

## UCL Statistics for Data Sets with Non-Detects

User Selected

Date/Time of C ProUCL 5.16/19/17 5:04:20 PM

From File ProUCLinput\_20-003(c)\_0-5.xls

Full Precision OFF

Confidence Cc 95%

Number of Boc 2000

### Cesium-137

#### General Statistics

Total Number of Observations	9	Number of Distinct Observations	9
Number of Detects	5	Number of Non-Detects	4
Number of Distinct Detects	5	Number of Distinct Non-Detects	4
Minimum Detect	0.154	Minimum Non-Detect	-0.0447
Maximum Detect	0.585	Maximum Non-Detect	0.0876
Variance Detects	0.0321	Percent Non-Detects	44.44%
Mean Detects	0.271	SD Detects	0.179
Median Detects	0.204	CV Detects	0.661
Skewness Detects	2.015	Kurtosis Detects	4.17

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

#### Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.729	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical	0.762	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.354	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.343	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	0.131	KM Standard Error of Mean	0.0735
KM SD	0.197	95% KM (BCA) UCL	0.256
95% KM (t) UCL	0.267	95% KM (Percentile Bootstrap) UCL	0.242
95% KM (z) UCL	0.252	95% KM Bootstrap t UCL	0.243
90% KM Chebyshev UCL	0.351	95% KM Chebyshev UCL	0.451
97.5% KM Chebyshev UCL	0.59	99% KM Chebyshev UCL	0.862

#### Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.593	<b>Anderson-Darling GOF Test</b>
5% A-D Critical Value	0.681	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.305	<b>Kolmogorov-Smirnov GOF</b>
5% K-S Critical Value	0.359	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)	3.911	k star (bias corrected ML	1.698
Theta hat (MLE)	0.0693	Theta star (bias correcte	0.16
nu hat (MLE)	39.11	nu star (bias corrected)	16.98
Mean (detects)	0.271		

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.131	SD (KM)	0.197
Variance (KM)	0.0389	SE of Mean (KM)	0.0735
k hat (KM)	0.44	k star (KM)	0.367
nu hat (KM)	7.916	nu star (KM)	6.611
theta hat (KM)	0.297	theta star (KM)	0.356
80% gamma percentile (	0.209	90% gamma percentile (	0.375
95% gamma percentile (	0.56	99% gamma percentile (	1.029

Gamma Kaplan-Meier (KM) Statistics

		Adjusted Level of Signific	0.0231
Approximate Chi Square	1.959	Adjusted Chi Square Val	1.472
95% Gamma Approxima	0.441	95% Gamma Adjusted K	0.587

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	N/A	KM Geo Mean	N/A
KM SD (logged)	N/A	95% Critical H Value (t	N/A
KM Standard Error of Me	N/A	95% H-UCL (KM -Log)	N/A
KM SD (logged)	N/A	95% Critical H Value (t	N/A
KM Standard Error of Me	N/A		

DL/2 Statistics

Mean in Original Scale	0.151	SD in Original Scale	0.192
95% t UCL (Assumes r	0.27		

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 Adjusted Gamrn	0.587	95% GROS Adjusted Ga	N/A
-----------------------	-------	----------------------	-----

Warning: Recommended UCL exceeds the maximum observation

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	9	Number of Distinct Observations	9
Number of Detects	6	Number of Non-Detects	3
Number of Distinct Detects	6	Number of Distinct Non-Detects	3
Minimum Detect	0.0776	Minimum Non-Detect	0.974
Maximum Detect	0.145	Maximum Non-Detect	1.07
Variance Detects	7.0828E-4	Percent Non-Detects	33.33%
Mean Detects	0.101	SD Detects	0.0266
Median Detects	0.0907	CV Detects	0.265
Skewness Detects	1.13	Kurtosis Detects	0.0988
Mean of Logged Detects	-2.324	SD of Logged Detects	0.248

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

## Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.863	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical Value	0.788	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.267	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.325	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	0.101	KM Standard Error of Mean	0.0109
KM SD	0.0243	95% KM (BCA) UCL	0.119
95% KM (t) UCL	0.121	95% KM (Percentile Bootstrap) UCL	0.118
95% KM (z) UCL	0.118	95% KM Bootstrap t UCL	0.158
90% KM Chebyshev UCL	0.133	95% KM Chebyshev UCL	0.148
97.5% KM Chebyshev UCL	0.168	99% KM Chebyshev UCL	0.209

## Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.425	<b>Anderson-Darling GOF Test</b>
5% A-D Critical Value	0.697	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.254	<b>Kolmogorov-Smirnov GOF</b>
5% K-S Critical Value	0.332	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)	18.83	k star (bias corrected MLE)	9.529
Theta hat (MLE)	0.00534	Theta star (bias corrected MLE)	0.0106
nu hat (MLE)	226	nu star (bias corrected)	114.3
Mean (detects)	0.101		

