ΠΕΡΙΕΧΟΜΕΝΑ ΠΑΡΑΡΤΗΜΑΤΟΣ

ΠΑΡΑΡΤΗΜΑ Α

Στατιστική ανάλυση δεδομένων για ποιότητα τσιμέντου CEM II 42,5

One-Variable Analysis - IR_2

```
Analysis Summary

Data variable: IR_2

47 values ranging from 4,22 to 7,89


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
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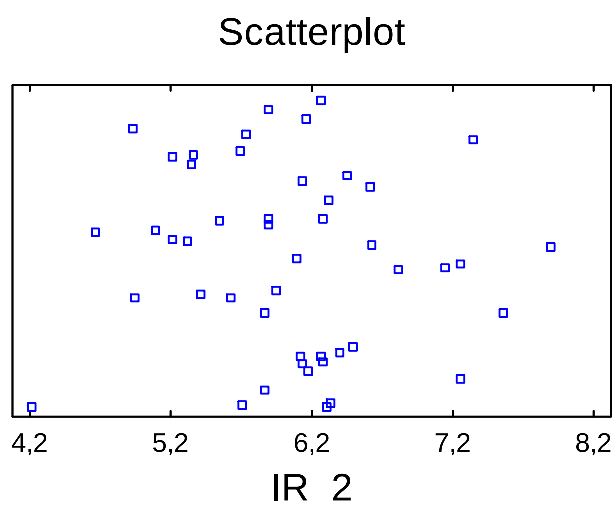


```
Summary Statistics for IR_2

Count = 47
Average = 6,04468
Variance = 0,576382
Standard deviation = 0,759198
Minimum = 4,22
Maximum = 7,89
Range = 3,67
Stnd. skewness = 0,440299
Stnd. kurtosis = 0,373963


The StatAdvisor
---------------
   This table shows summary statistics for IR_2.  It includes measures
of central tendency, measures of variability, and measures of shape.
Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
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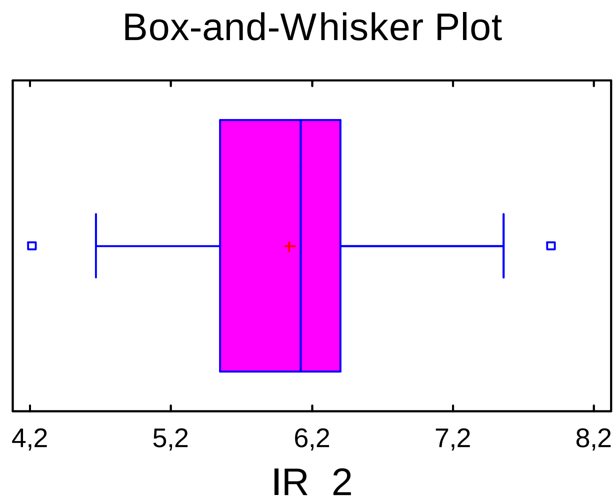
regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Uncensored Data - IR_2

Analysis Summary

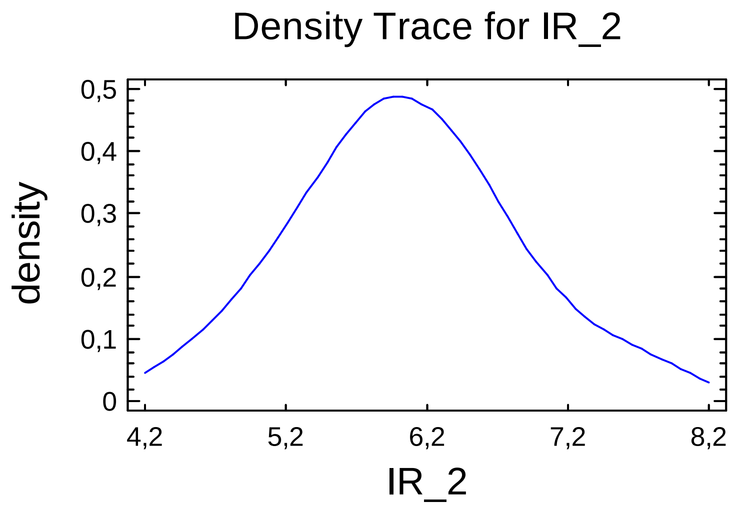
Data variable: IR_2

47 values ranging from 4,22 to 7,89

Fitted normal distribution:
mean = 6,04468
standard deviation = 0,759198

The StatAdvisor

This analysis shows the results of fitting a normal distribution to the data on IR_2. The estimated parameters of the fitted distribution are shown above. You can test whether the normal distribution fits the data adequately by selecting Goodness-of-Fit Tests from the list of Tabular Options. You can also assess visually how well the normal distribution fits by selecting Frequency Histogram from the list of Graphical Options. Other options within the procedure allow you to compute and display tail areas and critical values for the distribution. To select a different distribution, press the alternate mouse button and select Analysis Options.




```
Tests for Normality for IR_2

Computed Chi-Square goodness-of-fit statistic = 17,7234
P-Value = 0,277486

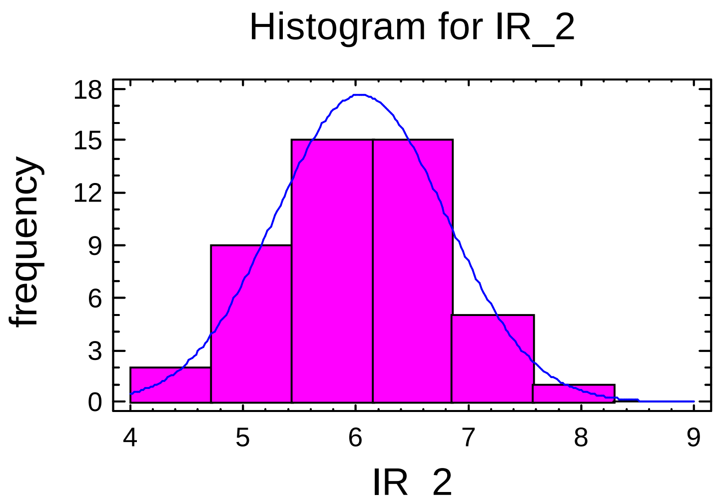
Shapiro-Wilks W statistic = 0,983113
P-Value = 0,846182

Z score for skewness = 0,336449
P-Value = 0,736528

Z score for kurtosis = 0,600469
P-Value = 0,548191



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether IR_2 can be adequately modeled by a normal distribution.  The
chi-square test divides the range of IR_2 into 18 equally probable
classes and compares the number of observations in each class to the
number expected.  The Shapiro-Wilks test is based upon comparing the
quantiles of the fitted normal distribution to the quantiles of the
data.  The standardized skewness test looks for lack of symmetry in
the data.  The standardized kurtosis test looks for distributional
shape which is either flatter or more peaked than the normal
distribution.
   The lowest P-value amongst the tests performed equals 0,277486.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that IR_2 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for IR_2

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	5,23418	7	6,71	0,01
	5,23418	5,61501	5	6,71	0,44
	5,61501	5,90801	9	6,71	0,78
	5,90801	6,18135	7	6,71	0,01
	6,18135	6,47435	9	6,71	0,78
	6,47435	6,85518	4	6,71	1,10
above	6,85518		6	6,71	0,08

Chi-Square = 3,19147 with 4 d.f.   P-Value = 0,526309

Estimated Kolmogorov statistic DPLUS = 0,0982058
Estimated Kolmogorov statistic DMINUS = 0,0634752
Estimated overall statistic DN = 0,0982058
Approximate P-Value = 0,755155

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0982058	0,684459	>=0.10*
Anderson-Darling A^2	0,359305	0,365404	0,4360*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether IR_2 can be adequately modeled by a normal distribution. The chi-square test divides the range of IR_2 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of IR_2 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0982058. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

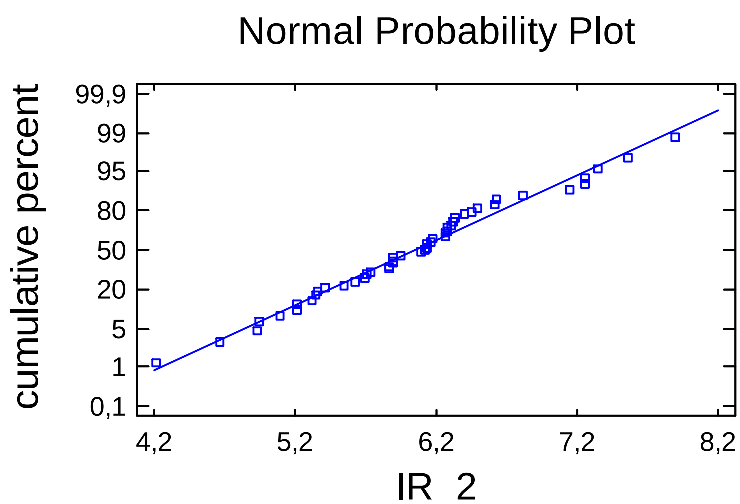
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that IR_2 comes from a normal distribution with 90% or higher confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: IR_2

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether IR_2 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - IR_2

X and MR(2) - Initial Study for IR_2

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 7,82833
Centerline      = 6,04468
LCL: -3,0 sigma = 4,26103

2 beyond limits

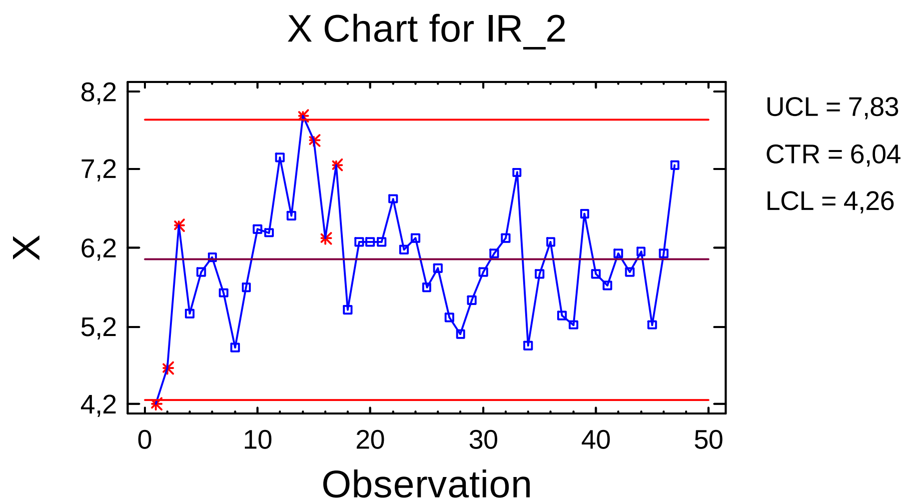
MR(2) Chart
-----------
UCL: +3,0 sigma = 2,19211
Centerline      = 0,670652
LCL: -3,0 sigma = 0,0

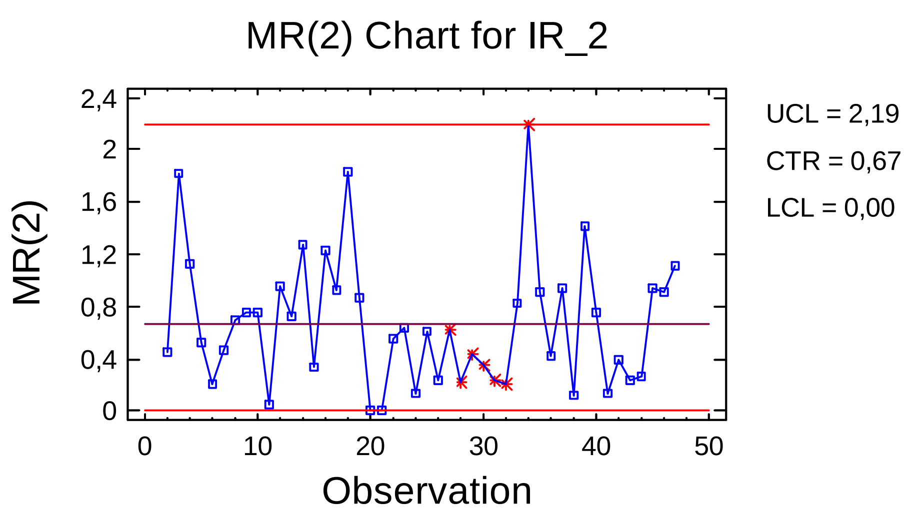
1 beyond limits

Estimates
---------
Process mean = 6,04468
Process sigma = 0,59455
Mean MR(2) = 0,670652
```

The StatAdvisor

This procedure creates an individuals chart for IR_2. It is designed to allow you to determine whether the data come from a process which is in a state of statistical control. The control charts are constructed under the assumption that the data come from a normal distribution with a mean equal to 6,04468 and a standard deviation equal to 0,59455. These parameters were estimated from the data. Of the 47 nonexcluded points shown on the charts, 2 are beyond the control limits on the first chart while 1 is beyond the limits on the second chart. Since the probability of seeing 2 or more points beyond the limits just by chance is 7,87369E-7 if the data comes from the assumed distribution, we can declare the process to be out of control at the 99% confidence level.





One-Variable Analysis - Al203_2

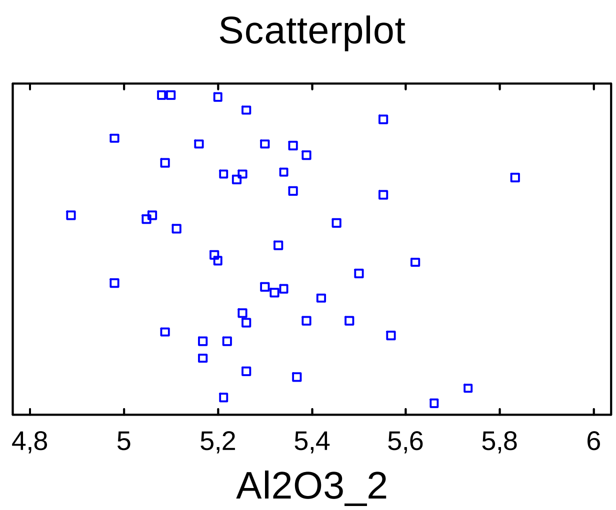
Analysis Summary

Data variable: Al203_2

47 values ranging from 4,89 to 5,83

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

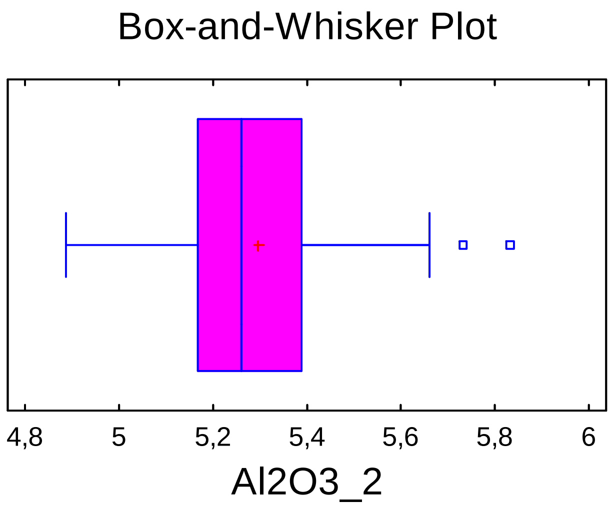


Summary Statistics for Al2O3_2

Count = 47
Average = 5,29447
Variance = 0,0405122
Standard deviation = 0,201276
Minimum = 4,89
Maximum = 5,83
Range = 0,94
Stnd. skewness = 1,48054
Stnd. kurtosis = 0,328911

The StatAdvisor

This table shows summary statistics for Al2O3_2. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Al2O3_2

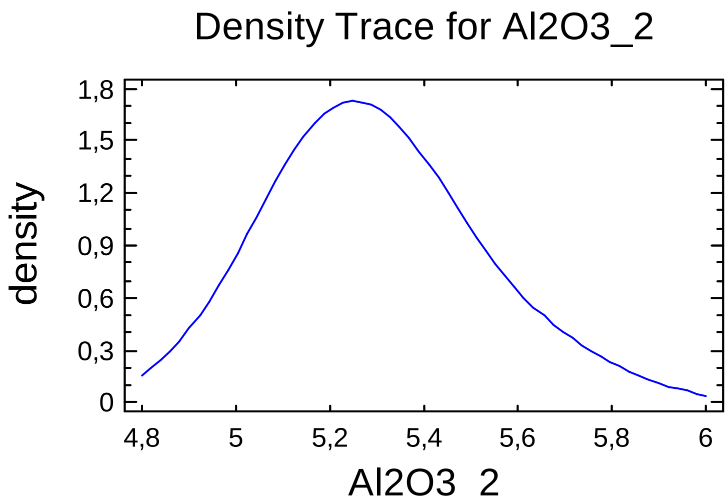
Analysis Summary

Data variable: Al2O3_2

47 values ranging from 4,89 to 5,83

Fitted normal distribution:
     mean = 5,29447
     standard deviation = 0,201276


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Al2O3_2.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Al2O3_2

Computed Chi-Square goodness-of-fit statistic = 13,8936
P-Value = 0,533612

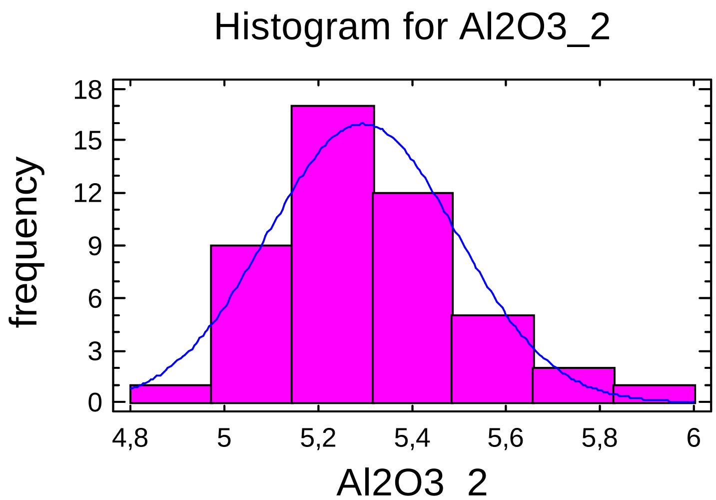
Shapiro-Wilks W statistic = 0,975214
P-Value = 0,573948

Z score for skewness = 1,09169
P-Value = 0,274967

Z score for kurtosis = 0,557095
P-Value = 0,577459



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Al2O3_2 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Al2O3_2 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,274967.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Al2O3_2 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Al2O3_2

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	5,07959	5	6,71	0,44
	5,07959	5,18056	8	6,71	0,25
	5,18056	5,25824	9	6,71	0,78
	5,25824	5,3307	7	6,71	0,01
	5,3307	5,40838	7	6,71	0,01
	5,40838	5,50935	4	6,71	1,10
above	5,50935		7	6,71	0,01

Chi-Square = 2,59573 with 4 d.f.   P-Value = 0,62758

Estimated Kolmogorov statistic DPLUS = 0,0999027
Estimated Kolmogorov statistic DMINUS = 0,0484313
Estimated overall statistic DN = 0,0999027
Approximate P-Value = 0,736206

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0999027	0,696286	>=0.10*
Anderson-Darling A^2	0,37407	0,38042	0,4026*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Al2O3_2 can be adequately modeled by a normal distribution. The chi-square test divides the range of Al2O3_2 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Al2O3_2 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0999027. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

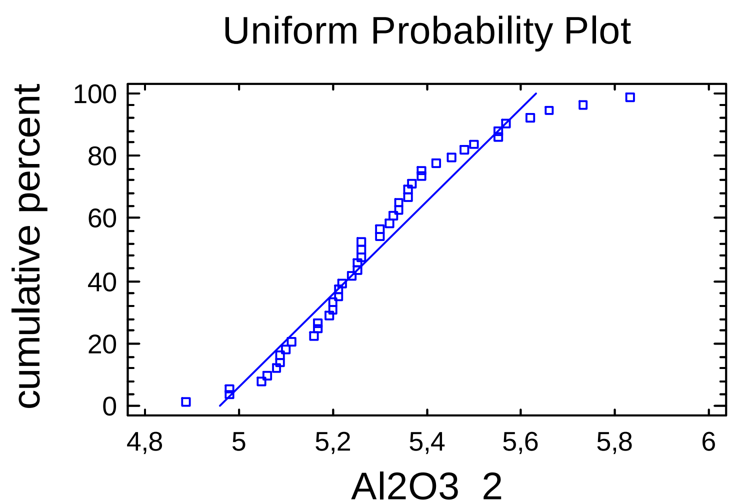
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that Al2O3_2 comes from a normal distribution with 90% or higher confidence.

