% BCA Bootstrap UC	81.8		
90% Chebyshev(Mean	86.03	95% Chebyshev(Mean	90.43
97.5% Chebyshev(Mear	96.53	99% Chebyshev(Mean	108.5

Suggested UCL to Use

95% Student's-t UCL	82.18

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 Observa	11	Number of Distinct Obse	11
		Number of Missing Obse	0
Minimum	5.23	Mean	8.572
Maximum	13.3	Median	7.7
SD	2.903	Std. Error of Mean	0.875

Coefficient of Variation	0.339	Skewness	0.532

Normal GOF Test

Shapiro Wilk Test Statist	0.883	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical	0.85	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.194	**Lilliefors GOF Test**	
5% Lilliefors Critical Valu	0.251	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	10.16	95% Adjusted-CLT UC	10.16
		95% Modified-t UCL (J	10.18

Gamma GOF Test

A-D Test Statistic	0.538	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.194	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.255	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	9.984	k star (bias corrected ML	7.322
Theta hat (MLE)	0.859	Theta star (bias correcte	1.171
nu hat (MLE)	219.6	nu star (bias corrected)	161.1
MLE Mean (bias correcte	8.572	MLE Sd (bias corrected)	3.168
		Approximate Chi Square	132.7
Adjusted Level of Signific	0.0278	Adjusted Chi Square Val	128.5

Assuming Gamma Distribution

95% Approximate Gam	10.4	95% Adjusted Gamma	10.74

Lognormal GOF Test

Shapiro Wilk Test Statist	0.91	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.188	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Valu	0.251	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	1.654	Mean of logged Data	2.098
Maximum of Logged Dat	2.588	SD of logged Data	0.333

Assuming Lognormal Distribution

95% H-UCL	10.6	90% Chebyshev (MVU	11.17
95% Chebyshev (MVU	12.34	97.5% Chebyshev (MVL	13.98
99% Chebyshev (MVU	17.19		

Nonparametric Distribution Free UCL Statistics
Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	10.01	95% Jackknife UCL	10.16
95% Standard Bootstra	9.96	95% Bootstrap-t UCL	10.44
95% Hall's Bootstrap U	9.837	95% Percentile Bootstr	9.914
95% BCA Bootstrap U(	10.11		
90% Chebyshev(Mean	11.2	95% Chebyshev(Mean	12.39
97.5% Chebyshev(Mear	14.04	99% Chebyshev(Mean	17.28

Suggested UCL to Use

95% Student's-t UCL	10.16

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).
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Cobalt

General Statistics

Total Number of Observa	11	Number of Distinct Obse	11
		Number of Missing Obse	0
Minimum	2.44	Mean	3.274
Maximum	4.68	Median	3.11
SD	0.689	Std. Error of Mean	0.208
Coefficient of Variation	0.211	Skewness	0.944

Normal GOF Test

Shapiro Wilk Test Statist	0.922	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical	0.85	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.162	**Lilliefors GOF Test**
5% Lilliefors Critical Valu	0.251	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	3.65	95% Adjusted-CLT UC	3.679
		95% Modified-t UCL (J	3.66

Gamma GOF Test

A-D Test Statistic	0.282	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.131	**Kolmogorov-Smirnov Gamma GOF Test**

5% K-S Critical Value	0.255	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	26.65	k star (bias corrected ML	19.44
Theta hat (MLE)	0.123	Theta star (bias correcte	0.168
nu hat (MLE)	586.3	nu star (bias corrected)	427.7
MLE Mean (bias correcte	3.274	MLE Sd (bias corrected)	0.742
		Approximate Chi Square	380.8
Adjusted Level of Signific	0.0278	Adjusted Chi Square Val	373.6

Assuming Gamma Distribution

95% Approximate Gam	3.677	95% Adjusted Gamma	3.748

Lognormal GOF Test

Shapiro Wilk Test Statist	0.957	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.128	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Valu	0.251	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.892	Mean of logged Data	1.167
Maximum of Logged Dat	1.543	SD of logged Data	0.201

