UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	3/6/2016 10:03:12 PM
From File	ProUCLinput 49-005(a) 0-5.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Arsenic

General Statistics

Total Number of Observations	11	Number of Distinct Observations	9
Number of Detects	9	Number of Non-Detects	2
Number of Distinct Detects	7	Number of Distinct Non-Detects	2
Minimum Detect	1.7	Minimum Non-Detect	1.2
Maximum Detect	3.2	Maximum Non-Detect	1.3
Variance Detects	0.249	Percent Non-Detects	18.18%
Mean Detects	2.578	SD Detects	0.499
Median Detects	2.8	CV Detects	0.194
Skewness Detects	-0.473	Kurtosis Detects	-0.782
Mean of Logged Detects	0.929	SD of Logged Detects	0.207

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.928	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.227	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.295	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

Mean	2.327	Standard Error of Mean	0.218
SD	0.681	95% KM (BCA) UCL	2.664
95% KM (t) UCL	2.722	95% KM (Percentile Bootstrap) UCL	2.664
95% KM (z) UCL	2.686	95% KM Bootstrap t UCL	2.671
90% KM Chebyshev UCL	2.981	95% KM Chebyshev UCL	3.277
97.5% KM Chebyshev UCL	3.687	99% KM Chebyshev UCL	4.494

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.422	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.721	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.249	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	27.71	k star (bias corrected MLE)	18.54
Theta hat (MLE)	0.093	Theta star (bias corrected MLE)	0.139
nu hat (MLE)	498.7	nu star (bias corrected)	333.8
MLE Mean (bias corrected)	2.578	MLE Sd (bias corrected)	0.599

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	11.68	nu hat (KM)	256.9
Approximate Chi Square Value (256.91, α)	220.8	Adjusted Chi Square Value (256.91, β)	215.3
95% Gamma Approximate KM-UCL (use when n>=50)	2.708	mma Adjusted KM-UCL (use when n<50)	2.777

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 detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	1.531	Mean	2.388
Maximum	3.2	Median	2.3
SD	0.615	CV	0.258
k hat (MLE)	15.38	k star (bias corrected MLE)	11.25
Theta hat (MLE)	0.155	Theta star (bias corrected MLE)	0.212
nu hat (MLE)	338.3	nu star (bias corrected)	247.4
MLE Mean (bias corrected)	2.388	MLE Sd (bias corrected)	0.712
		Adjusted Level of Significance (β)	0.0278
Approximate Chi Square Value (247.39, α)	212	Adjusted Chi Square Value (247.39, β)	206.6
95% Gamma Approximate UCL (use when n>=50)	2.786	% Gamma Adjusted UCL (use when n<50)	2.859

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.907	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.829	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.243	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.295	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	2.396	Mean in Log Scale	0.843
SD in Original Scale	0.602	SD in Log Scale	0.265
95% t UCL (assumes normality of ROS data)	2.725	95% Percentile Bootstrap UCL	2.678
95% BCA Bootstrap UCL	2.662	95% Bootstrap t UCL	2.735

95% H-UCL (Log ROS)					2.827							
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed												
KM Mean (logged)					0.793				95% H-UCL (KM -Log)			2.892
KM SD (logged)					0.338				95% Critical H Value (KM-Log)			1.987
KM Standard Error of Mean (logged)					0.108							
DL/2 Statistics												
DL/2 Normal									**DL/2 Log-Transformed**			
Mean in Original Scale					2.223				Mean in Log Scale			0.674
SD in Original Scale					0.908				SD in Log Scale			0.596
95% t UCL (Assumes normality)					2.719				95% H-Stat UCL			3.621
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					2.722				95% KM (Percentile Bootstrap) UCL			2.664
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												
Barium												
General Statistics												
Total Number of Observations					11				Number of Distinct Observations			11
									Number of Missing Observations			0
Minimum					62.1				Mean			136.7
Maximum					207				Median			138
SD					50.02				Std. Error of Mean			15.08
Coefficient of Variation					0.366				Skewness			-0.17
Normal GOF Test												
Shapiro Wilk Test Statistic					0.936				**Shapiro Wilk GOF Test**			
5% Shapiro Wilk Critical Value					0.85				Data appear Normal at 5% Significance Level			
Lilliefors Test Statistic					0.141				**Lilliefors GOF Test**			
5% Lilliefors Critical Value					0.267				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					164				95% Adjusted-CLT UCL (Chen-1995)			160.7
									95% Modified-t UCL (Johnson-1978)			163.9
Gamma GOF Test												
A-D Test Statistic					0.418				**Anderson-Darling Gamma GOF Test**			
5% A-D Critical Value					0.731				Detected data appear Gamma Distributed at 5% Significance Leve			
K-S Test Statistic					0.171				**Kolmogrov-Smirnoff Gamma GOF Test**			
5% K-S Critical Value					0.256				Detected data appear Gamma Distributed at 5% Significance Leve			
Detected data appear Gamma Distributed at 5% Significance Level												
Gamma Statistics												
k hat (MLE)					7.1				k star (bias corrected MLE)			5.224
Theta hat (MLE)					19.26				Theta star (bias corrected MLE)			26.17
nu hat (MLE)					156.2				nu star (bias corrected)			114.9
MLE Mean (bias corrected)					136.7				MLE Sd (bias corrected)			59.81
									Approximate Chi Square Value (0.05)			91.18
Adjusted Level of Significance					0.0278				Adjusted Chi Square Value			87.73
Assuming Gamma Distribution												
95% Approximate Gamma UCL (use when n>=50))					172.3				% Adjusted Gamma UCL (use when n<50)			179.1
Lognormal GOF Test												
Shapiro Wilk Test Statistic					0.9				**Shapiro Wilk Lognormal GOF Test**			
5% Shapiro Wilk Critical Value					0.85				Data appear Lognormal at 5% Significance Level			
Lilliefors Test Statistic					0.179				**Lilliefors Lognormal GOF Test**			
5% Lilliefors Critical Value					0.267				Data appear Lognormal at 5% Significance Level			
Data appear Lognormal at 5% Significance Level												
Lognormal Statistics												
Minimum of Logged Data					4.129				Mean of logged Data			4.846
Maximum of Logged Data					5.333				SD of logged Data			0.417
Assuming Lognormal Distribution												
95% H-UCL					182.4				90% Chebyshev (MVUE) UCL			190.3
95% Chebyshev (MVUE) UCL					214.2				97.5% Chebyshev (MVUE) UCL			247.4
99% Chebyshev (MVUE) UCL					312.5							
Nonparametric Distribution Free UCL Statistics												
Data appear to follow a Discernible Distribution at 5% Significance Level												