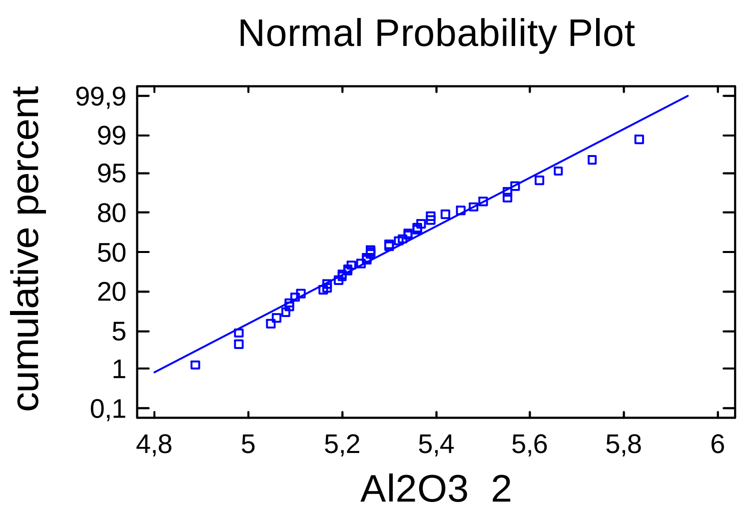
```
Probability Plots

Probability Plots
-----------------
Data variable: Al2O3_2

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Al2O3_2 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```






```
Individuals Charts - Al2O3_2

X and MR(2) - Initial Study for Al2O3_2

Number of observations = 47
```

```
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 5,67317
Centerline      = 5,29447
LCL: -3,0 sigma = 4,91577

3 beyond limits

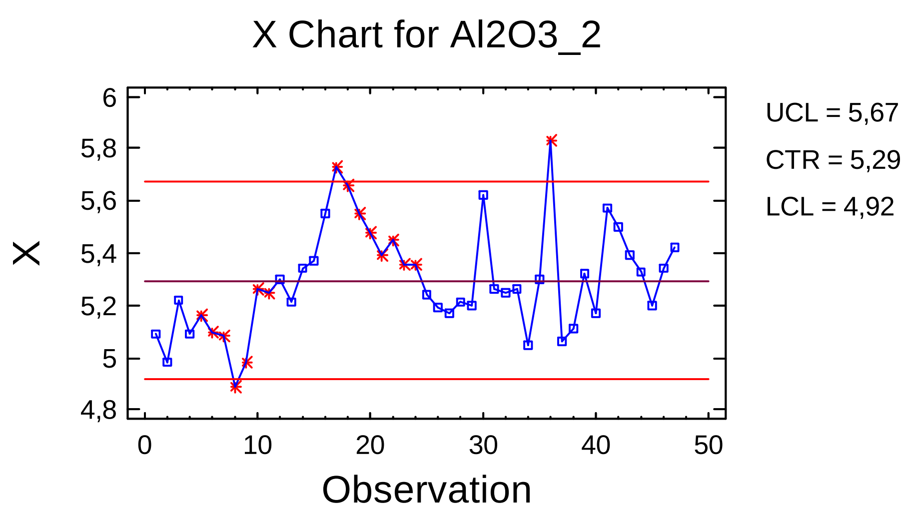
MR(2) Chart
-----------
UCL: +3,0 sigma = 0,465423
Centerline      = 0,142391
LCL: -3,0 sigma = 0,0

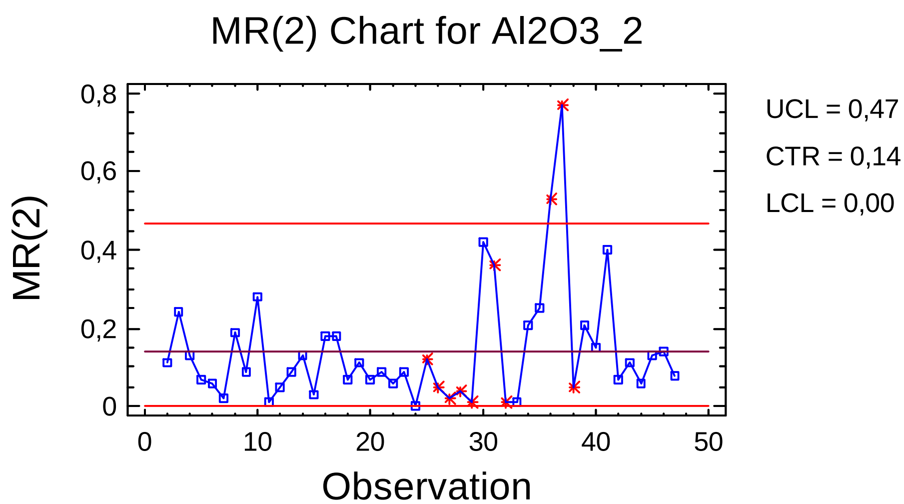
2 beyond limits

Estimates
---------
Process mean = 5,29447
Process sigma = 0,126233
Mean MR(2) = 0,142391
```

The StatAdvisor

This procedure creates an individuals chart for Al2O3_2. It is designed to allow you to determine whether the data come from a process which is in a state of statistical control. The control charts are constructed under the assumption that the data come from a normal distribution with a mean equal to 5,29447 and a standard deviation equal to 0,126233. These parameters were estimated from the data. Of the 47 nonexcluded points shown on the charts, 3 are beyond the control limits on the first chart while 2 are beyond the limits on the second chart. Since the probability of seeing 3 or more points beyond the limits just by chance is 3,17988E-10 if the data comes from the assumed distribution, we can declare the process to be out of control at the 99% confidence level.





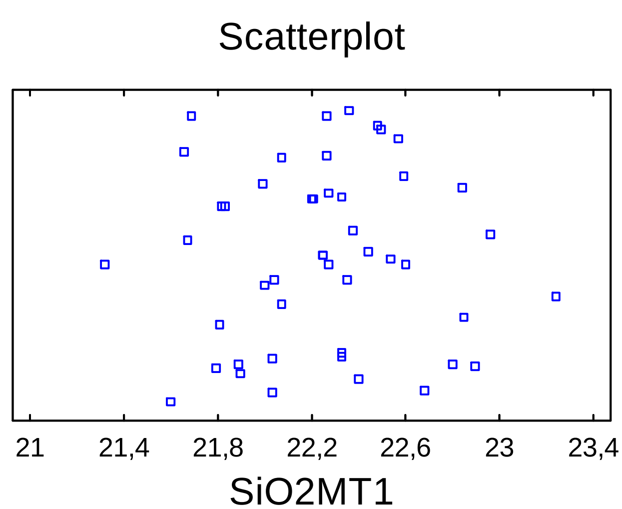

```
One-Variable Analysis - SiO2MT1

Analysis Summary

Data variable: SiO2MT1

47 values ranging from 21,32 to 23,24


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```



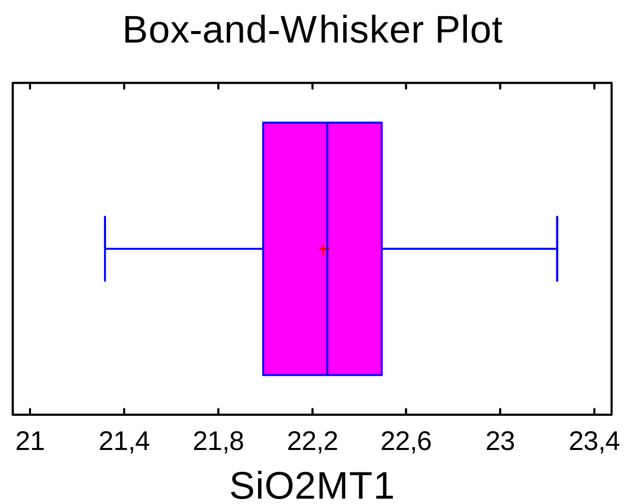

```
Summary Statistics for SiO2MT1

Count = 47
Average = 22,2479
Variance = 0,160952
```

```
Standard deviation = 0,401188
Minimum = 21,32
Maximum = 23,24
Range = 1,92
Stnd. skewness = 0,338989
Stnd. kurtosis = -0,0933634
```

The StatAdvisor

   This table shows summary statistics for SiO2MT1. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Uncensored Data - SiO2MT1

Analysis Summary

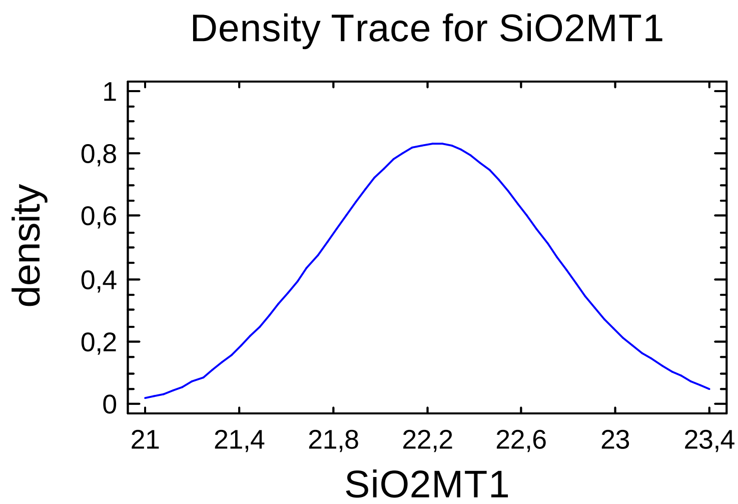
Data variable: SiO2MT1

47 values ranging from 21,32 to 23,24

```
Fitted normal distribution:
     mean = 22,2479
     standard deviation = 0,401188
```

The StatAdvisor

   This analysis shows the results of fitting a normal distribution to the data on SiO2MT1. The estimated parameters of the fitted distribution are shown above. You can test whether the normal distribution fits the data adequately by selecting Goodness-of-Fit Tests from the list of Tabular Options. You can also assess visually how well the normal distribution fits by selecting Frequency Histogram from the list of Graphical Options. Other options within the procedure allow you to compute and display tail areas and critical values for the distribution. To select a different distribution, press the alternate mouse button and select Analysis Options.




```
Tests for Normality for SiO2MT1

Computed Chi-Square goodness-of-fit statistic = 16,9574
P-Value = 0,321415

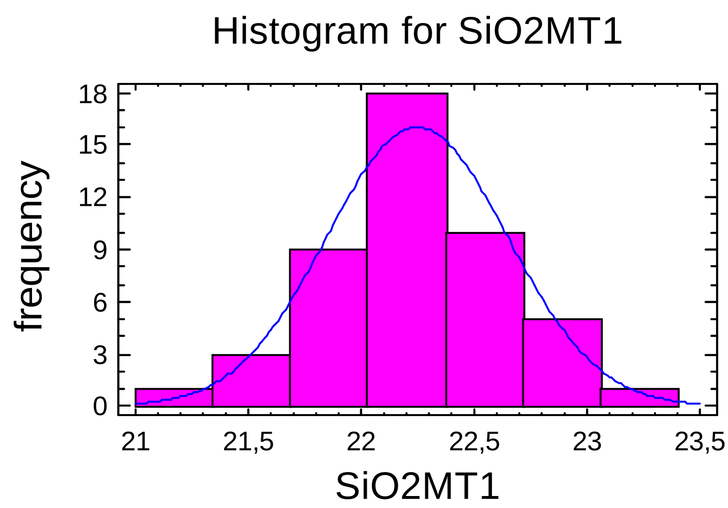
Shapiro-Wilks W statistic = 0,989491
P-Value = 0,976281

Z score for skewness = 0,259431
P-Value = 0,795298

Z score for kurtosis = 0,105692
P-Value = 0,915822



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether SiO2MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of SiO2MT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,321415.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that SiO2MT1 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for SiO2MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	21,8196	7	6,71	0,01
	21,8196	22,0208	6	6,71	0,08
	22,0208	22,1757	5	6,71	0,44
	22,1757	22,3201	8	6,71	0,25
	22,3201	22,4749	8	6,71	0,25
	22,4749	22,6762	6	6,71	0,08
above	22,6762		7	6,71	0,01

Chi-Square = 1,10625 with 4 d.f.   P-Value = 0,893279

Estimated Kolmogorov statistic DPLUS = 0,0543982
Estimated Kolmogorov statistic DMINUS = 0,0765867
Estimated overall statistic DN = 0,0765867
Approximate P-Value = 0,945629

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0765867	0,533782	>=0.10*
Anderson-Darling A^2	0,201625	0,205048	0,8729*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether SiO2MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of SiO2MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of SiO2MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0765867. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that SiO2MT1 comes from a normal distribution with 90% or higher confidence.

Probability Plots

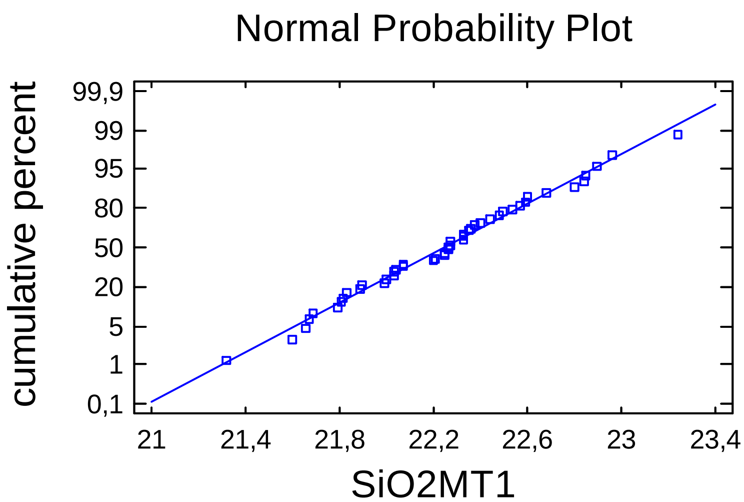
Probability Plots

Data variable: SiO2MT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

This procedure creates seven different types of probability plots to help you determine whether SiO2MT1 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



One-Variable Analysis - BLAINEMT1

Analysis Summary

One-Variable Analysis - BLAINEMT1

Analysis Summary

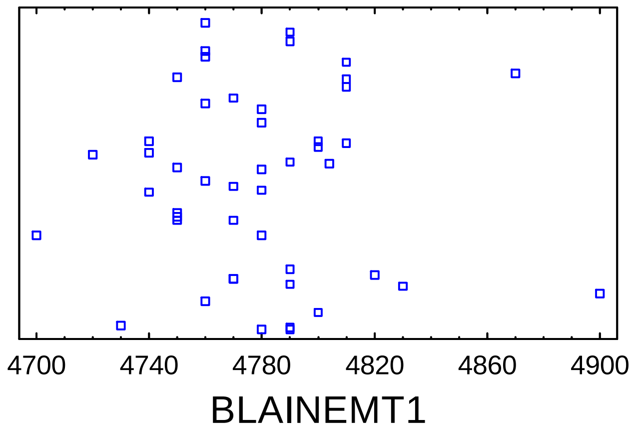
Data variable: BLAINEMT1

47 values ranging from 4700,0 to 4900,0

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

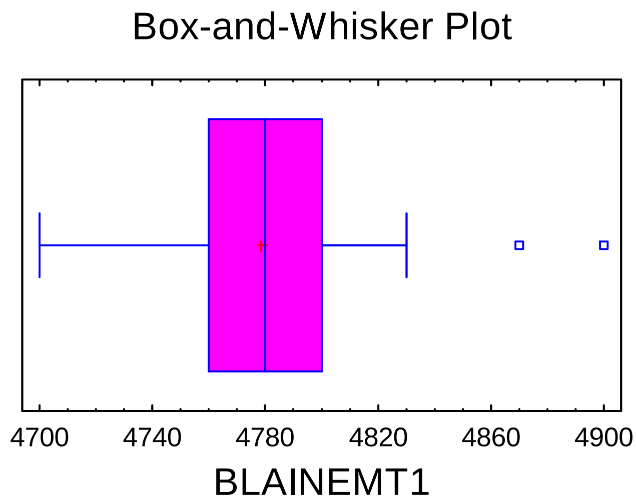
Scatterplot




```
Summary Statistics for BLAINEMT1

Count = 47
Average = 4778,81
Variance = 1245,85
Standard deviation = 35,2967
Minimum = 4700,0
Maximum = 4900,0
Range = 200,0
Stnd. skewness = 2,55893
Stnd. kurtosis = 3,70393


The StatAdvisor
---------------
   This table shows summary statistics for BLAINEMT1.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is not within the range expected for data from a normal
distribution.  The standardized kurtosis value is not within the range
expected for data from a normal distribution.
```




```
Uncensored Data - BLAINEMT1

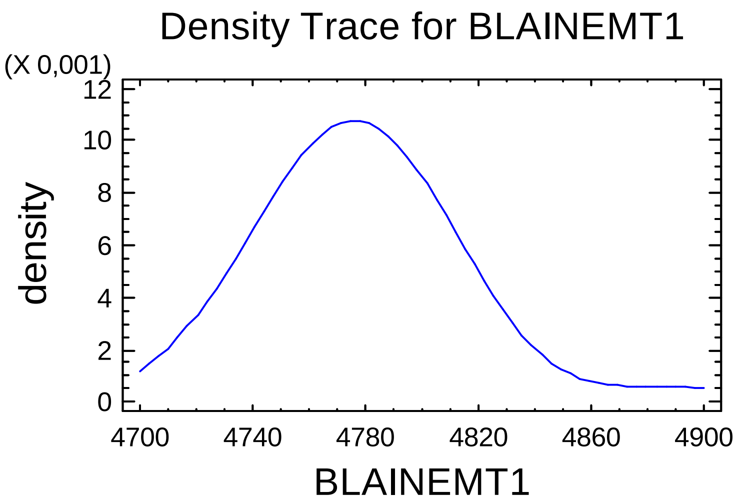
Analysis Summary

Data variable: BLAINEMT1

47 values ranging from 4700,0 to 4900,0

Fitted normal distribution:
     mean = 4778,81
     standard deviation = 35,2967


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on BLAINEMT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for BLAINEMT1

Computed Chi-Square goodness-of-fit statistic = 38,4043
P-Value = 0,000786098

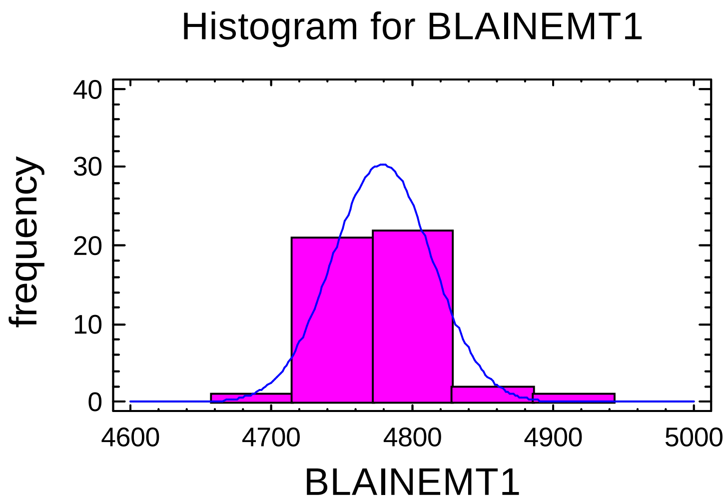
Shapiro-Wilks W statistic = 0,946815
P-Value = 0,0512854

Z score for skewness = 1,77145
P-Value = 0,0764857

Z score for kurtosis = 2,53646
P-Value = 0,0111979



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether BLAINEMT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of BLAINEMT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,000786098.
Because the P-value for this test is less than 0.01, we can reject the
idea that BLAINEMT1 comes from a normal distribution with 99%
confidence.
```



Goodness-of-Fit Tests for BLAINEMT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4741,13	6	6,71	0,08
	4741,13	4758,83	5	6,71	0,44
	4758,83	4772,45	11	6,71	2,74
	4772,45	4785,16	6	6,71	0,08
	4785,16	4798,78	7	6,71	0,01
	4798,78	4816,49	8	6,71	0,25
above	4816,49		4	6,71	1,10

Chi-Square = 4,68093 with 4 d.f.   P-Value = 0,321629

Estimated Kolmogorov statistic DPLUS = 0,120274
Estimated Kolmogorov statistic DMINUS = 0,0795373
Estimated overall statistic DN = 0,120274
Approximate P-Value = 0,517764

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,120274	0,838269	<0.10*
Anderson-Darling A^2	0,715646	0,727795	0,0578*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether BLAINEMT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of BLAINEMT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of BLAINEMT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,120274. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

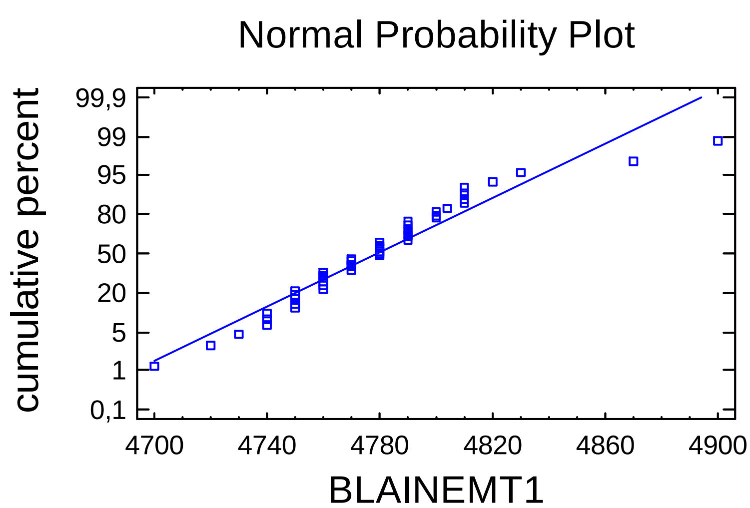
Since the smallest P-value amongst the tests performed is less than 0.10, we can reject the idea that BLAINEMT1 comes from a normal distribution with 90% confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: BLAINEMT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether BLAINEMT1 comes from a particular type
of distribution.  After examining these plots, you may fit a
distribution to the data by selecting the Distribution Fitting
procedure.
```




```
Individuals Charts - BLAINEMT1

X and MR(2) - Initial Study for BLAINEMT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 4883,92
Centerline      = 4778,81
LCL: -3,0 sigma = 4673,7

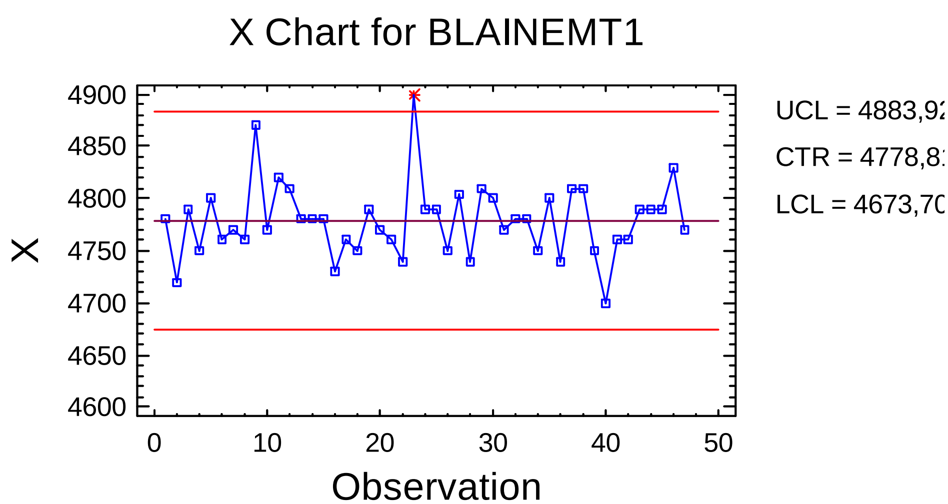
1 beyond limits

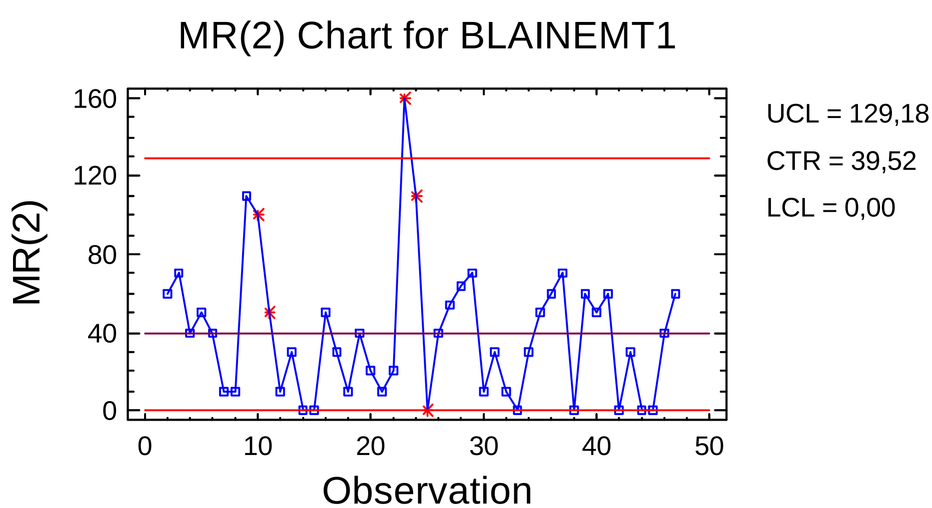
MR(2) Chart
-----------
UCL: +3,0 sigma = 129,181
Centerline      = 39,5217
LCL: -3,0 sigma = 0,0

1 beyond limits

Estimates
---------
Process mean = 4778,81
Process sigma = 35,037
Mean MR(2) = 39,5217
```

