UCL Statistics for Data Sets with Non-Detects

Aluminum

General Statistics

Total Number of Observations	71	Number of Distinct Observations	62
		Number of Missing Observations	0
Minimum	3210	Mean	10893
Maximum	20500	Median	11300
SD	3354	Std. Error of Mean	398.1
Coefficient of Variation	0.308	Skewness	-0.115

Normal GOF Test

Shapiro Wilk Test Statistic	0.98	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0.634	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.106	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.105	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	11557	95% Adjusted-CLT UCL (Chen-1995)	11542
		95% Modified-t UCL (Johnson-1978)	11556

Gamma GOF Test

A-D Test Statistic	1.312	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.751	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.151	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.106	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	9.012	k star (bias corrected MLE)	8.641
Theta hat (MLE)	1209	Theta star (bias corrected MLE)	1261
nu hat (MLE)	1280	nu star (bias corrected)	1227
MLE Mean (bias corrected)	10893	MLE Sd (bias corrected)	3706
		Approximate Chi Square Value (0.05)	1147
Adjusted Level of Significance	0.0466	Adjusted Chi Square Value	1145

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	11656	95% Adjusted Gamma UCL (use when n<50)	11672

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.919	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	1.1001E-4	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.169	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.105	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	8.074	Mean of logged Data	9.239
Maximum of Logged Data	9.928	SD of logged Data	0.36

Assuming Lognormal Distribution

95% H-UCL	11856	90% Chebyshev (MVUE) UCL	12421
95% Chebyshev (MVUE) UCL	13076	97.5% Chebyshev (MVUE) UCL	13986
99% Chebyshev (MVUE) UCL	15773		

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

Nonparametric Distribution Free UCLs

95% CLT UCL	11548	95% Jackknife UCL	11557
95% Standard Bootstrap UCL	11535	95% Bootstrap-t UCL	11573
95% Hall's Bootstrap UCL	11541	95% Percentile Bootstrap UCL	11558
95% BCA Bootstrap UCL	11504		
90% Chebyshev(Mean, Sd) UCL	12087	95% Chebyshev(Mean, Sd) UCL	12628
97.5% Chebyshev(Mean, Sd) UCL	13379	99% Chebyshev(Mean, Sd) UCL	14854

Suggested UCL to Use

95% Student's-t UCL	11557

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

These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)

and Singh and Singh (2003). 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	71	Number of Distinct Observations	61
		Number of Missing Observations	0
Minimum	41.3	Mean	155.1
Maximum	247	Median	164
SD	47.83	Std. Error of Mean	5.677
Coefficient of Variation	0.308	Skewness	-0.321

Normal GOF Test

Shapiro Wilk Test Statistic	0.96	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	0.0664	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.115	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.105	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	164.5	95% Adjusted-CLT UCL (Chen-1995)	164.2
		95% Modified-t UCL (Johnson-1978)	164.5

Gamma GOF Test

A-D Test Statistic	1.425	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.752	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.138	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.106	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	8.816	k star (bias corrected MLE)	8.453
Theta hat (MLE)	17.59	Theta star (bias corrected MLE)	18.35
nu hat (MLE)	1252	nu star (bias corrected)	1200
MLE Mean (bias corrected)	155.1	MLE Sd (bias corrected)	53.34
		Approximate Chi Square Value (0.05)	1121
Adjusted Level of Significance	0.0466	Adjusted Chi Square Value	1119

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	166.1	95% Adjusted Gamma UCL (use when n<50)	166.3

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.909	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	2.1331E-5	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.153	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.105	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.721	Mean of logged Data	4.986
Maximum of Logged Data	5.509	SD of logged Data	0.365

Assuming Lognormal Distribution

95% H-UCL	169	90% Chebyshev (MVUE) UCL	177.2
95% Chebyshev (MVUE) UCL	186.7	97.5% Chebyshev (MVUE) UCL	199.8
99% Chebyshev (MVUE) UCL	225.6		

