21 Mar 2014

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Torque Repeatability for the RAD Series of Tools

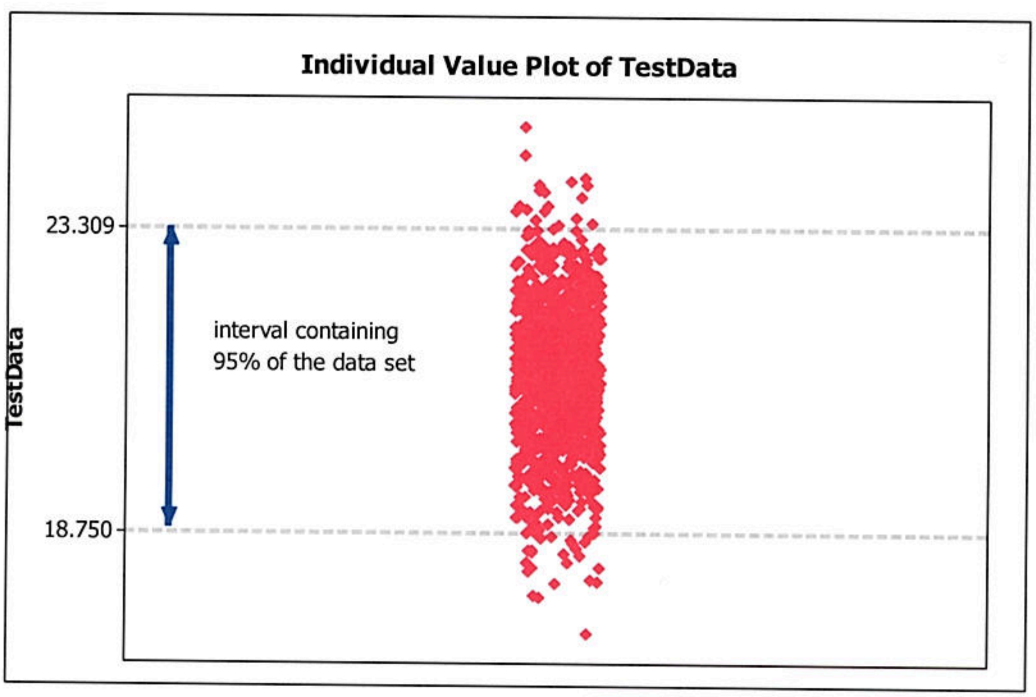
Belfield
consulting & training

Background

Calibration accuracies for the Pneumatic tools are listed as ± 5% of Full Scale where this value is the maximum torque value for the tool. As an example, for the RAD 34GX, maximum torque is 3400 ft·lbs. and 5% of this value is 170 ft·lbs. The accuracy as stated tells the user that any reading is within ± 170 ft·lbs of the true value. Some of our customers have asked about a value for accuracy as a percentage of the reading instead of full scale.

This value of 5% was derived some years ago and the purpose of this study is to determine a more precise value for our tool accuracy and also to report accuracy as a percentage of reading.

Any distribution of measurements, Gaussian or other, will tend to have a tail area that extends away from the mean. This theoretical distribution extends indefinitely. For this reason, it is common practice to describe the variation as the range that encompasses 95% of all the data. This is seen visually in the plot below.



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Purpose

The objective of this study was to determine the appropriate value that defines the accuracy of the RAD family of torque tools. This is currently identified as ± 5% of Full Scale. The company has calibrated several thousand pneumatic tools and this data was used to understand the variability in performance.

Findings

There is more variability at the low end of a tool than there is at the high end. This is taken into consideration when deciding on a single value for accuracy.

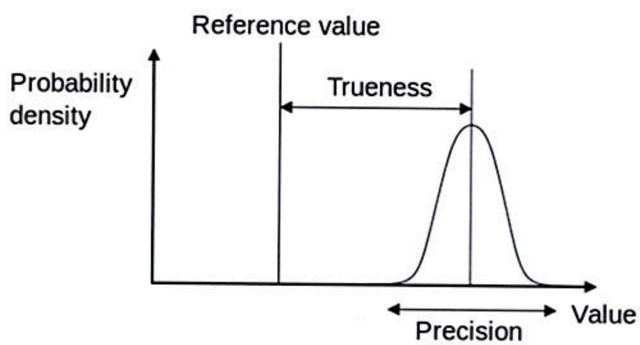
This is seen in the plots in Appendix A which show distributions of deviations for over 45,000 data points across a range of torque values. Note that each chart displays the differences from a specific range of the percentage of the tool's maximum torque value.