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for BLAINEMT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 4778,81 and a standard
deviation equal to 35,037.  These parameters were estimated from the
data.  Of the 47 nonexcluded points shown on the charts, 1 is beyond
the control limits on the first chart while 1 is beyond the limits on
the second chart.  Since the probability of seeing 1 or more points
beyond the limits just by chance is 0,00126818 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```





One-Variable Analysis - LOIMT1

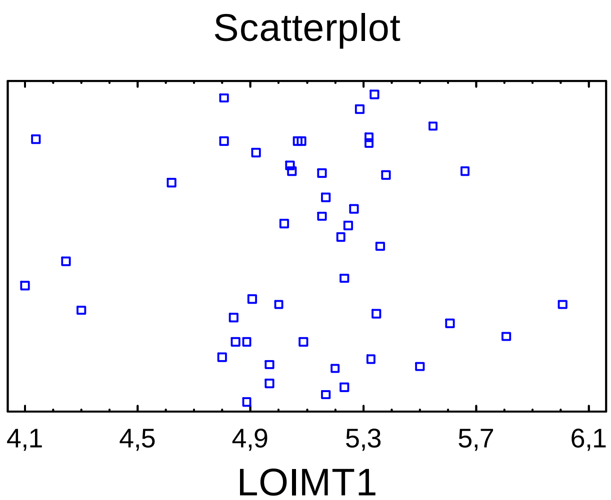
```
Analysis Summary

Data variable: LOIMT1
```

47 values ranging from 4,1 to 6,01

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

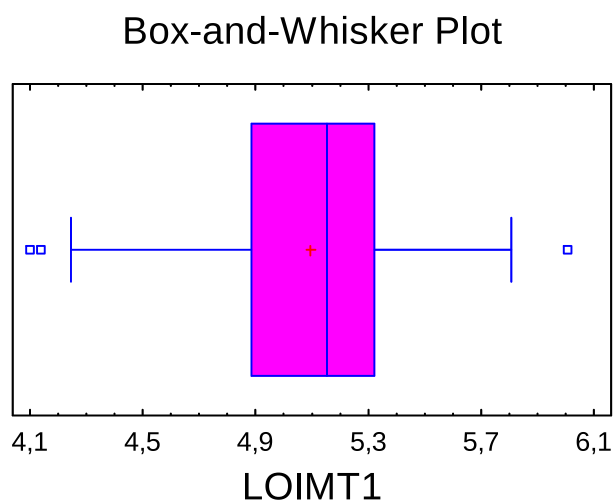


Summary Statistics for LOIMT1

Count = 47
Average = 5,09128
Variance = 0,151268
Standard deviation = 0,388932
Minimum = 4,1
Maximum = 6,01
Range = 1,91
Stnd. skewness = -1,4963
Stnd. kurtosis = 1,60564

The StatAdvisor

This table shows summary statistics for LOIMT1. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - LOIMT1

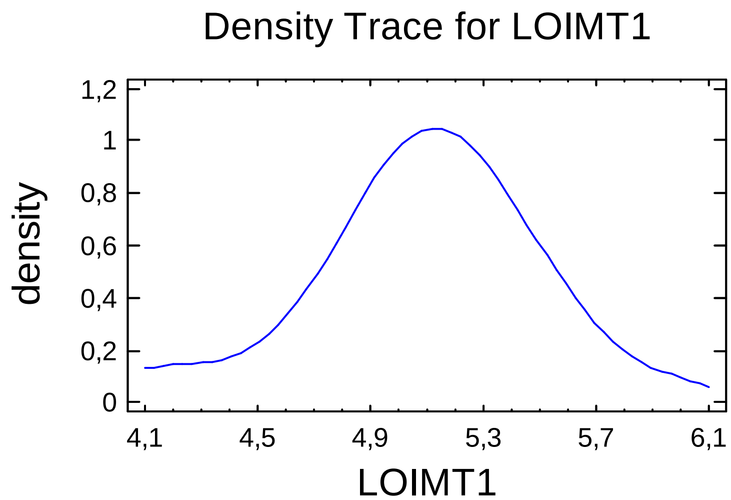
Analysis Summary

Data variable: LOIMT1

47 values ranging from 4,1 to 6,01

Fitted normal distribution:
     mean = 5,09128
     standard deviation = 0,388932


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on LOIMT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for LOIMT1

Computed Chi-Square goodness-of-fit statistic = 23,8511
P-Value = 0,0676662

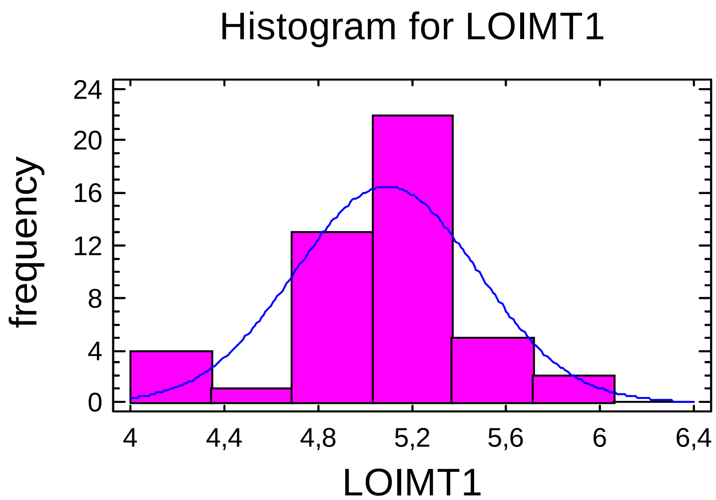
Shapiro-Wilks W statistic = 0,951019
P-Value = 0,0770139

Z score for skewness = 1,10246
P-Value = 0,270261

Z score for kurtosis = 1,54184
P-Value = 0,123111



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether LOIMT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of LOIMT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,0676662.
Because the P-value for this test is less than 0.10, we can reject the
idea that LOIMT1 comes from a normal distribution with 90% confidence.
```



Goodness-of-Fit Tests for LOIMT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4,67606	5	6,71	0,44
	4,67606	4,87116	5	6,71	0,44
	4,87116	5,02126	8	6,71	0,25
	5,02126	5,16129	7	6,71	0,01
	5,16129	5,31139	9	6,71	0,78
	5,31139	5,50649	8	6,71	0,25
above	5,50649		5	6,71	0,44

Chi-Square = 2,59572 with 4 d.f.   P-Value = 0,627581

Estimated Kolmogorov statistic DPLUS = 0,101277
Estimated Kolmogorov statistic DMINUS = 0,12057
Estimated overall statistic DN = 0,12057
Approximate P-Value = 0,514221

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,12057	0,840331	<0.10*
Anderson-Darling A^2	0,827538	0,841586	0,0303*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether LOIMT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of LOIMT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of LOIMT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,12057. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

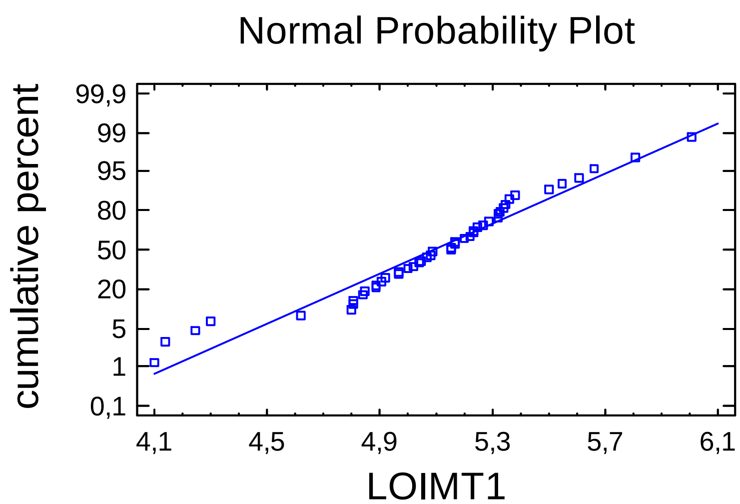
Since the smallest P-value amongst the tests performed is less than 0.10, we can reject the idea that LOIMT1 comes from a normal distribution with 90% confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: LOIMT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether LOIMT1 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - LOIMT1

X and MR(2) - Initial Study for LOIMT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 5,92153
Centerline      = 5,09128
LCL: -3,0 sigma = 4,26103

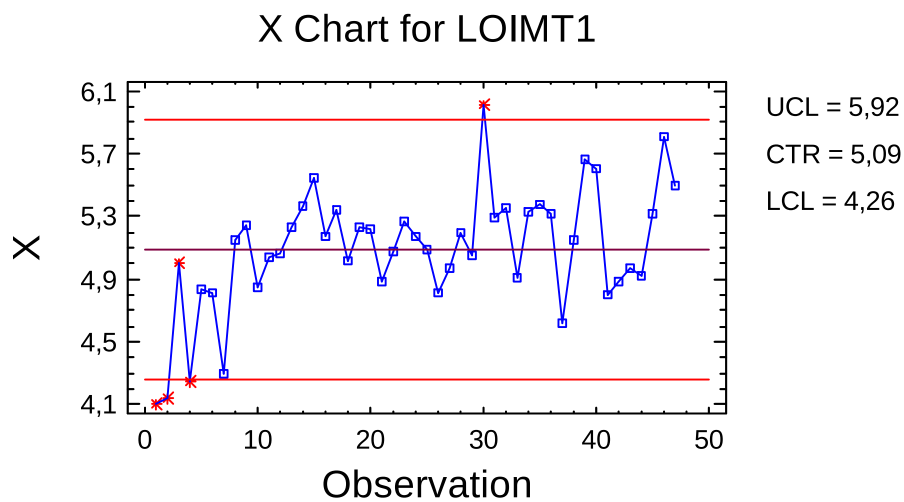
4 beyond limits

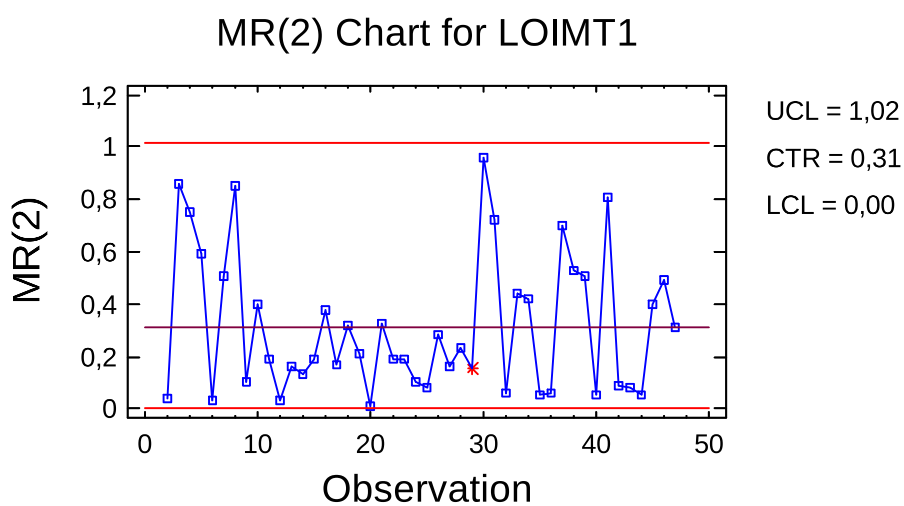
MR(2) Chart
-----------
UCL: +3,0 sigma = 1,02038
Centerline      = 0,312174
LCL: -3,0 sigma = 0,0

0 beyond limits

Estimates
---------
Process mean = 5,09128
Process sigma = 0,27675
Mean MR(2) = 0,312174
```

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for LOIMT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 5,09128 and a standard
deviation equal to 0,27675.  These parameters were estimated from the
data.  Of the 47 nonexcluded points shown on the charts, 4 are beyond
the control limits on the first chart while 0 are beyond the limits on
the second chart.  Since the probability of seeing 4 or more points
beyond the limits just by chance is 0,0 if the data comes from the
assumed distribution, we can declare the process to be out of control
at the 99% confidence level.
```






```
One-Variable Analysis - Est1MT1

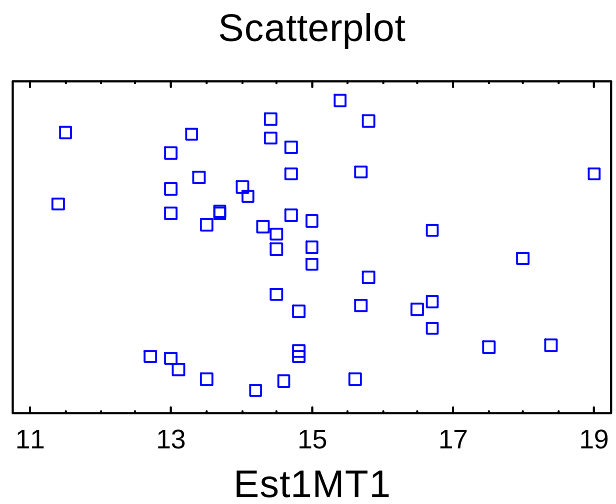
Analysis Summary

Data variable: Est1MT1

47 values ranging from 11,4 to 19,0
```

The StatAdvisor

   This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

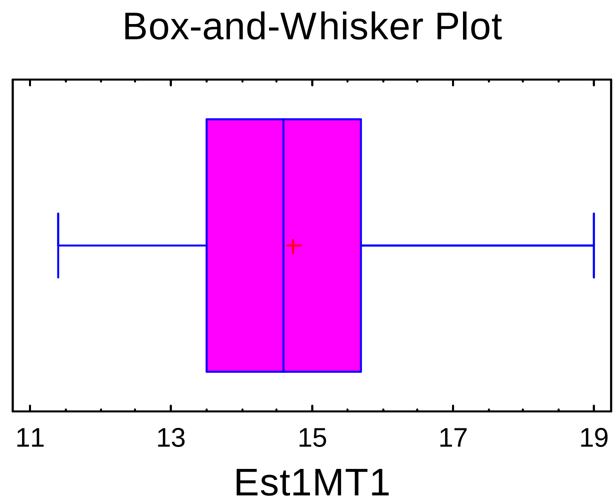


Summary Statistics for Est1MT1

Count = 47
Average = 14,7298
Variance = 2,64083
Standard deviation = 1,62506
Minimum = 11,4
Maximum = 19,0
Range = 7,6
Stnd. skewness = 1,49803
Stnd. kurtosis = 0,750746

The StatAdvisor

   This table shows summary statistics for Est1MT1. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Est1MT1

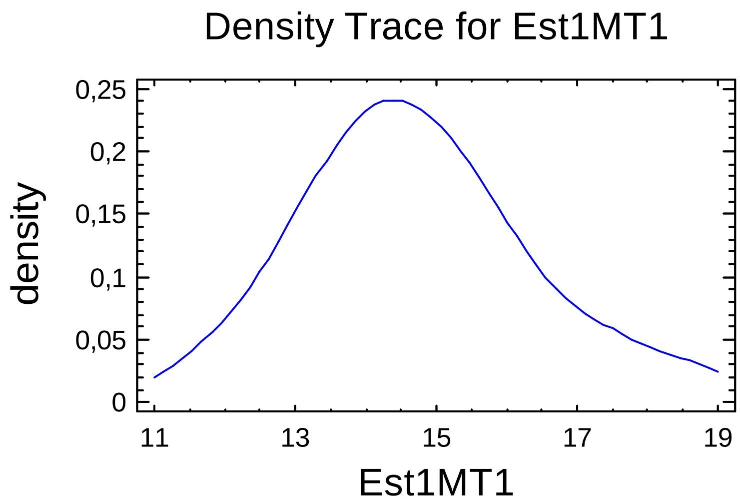
Analysis Summary

Data variable: Est1MT1

47 values ranging from 11,4 to 19,0

Fitted normal distribution:
     mean = 14,7298
     standard deviation = 1,62506


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est1MT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est1MT1

Computed Chi-Square goodness-of-fit statistic = 20,0213
P-Value = 0,171118

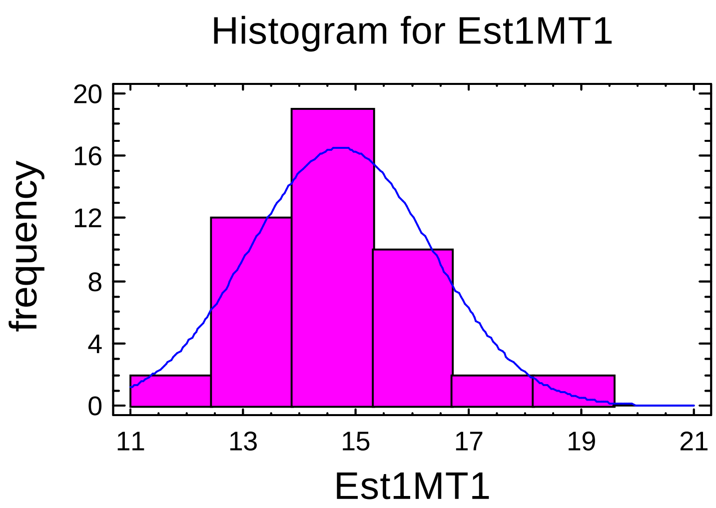
Shapiro-Wilks W statistic = 0,962556
P-Value = 0,220985

Z score for skewness = 1,10364
P-Value = 0,269747

Z score for kurtosis = 0,933899
P-Value = 0,350355



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est1MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est1MT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,171118.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Est1MT1 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Est1MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	12,9949	3	6,71	2,05
	12,9949	13,8101	11	6,71	2,74
	13,8101	14,4373	6	6,71	0,08
	14,4373	15,0223	13	6,71	5,88
	15,0223	15,6495	2	6,71	3,31
	15,6495	16,4647	4	6,71	1,10
above	16,4647		8	6,71	0,25

Chi-Square = 15,4035 with 4 d.f.   P-Value = 0,00393356

Estimated Kolmogorov statistic DPLUS = 0,136094
Estimated Kolmogorov statistic DMINUS = 0,0797338
Estimated overall statistic DN = 0,136094
Approximate P-Value = 0,351623

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,136094	0,948528	<0.05*
Anderson-Darling A^2	0,614573	0,625006	0,1036*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est1MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est1MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est1MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,136094. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

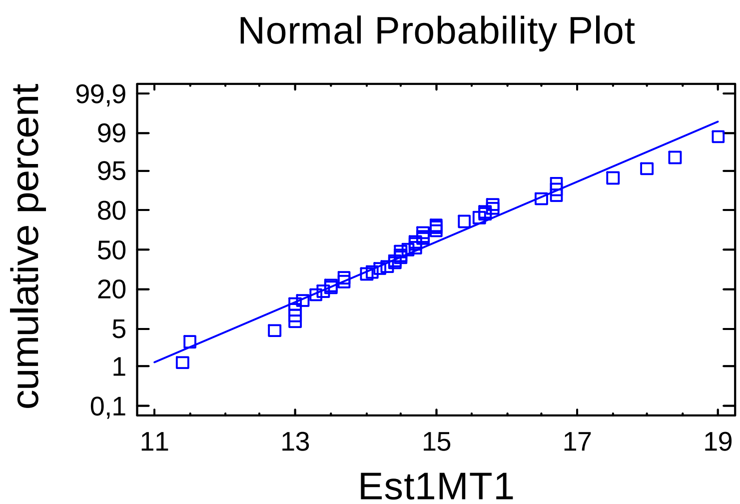
Since the smallest P-value amongst the tests performed is less than 0.01, we can reject the idea that Est1MT1 comes from a normal distribution with 99% confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: Est1MT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Est1MT1 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - Est1MT1

X and MR(2) - Initial Study for Est1MT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 18,141
Centerline      = 14,7298
LCL: -3,0 sigma = 11,3186

2 beyond limits

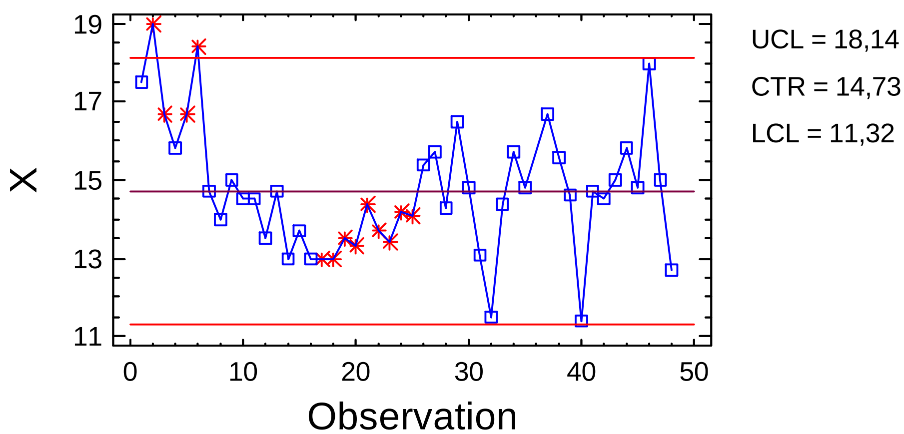
MR(2) Chart
-----------
UCL: +3,0 sigma = 4,19236
Centerline      = 1,28261
LCL: -3,0 sigma = 0,0

0 beyond limits

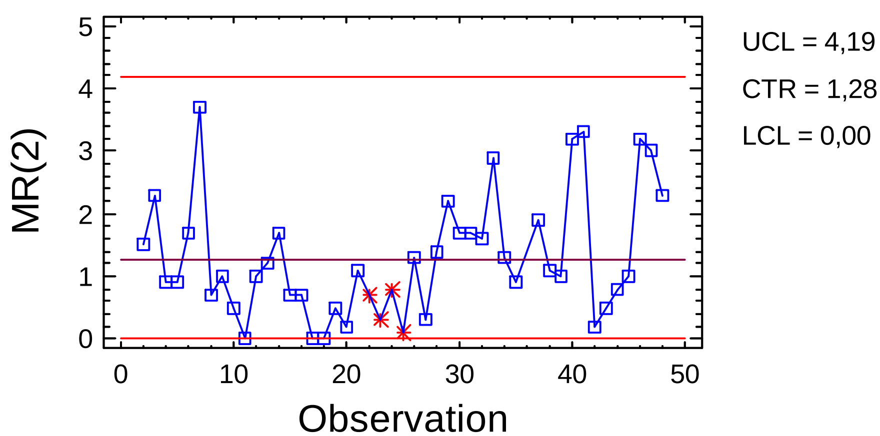
Estimates
---------
Process mean = 14,7298
Process sigma = 1,13706
Mean MR(2) = 1,28261
```