## 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	0.0776	Mean	0.1
Maximum	0.145	Median	0.0993
SD	0.021	CV	0.21
k hat (MLE)	28.14	k star (bias corrected ML	18.84
Theta hat (MLE)	0.00356	Theta star (bias correcte	0.00532
nu hat (MLE)	506.6	nu star (bias corrected)	339
Adjusted Level of Signific	0.0231		
Approximate Chi Square	297.4	Adjusted Chi Square Val	289.1
95% Gamma Approxima	0.114	95% Gamma Adjusted U	0.117

### Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.101	SD (KM)	0.0243
Variance (KM)	5.9023E-4	SE of Mean (KM)	0.0109
k hat (KM)	17.14	k star (KM)	11.5
nu hat (KM)	308.4	nu star (KM)	207
theta hat (KM)	0.00587	theta star (KM)	0.00875
80% gamma percentile (	0.124	90% gamma percentile (	0.14
95% gamma percentile (	0.154	99% gamma percentile (	0.182

### Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square	174.7	Adjusted Chi Square Val	168.4
95% Gamma Approxirr	0.119	95% Gamma Adjusted	0.124

### Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statist	0.892	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical	0.788	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.235	<b>Lilliefors GOF Test</b>
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	0.0997	Mean in Log Scale	-2.324
SD in Original Scale	0.0211	SD in Log Scale	0.196
95% t UCL (assumes r	0.113	95% Percentile Bootstr	0.111
95% BCA Bootstrap U	0.114	95% Bootstrap t UCL	0.123
95% H-UCL (Log ROS	0.114		

### Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	-2.324	KM Geo Mean	0.0979
KM SD (logged)	0.226	95% Critical H Value (t	1.934
KM Standard Error of Me	0.101	95% H-UCL (KM -Log)	0.117
KM SD (logged)	0.226	95% Critical H Value (t	1.934

KM Standard Error of Me 0.101

## DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.237	Mean in Log Scale	-1.774
SD in Original Scale	0.206	SD in Log Scale	0.847
95% t UCL (Assumes r	0.364	95% H-Stat UCL	0.58

**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 0.121

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-234

### General Statistics

Total Number of Observa	9	Number of Distinct Obse	9
		Number of Missing Obse	0
Minimum	1.31	Mean	2.116
Maximum	3.16	Median	1.88
SD	0.661	Std. Error of Mean	0.22
Coefficient of Variation	0.313	Skewness	0.451

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**

**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**

**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

### Normal GOF Test

Shapiro Wilk Test Statist	0.925	<b>Shapiro Wilk GOF Test</b>	
5% Shapiro Wilk Critical	0.829	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.195	<b>Lilliefors GOF Test</b>	
5% Lilliefors Critical Valu	0.274	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	2.525	95% Adjusted-CLT UC	2.514
		95% Modified-t UCL (J	2.531

Gamma GOF Test

A-D Test Statistic	0.298	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.722	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.172	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	11.63	k star (bias corrected ML	7.83
Theta hat (MLE)	0.182	Theta star (bias correcte	0.27
nu hat (MLE)	209.4	nu star (bias corrected)	140.9
MLE Mean (bias correcte	2.116	MLE Sd (bias corrected)	0.756
		Approximate Chi Square	114.5
Adjusted Level of Signific	0.0231	Adjusted Chi Square Val	109.5

Assuming Gamma Distribution

95% Approximate Garr	2.604	95% Adjusted Gamma	2.723
----------------------	-------	--------------------	-------

Lognormal GOF Test

Shapiro Wilk Test Statist	0.939	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.149	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Valu	0.274	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	0.27	Mean of logged Data	0.706
Maximum of Logged Dat	1.151	SD of logged Data	0.314

Assuming Lognormal Distribution

95% H-UCL	2.665	90% Chebyshev (MVU	2.785
95% Chebyshev (MVU	3.087	97.5% Chebyshev (MVL	3.508
99% Chebyshev (MVU	4.334		

Nonparametric Distribution Free UCL Statistics

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

Nonparametric Distribution Free UCLs

95% CLT UCL	2.478	95% Jackknife UCL	2.525
95% Standard Bootstrap	2.456	95% Bootstrap-t UCL	2.584
95% Hall's Bootstrap U	2.581	95% Percentile Bootstr	2.469
95% BCA Bootstrap U	2.493		
90% Chebyshev(Mean	2.777	95% Chebyshev(Mean	3.076
97.5% Chebyshev(Mear	3.492	99% Chebyshev(Mean	4.309

Suggested UCL to Use

95% Student's-t UCL 2.525

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	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	0.062	Mean	0.121
Maximum	0.216	Median	0.12
SD	0.0491	Std. Error of Mean	0.0164
Coefficient of Variation	0.405	Skewness	0.724