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

Nonparametric Distribution Free UCLs

95% CLT UCL	164.4	95% Jackknife UCL	164.5
95% Standard Bootstrap UCL	164.6	95% Bootstrap-t UCL	164.4
95% Hall's Bootstrap UCL	164.7	95% Percentile Bootstrap UCL	164.4
95% BCA Bootstrap UCL	163.8		
90% Chebyshev(Mean, Sd) UCL	172.1	95% Chebyshev(Mean, Sd) UCL	179.8
97.5% Chebyshev(Mean, Sd) UCL	190.5	99% Chebyshev(Mean, Sd) UCL	211.6

Suggested UCL to Use

95% Student's-t UCL	164.5

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). However, simulations results will not cover all Real World data sets
For additional insight the user may want to consult a statistician.

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.

Copper

	A	B	C	D	E	F	G	H	I	J	K	L
171												
172						**General Statistics**						
173		Total Number of Observations				71			Number of Distinct Observations			69
174									Number of Missing Observations			0
175					Minimum	2.82					Mean	8.576
176					Maximum	98.9					Median	6.42
177					SD	11.34				Std. Error of Mean		1.345
178				Coefficient of Variation		1.322					Skewness	7.473
179												
180						**Normal GOF Test**						
181		Shapiro Wilk Test Statistic				0.294			**Shapiro Wilk GOF Test**			
182		5% Shapiro Wilk P Value				0			Data Not Normal at 5% Significance Level			
183		Lilliefors Test Statistic				0.345			**Lilliefors GOF Test**			
184		5% Lilliefors Critical Value				0.105			Data Not Normal at 5% Significance Level			
185						**Data Not Normal at 5% Significance Level**						
186												
187						**Assuming Normal Distribution**						
188				**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**			
189				95% Student's-t UCL		10.82			95% Adjusted-CLT UCL (Chen-1995)			12.06
190									95% Modified-t UCL (Johnson-1978)			11.02
191												
192						**Gamma GOF Test**						
193				A-D Test Statistic		8.823			**Anderson-Darling Gamma GOF Test**			
194				5% A-D Critical Value		0.759			Data Not Gamma Distributed at 5% Significance Level			
195				K-S Test Statistic		0.276			**Kolmogrov-Smirnoff Gamma GOF Test**			
196				5% K-S Critical Value		0.107			Data Not Gamma Distributed at 5% Significance Level			
197						**Data Not Gamma Distributed at 5% Significance Level**						
198												
199						**Gamma Statistics**						
200					k hat (MLE)	2.77			k star (bias corrected MLE)			2.663
201					Theta hat (MLE)	3.096			Theta star (bias corrected MLE)			3.221
202					nu hat (MLE)	393.4			nu star (bias corrected)			378.1
203				MLE Mean (bias corrected)		8.576			MLE Sd (bias corrected)			5.256
204									Approximate Chi Square Value (0.05)			334
205				Adjusted Level of Significance		0.0466			Adjusted Chi Square Value			333.2
206												