171	**Nonparametric Distribution Free UCLs**											
172	95% CLT UCL	161.5				95% Jackknife UCL	164					
173	95% Standard Bootstrap UCL	160				95% Bootstrap-t UCL	160.8					
174	95% Hall's Bootstrap UCL	160.3				95% Percentile Bootstrap UCL	160.5					
175	95% BCA Bootstrap UCL	159										
176	90% Chebyshev(Mean, Sd) UCL	182				95% Chebyshev(Mean, Sd) UCL	202.5					
177	97.5% Chebyshev(Mean, Sd) UCL	230.9				99% Chebyshev(Mean, Sd) UCL	286.8					
178												
179	**Suggested UCL to Use**											
180	95% Student's-t UCL	164										
181												
182	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
183	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
184	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets											
185	For additional insight the user may want to consult a statistician.											
186												
187	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
188	**reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.**											
189												
190	**Beryllium**											
191												
192	**General Statistics**											
193	Total Number of Observations	11				Number of Distinct Observations	10					
194	Number of Detects	9				Number of Non-Detects	2					
195	Number of Distinct Detects	8				Number of Distinct Non-Detects	2					
196	Minimum Detect	0.84				Minimum Non-Detect	0.51					
197	Maximum Detect	1.2				Maximum Non-Detect	0.52					
198	Variance Detects	0.0112				Percent Non-Detects	18.18%					
199	Mean Detects	0.948				SD Detects	0.106					
200	Median Detects	0.92				CV Detects	0.112					
201	Skewness Detects	1.937				Kurtosis Detects	4.529					
202	Mean of Logged Detects	-0.0587				SD of Logged Detects	0.104					
203												
204	**Normal GOF Test on Detects Only**											
205	Shapiro Wilk Test Statistic	0.809				**Shapiro Wilk GOF Test**						
206	5% Shapiro Wilk Critical Value	0.829				Detected Data Not Normal at 5% Significance Level						
207	Lilliefors Test Statistic	0.233				**Lilliefors GOF Test**						
208	5% Lilliefors Critical Value	0.295				Detected Data appear Normal at 5% Significance Level						
209	**Detected Data appear Approximate Normal at 5% Significance Level**											
210												
211	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
212	Mean	0.868				Standard Error of Mean	0.0612					
213	SD	0.191				95% KM (BCA) UCL	0.96					
214	95% KM (t) UCL	0.979				95% KM (Percentile Bootstrap) UCL	0.963					
215	95% KM (z) UCL	0.969				95% KM Bootstrap t UCL	0.958					
216	90% KM Chebyshev UCL	1.052				95% KM Chebyshev UCL	1.135					
217	97.5% KM Chebyshev UCL	1.25				99% KM Chebyshev UCL	1.477					
218												
219	**Gamma GOF Tests on Detected Observations Only**											
220	A-D Test Statistic	0.637				**Anderson-Darling GOF Test**						
221	5% A-D Critical Value	0.72				Detected data appear Gamma Distributed at 5% Significance Leve						
222	K-S Test Statistic	0.228				**Kolmogrov-Smirnoff GOF**						
223	5% K-S Critical Value	0.279				Detected data appear Gamma Distributed at 5% Significance Leve						
224	**Detected data appear Gamma Distributed at 5% Significance Level**											
225												
226	**Gamma Statistics on Detected Data Only**											
227	k hat (MLE)	99.58				k star (bias corrected MLE)	66.46					
228	Theta hat (MLE)	0.00952				Theta star (bias corrected MLE)	0.0143					
229	nu hat (MLE)	1792				nu star (bias corrected)	1196					
230	MLE Mean (bias corrected)	0.948				MLE Sd (bias corrected)	0.116					
231												
232	**Gamma Kaplan-Meier (KM) Statistics**											
233	k hat (KM)	20.58				nu hat (KM)	452.7					
234	Approximate Chi Square Value (452.66, α)	404.3				Adjusted Chi Square Value (452.66, β)	396.9					
235	95% Gamma Approximate KM-UCL (use when n>=50)	0.972				mma Adjusted KM-UCL (use when n<50)	0.99					
236												
237	**Gamma ROS Statistics using Imputed Non-Detects**											
238	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
239	GROS may not be used when kstar of detected data is small such as < 0.1											
240	For such situations, GROS method tends to yield inflated values of UCLs and BTVs											
241	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
242	Minimum	0.724				Mean	0.907					
243	Maximum	1.2				Median	0.92					
244	SD	0.131				CV	0.144					
245	k hat (MLE)	54.49				k star (bias corrected MLE)	39.69					
246	Theta hat (MLE)	0.0166				Theta star (bias corrected MLE)	0.0229					
247	nu hat (MLE)	1199				nu star (bias corrected)	873.1					
248	MLE Mean (bias corrected)	0.907				MLE Sd (bias corrected)	0.144					
249						Adjusted Level of Significance (β)	0.0278					
250	Approximate Chi Square Value (873.11, α)	805.5				Adjusted Chi Square Value (873.11, β)	794.9					
251	95% Gamma Approximate UCL (use when n>=50)	0.983				% Gamma Adjusted UCL (use when n<50)	0.996					
252												
253	**Lognormal GOF Test on Detected Observations Only**											
254	Shapiro Wilk Test Statistic	0.85				**Shapiro Wilk GOF Test**						
255	5% Shapiro Wilk Critical Value	0.829				Detected Data appear Lognormal at 5% Significance Level						