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for Est1MT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 14,7298 and a standard
deviation equal to 1,13706.  These parameters were estimated from the
data.  Of the 47 nonexcluded points shown on the charts, 2 are beyond
the control limits on the first chart while 0 are beyond the limits on
the second chart.  Since the probability of seeing 2 or more points
beyond the limits just by chance is 7,87369E-7 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```

X Chart for Est1MT1



MR(2) Chart for Est1MT1



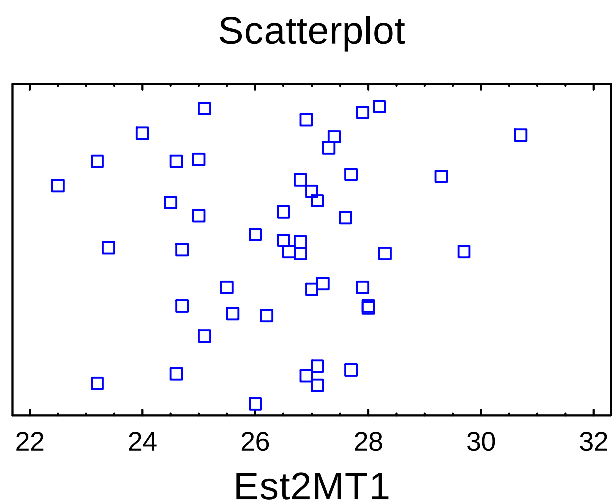
One-Variable Analysis - Est2MT1

Analysis Summary

Data variable: Est2MT1

47 values ranging from 22,5 to 30,7

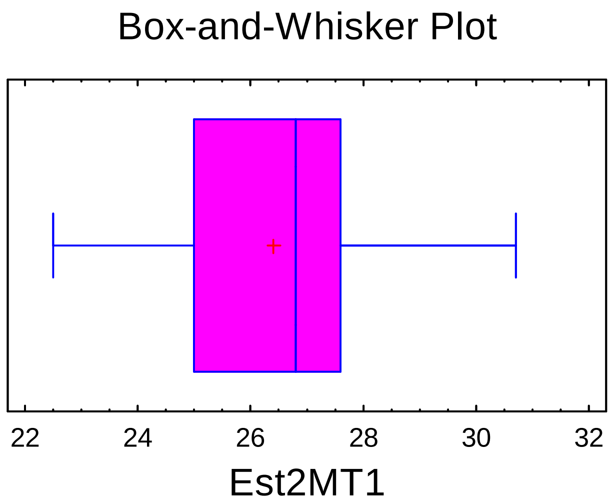
```
The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```




```
Summary Statistics for Est2MT1

Count = 47
Average = 26,4021
Variance = 3,0476
Standard deviation = 1,74574
Minimum = 22,5
Maximum = 30,7
Range = 8,2
Stnd. skewness = -0,339696
Stnd. kurtosis = 0,0280958


The StatAdvisor
---------------
   This table shows summary statistics for Est2MT1.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```




```
Uncensored Data - Est2MT1

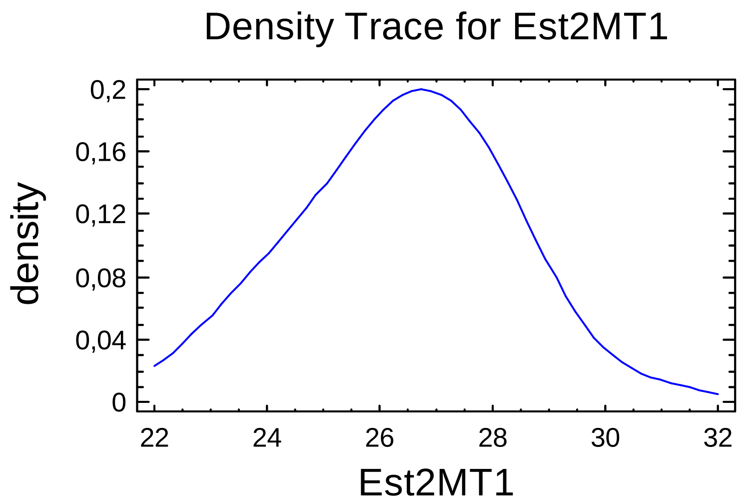
Analysis Summary

Data variable: Est2MT1

47 values ranging from 22,5 to 30,7

Fitted normal distribution:
     mean = 26,4021
     standard deviation = 1,74574


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est2MT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est2MT1

Computed Chi-Square goodness-of-fit statistic = 19,2553
P-Value = 0,202396

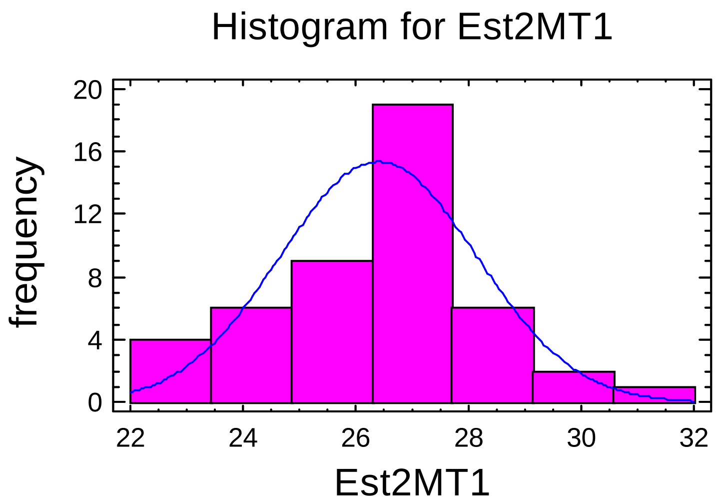
Shapiro-Wilks W statistic = 0,974384
P-Value = 0,544778

Z score for skewness = 0,259969
P-Value = 0,794883

Z score for kurtosis = 0,244614
P-Value = 0,806751



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est2MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est2MT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,202396.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Est2MT1 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Est2MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	24,5384	6	6,71	0,08
	24,5384	25,4141	8	6,71	0,25
	25,4141	26,0879	4	6,71	1,10
	26,0879	26,7164	4	6,71	1,10
	26,7164	27,3901	12	6,71	4,16
	27,3901	28,2658	9	6,71	0,78
above	28,2658		4	6,71	1,10

Chi-Square = 8,55345 with 4 d.f.   P-Value = 0,0732836

Estimated Kolmogorov statistic DPLUS = 0,0746559
Estimated Kolmogorov statistic DMINUS = 0,122059
Estimated overall statistic DN = 0,122059
Approximate P-Value = 0,496658

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,122059	0,850709	<0.10*
Anderson-Darling A^2	0,529035	0,538016	0,1680*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est2MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est2MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est2MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,122059. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

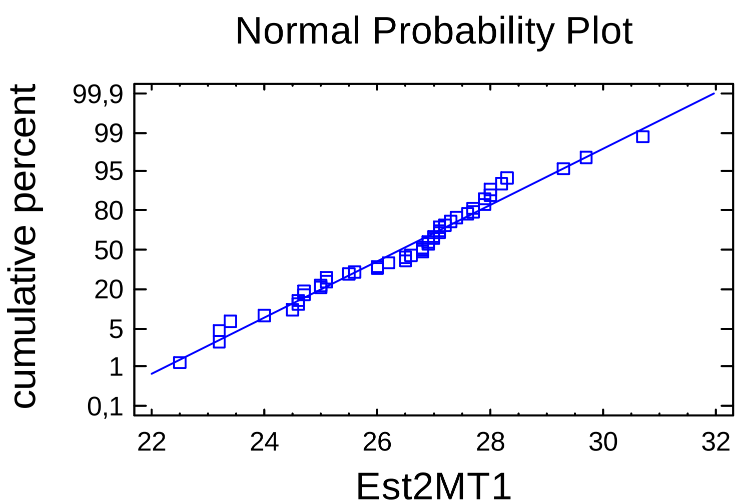
Since the smallest P-value amongst the tests performed is less than 0.10, we can reject the idea that Est2MT1 comes from a normal distribution with 90% confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: Est2MT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Est2MT1 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - Est2MT1

X and MR(2) - Initial Study for Est2MT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 29,9058
Centerline      = 26,4021
LCL: -3,0 sigma = 22,8984

2 beyond limits

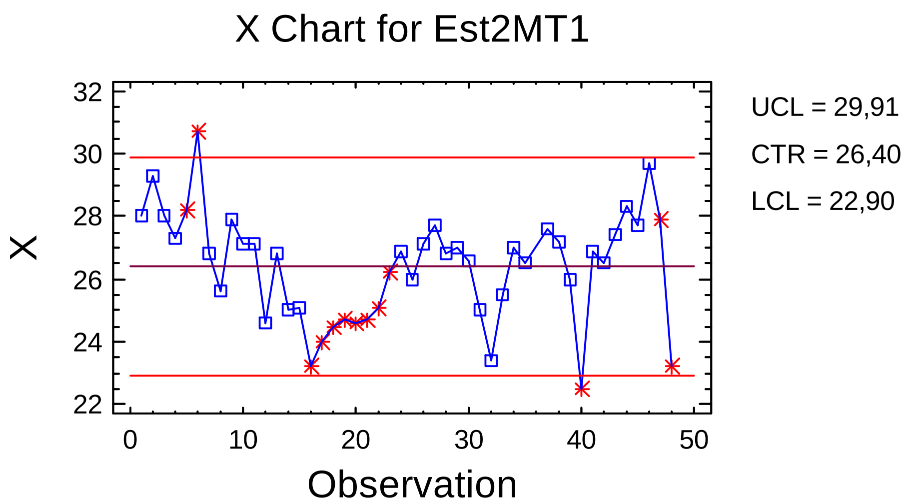
MR(2) Chart
-----------
UCL: +3,0 sigma = 4,30605
Centerline      = 1,31739
LCL: -3,0 sigma = 0,0

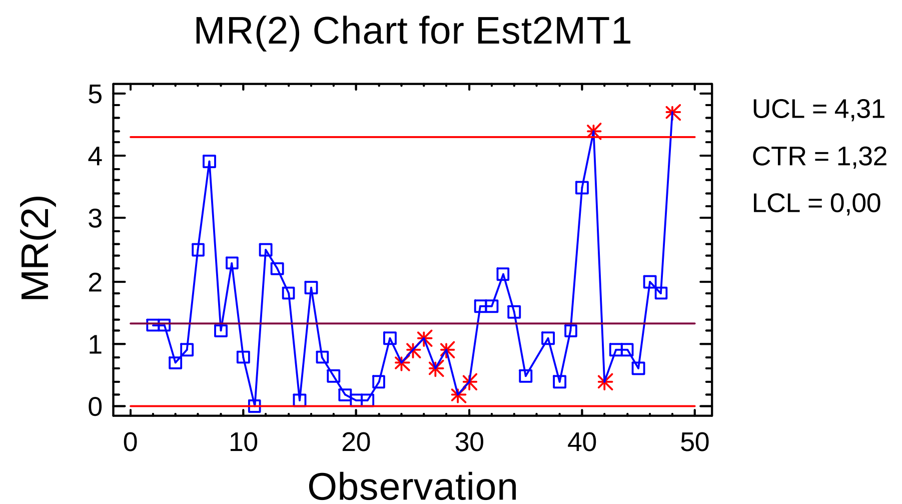
2 beyond limits

Estimates
---------
Process mean = 26,4021
Process sigma = 1,1679
Mean MR(2) = 1,31739
```

The StatAdvisor

   This procedure creates an individuals chart for Est2MT1. It is designed to allow you to determine whether the data come from a process which is in a state of statistical control. The control charts are constructed under the assumption that the data come from a normal distribution with a mean equal to 26,4021 and a standard deviation equal to 1,1679. These parameters were estimated from the data. Of the 47 nonexcluded points shown on the charts, 2 are beyond the control limits on the first chart while 2 are beyond the limits on the second chart. Since the probability of seeing 2 or more points beyond the limits just by chance is 7,87369E-7 if the data comes from the assumed distribution, we can declare the process to be out of control at the 99% confidence level.





One-Variable Analysis - Est7MT1

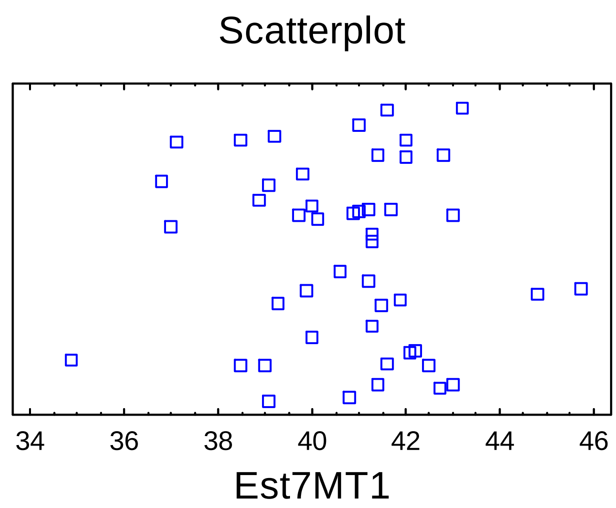
Analysis Summary

Data variable: Est7MT1

47 values ranging from 34,9 to 45,7

The StatAdvisor

   This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

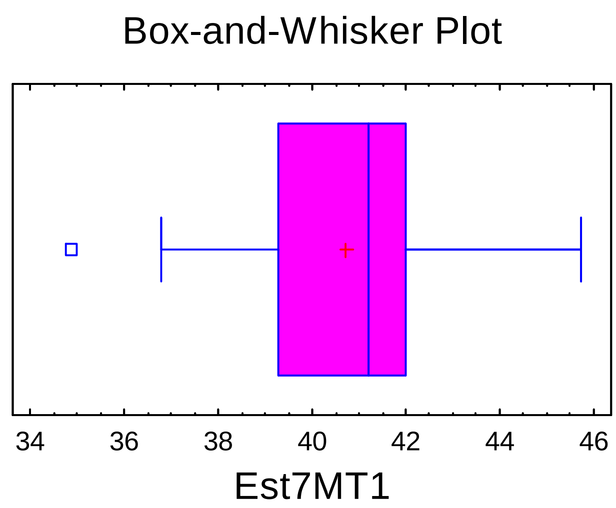


Summary Statistics for Est7MT1

Count = 47
Average = 40,7362
Variance = 4,12497
Standard deviation = 2,031
Minimum = 34,9
Maximum = 45,7
Range = 10,8
Stnd. skewness = -1,12259
Stnd. kurtosis = 1,41632

The StatAdvisor

   This table shows summary statistics for Est7MT1. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Est7MT1

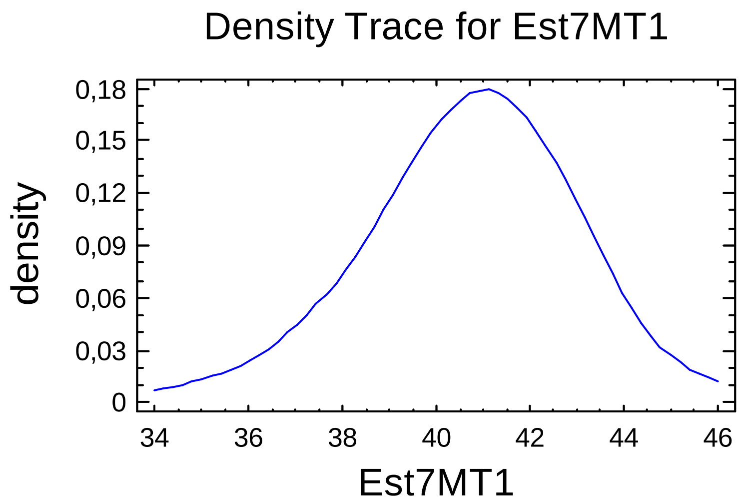
Analysis Summary

Data variable: Est7MT1

47 values ranging from 34,9 to 45,7

Fitted normal distribution:
     mean = 40,7362
     standard deviation = 2,031


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est7MT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est7MT1

Computed Chi-Square goodness-of-fit statistic = 18,4894
P-Value = 0,237812

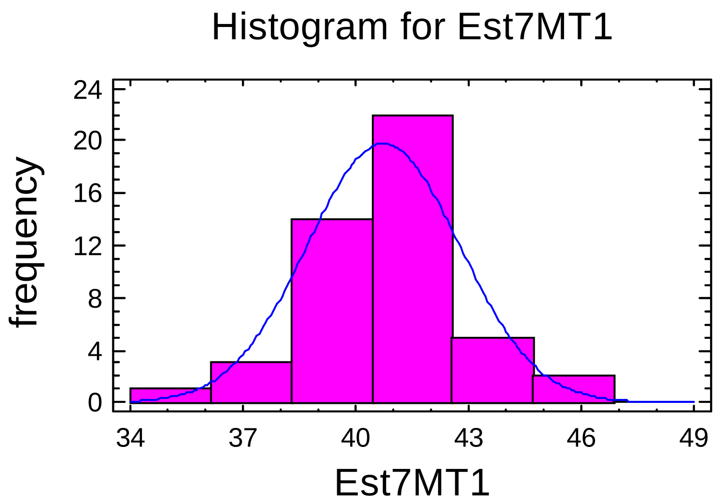
Shapiro-Wilks W statistic = 0,973938
P-Value = 0,529335

Z score for skewness = 0,841074
P-Value = 0,400305

Z score for kurtosis = 1,42152
P-Value = 0,155166



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est7MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est7MT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,155166.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Est7MT1 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Est7MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	38,5679	6	6,71	0,08
	38,5679	39,5867	6	6,71	0,08
	39,5867	40,3706	6	6,71	0,08
	40,3706	41,1018	5	6,71	0,44
	41,1018	41,8856	11	6,71	2,74
	41,8856	42,9044	8	6,71	0,25
above	42,9044		5	6,71	0,44

Chi-Square = 4,08527 with 4 d.f.   P-Value = 0,394589

Estimated Kolmogorov statistic DPLUS = 0,0699902
Estimated Kolmogorov statistic DMINUS = 0,108283
Estimated overall statistic DN = 0,108283
Approximate P-Value = 0,640051

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,108283	0,754696	>=0.10*
Anderson-Darling A^2	0,566604	0,576222	0,1345*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est7MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est7MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est7MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,108283. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

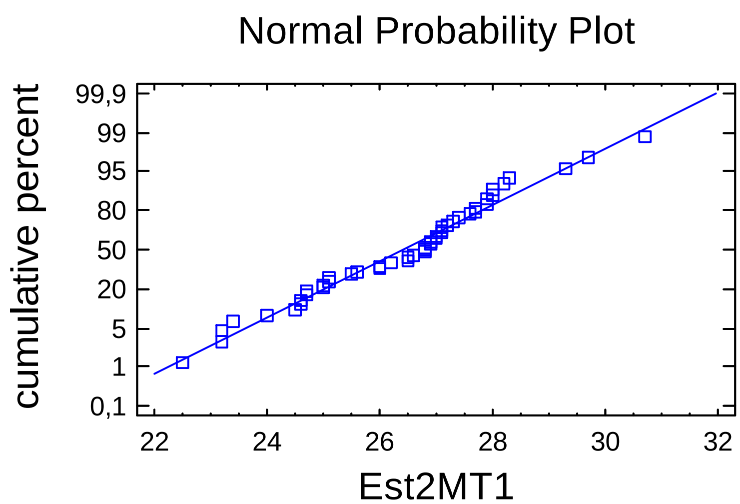
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that Est7MT1 comes from a normal distribution with 90% or higher confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: Est2MT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Est2MT1 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - Est2MT1

X and MR(2) - Initial Study for Est2MT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 29,9058
Centerline      = 26,4021
LCL: -3,0 sigma = 22,8984

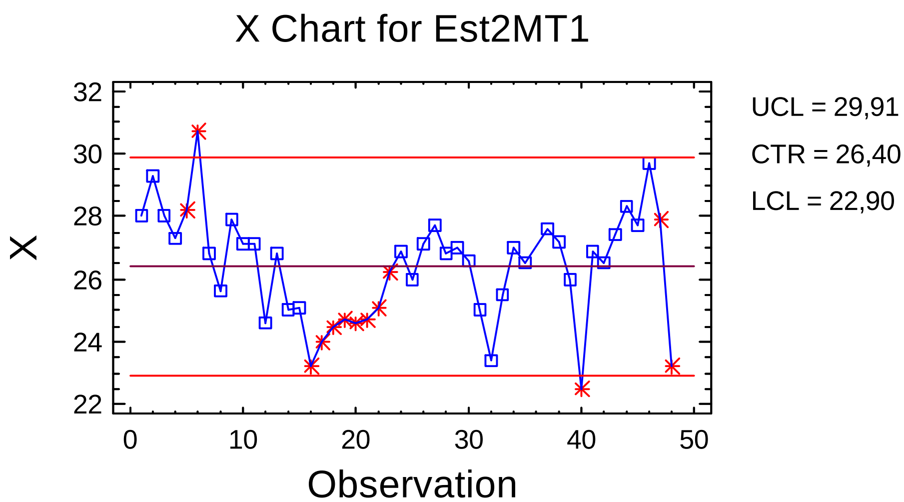
2 beyond limits

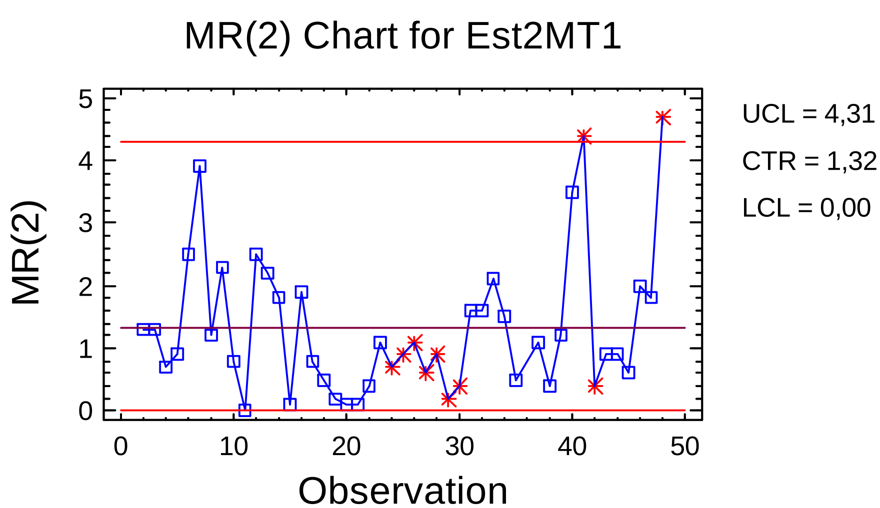
MR(2) Chart
-----------
UCL: +3,0 sigma = 4,30605
Centerline      = 1,31739
LCL: -3,0 sigma = 0,0