The findings shown in Appendix A are measures of precision. In order to estimate accuracy, we require both precision and a measure of trueness (or bias). The uncertainty from our calibration program's uncertainty budget is used to estimate the trueness. This value, to one standard deviation, is 1.09%.

The following table lists estimates of precision and accuracy for all the pneumatic tools.

Setting (% of Max)	Repeatability (1 std dev)	Uncertainty (1 std dev)	95% Accuracy
up to 30%	2.1%	1.09%	4.6%
30 - 40%	1.8%	1.09%	4.1%
40 - 50%	1.8%	1.09%	4.1%
50 - 60%	1.6%	1.09%	3.7%
60 - 70%	1.5%	1.09%	3.6%
70 - 80%	1.4%	1.09%	3.5%
80 - 90%	1.3%	1.09%	3.3%
90 - 100%	1.2%	1.09%	3.1%
over 100%	1.2%	1.09%	3.2%

Accuracy



Conclusions

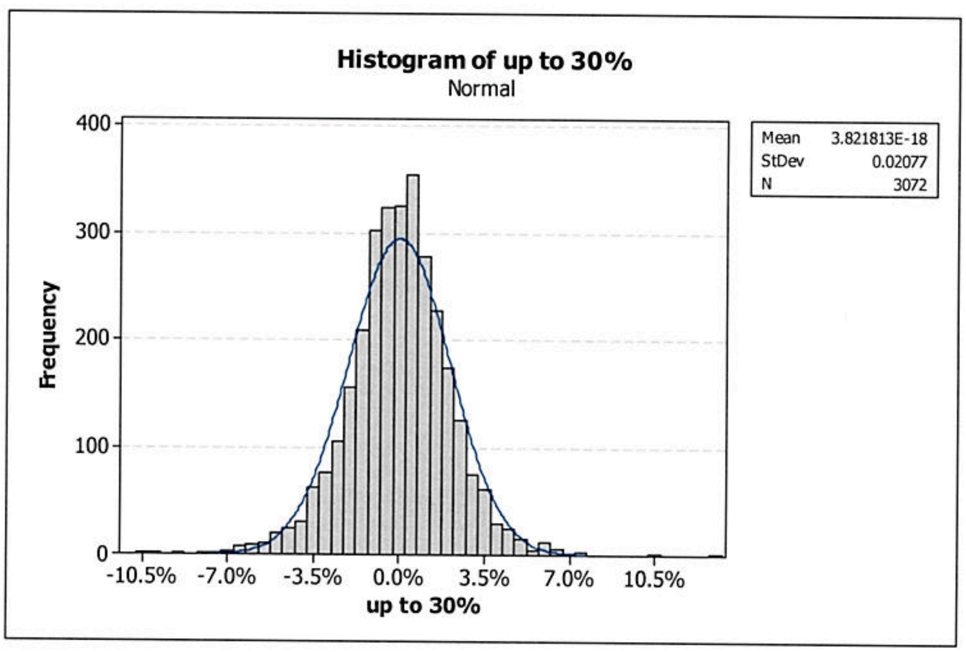
Equipment accuracy should be stated as ± 4.0% of reading for all Pneumatic tools.