207						**Assuming Gamma Distribution**						
208		95% Approximate Gamma UCL (use when n>=50))				9.707	Adjusted Gamma UCL (use when n<50)					9.732
209												
210						**Lognormal GOF Test**						
211		Shapiro Wilk Test Statistic				0.761			**Shapiro Wilk Lognormal GOF Test**			
212		5% Shapiro Wilk P Value				8.882E-16			Data Not Lognormal at 5% Significance Level			
213		Lilliefors Test Statistic				0.225			**Lilliefors Lognormal GOF Test**			
214		5% Lilliefors Critical Value				0.105			Data Not Lognormal at 5% Significance Level			
215						**Data Not Lognormal at 5% Significance Level**						
216												
217						**Lognormal Statistics**						
218			Minimum of Logged Data			1.037			Mean of logged Data			1.958
219			Maximum of Logged Data			4.594			SD of logged Data			0.464
220												
221						**Assuming Lognormal Distribution**						
222				95% H-UCL		8.732			90% Chebyshev (MVUE) UCL			9.238
223		95% Chebyshev (MVUE) UCL				9.855			97.5% Chebyshev (MVUE) UCL			10.71
224		99% Chebyshev (MVUE) UCL				12.39						
225												
226						**Nonparametric Distribution Free UCL Statistics**						
227						**Data do not follow a Discernible Distribution (0.05)**						
228												
229						**Nonparametric Distribution Free UCLs**						
230				95% CLT UCL		10.79			95% Jackknife UCL			10.82
231		95% Standard Bootstrap UCL				10.76			95% Bootstrap-t UCL			16.75
232		95% Hall's Bootstrap UCL				18.49			95% Percentile Bootstrap UCL			11.09
233		95% BCA Bootstrap UCL				12.47						
234		90% Chebyshev(Mean, Sd) UCL				12.61			95% Chebyshev(Mean, Sd) UCL			14.44
235		97.5% Chebyshev(Mean, Sd) UCL				16.98			99% Chebyshev(Mean, Sd) UCL			21.96
236												
237						**Suggested UCL to Use**						
238				95% Student's-t UCL		10.82			or 95% Modified-t UCL			11.02
239												
240		Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL										
241		These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)										
242		and Singh and Singh (2003). However, simulations results will not cover all Real World data sets										
243		For additional insight the user may want to consult a statistician.										
244												
245	Mercury											
246												
247						**General Statistics**						
248		Total Number of Observations				71			Number of Distinct Observations			61
249		Number of Detects				59			Number of Non-Detects			12
250		Number of Distinct Detects				55			Number of Distinct Non-Detects			7
251		Minimum Detect				0.00533			Minimum Non-Detect			0.0112
252		Maximum Detect				0.72			Maximum Non-Detect			0.05
253		Variance Detects				0.0102			Percent Non-Detects			16.9%
254		Mean Detects				0.0359			SD Detects			0.101
255		Median Detects				0.0162			CV Detects			2.823