Lilliefors Test Statistic					0.22	**Lilliefors GOF Test**						
5% Lilliefors Critical Value					0.295	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					0.911	Mean in Log Scale						-0.101
SD in Original Scale					0.125	SD in Log Scale						0.133
95% t UCL (assumes normality of ROS data)					0.979	95% Percentile Bootstrap UCL						0.97
95% BCA Bootstrap UCL					0.978	95% Bootstrap t UCL						0.992
95% H-UCL (Log ROS)					0.984							
UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed												
KM Mean (logged)					-0.17	95% H-UCL (KM -Log)						1.014
KM SD (logged)					0.253	95% Critical H Value (KM-Log)						1.905
KM Standard Error of Mean (logged)					0.0809							
DL/2 Statistics												
DL/2 Normal						**DL/2 Log-Transformed**						
Mean in Original Scale					0.822	Mean in Log Scale						-0.295
SD in Original Scale					0.295	SD in Log Scale						0.533
95% t UCL (Assumes normality)					0.983	95% H-Stat UCL						1.248
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					0.979	95% KM (Percentile Bootstrap) UCL						0.963
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					11	Number of Distinct Observations						11
						Number of Missing Observations						0
Minimum					4.4	Mean						8.473
Maximum					18.4	Median						8.2
SD					3.68	Std. Error of Mean						1.11
Coefficient of Variation					0.434	Skewness						2.083
Normal GOF Test												
Shapiro Wilk Test Statistic					0.757	**Shapiro Wilk GOF Test**						
5% Shapiro Wilk Critical Value					0.85	Data Not Normal at 5% Significance Level						
Lilliefors Test Statistic					0.289	**Lilliefors GOF Test**						
5% Lilliefors Critical Value					0.267	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					10.48	95% Adjusted-CLT UCL (Chen-1995)						11.04
						95% Modified-t UCL (Johnson-1978)						10.6
Gamma GOF Test												
A-D Test Statistic					0.735	**Anderson-Darling Gamma GOF Test**						
5% A-D Critical Value					0.73	Data Not Gamma Distributed at 5% Significance Level						
K-S Test Statistic					0.229	**Kolmogrov-Smirnoff Gamma GOF Test**						
5% K-S Critical Value					0.256	Detected data appear Gamma Distributed at 5% Significance Leve						
Detected data follow Appr. Gamma Distribution at 5% Significance Level												
Gamma Statistics												
k hat (MLE)					7.365	k star (bias corrected MLE)						5.417
Theta hat (MLE)					1.15	Theta star (bias corrected MLE)						1.564
nu hat (MLE)					162	nu star (bias corrected)						119.2
MLE Mean (bias corrected)					8.473	MLE Sd (bias corrected)						3.64
						Approximate Chi Square Value (0.05)						94.97
Adjusted Level of Significance					0.0278	Adjusted Chi Square Value						91.45
Assuming Gamma Distribution												
95% Approximate Gamma UCL (use when n>=50)					10.63	% Adjusted Gamma UCL (use when n<50)						11.04
Lognormal GOF Test												
Shapiro Wilk Test Statistic					0.883	**Shapiro Wilk Lognormal GOF Test**						
5% Shapiro Wilk Critical Value					0.85	Data appear Lognormal at 5% Significance Level						
Lilliefors Test Statistic					0.213	**Lilliefors Lognormal GOF Test**						
5% Lilliefors Critical Value					0.267	Data appear Lognormal at 5% Significance Level						
Data appear Lognormal at 5% Significance Level												
Lognormal Statistics												
Minimum of Logged Data					1.482	Mean of logged Data						2.067