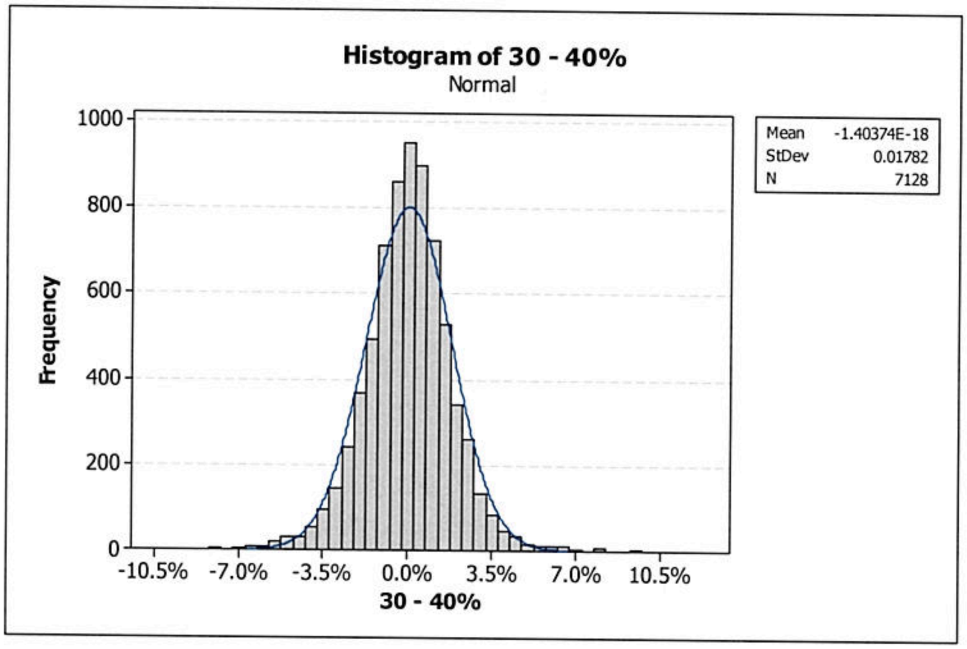
Chris Butterworth

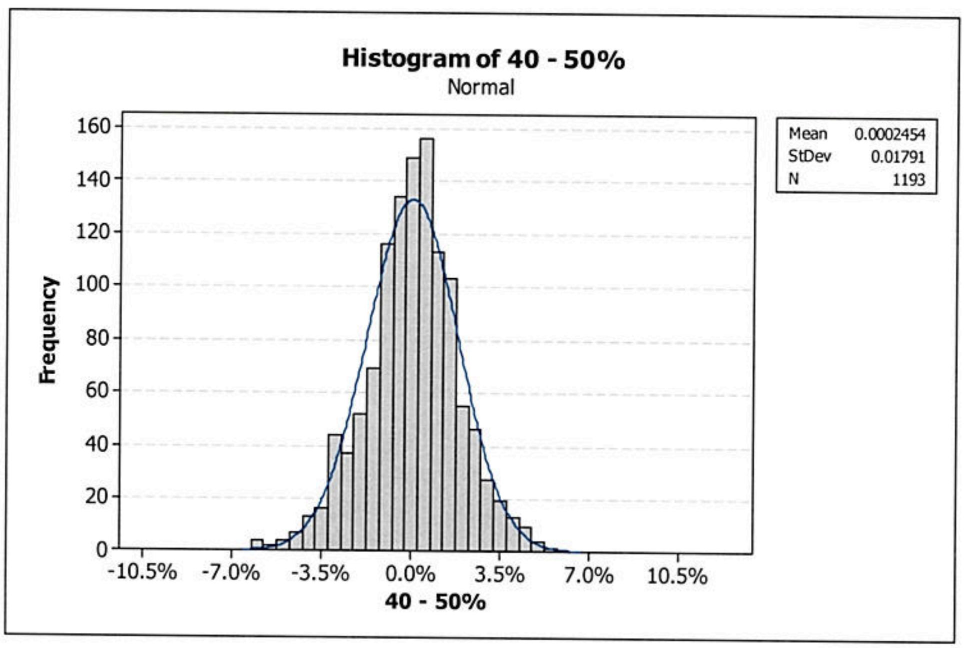
Appendix A

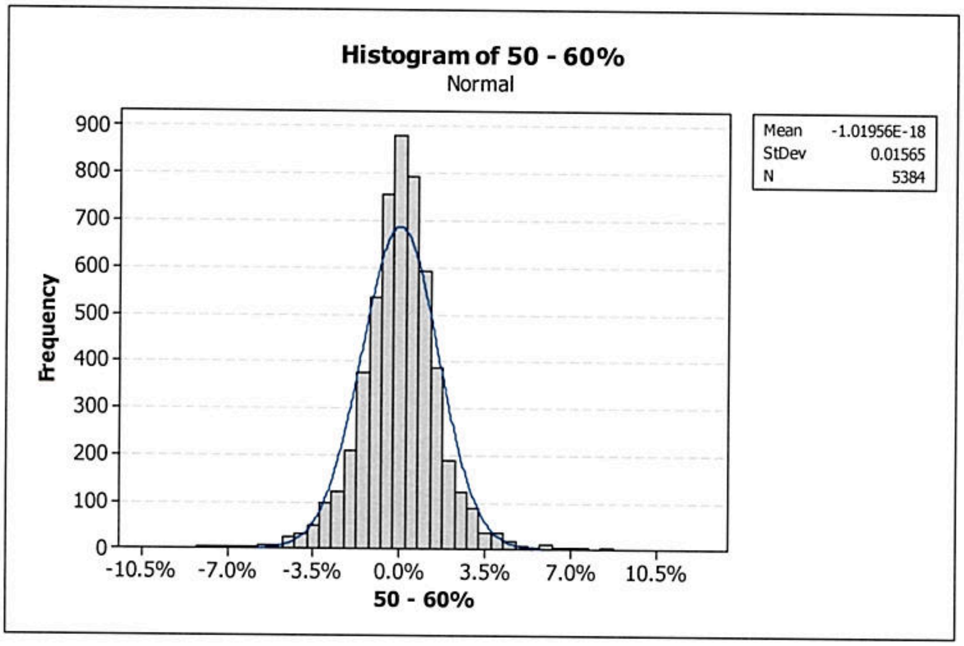
The following histograms show the variability in torque readings at different ranges. Variability decreases as the setting approaches maximum torque for the tool.