Assuming Lognormal Distribution

95% H-UCL	3.689	90% Chebyshev (MVU	3.868
95% Chebyshev (MVU	4.139	97.5% Chebyshev (MVU	4.514
99% Chebyshev (MVU	5.25		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	3.615	95% Jackknife UCL	3.65
95% Standard Bootstra	3.596	95% Bootstrap-t UCL	3.753
95% Hall's Bootstrap U	3.93	95% Percentile Bootstr	3.641
95% BCA Bootstrap UC	3.678		
90% Chebyshev(Mean	3.897	95% Chebyshev(Mean	4.179
97.5% Chebyshev(Mear	4.571	99% Chebyshev(Mean	5.341

Suggested UCL to Use

95% Student's-t UCL	3.65

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.

Nitrate

General Statistics

Total Number of Observa	11	Number of Distinct Obse	10
Number of Detects	6	Number of Non-Detects	5
Number of Distinct Detec	6	Number of Distinct Non-I	4
Minimum Detect	1.13	Minimum Non-Detect	1.04
Maximum Detect	38.1	Maximum Non-Detect	1.1
Variance Detects	330.6	Percent Non-Detects	45.45%
Mean Detects	14.57	SD Detects	18.18
Median Detects	4.57	CV Detects	1.248
Skewness Detects	0.935	Kurtosis Detects	-1.876
Mean of Logged Detects	1.768	SD of Logged Detects	1.57

Normal GOF Test on Detects Only

Shapiro Wilk Test Statist	0.707	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical	0.788	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.36	**Lilliefors GOF Test**
5% Lilliefors Critical Valu	0.325	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	8.418	KM Standard Error of Me	4.62
KM SD	13.99	95% KM (BCA) UCL	15.51
95% KM (t) UCL	16.79	95% KM (Percentile Bo	15.35
95% KM (z) UCL	16.02	95% KM Bootstrap t UCL	64.92
90% KM Chebyshev UCI	22.28	95% KM Chebyshev UCI	28.56
97.5% KM Chebyshev U	37.27	99% KM Chebyshev UCI	54.39

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.595	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.726	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.271	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.345	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)	0.668	k star (bias corrected ML	0.445
Theta hat (MLE)	21.81	Theta star (bias correcte	32.73
nu hat (MLE)	8.016	nu star (bias corrected)	5.341
Mean (detects)	14.57		

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	7.95
Maximum	38.1	Median	1.13
SD	14.94	CV	1.879
k hat (MLE)	0.226	k star (bias corrected ML	0.225
Theta hat (MLE)	35.25	Theta star (bias correcte	35.39
nu hat (MLE)	4.961	nu star (bias corrected)	4.942
Adjusted Level of Signific	0.0278		
Approximate Chi Square	1.125	Adjusted Chi Square Val	0.86
95% Gamma Approxima	34.91	95% Gamma Adjusted U	45.66

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	8.418	SD (KM)	13.99
Variance (KM)	195.7	SE of Mean (KM)	4.62
k hat (KM)	0.362	k star (KM)	0.324
nu hat (KM)	7.968	nu star (KM)	7.128
theta hat (KM)	23.24	theta star (KM)	25.98
80% gamma percentile (	13.14	90% gamma percentile (	24.58
95% gamma percentile (	37.56	99% gamma percentile (	70.96

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square	2.241	Adjusted Chi Square Val	1.822
95% Gamma Approxima	26.77	95% Gamma Adjusted K	32.94

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statist	0.859	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical	0.788	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.216	**Lilliefors GOF Test**
5% Lilliefors Critical Valu	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	7.984	Mean in Log Scale	-0.208
SD in Original Scale	14.92	SD in Log Scale	2.551
95% t UCL (assumes r	16.14	95% Percentile Bootstr	15.02
95% BCA Bootstrap UC	18.17	95% Bootstrap t UCL	64.95
95% H-UCL (Log ROS	3772		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	0.982	KM Geo Mean	2.67
KM SD (logged)	1.365	95% Critical H Value (K	3.74
KM Standard Error of Me	0.451	95% H-UCL (KM -Log)	34.03
KM SD (logged)	1.365	95% Critical H Value (K	3.74
KM Standard Error of Me	0.451		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	8.189	Mean in Log Scale	0.681
SD in Original Scale	14.8	SD in Log Scale	1.671
95% t UCL (Assumes r	16.28	95% H-Stat UCL	82.19

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

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

Suggested UCL to Use

95% KM Bootstrap t UCL	64.92	Gamma Adjusted KM-UC	32.94

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.