341					Maximum of Logged Data	2.912					SD of logged Data	0.378
342												
343						**Assuming Lognormal Distribution**							
344					95% H-UCL	10.83					90% Chebyshev (MVUE) UCL	11.36
345					95% Chebyshev (MVUE) UCL	12.68					97.5% Chebyshev (MVUE) UCL	14.52
346					99% Chebyshev (MVUE) UCL	18.13						
347												
348						**Nonparametric Distribution Free UCL Statistics**							
349						**Data appear to follow a Discernible Distribution at 5% Significance Level**							
350												
351						**Nonparametric Distribution Free UCLs**							
352					95% CLT UCL	10.3					95% Jackknife UCL	10.48
353					95% Standard Bootstrap UCL	10.22					95% Bootstrap-t UCL	11.72
354					95% Hall's Bootstrap UCL	19.48					95% Percentile Bootstrap UCL	10.36
355					95% BCA Bootstrap UCL	11.04						
356					90% Chebyshev(Mean, Sd) UCL	11.8					95% Chebyshev(Mean, Sd) UCL	13.31
357					97.5% Chebyshev(Mean, Sd) UCL	15.4					99% Chebyshev(Mean, Sd) UCL	19.51
358												
359						**Suggested UCL to Use**							
360					95% Adjusted Gamma UCL	11.04						
361												
362						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL							
363						These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002'							
364						and Singh and Singh (2003). However, simulations results will not cover all Real World data sets							
365						For additional insight the user may want to consult a statistician.							
366												
367												
368	**Cobalt**											
369												
370						**General Statistics**							
371					Total Number of Observations	11					Number of Distinct Observations	11
372											Number of Missing Observations	0
373					Minimum	2.1					Mean	4.164
374					Maximum	6.4					Median	4.3
375					SD	1.479					Std. Error of Mean	0.446
376					Coefficient of Variation	0.355					Skewness	0.0257
377												
378						**Normal GOF Test**							
379					Shapiro Wilk Test Statistic	0.941					**Shapiro Wilk GOF Test**	
380					5% Shapiro Wilk Critical Value	0.85					Data appear Normal at 5% Significance Level	
381					Lilliefors Test Statistic	0.148					**Lilliefors GOF Test**	
382					5% Lilliefors Critical Value	0.267					Data appear Normal at 5% Significance Level	
383						**Data appear Normal at 5% Significance Level**							
384												
385						**Assuming Normal Distribution**							
386					**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**	
387					95% Student's-t UCL	4.972					95% Adjusted-CLT UCL (Chen-1995)	4.901
388											95% Modified-t UCL (Johnson-1978)	4.973
389												
390						**Gamma GOF Test**							
391					A-D Test Statistic	0.366					**Anderson-Darling Gamma GOF Test**	
392					5% A-D Critical Value	0.73					Detected data appear Gamma Distributed at 5% Significance Leve	
393					K-S Test Statistic	0.193					**Kolmogrov-Smirnoff Gamma GOF Test**	
394					5% K-S Critical Value	0.256					Detected data appear Gamma Distributed at 5% Significance Leve	
395						**Detected data appear Gamma Distributed at 5% Significance Level**							
396												
397						**Gamma Statistics**							
398					k hat (MLE)	8.026					k star (bias corrected MLE)	5.898
399					Theta hat (MLE)	0.519					Theta star (bias corrected MLE)	0.706
400					nu hat (MLE)	176.6					nu star (bias corrected)	129.8
401					MLE Mean (bias corrected)	4.164					MLE Sd (bias corrected)	1.714
402											Approximate Chi Square Value (0.05)	104.4
403					Adjusted Level of Significance	0.0278					Adjusted Chi Square Value	100.7
404												
405						**Assuming Gamma Distribution**							
406					95% Approximate Gamma UCL (use when n>=50))	5.173					% Adjusted Gamma UCL (use when n<50)	5.363
407												
408						**Lognormal GOF Test**							
409					Shapiro Wilk Test Statistic	0.924					**Shapiro Wilk Lognormal GOF Test**	
410					5% Shapiro Wilk Critical Value	0.85					Data appear Lognormal at 5% Significance Level	
411					Lilliefors Test Statistic	0.211					**Lilliefors Lognormal GOF Test**	
412					5% Lilliefors Critical Value	0.267					Data appear Lognormal at 5% Significance Level	
413						**Data appear Lognormal at 5% Significance Level**							
414												
415						**Lognormal Statistics**							
416					Minimum of Logged Data	0.742					Mean of logged Data	1.363
417					Maximum of Logged Data	1.856					SD of logged Data	0.385
418												
419						**Assuming Lognormal Distribution**							
420					95% H-UCL	5.39					90% Chebyshev (MVUE) UCL	5.65
421					95% Chebyshev (MVUE) UCL	6.316					97.5% Chebyshev (MVUE) UCL	7.242
422					99% Chebyshev (MVUE) UCL	9.06						
423												
424						**Nonparametric Distribution Free UCL Statistics**							
425						**Data appear to follow a Discernible Distribution at 5% Significance Level**							