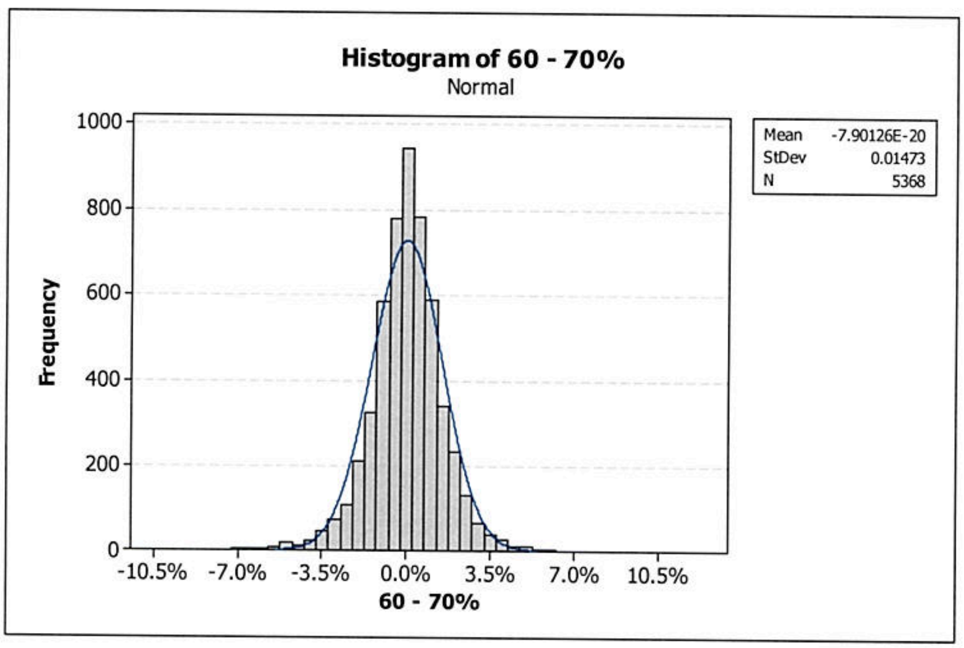
The following histograms show the distribution of differences in torque values. These differences are determined within each set of four pulls taken during calibration. So for example, with four pulls taken at 80%, we determine the difference between each of the four values and the average of the four. These differences are then converted to a percentage of the average. In this manner, we are able to acquire larege amounts of data on the precision of a pneumatic torque tool.