2 beyond limits

Estimates
---------
Process mean = 26,4021
Process sigma = 1,1679
Mean MR(2) = 1,31739
```

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for Est2MT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 26,4021 and a standard
deviation equal to 1,1679.  These parameters were estimated from the
data.  Of the 47 nonexcluded points shown on the charts, 2 are beyond
the control limits on the first chart while 2 are beyond the limits on
the second chart.  Since the probability of seeing 2 or more points
beyond the limits just by chance is 7,87369E-7 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```





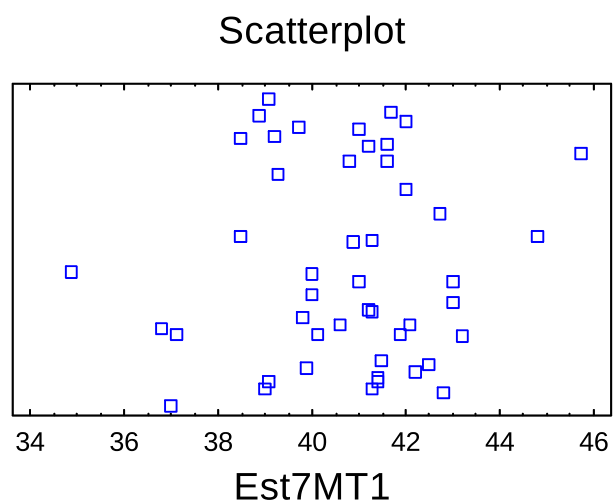

```
One-Variable Analysis - Est7MT1

Analysis Summary

Data variable: Est7MT1

47 values ranging from 34,9 to 45,7
```

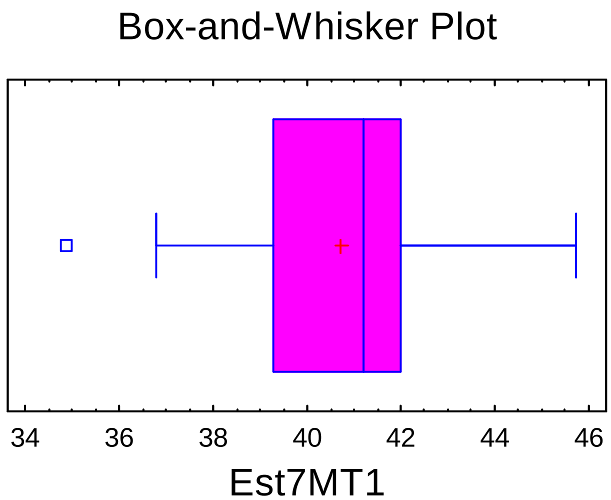
```
The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```




```
Summary Statistics for Est7MT1

Count = 47
Average = 40,7362
Variance = 4,12497
Standard deviation = 2,031
Minimum = 34,9
Maximum = 45,7
Range = 10,8
Stnd. skewness = -1,12259
Stnd. kurtosis = 1,41632


The StatAdvisor
---------------
   This table shows summary statistics for Est7MT1.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```




```
Uncensored Data - Est7MT1

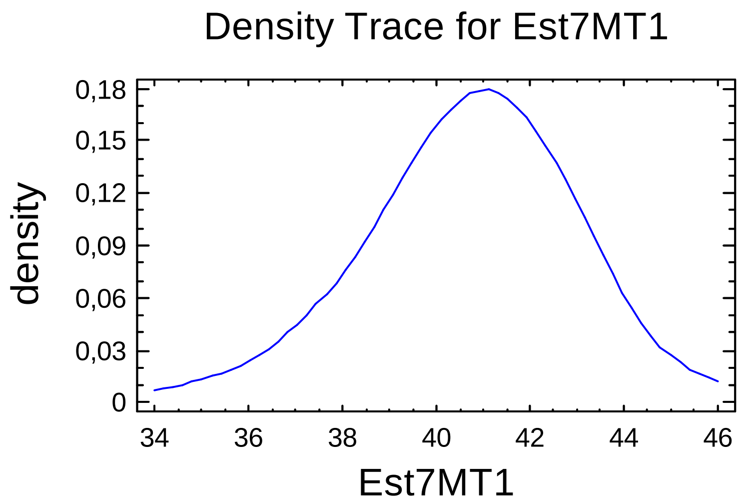
Analysis Summary

Data variable: Est7MT1

47 values ranging from 34,9 to 45,7

Fitted normal distribution:
     mean = 40,7362
     standard deviation = 2,031


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est7MT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est7MT1

Computed Chi-Square goodness-of-fit statistic = 18,4894
P-Value = 0,237812

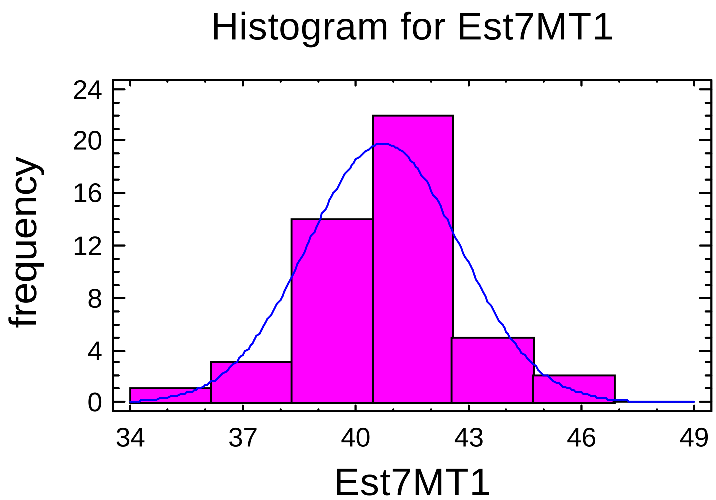
Shapiro-Wilks W statistic = 0,973938
P-Value = 0,529335

Z score for skewness = 0,841074
P-Value = 0,400305

Z score for kurtosis = 1,42152
P-Value = 0,155166



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est7MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est7MT1 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,155166.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Est7MT1 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Est7MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	38,5679	6	6,71	0,08
	38,5679	39,5867	6	6,71	0,08
	39,5867	40,3706	6	6,71	0,08
	40,3706	41,1018	5	6,71	0,44
	41,1018	41,8856	11	6,71	2,74
	41,8856	42,9044	8	6,71	0,25
above	42,9044		5	6,71	0,44

Chi-Square = 4,08527 with 4 d.f.   P-Value = 0,394589

Estimated Kolmogorov statistic DPLUS = 0,0699902
Estimated Kolmogorov statistic DMINUS = 0,108283
Estimated overall statistic DN = 0,108283
Approximate P-Value = 0,640051

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,108283	0,754696	>=0.10*
Anderson-Darling A^2	0,566604	0,576222	0,1345*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est7MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est7MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est7MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,108283. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

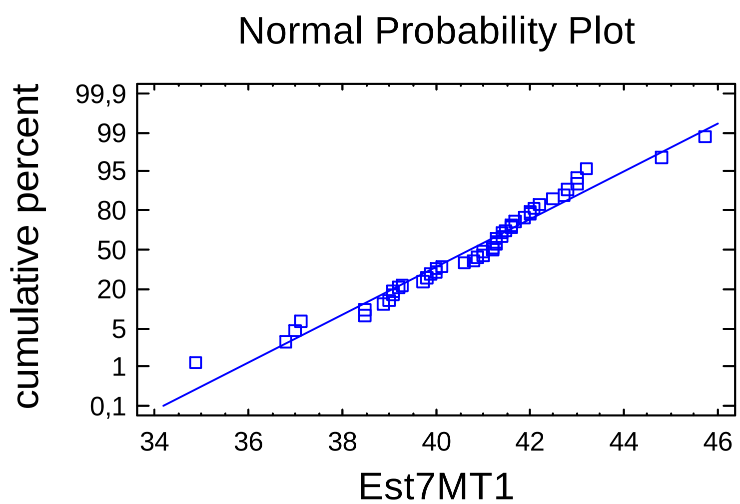
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that Est7MT1 comes from a normal distribution with 90% or higher confidence.

```
Probability Plots

Probability Plots
-----------------
Data variable: Est7MT1

Number of observations = 47
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Est7MT1 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
Individuals Charts - Est7MT1

X and MR(2) - Initial Study for Est7MT1

Number of observations = 47
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 45,4598
Centerline      = 40,7362
LCL: -3,0 sigma = 36,0125

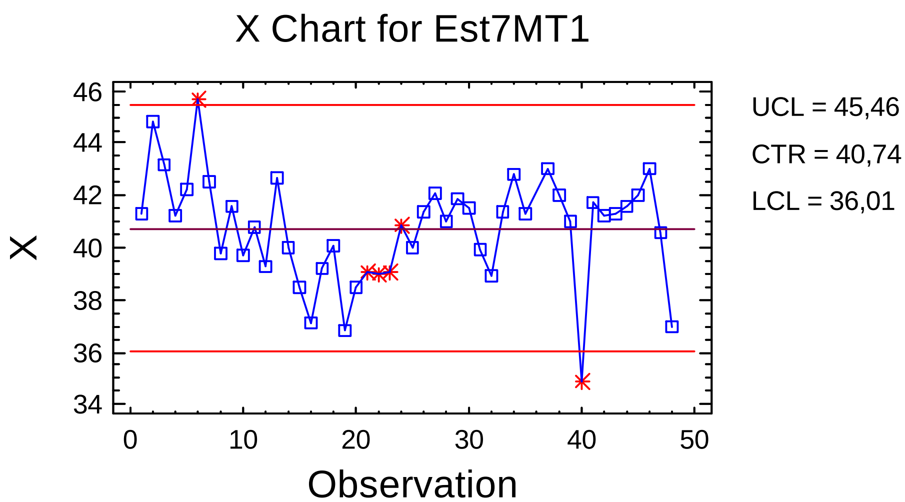
2 beyond limits

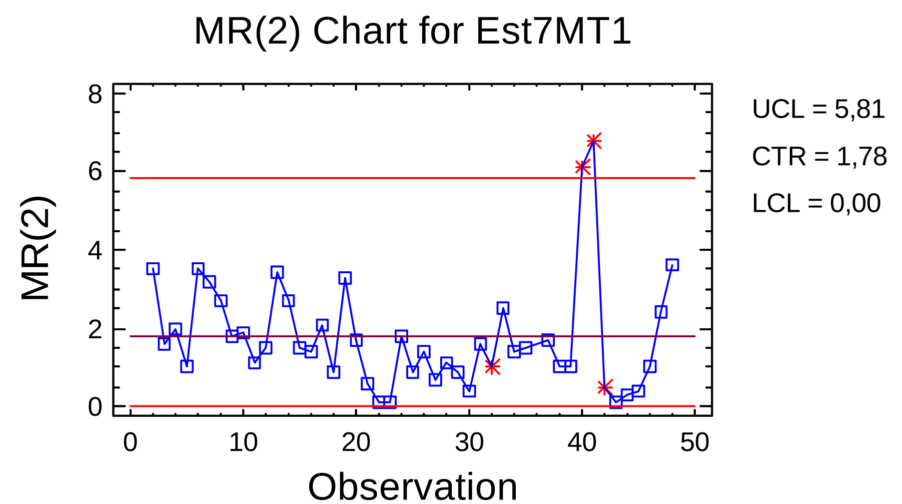
MR(2) Chart
-----------
UCL: +3,0 sigma = 5,80535
Centerline      = 1,77609
LCL: -3,0 sigma = 0,0

2 beyond limits

Estimates
---------
Process mean = 40,7362
Process sigma = 1,57455
Mean MR(2) = 1,77609
```

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for Est7MT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 40,7362 and a standard
deviation equal to 1,57455.  These parameters were estimated from the
data.  Of the 47 nonexcluded points shown on the charts, 2 are beyond
the control limits on the first chart while 2 are beyond the limits on
the second chart.  Since the probability of seeing 2 or more points
beyond the limits just by chance is 7,87369E-7 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```





One-Variable Analysis - Est28MT1

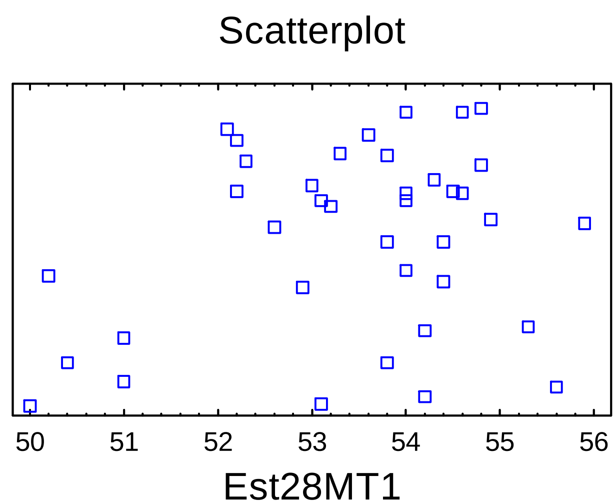
Analysis Summary

Data variable: Est28MT1

38 values ranging from 50,0 to 55,9

The StatAdvisor

   This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

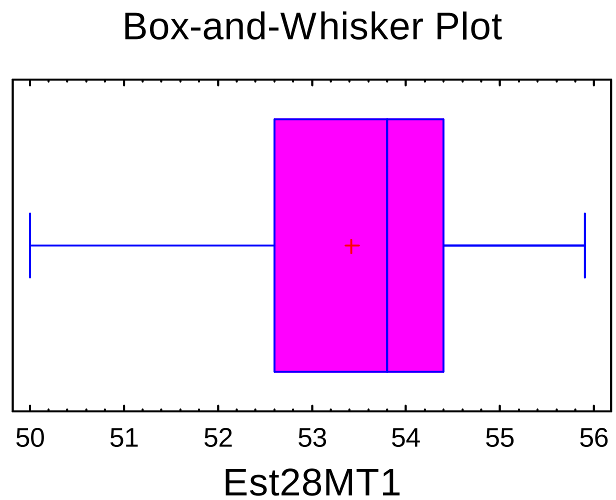


Summary Statistics for Est28MT1

Count = 38
Average = 53,4237
Variance = 2,17213
Standard deviation = 1,47381
Minimum = 50,0
Maximum = 55,9
Range = 5,9
Stnd. skewness = -1,98657
Stnd. kurtosis = 0,145137

The StatAdvisor

   This table shows summary statistics for Est28MT1. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Est28MT1

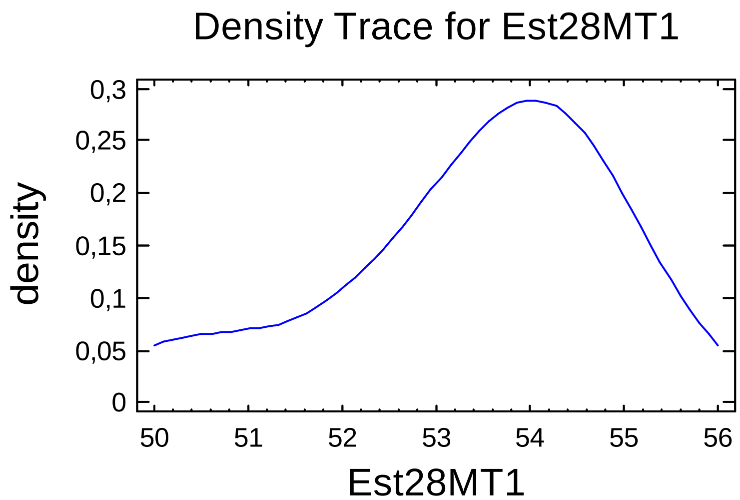
Analysis Summary

Data variable: Est28MT1

38 values ranging from 50,0 to 55,9

Fitted normal distribution:
     mean = 53,4237
     standard deviation = 1,47381


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est28MT1.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est28MT1

Computed Chi-Square goodness-of-fit statistic = 14,2105
P-Value = 0,359187

Shapiro-Wilks W statistic = 0,930875
P-Value = 0,0270984

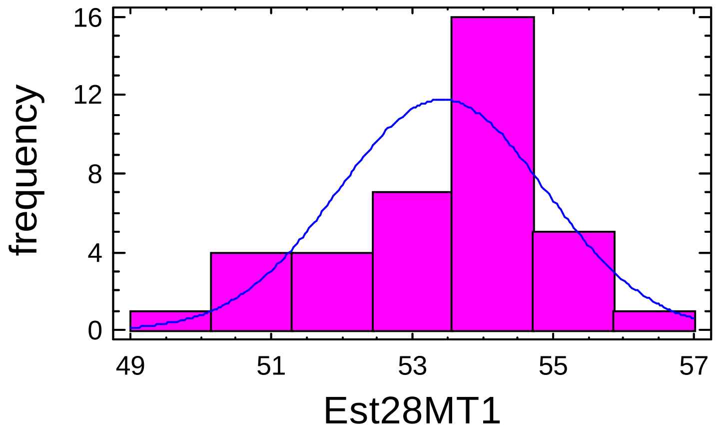
Z score for skewness = 1,43215
P-Value = 0,152101

Z score for kurtosis = 0,379036
P-Value = 0,704658



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est28MT1 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est28MT1 into 16 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,0270984.
Because the P-value for this test is less than 0.05, we can reject the
idea that Est28MT1 comes from a normal distribution with 95%
confidence.
```

Histogram for Est28MT1



Goodness-of-Fit Tests for Est28MT1

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	51,8503	5	5,43	0,03
	51,8503	52,5896	4	5,43	0,38
	52,5896	53,1584	5	5,43	0,03
	53,1584	53,689	3	5,43	1,09
	53,689	54,2578	9	5,43	2,35
	54,2578	54,9971	9	5,43	2,35
above	54,9971		3	5,43	1,09

Chi-Square = 7,31601 with 4 d.f.   P-Value = 0,120101

Estimated Kolmogorov statistic DPLUS = 0,0815425
Estimated Kolmogorov statistic DMINUS = 0,153401
Estimated overall statistic DN = 0,153401
Approximate P-Value = 0,335227

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,153401	0,965248	<0.05*
Anderson-Darling A^2	0,882269	0,901057	0,0216*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est28MT1 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est28MT1 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est28MT1 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,153401. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.05, we can reject the idea that Est28MT1 comes from a normal distribution with 95% confidence.

Probability Plots

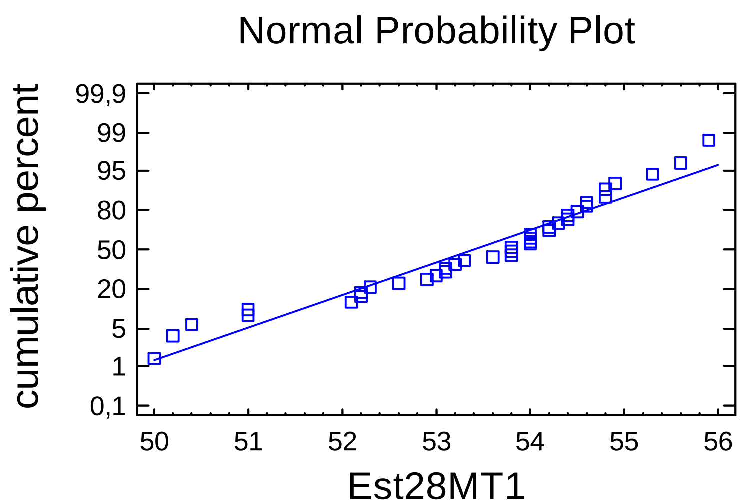
Probability Plots

Data variable: Est28MT1

Number of observations = 38
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

This procedure creates seven different types of probability plots to help you determine whether Est28MT1 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



Individuals Charts - Est28MT1

X and MR(2) - Initial Study for Est28MT1

Number of observations = 38
0 observations excluded

X Chart

UCL: +3,0 sigma = 56,2701
Centerline = 53,4237
LCL: -3,0 sigma = 50,5772

3 beyond limits

MR(2) Chart

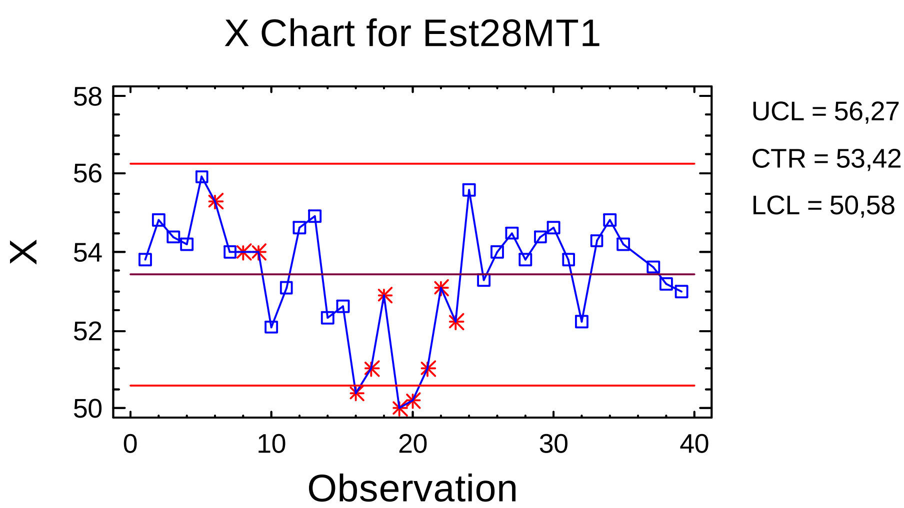
UCL: +3,0 sigma = 3,4983
Centerline = 1,07027
LCL: -3,0 sigma = 0,0

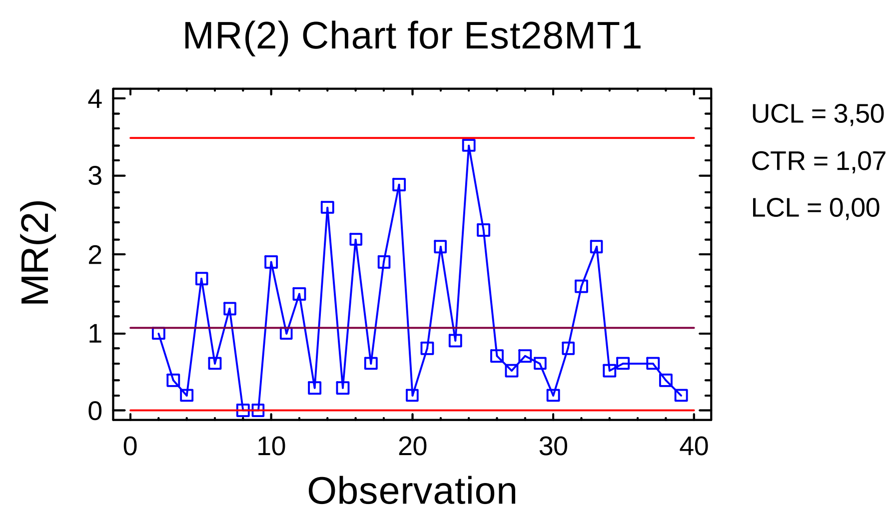
0 beyond limits

Estimates

Process mean = 53,4237
Process sigma = 0,948821
Mean MR(2) = 1,07027