Selenium

General Statistics

Total Number of Observa	11	Number of Distinct Obse	11
Number of Detects	5	Number of Non-Detects	6
Number of Distinct Detec	5	Number of Distinct Non-I	6
Minimum Detect	0.682	Minimum Non-Detect	0.911
Maximum Detect	1.75	Maximum Non-Detect	1.02
Variance Detects	0.19	Percent Non-Detects	54.55%
Mean Detects	1.366	SD Detects	0.436
Median Detects	1.44	CV Detects	0.319
Skewness Detects	-1.11	Kurtosis Detects	0.852
Mean of Logged Detects	0.26	SD of Logged Detects	0.386

Normal GOF Test on Detects Only

Shapiro Wilk Test Statist	0.895	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical	0.762	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.191	**Lilliefors GOF Test**	
5% Lilliefors Critical Valu	0.343	Detected Data appear Normal at 5% Significance Level	

Detected Data appear Normal at 5% Significance Level

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

KM Mean	0.993	KM Standard Error of Me	0.145
KM SD	0.431	95% KM (BCA) UCL	1.341
95% KM (t) UCL	1.256	95% KM (Percentile Boo	1.298
95% KM (z) UCL	1.232	95% KM Bootstrap t UC	1.198
90% KM Chebyshev UCL	1.429	95% KM Chebyshev UCL	1.626
97.5% KM Chebyshev U	1.9	99% KM Chebyshev UCL	2.437

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.444	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.679	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.225	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.358	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)	9.708	k star (bias corrected ML	4.017
Theta hat (MLE)	0.141	Theta star (bias correcte	0.34
nu hat (MLE)	97.08	nu star (bias corrected)	40.17
Mean (detects)	1.366		

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	0.682	Mean	1.011
Maximum	1.75	Median	0.714
SD	0.438	CV	0.434
k hat (MLE)	6.73	k star (bias corrected ML	4.955
Theta hat (MLE)	0.15	Theta star (bias correcte	0.204
nu hat (MLE)	148.1	nu star (bias corrected)	109
Adjusted Level of Signific	0.0278		
Approximate Chi Square	85.92	Adjusted Chi Square Val	82.58
95% Gamma Approxima	1.282	95% Gamma Adjusted U	1.334

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.993	SD (KM)	0.431
Variance (KM)	0.185	SE of Mean (KM)	0.145
k hat (KM)	5.319	k star (KM)	3.929
nu hat (KM)	117	nu star (KM)	86.44
theta hat (KM)	0.187	theta star (KM)	0.253
80% gamma percentile (	1.372	90% gamma percentile (	1.665
95% gamma percentile (	1.934	99% gamma percentile (	2.51

Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square	66.01	Adjusted Chi Square Val	63.11
95% Gamma Approxim	1.3	95% Gamma Adjusted	1.36

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statist	0.835	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical	0.762	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.254	**Lilliefors GOF Test**
5% Lilliefors Critical Valu	0.343	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	1.01	Mean in Log Scale	-0.0667
SD in Original Scale	0.439	SD in Log Scale	0.397
95% t UCL (assumes r	1.25	95% Percentile Bootstr	1.241
95% BCA Bootstrap UC	1.27	95% Bootstrap t UCL	1.325
95% H-UCL (Log ROS	1.309		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-0.0907	KM Geo Mean	0.913
KM SD (logged)	0.396	95% Critical H Value (K	2.049
KM Standard Error of Me	0.133	95% H-UCL (KM -Log)	1.276
KM SD (logged)	0.396	95% Critical H Value (K	2.049
KM Standard Error of Me	0.133		

DL/2 Statistics

DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.885	Mean in Log Scale	-0.279
SD in Original Scale	0.538	SD in Log Scale	0.572
95% t UCL (Assumes r	1.179	95% H-Stat UCL	1.343

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

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

Suggested UCL to Use

95% KM (t) UCL	1.256

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.