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

### Normal GOF Test

Shapiro Wilk Test Statistic	0.939	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.183	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.274	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	0.152	95% Adjusted-CLT UCL	0.152
		95% Modified-t UCL (J)	0.152

### Gamma GOF Test

A-D Test Statistic	0.236	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.722	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.143	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.28	Detected data appear Gamma Distributed at 5% Significance Level

**Detected data appear Gamma Distributed at 5% Significance Level**

### Gamma Statistics

k hat (MLE)	6.92	k star (bias corrected ML)	4.687
Theta hat (MLE)	0.0175	Theta star (bias corrected)	0.0258
nu hat (MLE)	124.6	nu star (bias corrected)	84.37
MLE Mean (bias corrected)	0.121	MLE Sd (bias corrected)	0.056

		Approximate Chi Square	64.2
Adjusted Level of Signific	0.0231	Adjusted Chi Square Val	60.5

### Assuming Gamma Distribution

95% Approximate Garr	0.159	95% Adjusted Gamma	0.169
----------------------	-------	--------------------	-------

### Lognormal GOF Test

Shapiro Wilk Test Statist	0.952	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.141	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Valu	0.274	Data appear Lognormal at 5% Significance Level
<b>Data appear Lognormal at 5% Significance Level</b>		

### Lognormal Statistics

Minimum of Logged Data	-2.781	Mean of logged Data	-2.185
Maximum of Logged Dat	-1.532	SD of logged Data	0.413

### Assuming Lognormal Distribution

95% H-UCL	0.168	90% Chebyshev (MVU	0.172
95% Chebyshev (MVU	0.195	97.5% Chebyshev (MVL	0.227
99% Chebyshev (MVU	0.289		

### Nonparametric Distribution Free UCL Statistics

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

### Nonparametric Distribution Free UCLs

95% CLT UCL	0.148	95% Jackknife UCL	0.152
95% Standard Bootstrap	0.147	95% Bootstrap-t UCL	0.158
95% Hall's Bootstrap U	0.175	95% Percentile Bootstr	0.147
95% BCA Bootstrap U	0.15		
90% Chebyshev(Mean	0.17	95% Chebyshev(Mean	0.193
97.5% Chebyshev(Mear	0.223	99% Chebyshev(Mean	0.284

### Suggested UCL to Use

95% Student's-t UCL	0.152
---------------------	-------

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-238

### General Statistics

Total Number of Observa	9	Number of Distinct Obse	9
		Number of Missing Obse	0



Minimum	1.4	Mean	2.179
Maximum	3.11	Median	2.12
SD	0.609	Std. Error of Mean	0.203
Coefficient of Variation	0.28	Skewness	0.472

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

#### Normal GOF Test

Shapiro Wilk Test Statist	0.925	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.144	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Valu	0.274	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	2.557	95% Adjusted-CLT UC	2.547
		95% Modified-t UCL (J	2.562

#### Gamma GOF Test

A-D Test Statistic	0.28	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.721	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.151	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

**Detected data appear Gamma Distributed at 5% Significance Level**

#### Gamma Statistics

k hat (MLE)	14.66	k star (bias corrected ML	9.85
Theta hat (MLE)	0.149	Theta star (bias correcte	0.221
nu hat (MLE)	264	nu star (bias corrected)	177.3
MLE Mean (bias correcte	2.179	MLE Sd (bias corrected)	0.694
		Approximate Chi Square	147.5
Adjusted Level of Signific	0.0231	Adjusted Chi Square Val	141.8

#### Assuming Gamma Distribution

95% Approximate Garr	2.619	95% Adjusted Gamma	2.725
----------------------	-------	--------------------	-------

#### Lognormal GOF Test

Shapiro Wilk Test Statist	0.948	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.137	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Valu	0.274	Data appear Lognormal at 5% Significance Level

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

Minimum of Logged Data	0.336	Mean of logged Data	0.744
Maximum of Logged Data	1.135	SD of logged Data	0.278

**Assuming Lognormal Distribution**

95% H-UCL	2.661	90% Chebyshev (MVU)	2.788
95% Chebyshev (MVU)	3.064	97.5% Chebyshev (MVL)	3.448
99% Chebyshev (MVU)	4.2		

**Nonparametric Distribution Free UCL Statistics**

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

**Nonparametric Distribution Free UCLs**

95% CLT UCL	2.513	95% Jackknife UCL	2.557
95% Standard Bootstrap	2.496	95% Bootstrap-t UCL	2.646
95% Hall's Bootstrap UCL	2.612	95% Percentile Bootstrap	2.509
95% BCA Bootstrap UCL	2.544		
90% Chebyshev(Mean)	2.788	95% Chebyshev(Mean)	3.064
97.5% Chebyshev(Mean)	3.447	99% Chebyshev(Mean)	4.2

**Suggested UCL to Use**

95% Student's-t UCL	2.557
---------------------	-------

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.