```
The StatAdvisor
---------------
   This procedure creates an individuals chart for Est28MT1.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 53,4237 and a standard
deviation equal to 0,948821.  These parameters were estimated from the
data.  Of the 38 nonexcluded points shown on the charts, 3 are beyond
the control limits on the first chart while 0 are beyond the limits on
the second chart.  Since the probability of seeing 3 or more points
beyond the limits just by chance is 1,65354E-10 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```





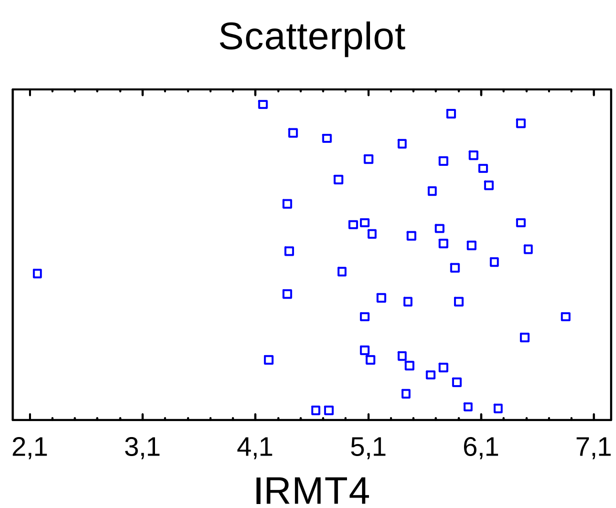
One-Variable Analysis - IRMT4

```
Analysis Summary

Data variable: IRMT4

48 values ranging from 2,16 to 6,85


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```

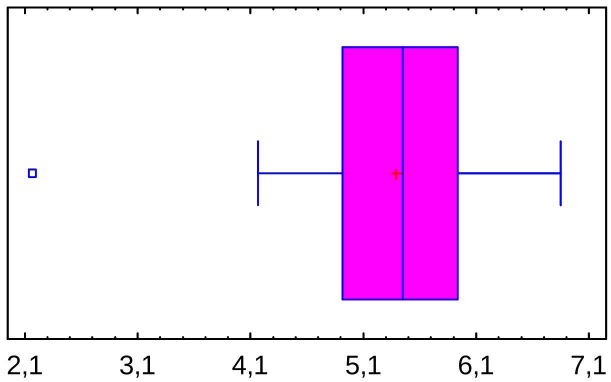



```
Summary Statistics for IRMT4

Count = 48
Average = 5,38812
Variance = 0,684092
Standard deviation = 0,827099
Minimum = 2,16
Maximum = 6,85
Range = 4,69
Stnd. skewness = -3,42009
Stnd. kurtosis = 4,97428


The StatAdvisor
---------------
   This table shows summary statistics for IRMT4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is not within the range expected for data from a normal
distribution.  The standardized kurtosis value is not within the range
expected for data from a normal distribution.
```

Box-and-Whisker Plot




```
Uncensored Data - IRMT4

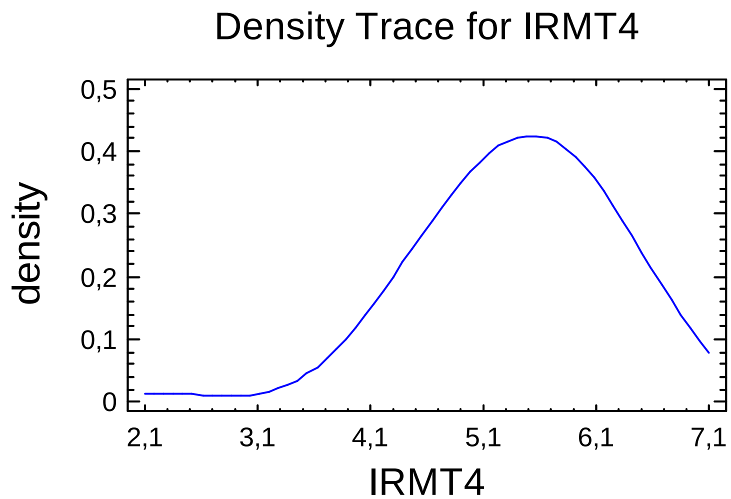
Analysis Summary

Data variable: IRMT4

48 values ranging from 2,16 to 6,85

Fitted normal distribution:
     mean = 5,38812
     standard deviation = 0,827099


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on IRMT4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for IRMT4

Computed Chi-Square goodness-of-fit statistic = 22,5
P-Value = 0,0953482

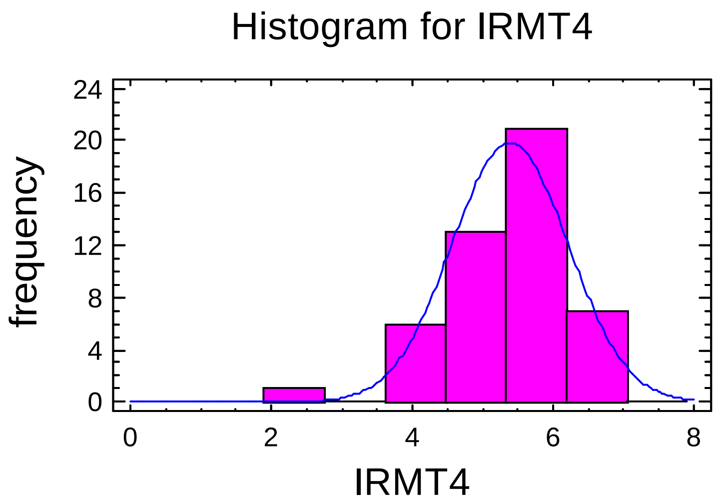
Shapiro-Wilks W statistic = 0,933851
P-Value = 0,0127672

Z score for skewness = 2,23362
P-Value = 0,0255076

Z score for kurtosis = 2,95247
P-Value = 0,00315256



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether IRMT4 can be adequately modeled by a normal distribution.  The
chi-square test divides the range of IRMT4 into 18 equally probable
classes and compares the number of observations in each class to the
number expected.  The Shapiro-Wilks test is based upon comparing the
quantiles of the fitted normal distribution to the quantiles of the
data.  The standardized skewness test looks for lack of symmetry in
the data.  The standardized kurtosis test looks for distributional
shape which is either flatter or more peaked than the normal
distribution.
   The lowest P-value amongst the tests performed equals 0,00315256.
Because the P-value for this test is less than 0.01, we can reject the
idea that IRMT4 comes from a normal distribution with 99% confidence.
```



Goodness-of-Fit Tests for IRMT4

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4,50514	7	6,86	0,00
	4,50514	4,92003	5	6,86	0,50
	4,92003	5,23924	8	6,86	0,19
	5,23924	5,53701	6	6,86	0,11
	5,53701	5,85622	7	6,86	0,00
	5,85622	6,27111	10	6,86	1,44
above	6,27111		5	6,86	0,50

Chi-Square = 2,75009 with 4 d.f.   P-Value = 0,600478

Estimated Kolmogorov statistic DPLUS = 0,0666527
Estimated Kolmogorov statistic DMINUS = 0,0890638
Estimated overall statistic DN = 0,0890638
Approximate P-Value = 0,840931

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0890638	0,627088	>=0.10*
Anderson-Darling A^2	0,521185	0,529838	0,1761*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether IRMT4 can be adequately modeled by a normal distribution. The chi-square test divides the range of IRMT4 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of IRMT4 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0890638. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that IRMT4 comes from a normal distribution with 90% or higher confidence.

Probability Plots

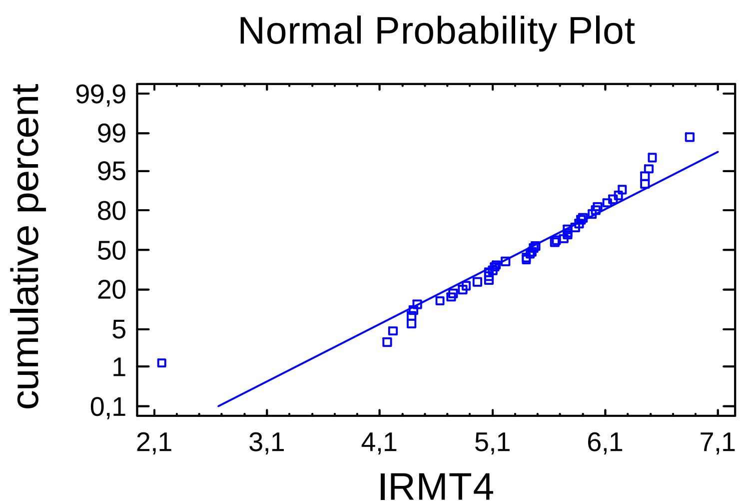
Probability Plots

Data variable: IRMT4

Number of observations = 48
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

This procedure creates seven different types of probability plots to help you determine whether IRMT4 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



One-Variable Analysis - SIO2MT4

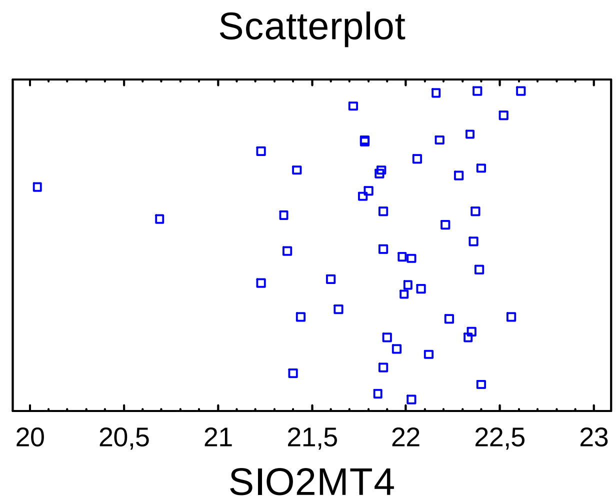
Analysis Summary

Data variable: SIO2MT4

49 values ranging from 20,04 to 22,61

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

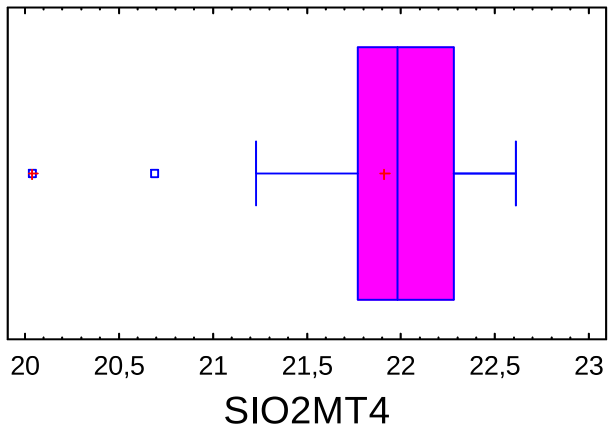



```
Summary Statistics for SIO2MT4

Count = 49
Average = 21,9122
Variance = 0,235714
Standard deviation = 0,485503
Minimum = 20,04
Maximum = 22,61
Range = 2,57
Stnd. skewness = -4,29694
Stnd. kurtosis = 5,34637


The StatAdvisor
---------------
   This table shows summary statistics for SIO2MT4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is not within the range expected for data from a normal
distribution.  The standardized kurtosis value is not within the range
expected for data from a normal distribution.
```

Box-and-Whisker Plot




```
Uncensored Data - SIO2MT4

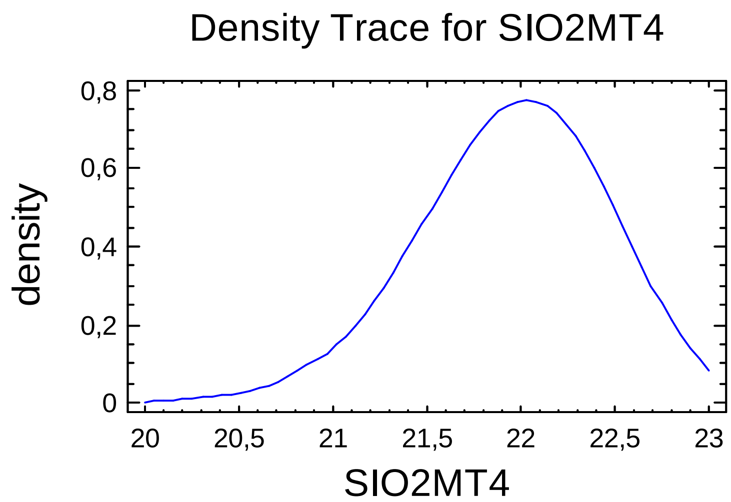
Analysis Summary

Data variable: SIO2MT4

48 values ranging from 20,69 to 22,61

Fitted normal distribution:
     mean = 21,9513
     standard deviation = 0,405702


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on SIO2MT4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for SIO2MT4

Computed Chi-Square goodness-of-fit statistic = 21,75
P-Value = 0,114529

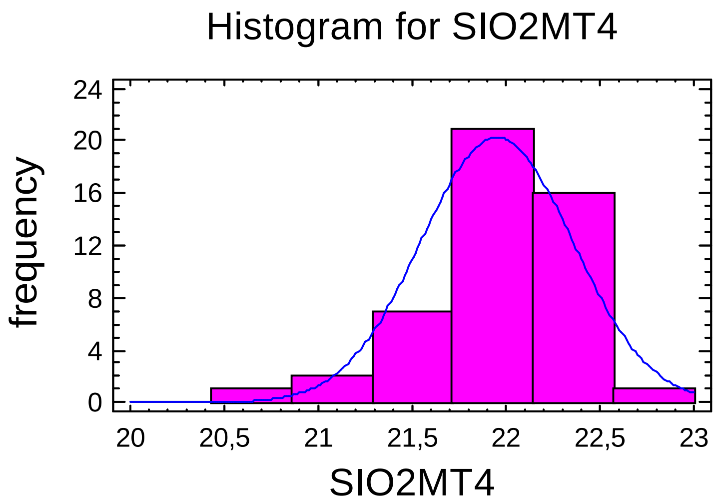
Shapiro-Wilks W statistic = 0,952734
P-Value = 0,0857084

Z score for skewness = 1,51611
P-Value = 0,12949

Z score for kurtosis = 1,0764
P-Value = 0,281746



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether SIO2MT4 can be adequately modeled by a normal distribution.
The chi-square test divides the range of SIO2MT4 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,0857084.
Because the P-value for this test is less than 0.10, we can reject the
idea that SIO2MT4 comes from a normal distribution with 90% confidence.
```




```
Goodness-of-Fit Tests for SIO2MT4

                              Chi-Square Test
----------------------------------------------------------------------------
               Lower          Upper       Observed      Expected
               Limit          Limit      Frequency     Frequency    Chi-Square
----------------------------------------------------------------------------
         at or below        21,5181              8          6,86          0,19
             21,5181        21,7216              3          6,86          2,17
             21,7216        21,8782              7          6,86          0,00
             21,8782        22,0243              8          6,86          0,19
             22,0243        22,1809              7          6,86          0,00
             22,1809        22,3844              9          6,86          0,67
above        22,3844                             6          6,86          0,11
----------------------------------------------------------------------------
Chi-Square = 3,33324 with 4 d.f.   P-Value = 0,503684

Estimated Kolmogorov statistic DPLUS = 0,0718395
Estimated Kolmogorov statistic DMINUS = 0,0983571
Estimated overall statistic DN = 0,0983571
Approximate P-Value = 0,741872

EDF Statistic          Value          Modified Form   P-Value
---------------------------------------------------------------------
Kolmogorov-Smirnov D   0,0983571      0,692522        >=0.10*
Anderson-Darling A^2   0,571401       0,580887        0,1309*
---------------------------------------------------------------------
*Indicates that the P-Value has been compared to tables of critical values
specially constructed for fitting the currently selected distribution.
Other P-values are based on general tables and may be very conservative.


The StatAdvisor
---------------
   This pane shows the results of tests run to determine whether
SIO2MT4 can be adequately modeled by a normal distribution.  The
chi-square test divides the range of SIO2MT4 into nonoverlapping
intervals and compares the number of observations in each class to the
number expected based on the fitted distribution.  The
Kolmogorov-Smirnov test computes the maximum distance between the
cumulative distribution of SIO2MT4 and the CDF of the fitted normal
distribution.  In this case, the maximum distance is 0,0983571.  The
other EDF statistics compare the empirical distribution function to
the fitted CDF in different ways.
   Since the smallest P-value amongst the tests performed is greater
than or equal to 0.10, we can not reject the idea that SIO2MT4 comes
from a normal distribution with 90% or higher confidence.
```

Probability Plots

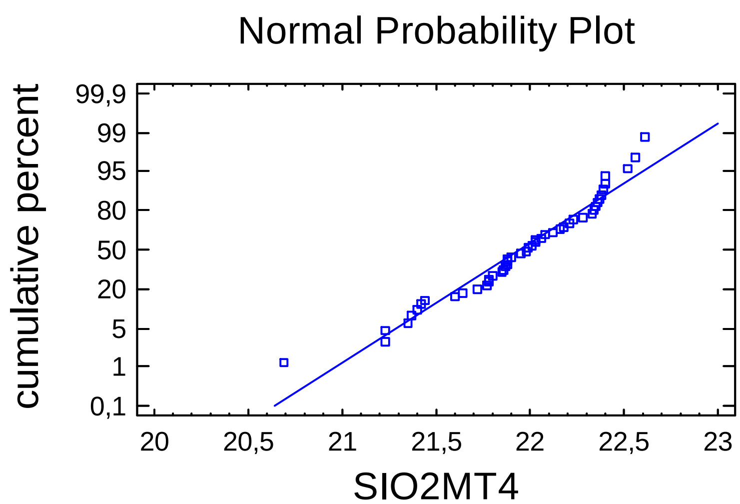
Probability Plots

Data variable: SIO2MT4

Number of observations = 48
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

   This procedure creates seven different types of probability plots to help you determine whether SIO2MT4 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



One-Variable Analysis - AMT4l2O3

Analysis Summary

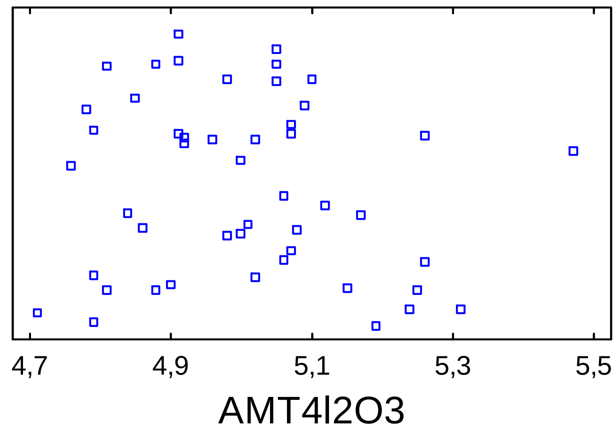
Data variable: AMT4l2O3

48 values ranging from 4,71 to 5,47

The StatAdvisor

   This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

Scatterplot

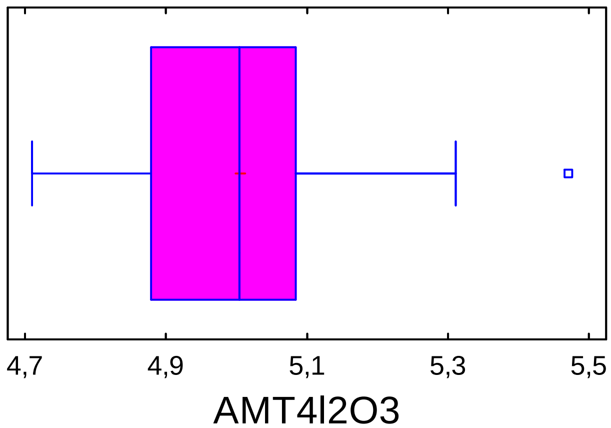



```
Summary Statistics for AMT4l2O3

Count = 48
Average = 5,00333
Variance = 0,0270014
Standard deviation = 0,164321
Minimum = 4,71
Maximum = 5,47
Range = 0,76
Stnd. skewness = 1,38937
Stnd. kurtosis = 0,147439


The StatAdvisor
---------------
   This table shows summary statistics for AMT4l2O3.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```

Box-and-Whisker Plot




```
Uncensored Data - AMT4l2O3

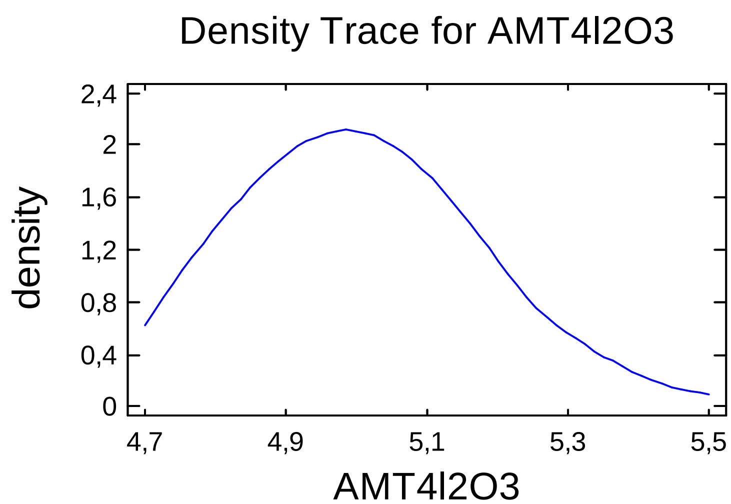
Analysis Summary

Data variable: AMT4l2O3

48 values ranging from 4,71 to 5,47

Fitted normal distribution:
     mean = 5,00333
     standard deviation = 0,164321


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on AMT4l2O3.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```



Goodness-of-Fit Tests for AMT4l2O3

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4,82791	8	6,86	0,19
	4,82791	4,91034	9	6,86	0,67
	4,91034	4,97375	3	6,86	2,17
	4,97375	5,03291	7	6,86	0,00
	5,03291	5,09633	10	6,86	1,44
	5,09633	5,17876	4	6,86	1,19
above	5,17876		7	6,86	0,00

Chi-Square = 5,66669 with 4 d.f.   P-Value = 0,225461

Estimated Kolmogorov statistic DPLUS = 0,0898056
Estimated Kolmogorov statistic DMINUS = 0,0501047
Estimated overall statistic DN = 0,0898056
Approximate P-Value = 0,833607

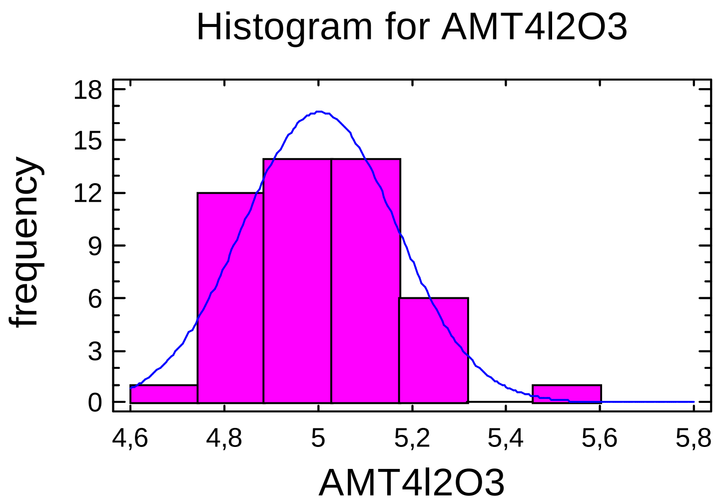
EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0898056	0,632311	>=0.10*
Anderson-Darling A^2	0,361605	0,367609	0,4309*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether AMT4l2O3 can be adequately modeled by a normal distribution. The chi-square test divides the range of AMT4l2O3 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of AMT4l2O3 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0898056. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that AMT4l2O3 comes from a normal distribution with 90% or higher confidence.

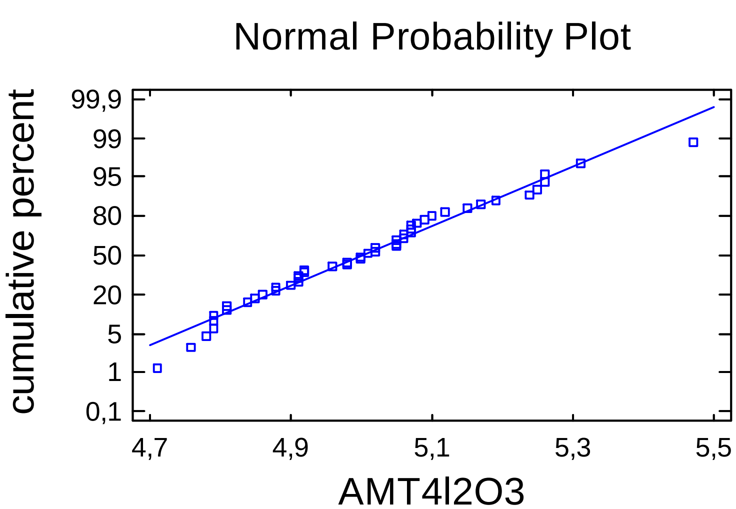