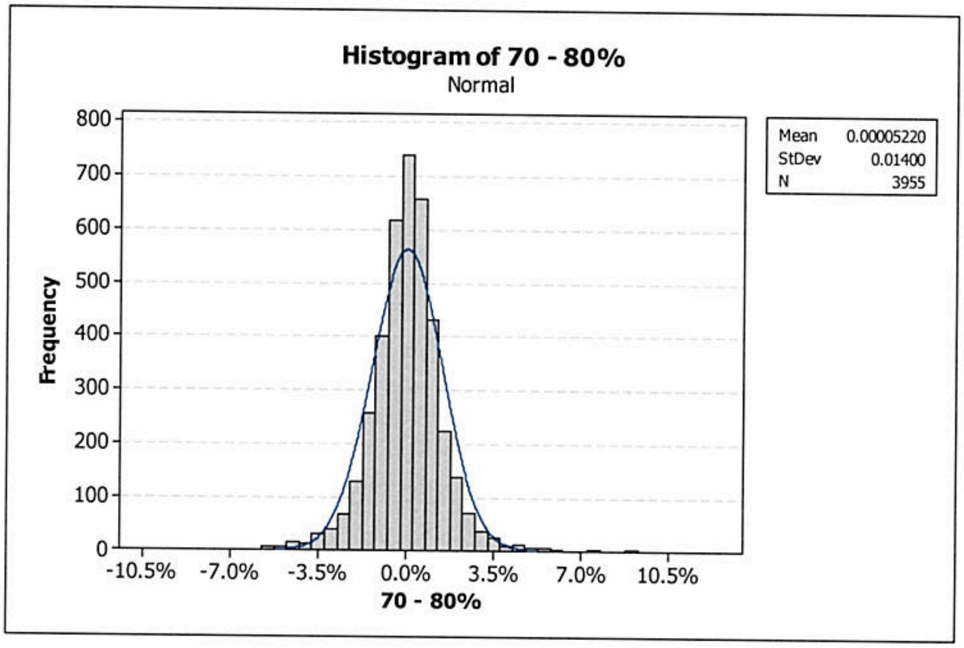


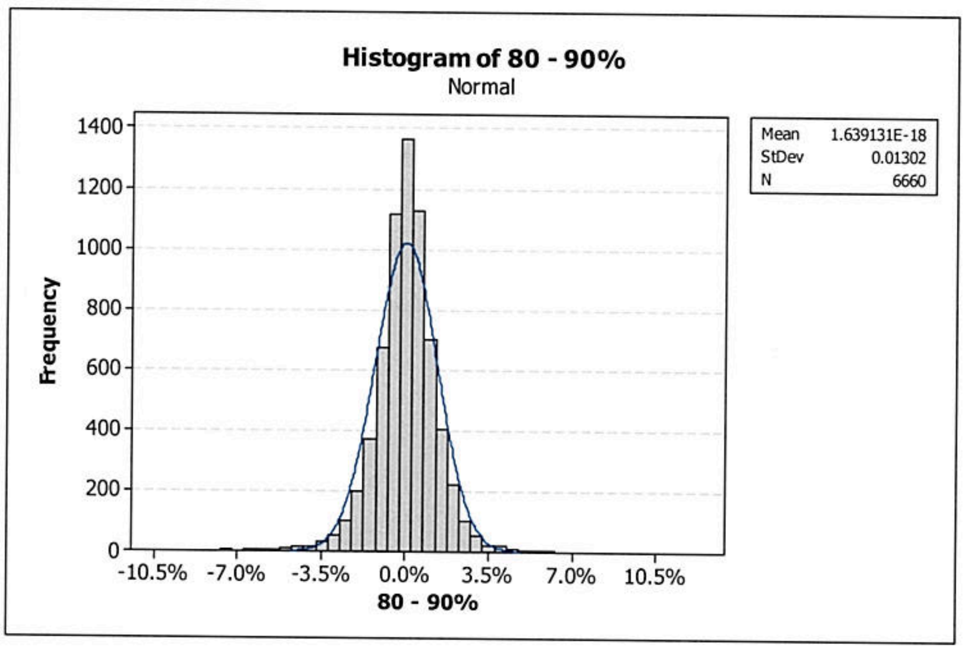

Histogram of 30 - 40%
Normal
Mean -1.40374E-18
StDev 0.01782
N 7128
Frequency
1000
800
600
400
200
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
30 - 40%