426												
427	**Nonparametric Distribution Free UCLs**											
428	95% CLT UCL				4.897		95% Jackknife UCL					4.972
429	95% Standard Bootstrap UCL				4.854		95% Bootstrap-t UCL					5.007
430	95% Hall's Bootstrap UCL				4.837		95% Percentile Bootstrap UCL					4.864
431	95% BCA Bootstrap UCL				4.836							
432	90% Chebyshev(Mean, Sd) UCL				5.502		95% Chebyshev(Mean, Sd) UCL					6.108
433	97.5% Chebyshev(Mean, Sd) UCL				6.949		99% Chebyshev(Mean, Sd) UCL					8.602
434												
435	**Suggested UCL to Use**											
436	95% Student's-t UCL				4.972							
437												
438	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
439	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002											
440	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets											
441	For additional insight the user may want to consult a statistician.											
442												
443												
444	**Copper**											
445												
446	**General Statistics**											
447	Total Number of Observations				11		Number of Distinct Observations					11
448							Number of Missing Observations					0
449	Minimum				4.3		Mean					5.982
450	Maximum				8.5		Median					5.9
451	SD				1.395		Std. Error of Mean					0.421
452	Coefficient of Variation				0.233		Skewness					0.582
453												
454	**Normal GOF Test**											
455	Shapiro Wilk Test Statistic				0.936		**Shapiro Wilk GOF Test**					
456	5% Shapiro Wilk Critical Value				0.85		Data appear Normal at 5% Significance Level					
457	Lilliefors Test Statistic				0.145		**Lilliefors GOF Test**					
458	5% Lilliefors Critical Value				0.267		Data appear Normal at 5% Significance Level					
459	**Data appear Normal at 5% Significance Level**											
460												
461	**Assuming Normal Distribution**											
462	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
463	95% Student's-t UCL				6.744		95% Adjusted-CLT UCL (Chen-1995)					6.752
464							95% Modified-t UCL (Johnson-1978)					6.756
465												
466	**Gamma GOF Test**											
467	A-D Test Statistic				0.263		**Anderson-Darling Gamma GOF Test**					
468	5% A-D Critical Value				0.729		Detected data appear Gamma Distributed at 5% Significance Leve					
469	K-S Test Statistic				0.155		**Kolmogrov-Smirnoff Gamma GOF Test**					
470	5% K-S Critical Value				0.255		Detected data appear Gamma Distributed at 5% Significance Leve					
471	**Detected data appear Gamma Distributed at 5% Significance Level**											
472												
473	**Gamma Statistics**											
474	k hat (MLE)				21		k star (bias corrected MLE)					15.34
475	Theta hat (MLE)				0.285		Theta star (bias corrected MLE)					0.39
476	nu hat (MLE)				462.1		nu star (bias corrected)					337.4
477	MLE Mean (bias corrected)				5.982		MLE Sd (bias corrected)					1.527
478							Approximate Chi Square Value (0.05)					295.8
479	Adjusted Level of Significance				0.0278		Adjusted Chi Square Value					289.5
480												
481	**Assuming Gamma Distribution**											
482	95% Approximate Gamma UCL (use when n>=50))				6.822		% Adjusted Gamma UCL (use when n<50)					6.972
483												
484	**Lognormal GOF Test**											
485	Shapiro Wilk Test Statistic				0.953		**Shapiro Wilk Lognormal GOF Test**					
486	5% Shapiro Wilk Critical Value				0.85		Data appear Lognormal at 5% Significance Level					
487	Lilliefors Test Statistic				0.143		**Lilliefors Lognormal GOF Test**					
488	5% Lilliefors Critical Value				0.267		Data appear Lognormal at 5% Significance Level					
489	**Data appear Lognormal at 5% Significance Level**											
490												
491	**Lognormal Statistics**											
492	Minimum of Logged Data				1.459		Mean of logged Data					1.765
493	Maximum of Logged Data				2.14		SD of logged Data					0.228
494												
495	**Assuming Lognormal Distribution**											
496	95% H-UCL				6.867		90% Chebyshev (MVUE) UCL					7.22
497	95% Chebyshev (MVUE) UCL				7.782		97.5% Chebyshev (MVUE) UCL					8.563
498	99% Chebyshev (MVUE) UCL				10.09							
499												
500	**Nonparametric Distribution Free UCL Statistics**											
501	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
502												
503	**Nonparametric Distribution Free UCLs**											
504	95% CLT UCL				6.674		95% Jackknife UCL					6.744
505	95% Standard Bootstrap UCL				6.659		95% Bootstrap-t UCL					6.844
506	95% Hall's Bootstrap UCL				6.841		95% Percentile Bootstrap UCL					6.655
507	95% BCA Bootstrap UCL				6.664							
508	90% Chebyshev(Mean, Sd) UCL				7.244		95% Chebyshev(Mean, Sd) UCL					7.815
509	97.5% Chebyshev(Mean, Sd) UCL				8.608		99% Chebyshev(Mean, Sd) UCL					10.17
510												