```
Probability Plots

Probability Plots
-----------------
Data variable: AMT4l2O3

Number of observations = 48
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether AMT4l2O3 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```



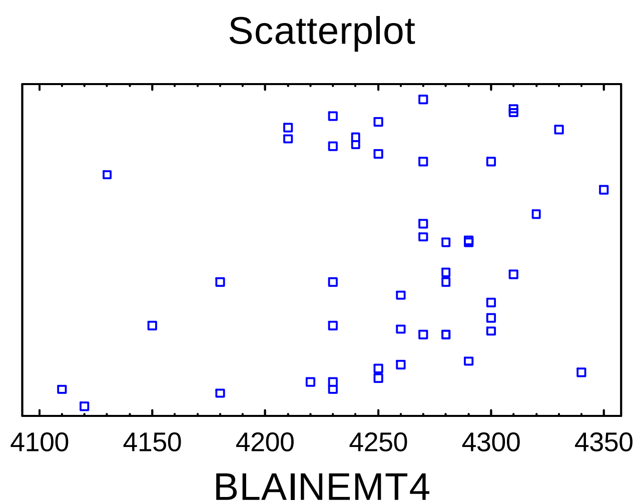

```
One-Variable Analysis - BLAINEMT4

Analysis Summary
```

```
Data variable: BLAINEMT4

48 values ranging from 4110,0 to 4350,0

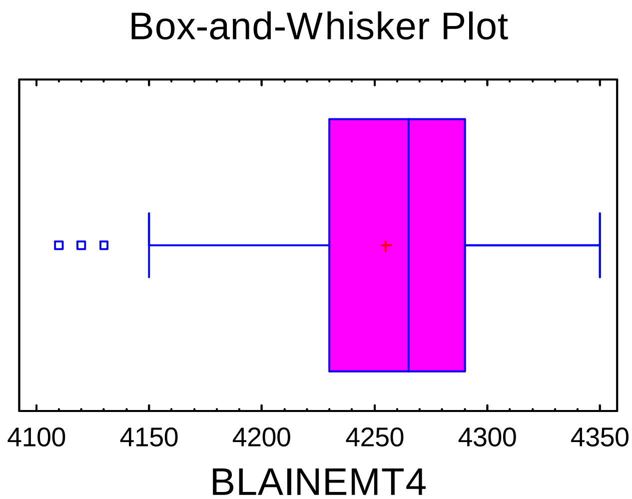

The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```




```
Summary Statistics for BLAINEMT4

Count = 48
Average = 4255,0
Variance = 2936,17
Standard deviation = 54,1864
Minimum = 4110,0
Maximum = 4350,0
Range = 240,0
Stnd. skewness = -2,57892
Stnd. kurtosis = 1,21891


The StatAdvisor
---------------
   This table shows summary statistics for BLAINEMT4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is not within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```




```
Uncensored Data - BLAINEMT4

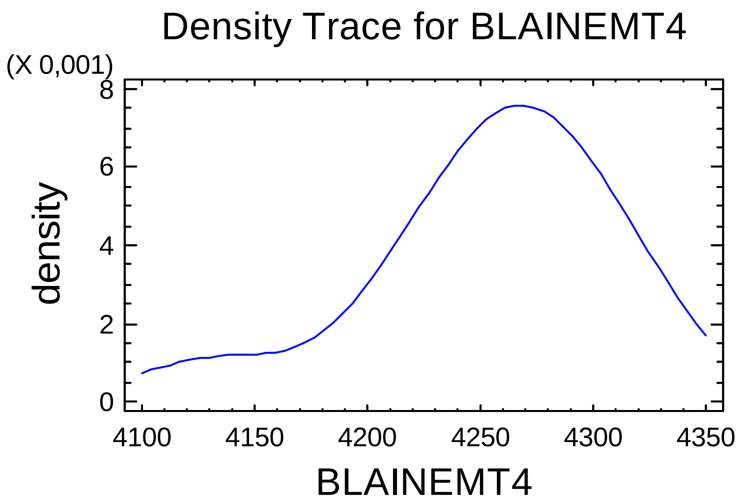
Analysis Summary

Data variable: BLAINEMT4

48 values ranging from 4110,0 to 4350,0

Fitted normal distribution:
     mean = 4255,0
     standard deviation = 54,1864


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on BLAINEMT4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for BLAINEMT4

Computed Chi-Square goodness-of-fit statistic = 21,75
P-Value = 0,114529

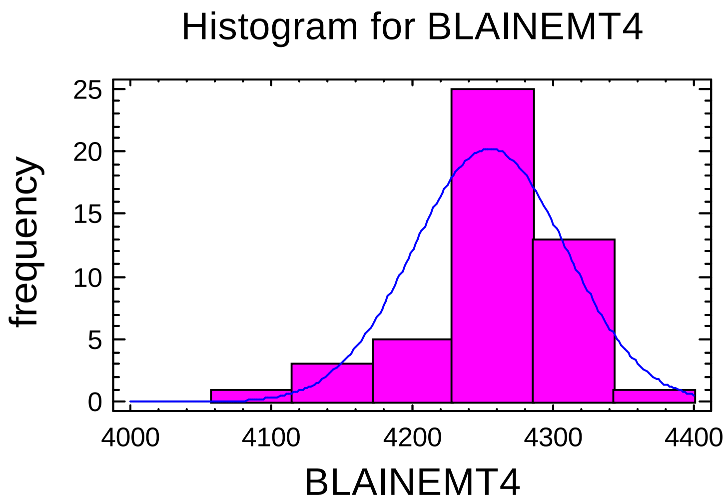
Shapiro-Wilks W statistic = 0,931973
P-Value = 0,010514

Z score for skewness = 1,78276
P-Value = 0,0746257

Z score for kurtosis = 1,28702
P-Value = 0,198087



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether BLAINEMT4 can be adequately modeled by a normal distribution.
The chi-square test divides the range of BLAINEMT4 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,010514.
Because the P-value for this test is less than 0.05, we can reject the
idea that BLAINEMT4 comes from a normal distribution with 95%
confidence.
```



Goodness-of-Fit Tests for BLAINEMT4

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4197,15	6	6,86	0,11
	4197,15	4224,33	3	6,86	2,17
	4224,33	4245,25	8	6,86	0,19
	4245,25	4264,75	7	6,86	0,00
	4264,75	4285,67	10	6,86	1,44
	4285,67	4312,85	10	6,86	1,44
above	4312,85		4	6,86	1,19

Chi-Square = 6,54168 with 4 d.f.   P-Value = 0,162183

Estimated Kolmogorov statistic DPLUS = 0,0717156
Estimated Kolmogorov statistic DMINUS = 0,134765
Estimated overall statistic DN = 0,134765
Approximate P-Value = 0,350746

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,134765	0,948865	<0.05*
Anderson-Darling A^2	0,952259	0,968068	0,0148*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether BLAINEMT4 can be adequately modeled by a normal distribution. The chi-square test divides the range of BLAINEMT4 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of BLAINEMT4 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,134765. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.05, we can reject the idea that BLAINEMT4 comes from a normal distribution with 95% confidence.

Probability Plots

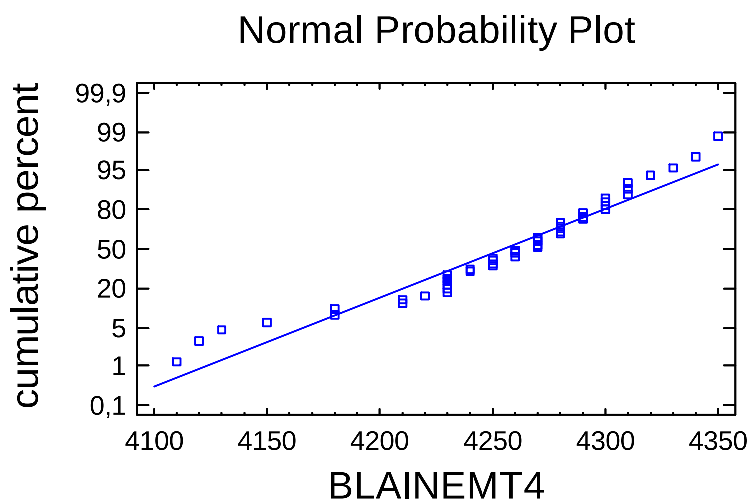
Probability Plots

Data variable: BLAINEMT4

Number of observations = 48
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

This procedure creates seven different types of probability plots to help you determine whether BLAINEMT4 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



One-Variable Analysis - LOIMT4

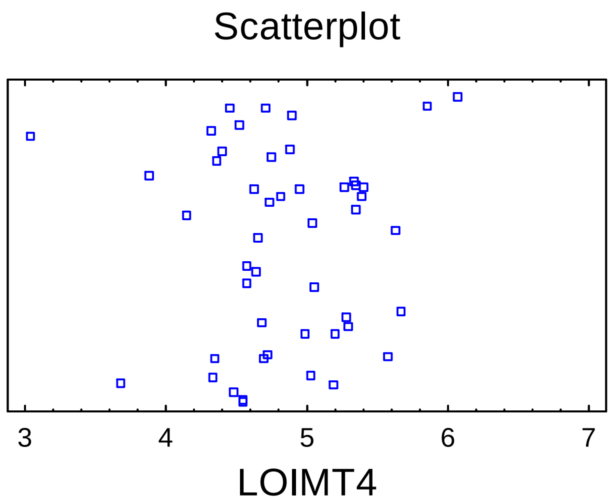
Analysis Summary

Data variable: LOIMT4

48 values ranging from 3,04 to 6,07

The StatAdvisor

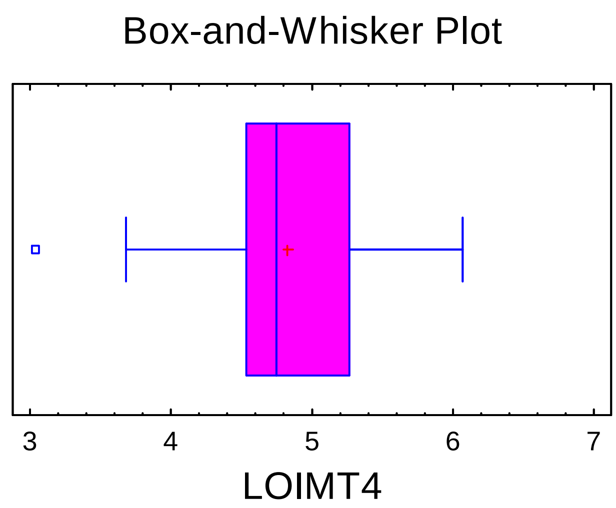
This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.




```
Summary Statistics for LOIMT4

Count = 48
Average = 4,82917
Variance = 0,315659
Standard deviation = 0,561835
Minimum = 3,04
Maximum = 6,07
Range = 3,03
Stnd. skewness = -1,26573
Stnd. kurtosis = 1,85195


The StatAdvisor
---------------
   This table shows summary statistics for LOIMT4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```




```
Uncensored Data - LOIMT4

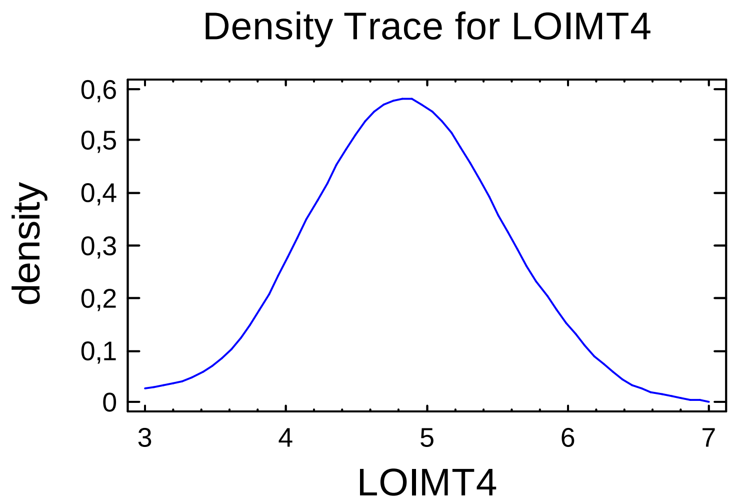
Analysis Summary

Data variable: LOIMT4

48 values ranging from 3,04 to 6,07

Fitted normal distribution:
     mean = 4,82917
     standard deviation = 0,561835


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on LOIMT4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```



Goodness-of-Fit Tests for LOIMT4

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	4,22937	4	6,86	1,19
	4,22937	4,5112	7	6,86	0,00
	4,5112	4,72803	12	6,86	3,86
	4,72803	4,9303	5	6,86	0,50
	4,9303	5,14714	5	6,86	0,50
	5,14714	5,42897	10	6,86	1,44
above	5,42897		5	6,86	0,50

Chi-Square = 8,00019 with 4 d.f.   P-Value = 0,0915711

Estimated Kolmogorov statistic DPLUS = 0,0768642
Estimated Kolmogorov statistic DMINUS = 0,099066
Estimated overall statistic DN = 0,099066
Approximate P-Value = 0,733824

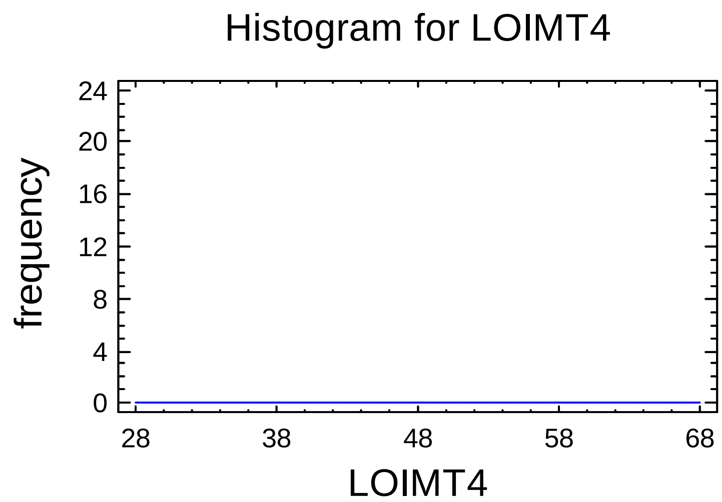
EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,099066	0,697513	>=0.10*
Anderson-Darling A^2	0,410302	0,417113	0,3305*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether LOIMT4 can be adequately modeled by a normal distribution. The chi-square test divides the range of LOIMT4 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of LOIMT4 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,099066. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.10, we can reject the idea that LOIMT4 comes from a normal distribution with 90% confidence.

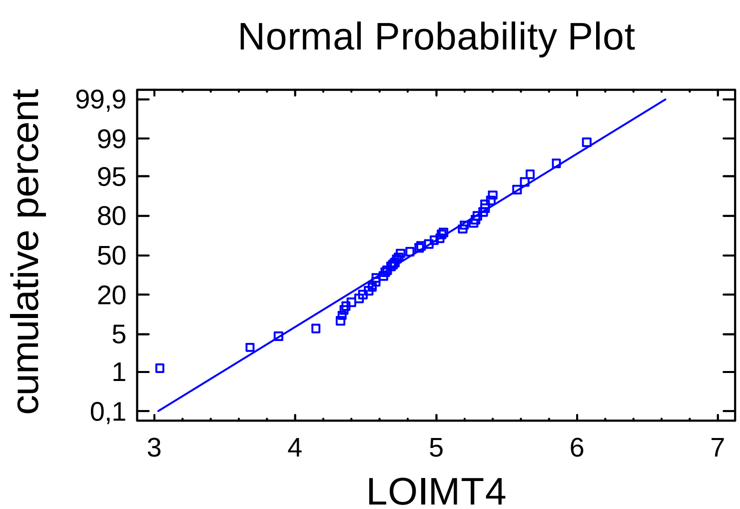



```
Probability Plots

Probability Plots
-----------------
Data variable: LOIMT4

Number of observations = 48
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether LOIMT4 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```




```
One-Variable Analysis - Est1MT4

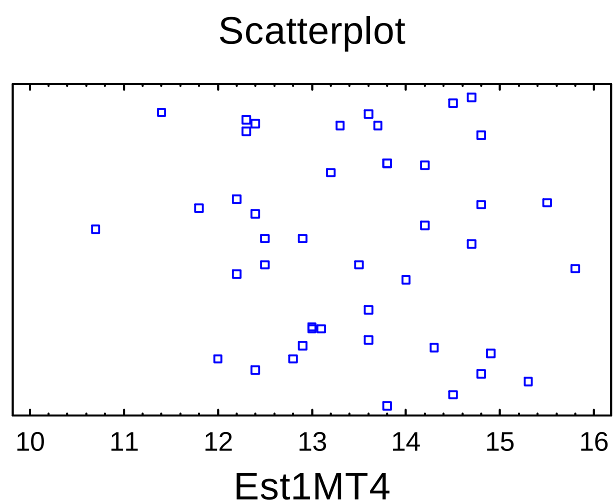
Analysis Summary
```

Data variable: Est1MT4

44 values ranging from 10,7 to 15,8

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

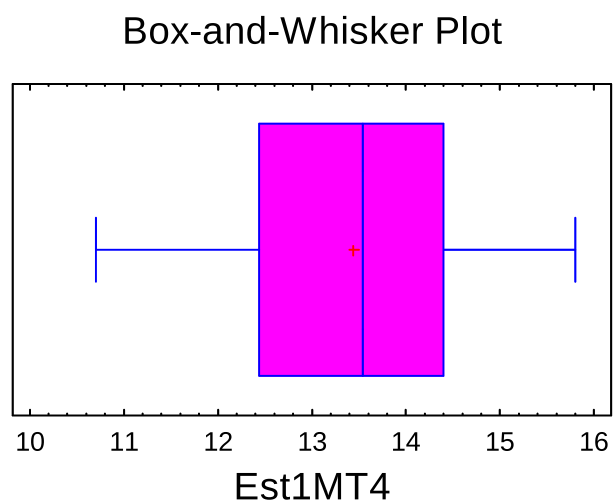


Summary Statistics for Est1MT4

Count = 44
Average = 13,4477
Variance = 1,34441
Standard deviation = 1,15949
Minimum = 10,7
Maximum = 15,8
Range = 5,1
Stnd. skewness = -0,13506
Stnd. kurtosis = -0,682939

The StatAdvisor

This table shows summary statistics for Est1MT4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Est1MT4

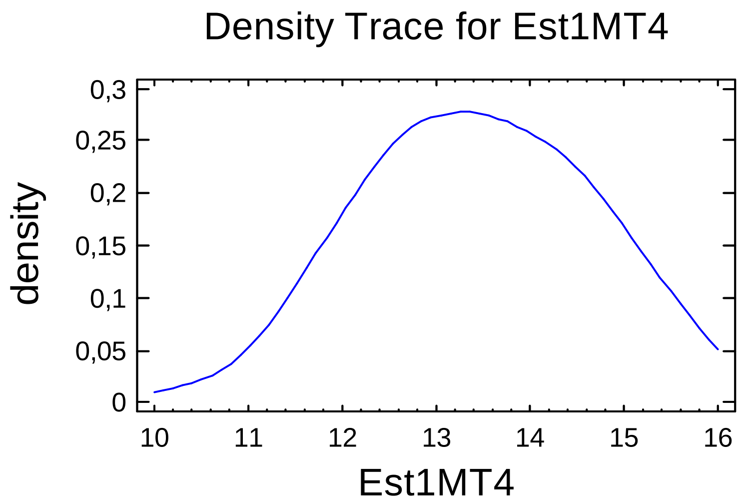
Analysis Summary

Data variable: Est1MT4

44 values ranging from 10,7 to 15,8

Fitted normal distribution:
     mean = 13,4477
     standard deviation = 1,15949


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est1MT4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est1MT4

Computed Chi-Square goodness-of-fit statistic = 12,4091
P-Value = 0,573486

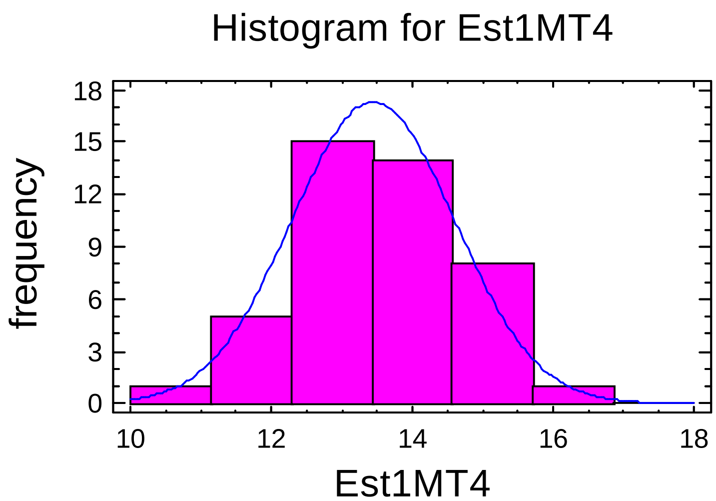
Shapiro-Wilks W statistic = 0,980089
P-Value = 0,765114

Z score for skewness = 0,103916
P-Value = 0,917231

Z score for kurtosis = -0,713759
P-Value = 0,475374



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est1MT4 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est1MT4 into 17 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,475374.
Because the P-value for this test is greater than or equal to 0.10, we
can not reject the idea that Est1MT4 comes from a normal distribution
with 90% or higher confidence.
```



Goodness-of-Fit Tests for Est1MT4

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
at or below		12,2099	6	6,29	0,01
	12,2099	12,7915	7	6,29	0,08
	12,7915	13,239	7	6,29	0,08
	13,239	13,6565	5	6,29	0,26
	13,6565	14,1039	5	6,29	0,26
	14,1039	14,6856	5	6,29	0,26
above	14,6856		9	6,29	1,17

Chi-Square = 2,1365 with 4 d.f.   P-Value = 0,71067

Estimated Kolmogorov statistic DPLUS = 0,0885961
Estimated Kolmogorov statistic DMINUS = 0,067938
Estimated overall statistic DN = 0,0885961
Approximate P-Value = 0,880163

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,0885961	0,598147	>=0.10*
Anderson-Darling A^2	0,281607	0,286734	0,6227*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est1MT4 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est1MT4 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est1MT4 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,0885961. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can not reject the idea that Est1MT4 comes from a normal distribution with 90% or higher confidence.