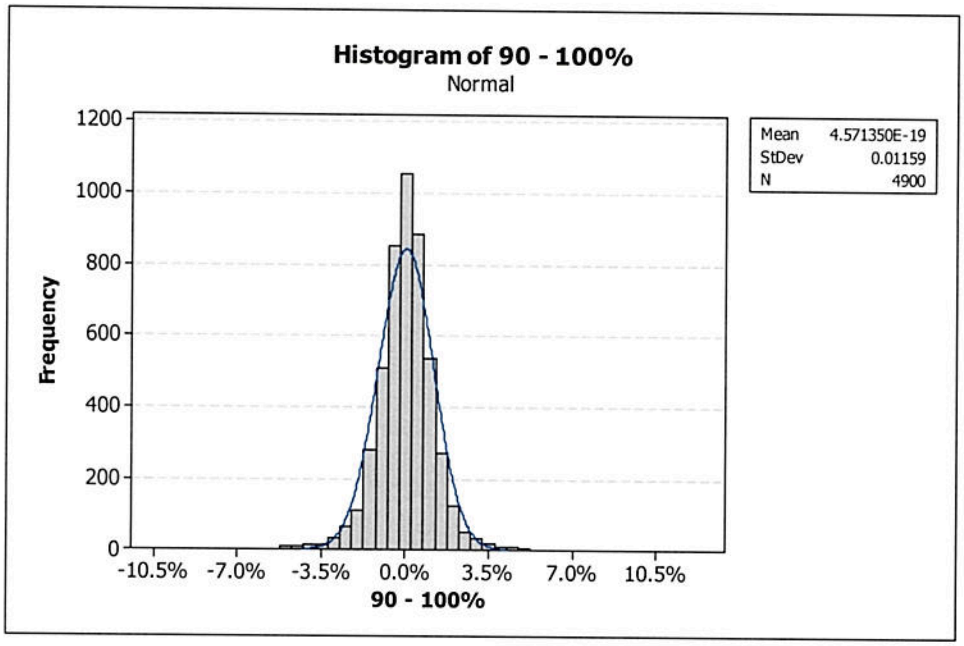

Histogram of 40 - 50%
Normal
Mean 0.0002454
StDev 0.01791
N 1193
Frequency
160
140
120
100
80
60
40
20
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
40 - 50%

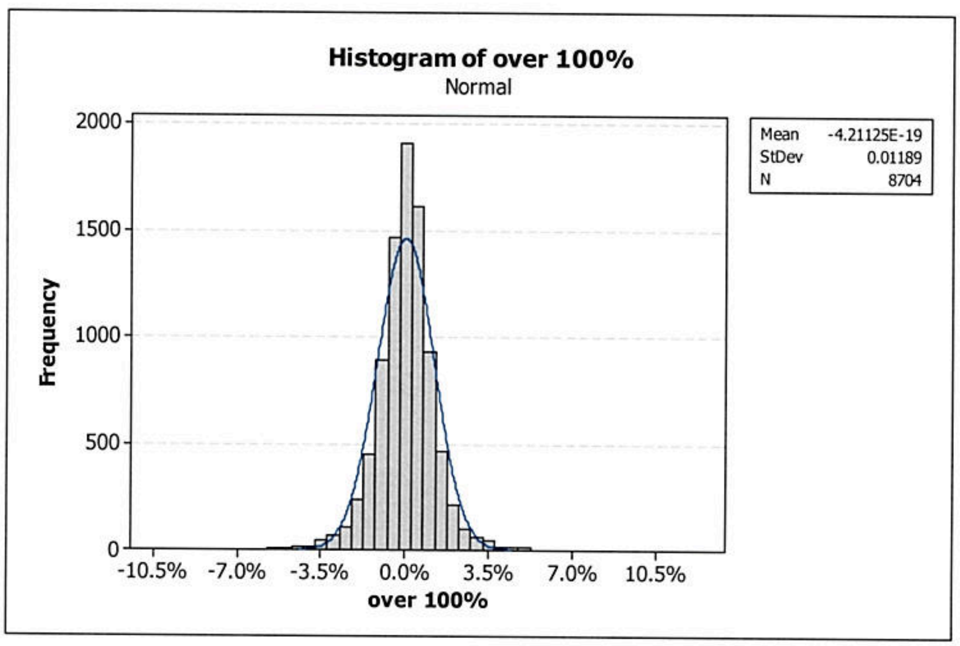

Histogram of 50 - 60%
Normal
Mean -1.01956E-18
StDev 0.01565
N 5384
Frequency
900
800
700
600
500
400
300
200
100
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
50 - 60%


Histogram of 60 - 70%
Normal
Mean -7.90126E-20
StDev 0.01473
N 5368
Frequency
1000
800
600
400
200
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
60 - 70%


Histogram of 70 - 80%
Normal
Mean 0.00005220
StDev 0.01400
N 3955
Frequency
800
700
600
500
400
300
200
100
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
70 - 80%


Histogram of 80 - 90%
Normal
Mean 1.639131E-18
StDev 0.01302
N 6660
Frequency
1400
1200
1000
800
600
400
200
0
-10.5% -7.0% -3.5% 0.0% 3.5% 7.0% 10.5%
80 - 90%


Histogram of 90 - 100%
Normal
Mean 4.571350E-19
StDev 0.01159
N 4900
Frequency
1200
1000
800
600
400
200
0
-10.5%
-7.0%
-3.5%
0.0%
3.5%
7.0%
10.5%
90 - 100%


Histogram of over 100%
Normal
Mean -4.21125E-19
StDev 0.01189
N 8704
Frequency
2000
1500
1000
500
0
-10.5%
-7.0%
-3.5%
0.0%
3.5%
7.0%
10.5%
over 100%