511	**Suggested UCL to Use**											
512	95% Student's-t UCL				6.744							
513												
514	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
515	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
516	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets											
517	For additional insight the user may want to consult a statistician.											
518												
519												
520	**Nickel**											
521												
522	**General Statistics**											
523	Total Number of Observations				11		Number of Distinct Observations					9
524							Number of Missing Observations					0
525	Minimum				3.9		Mean					7.182
526	Maximum				9		Median					7.5
527	SD				1.701		Std. Error of Mean					0.513
528	Coefficient of Variation				0.237		Skewness					-0.933
529												
530	**Normal GOF Test**											
531	Shapiro Wilk Test Statistic				0.895		**Shapiro Wilk GOF Test**					
532	5% Shapiro Wilk Critical Value				0.85		Data appear Normal at 5% Significance Level					
533	Lilliefors Test Statistic				0.211		**Lilliefors GOF Test**					
534	5% Lilliefors Critical Value				0.267		Data appear Normal at 5% Significance Level					
535	**Data appear Normal at 5% Significance Level**											
536												
537	**Assuming Normal Distribution**											
538	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
539	95% Student's-t UCL				8.111		95% Adjusted-CLT UCL (Chen-1995)					7.871
540							95% Modified-t UCL (Johnson-1978)					8.087
541												
542	**Gamma GOF Test**											
543	A-D Test Statistic				0.648		**Anderson-Darling Gamma GOF Test**					
544	5% A-D Critical Value				0.729		Detected data appear Gamma Distributed at 5% Significance Leve					
545	K-S Test Statistic				0.238		**Kolmogrov-Smirnoff Gamma GOF Test**					
546	5% K-S Critical Value				0.255		Detected data appear Gamma Distributed at 5% Significance Leve					
547	**Detected data appear Gamma Distributed at 5% Significance Level**											
548												
549	**Gamma Statistics**											
550	k hat (MLE)				16.35		k star (bias corrected MLE)					11.95
551	Theta hat (MLE)				0.439		Theta star (bias corrected MLE)					0.601
552	nu hat (MLE)				359.7		nu star (bias corrected)					263
553	MLE Mean (bias corrected)				7.182		MLE Sd (bias corrected)					2.077
554							Approximate Chi Square Value (0.05)					226.4
555	Adjusted Level of Significance				0.0278		Adjusted Chi Square Value					220.9
556												
557	**Assuming Gamma Distribution**											
558	95% Approximate Gamma UCL (use when n>=50))				8.341		% Adjusted Gamma UCL (use when n<50)					8.55
559												
560	**Lognormal GOF Test**											
561	Shapiro Wilk Test Statistic				0.844		**Shapiro Wilk Lognormal GOF Test**					
562	5% Shapiro Wilk Critical Value				0.85		Data Not Lognormal at 5% Significance Level					
563	Lilliefors Test Statistic				0.243		**Lilliefors Lognormal GOF Test**					
564	5% Lilliefors Critical Value				0.267		Data appear Lognormal at 5% Significance Level					
565	**Data appear Approximate Lognormal at 5% Significance Level**											
566												
567	**Lognormal Statistics**											
568	Minimum of Logged Data				1.361		Mean of logged Data					1.941
569	Maximum of Logged Data				2.197		SD of logged Data					0.274
570												
571	**Assuming Lognormal Distribution**											
572	95% H-UCL				8.542		90% Chebyshev (MVUE) UCL					9.003
573	95% Chebyshev (MVUE) UCL				9.817		97.5% Chebyshev (MVUE) UCL					10.95
574	99% Chebyshev (MVUE) UCL				13.17							
575												
576	**Nonparametric Distribution Free UCL Statistics**											
577	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
578												
579	**Nonparametric Distribution Free UCLs**											
580	95% CLT UCL				8.025		95% Jackknife UCL					8.111
581	95% Standard Bootstrap UCL				7.986		95% Bootstrap-t UCL					7.983
582	95% Hall's Bootstrap UCL				7.898		95% Percentile Bootstrap UCL					7.973
583	95% BCA Bootstrap UCL				7.891							
584	90% Chebyshev(Mean, Sd) UCL				8.72		95% Chebyshev(Mean, Sd) UCL					9.417
585	97.5% Chebyshev(Mean, Sd) UCL				10.38		99% Chebyshev(Mean, Sd) UCL					12.29
586												
587	**Suggested UCL to Use**											
588	95% Student's-t UCL				8.111							
589												
590	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
591	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
592	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets											
593	For additional insight the user may want to consult a statistician.											
594												
595	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											

reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Selenium

General Statistics

Total Number of Observations	11	Number of Distinct Observations	11
Number of Detects	10	Number of Non-Detects	1
Number of Distinct Detects	10	Number of Distinct Non-Detects	1
Minimum Detect	0.77	Minimum Non-Detect	0.81
Maximum Detect	1	Maximum Non-Detect	0.81
Variance Detects	0.00677	Percent Non-Detects	9.091%
Mean Detects	0.878	SD Detects	0.0823
Median Detects	0.855	CV Detects	0.0937
Skewness Detects	0.352	Kurtosis Detects	-1.41
Mean of Logged Detects	-0.134	SD of Logged Detects	0.093

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.92	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.187	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	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

Mean	0.869	Standard Error of Mean	0.0253
SD	0.0797	95% KM (BCA) UCL	0.905
95% KM (t) UCL	0.915	95% KM (Percentile Bootstrap) UCL	0.909
95% KM (z) UCL	0.911	95% KM Bootstrap t UCL	0.917
90% KM Chebyshev UCL	0.945	95% KM Chebyshev UCL	0.98
97.5% KM Chebyshev UCL	1.027	99% KM Chebyshev UCL	1.121

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.379	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Leve	
K-S Test Statistic	0.181	**Kolmogrov-Smirnoff GOF**	
5% K-S Critical Value	0.266	Detected data appear Gamma Distributed at 5% Significance Leve	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	128.1	k star (bias corrected MLE)	89.71
Theta hat (MLE)	0.00686	Theta star (bias corrected MLE)	0.00979
nu hat (MLE)	2561	nu star (bias corrected)	1794
MLE Mean (bias corrected)	0.878	MLE Sd (bias corrected)	0.0927

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	119	nu hat (KM)	2619
Approximate Chi Square Value (N/A, α)	2501	Adjusted Chi Square Value (N/A, β)	2482
95% Gamma Approximate KM-UCL (use when n>=50)	0.91	mma Adjusted KM-UCL (use when n<50)	0.917

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 detected data is small such as < 0.1

For such situations, GROS method tends to yield inflated values of UCLs and BTVs

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

Minimum	0.766	Mean	0.868
Maximum	1	Median	0.85
SD	0.085	CV	0.098
k hat (MLE)	116.7	k star (bias corrected MLE)	84.9
Theta hat (MLE)	0.00744	Theta star (bias corrected MLE)	0.0102
nu hat (MLE)	2567	nu star (bias corrected)	1868
MLE Mean (bias corrected)	0.868	MLE Sd (bias corrected)	0.0942
		Adjusted Level of Significance (β)	0.0278
Approximate Chi Square Value (N/A, α)	1769	Adjusted Chi Square Value (N/A, β)	1753
95% Gamma Approximate UCL (use when n>=50)	0.917	% Gamma Adjusted UCL (use when n<50)	0.925

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.928	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.172	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	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	0.868	Mean in Log Scale	-0.146
SD in Original Scale	0.0847	SD in Log Scale	0.0963
95% t UCL (assumes normality of ROS data)	0.914	95% Percentile Bootstrap UCL	0.907
95% BCA Bootstrap UCL	0.912	95% Bootstrap t UCL	0.923
95% H-UCL (Log ROS)	N/A		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.144	95% H-UCL (KM -Log)	N/A
KM SD (logged)	0.0904	95% Critical H Value (KM-Log)	N/A
KM Standard Error of Mean (logged)	0.0288		