	A	B	C	D	E	F	G	H	I	J	K	L
256					Skewness Detects	6.031				Kurtosis Detects		38.47
257					Mean of Logged Detects	-4.025				SD of Logged Detects		0.799
258												
259				**Normal GOF Test on Detects Only**								
260				Shapiro Wilk Test Statistic		0.265	**Normal GOF Test on Detected Observations Only**					
261				5% Shapiro Wilk P Value		0	Detected Data Not Normal at 5% Significance Level					
262				Lilliefors Test Statistic		0.436	**Lilliefors GOF Test**					
263				5% Lilliefors Critical Value		0.115	Detected Data Not Normal at 5% Significance Level					
264				**Detected Data Not Normal at 5% Significance Level**								
265												
266			**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**									
267					Mean	0.0318			Standard Error of Mean			0.011
268					SD	0.092			95% KM (BCA) UCL			0.0533
269				95% KM (t) UCL		0.0502		95% KM (Percentile Bootstrap) UCL				0.0514
270				95% KM (z) UCL		0.05			95% KM Bootstrap t UCL			0.189
271				90% KM Chebyshev UCL		0.0649			95% KM Chebyshev UCL			0.0798
272				97.5% KM Chebyshev UCL		0.101			99% KM Chebyshev UCL			0.141
273												
274				**Gamma GOF Tests on Detected Observations Only**								
275				A-D Test Statistic		10.3	**Anderson-Darling GOF Test**					
276				5% A-D Critical Value		0.787	Detected Data Not Gamma Distributed at 5% Significance Level					
277				K-S Test Statistic		0.338	**Kolmogrov-Smirnoff GOF**					
278				5% K-S Critical Value		0.12	Detected Data Not Gamma Distributed at 5% Significance Level					
279				**Detected Data Not Gamma Distributed at 5% Significance Level**								
280												
281				**Gamma Statistics on Detected Data Only**								
282				k hat (MLE)		0.846			k star (bias corrected MLE)			0.814
283				Theta hat (MLE)		0.0424			Theta star (bias corrected MLE)			0.044
284				nu hat (MLE)		99.81			nu star (bias corrected)			96.07
285			MLE Mean (bias corrected)			0.0359			MLE Sd (bias corrected)			0.0397
286												
287				**Gamma Kaplan-Meier (KM) Statistics**								
288				k hat (KM)		0.12			nu hat (KM)			17.03
289			Approximate Chi Square Value (17.03, α)			8.694		Adjusted Chi Square Value (17.03, β)				8.57
290		95% Gamma Approximate KM-UCL (use when n>=50)				0.0624	Gamma Adjusted KM-UCL (use when n<50)					0.0633
291												
292				**Gamma ROS Statistics using Imputed Non-Detects**								
293			GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs									
294			GROS may not be used when kstar of detected data is small such as < 0.1									
295			For such situations, GROS method tends to yield inflated values of UCLs and BTVs									
296		For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates										
297					Minimum	0.00533				Mean		0.0326
298					Maximum	0.72				Median		0.0155
299					SD	0.0927				CV		2.843
300					k hat (MLE)	0.891			k star (bias corrected MLE)			0.863
301					Theta hat (MLE)	0.0366			Theta star (bias corrected MLE)			0.0378
302					nu hat (MLE)	126.5			nu star (bias corrected)			122.5
303				MLE Mean (bias corrected)		0.0326			MLE Sd (bias corrected)			0.0351
304									Adjusted Level of Significance (β)			0.0466
305			Approximate Chi Square Value (122.48, α)			97.92		Adjusted Chi Square Value (122.48, β)				97.46
306			95% Gamma Approximate UCL (use when n>=50)			0.0408	95% Gamma Adjusted UCL (use when n<50)					0.041
307												
308				**Lognormal GOF Test on Detected Observations Only**								
309				Lilliefors Test Statistic		0.209	**Lilliefors GOF Test**					
310				5% Lilliefors Critical Value		0.115	Detected Data Not Lognormal at 5% Significance Level					
311				**Detected Data Not Lognormal at 5% Significance Level**								
312												
313				**Lognormal ROS Statistics Using Imputed Non-Detects**								
314				Mean in Original Scale		0.0318			Mean in Log Scale			-4.115
315				SD in Original Scale		0.0926			SD in Log Scale			0.777
316			95% t UCL (assumes normality of ROS data)			0.0501		95% Percentile Bootstrap UCL				0.0514
317				95% BCA Bootstrap UCL		0.0648			95% Bootstrap t UCL			0.141
318				95% H-UCL (Log ROS)		0.0267						
319												
320				**DL/2 Statistics**								
321		**DL/2 Normal**						**DL/2 Log-Transformed**				
322				Mean in Original Scale		0.0322			Mean in Log Scale			-4.104
323				SD in Original Scale		0.0926			SD in Log Scale			0.8
324			95% t UCL (Assumes normality)			0.0505			95% H-Stat UCL			0.0277
325				**DL/2 is not a recommended method, provided for comparisons and historical reasons**								
326												
327				**Nonparametric Distribution Free UCL Statistics**								
328				**Data do not follow a Discernible Distribution at 5% Significance Level**								
329												
330				**Suggested UCL to Use**								
331			95% KM (BCA) UCL			0.0533						
332												
333		Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL										
334				Recommendations are based upon data size, data distribution, and skewness.								
335			These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006)									
336		However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician										
337												
338	Zinc											
339												
340					**General Statistics**							