681												
682						DL/2 Statistics						
683					DL/2 Normal					DL/2 Log-Transformed		
684					Mean in Original Scale	0.835				Mean in Log Scale	-0.204	
685					SD in Original Scale	0.163				SD in Log Scale	0.248	
686					95% t UCL (Assumes normality)	0.924				95% H-Stat UCL	0.976	
687					DL/2 is not a recommended method, provided for comparisons and historical reasons							
688												
689						Nonparametric Distribution Free UCL Statistics						
690						Detected Data appear Normal Distributed at 5% Significance Level						
691												
692						Suggested UCL to Use						
693					95% KM (t) UCL	0.915				95% KM (Percentile Bootstrap) UCL	0.909	
694												
695						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL						
696						Recommendations are based upon data size, data distribution, and skewness.						
697						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006)						
698						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician						
699												
700												
701	Vanadium											
702												
703						General Statistics						
704					Total Number of Observations	11				Number of Distinct Observations	11	
705										Number of Missing Observations	0	
706					Minimum	8.9				Mean	17.08	
707					Maximum	22.6				Median	18.4	
708					SD	4.824				Std. Error of Mean	1.454	
709					Coefficient of Variation	0.282				Skewness	-0.7	
710												
711						Normal GOF Test						
712					Shapiro Wilk Test Statistic	0.905				Shapiro Wilk GOF Test		
713					5% Shapiro Wilk Critical Value	0.85				Data appear Normal at 5% Significance Level		
714					Lilliefors Test Statistic	0.153				Lilliefors GOF Test		
715					5% Lilliefors Critical Value	0.267				Data appear Normal at 5% Significance Level		
716						Data appear Normal at 5% Significance Level						
717												
718						Assuming Normal Distribution						
719					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
720					95% Student's-t UCL	19.72				95% Adjusted-CLT UCL (Chen-1995)	19.15	
721										95% Modified-t UCL (Johnson-1978)	19.67	
722												
723						Gamma GOF Test						
724					A-D Test Statistic	0.594				Anderson-Darling Gamma GOF Test		
725					5% A-D Critical Value	0.729				Detected data appear Gamma Distributed at 5% Significance Leve		
726					K-S Test Statistic	0.185				Kolmogrov-Smirnoff Gamma GOF Test		
727					5% K-S Critical Value	0.255				Detected data appear Gamma Distributed at 5% Significance Leve		
728						Detected data appear Gamma Distributed at 5% Significance Level						
729												
730						Gamma Statistics						
731					k hat (MLE)	11.52				k star (bias corrected MLE)	8.438	
732					Theta hat (MLE)	1.483				Theta star (bias corrected MLE)	2.024	
733					nu hat (MLE)	253.4				nu star (bias corrected)	185.6	
734					MLE Mean (bias corrected)	17.08				MLE Sd (bias corrected)	5.88	
735										Approximate Chi Square Value (0.05)	155.1	
736					Adjusted Level of Significance	0.0278				Adjusted Chi Square Value	150.6	
737												
738						Assuming Gamma Distribution						
739					95% Approximate Gamma UCL (use when n>=50))	20.44				% Adjusted Gamma UCL (use when n<50)	21.06	
740												
741						Lognormal GOF Test						
742					Shapiro Wilk Test Statistic	0.856				Shapiro Wilk Lognormal GOF Test		
743					5% Shapiro Wilk Critical Value	0.85				Data appear Lognormal at 5% Significance Level		
744					Lilliefors Test Statistic	0.198				Lilliefors Lognormal GOF Test		
745					5% Lilliefors Critical Value	0.267				Data appear Lognormal at 5% Significance Level		
746						Data appear Lognormal at 5% Significance Level						
747												
748						Lognormal Statistics						
749					Minimum of Logged Data	2.186				Mean of logged Data	2.794	
750					Maximum of Logged Data	3.118				SD of logged Data	0.327	
751												
752						Assuming Lognormal Distribution						
753					95% H-UCL	21.16				90% Chebyshev (MVUE) UCL	22.29	
754					95% Chebyshev (MVUE) UCL	24.61				97.5% Chebyshev (MVUE) UCL	27.84	
755					99% Chebyshev (MVUE) UCL	34.17						
756												
757						Nonparametric Distribution Free UCL Statistics						
758						Data appear to follow a Discernible Distribution at 5% Significance Level						
759												
760						Nonparametric Distribution Free UCLs						
761					95% CLT UCL	19.47				95% Jackknife UCL	19.72	
762					95% Standard Bootstrap UCL	19.35				95% Bootstrap-t UCL	19.34	
763					95% Hall's Bootstrap UCL	19.05				95% Percentile Bootstrap UCL	19.27	
764					95% BCA Bootstrap UCL	19.05						
765					90% Chebyshev(Mean, Sd) UCL	21.44				95% Chebyshev(Mean, Sd) UCL	23.42	

	A	B	C	D	E	F	G	H	I	J	K	L
766	97.5% Chebyshev(Mean, Sd) UCL					26.16	99% Chebyshev(Mean, Sd) UCL					31.55
767												
768	**Suggested UCL to Use**											
769	95% Student's-t UCL					19.72						
770												
771	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
772	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
773	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets											
774	For additional insight the user may want to consult a statistician.											
775												
776	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
777	**reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.**											
778												