	A	B	C	D	E	F	G	H	I	J	K	L
341				Total Number of Observations		71			Number of Distinct Observations			65
342									Number of Missing Observations			0
343					Minimum	20.3					Mean	45.53
344					Maximum	446					Median	28.8
345					SD	60.34				Std. Error of Mean		7.161
346				Coefficient of Variation		1.325					Skewness	5.372
347												
348						**Normal GOF Test**						
349				Shapiro Wilk Test Statistic		0.384			**Shapiro Wilk GOF Test**			
350				5% Shapiro Wilk P Value		0			Data Not Normal at 5% Significance Level			
351				Lilliefors Test Statistic		0.35			**Lilliefors GOF Test**			
352				5% Lilliefors Critical Value		0.105			Data Not Normal at 5% Significance Level			
353					**Data Not Normal at 5% Significance Level**							
354												
355						**Assuming Normal Distribution**						
356			**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**			
357				95% Student's-t UCL		57.46		95% Adjusted-CLT UCL (Chen-1995)				62.18
358								95% Modified-t UCL (Johnson-1978)				58.22
359												
360						**Gamma GOF Test**						
361				A-D Test Statistic		9.187			**Anderson-Darling Gamma GOF Test**			
362				5% A-D Critical Value		0.763			Data Not Gamma Distributed at 5% Significance Level			
363				K-S Test Statistic		0.27			**Kolmogrov-Smirnoff Gamma GOF Test**			
364				5% K-S Critical Value		0.107			Data Not Gamma Distributed at 5% Significance Level			
365				**Data Not Gamma Distributed at 5% Significance Level**								
366												
367						**Gamma Statistics**						
368				k hat (MLE)		2.089			k star (bias corrected MLE)			2.01
369				Theta hat (MLE)		21.79			Theta star (bias corrected MLE)			22.64
370				nu hat (MLE)		296.7			nu star (bias corrected)			285.5
371			MLE Mean (bias corrected)			45.53			MLE Sd (bias corrected)			32.11
372									Approximate Chi Square Value (0.05)			247.3
373			Adjusted Level of Significance			0.0466			Adjusted Chi Square Value			246.6
374												
375						**Assuming Gamma Distribution**						
376		95% Approximate Gamma UCL (use when n>=50))				52.54	ь Adjusted Gamma UCL (use when n<50)					52.7
377												
378						**Lognormal GOF Test**						
379				Shapiro Wilk Test Statistic		0.728			**Shapiro Wilk Lognormal GOF Test**			
380				5% Shapiro Wilk P Value		0			Data Not Lognormal at 5% Significance Level			
381				Lilliefors Test Statistic		0.224			**Lilliefors Lognormal GOF Test**			
382				5% Lilliefors Critical Value		0.105			Data Not Lognormal at 5% Significance Level			
383				**Data Not Lognormal at 5% Significance Level**								
384												
385						**Lognormal Statistics**						
386				Minimum of Logged Data		3.011			Mean of logged Data			3.56
387				Maximum of Logged Data		6.1			SD of logged Data			0.559
388												
389						**Assuming Lognormal Distribution**						
390				95% H-UCL		46.67			90% Chebyshev (MVUE) UCL			49.74
391			95% Chebyshev (MVUE) UCL			53.68			97.5% Chebyshev (MVUE) UCL			59.16
392			99% Chebyshev (MVUE) UCL			69.92						
393												
394					**Nonparametric Distribution Free UCL Statistics**							
395					**Data do not follow a Discernible Distribution (0.05)**							
396												
397						**Nonparametric Distribution Free UCLs**						
398				95% CLT UCL		57.3			95% Jackknife UCL			57.46
399			95% Standard Bootstrap UCL			57.06			95% Bootstrap-t UCL			78.67
400				95% Hall's Bootstrap UCL		110.3			95% Percentile Bootstrap UCL			58.37
401				95% BCA Bootstrap UCL		64.26						
402			90% Chebyshev(Mean, Sd) UCL			67.01			95% Chebyshev(Mean, Sd) UCL			76.74
403			97.5% Chebyshev(Mean, Sd) UCL			90.25			99% Chebyshev(Mean, Sd) UCL			116.8
404												
405						**Suggested UCL to Use**						
406			95% Chebyshev (Mean, Sd) UCL			76.74						
407												
408		Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL										
409		These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)										
410		and Singh and Singh (2003). However, simulations results will not cover all Real World data sets										
411		For additional insight the user may want to consult a statistician.										
412												