Probability Plots

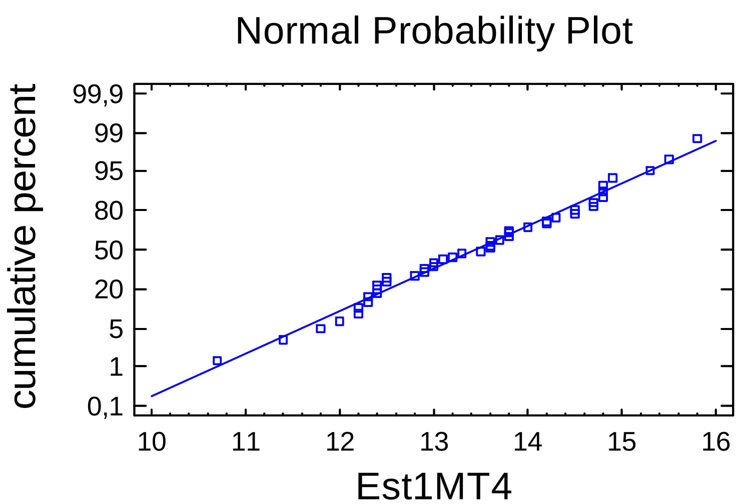
Probability Plots

Data variable: Est1MT4

Number of observations = 44
Number of values below minimum: 0
Number of values above maximum: 0

The StatAdvisor

This procedure creates seven different types of probability plots to help you determine whether Est1MT4 comes from a particular type of distribution. After examining these plots, you may fit a distribution to the data by selecting the Distribution Fitting procedure.



One-Variable Analysis - Est2MT1

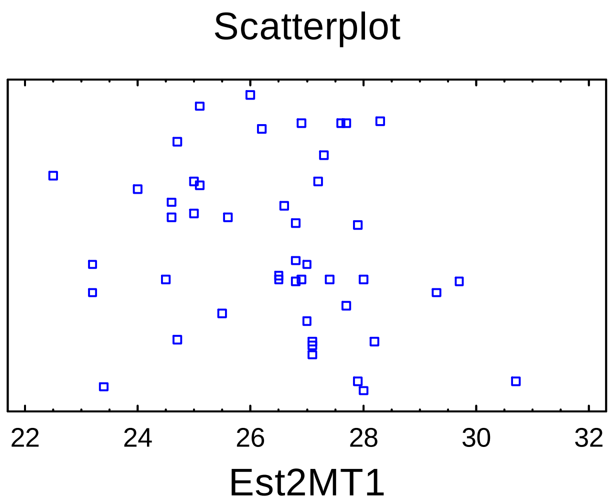
Analysis Summary

Data variable: Est2MT1

46 values ranging from 22,5 to 30,7

The StatAdvisor

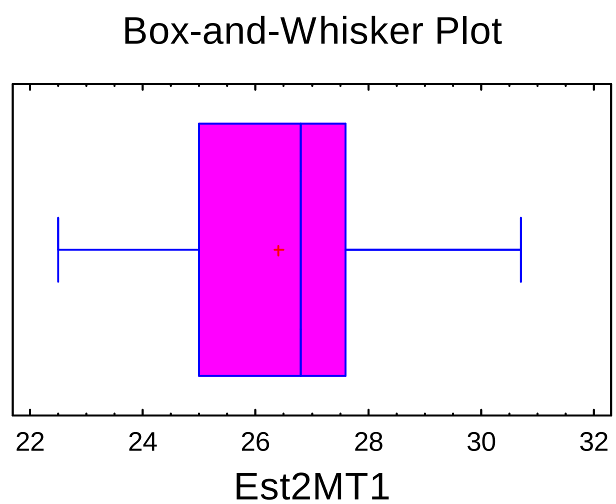
This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.




```
Summary Statistics for Est2MT1

Count = 46
Average = 26,4109
Variance = 3,11166
Standard deviation = 1,76399
Minimum = 22,5
Maximum = 30,7
Range = 8,2
Stnd. skewness = -0,375575
Stnd. kurtosis = -0,0491938


The StatAdvisor
---------------
   This table shows summary statistics for Est2MT1.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```

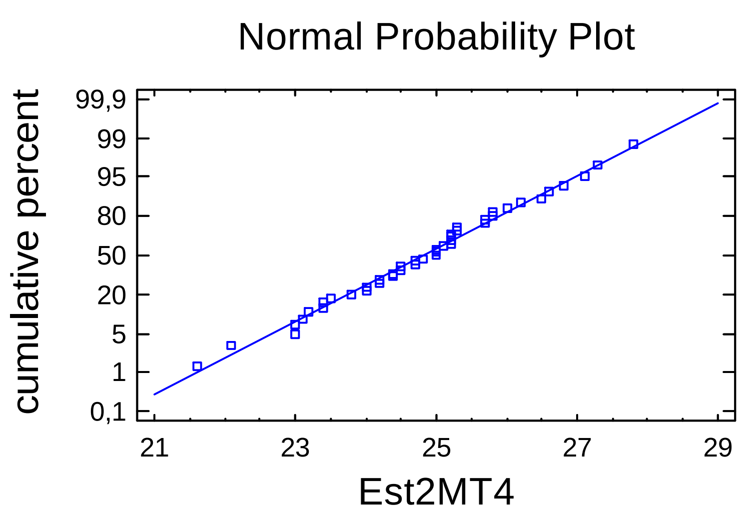



```
Probability Plots

Probability Plots
-----------------
Data variable: Est2MT4

Number of observations = 43
Number of values below minimum: 0
Number of values above maximum: 0


The StatAdvisor
---------------
   This procedure creates seven different types of probability plots
to help you determine whether Est2MT4 comes from a particular type of
distribution.  After examining these plots, you may fit a distribution
to the data by selecting the Distribution Fitting procedure.
```



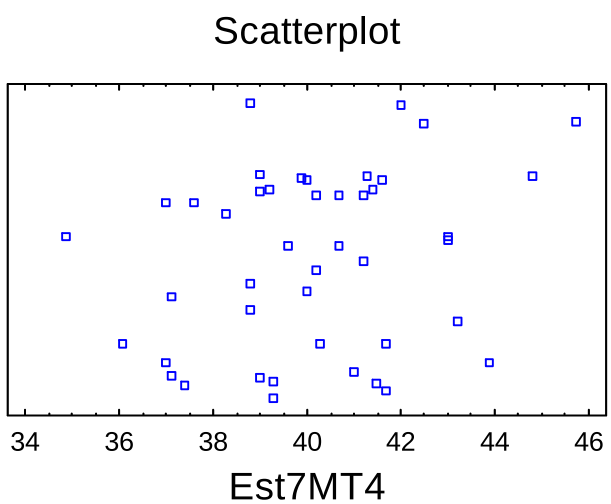

```
One-Variable Analysis - Est7MT4

Analysis Summary
```

```
Data variable: Est7MT4

44 values ranging from 34,9 to 45,7

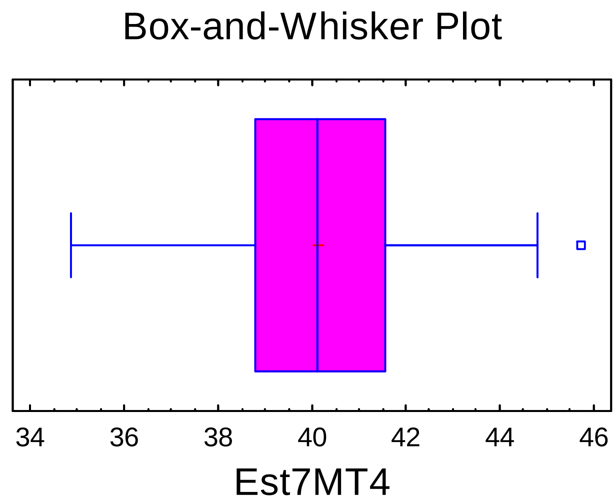

The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```




```
Summary Statistics for Est7MT4

Count = 44
Average = 40,1364
Variance = 5,30795
Standard deviation = 2,3039
Minimum = 34,9
Maximum = 45,7
Range = 10,8
Stnd. skewness = 0,317924
Stnd. kurtosis = 0,0480608


The StatAdvisor
---------------
   This table shows summary statistics for Est7MT4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```


Box-and-Whisker Plot
34
36
38
40
42
44
46
Est7MT4

Στατιστική ανάλυση δεδομένων ποιότητα τσιμέντου OPC –μύλος 3

One-Variable Analysis - CLK_3

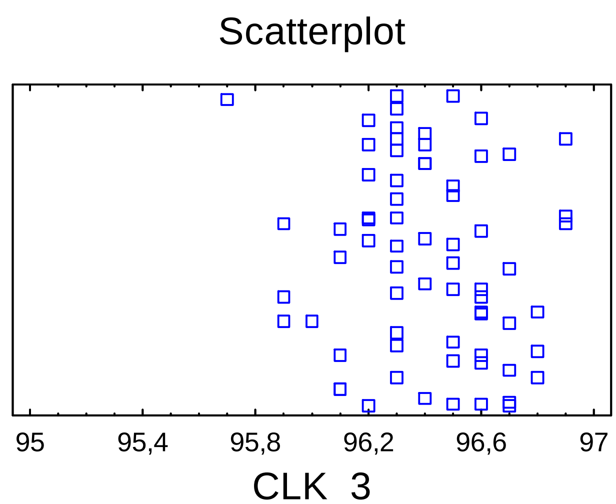
Analysis Summary

Data variable: CLK_3

69 values ranging from 95,7 to 96,9

The StatAdvisor

   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.



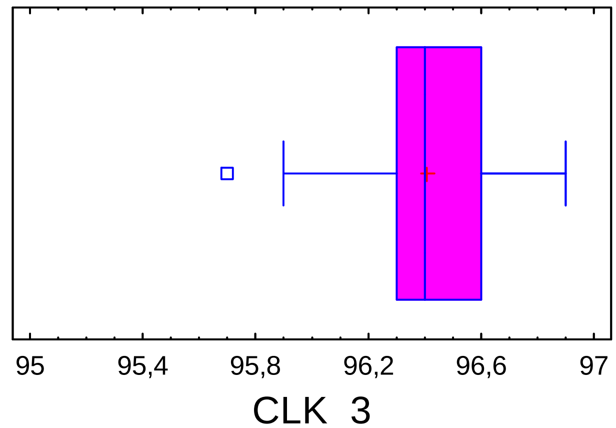
Summary Statistics for CLK_3

Count = 69
Average = 96,4072
Variance = 0,0665644
Standard deviation = 0,258001
Minimum = 95,7
Maximum = 96,9
Range = 1,2
Stnd. skewness = -0,799751
Stnd. kurtosis = -0,140826

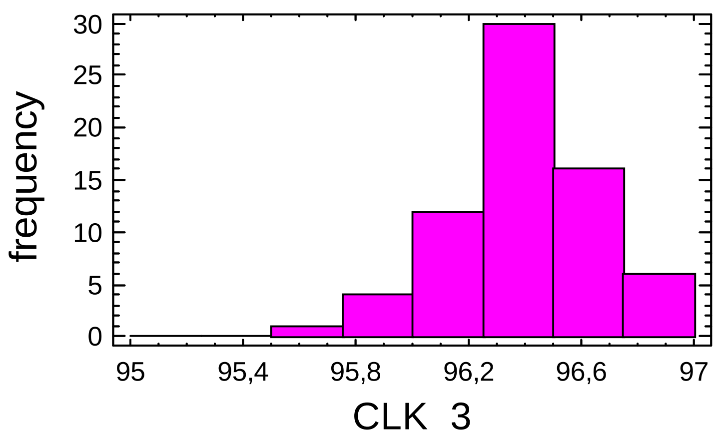
The StatAdvisor

   This table shows summary statistics for CLK_3. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.

Box-and-Whisker Plot



Histogram



Individuals Charts - CLK_3

```
X and MR(2) - Initial Study for CLK_3

Number of observations = 66
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 97,0284
Centerline      = 96,4106
LCL: -3,0 sigma = 95,7928

1 beyond limits

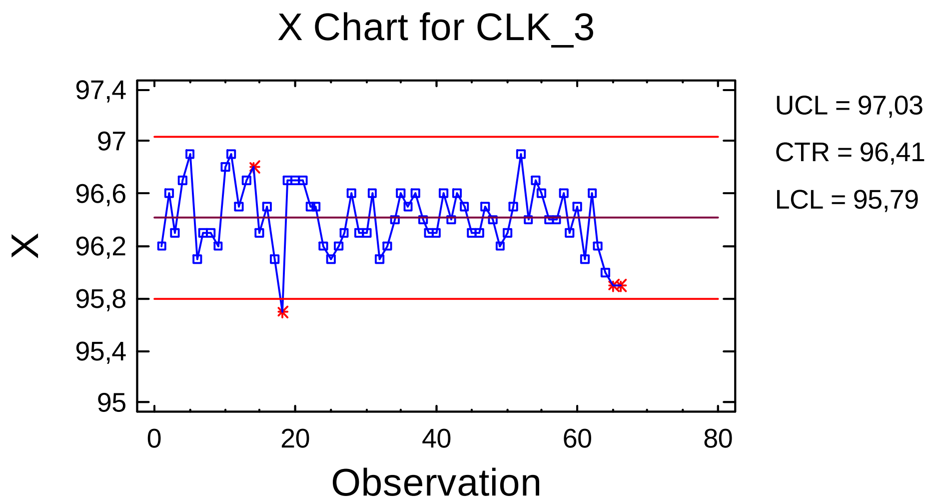
MR(2) Chart
-----------
UCL: +3,0 sigma = 0,759325
Centerline      = 0,232308
LCL: -3,0 sigma = 0,0

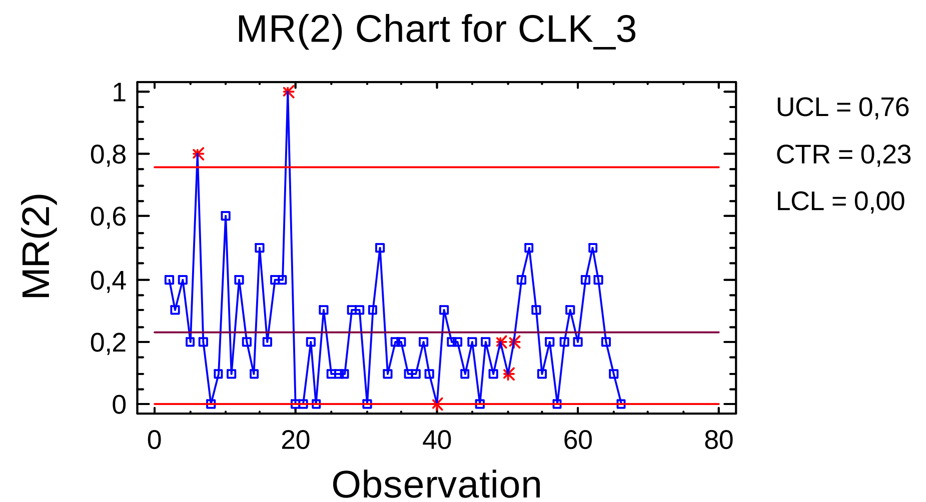
2 beyond limits

Estimates
---------
Process mean = 96,4106
```

```
Process sigma = 0,205947
Mean MR(2) = 0,232308


The StatAdvisor
---------------
   This procedure creates an individuals chart for CLK_3.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 96,4106 and a standard
deviation equal to 0,205947.  These parameters were estimated from the
data.  Of the 66 nonexcluded points shown on the charts, 1 is beyond
the control limits on the first chart while 2 are beyond the limits on
the second chart.  Since the probability of seeing 2 or more points
beyond the limits just by chance is 0,00000156182 if the data comes
from the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```






```
One-Variable Analysis - GYP_3
```

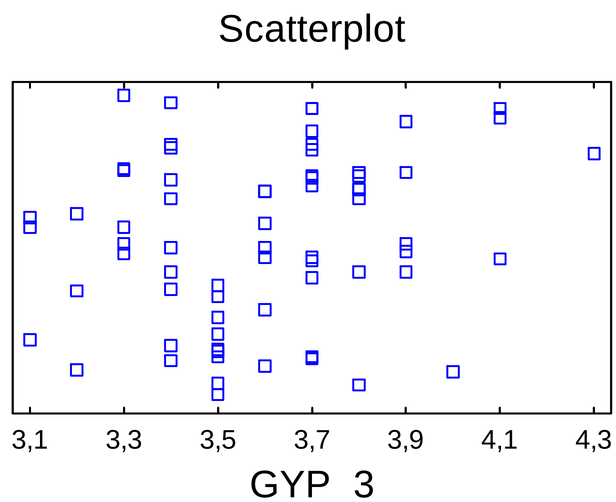
Analysis Summary

Data variable: GYP_3

69 values ranging from 3,1 to 4,3

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

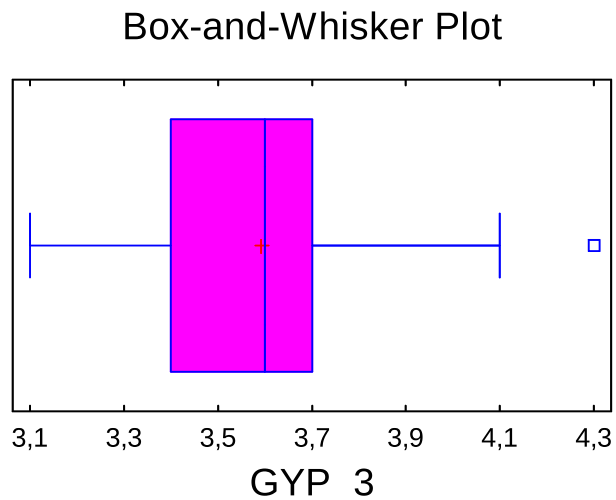


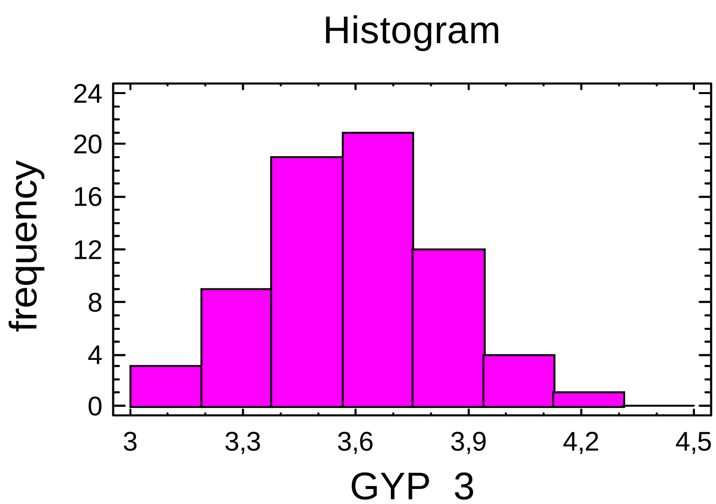
Summary Statistics for GYP_3

Count = 69
Average = 3,59275
Variance = 0,0665644
Standard deviation = 0,258001
Minimum = 3,1
Maximum = 4,3
Range = 1,2
Stnd. skewness = 0,799751
Stnd. kurtosis = -0,140826

The StatAdvisor

This table shows summary statistics for GYP_3. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.





Individuals Charts - GYP_3

```
X and MR(2) - Initial Study for GYP_3

Number of observations = 66
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 4,20723
Centerline      = 3,58939
LCL: -3,0 sigma = 2,97155

1 beyond limits

MR(2) Chart
-----------
```

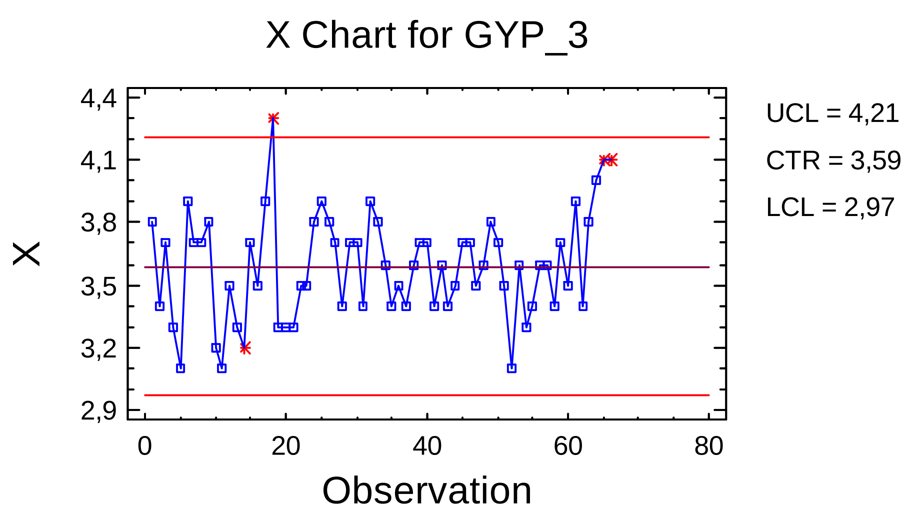
```
UCL: +3,0 sigma = 0,759325
Centerline      = 0,232308
LCL: -3,0 sigma = 0,0

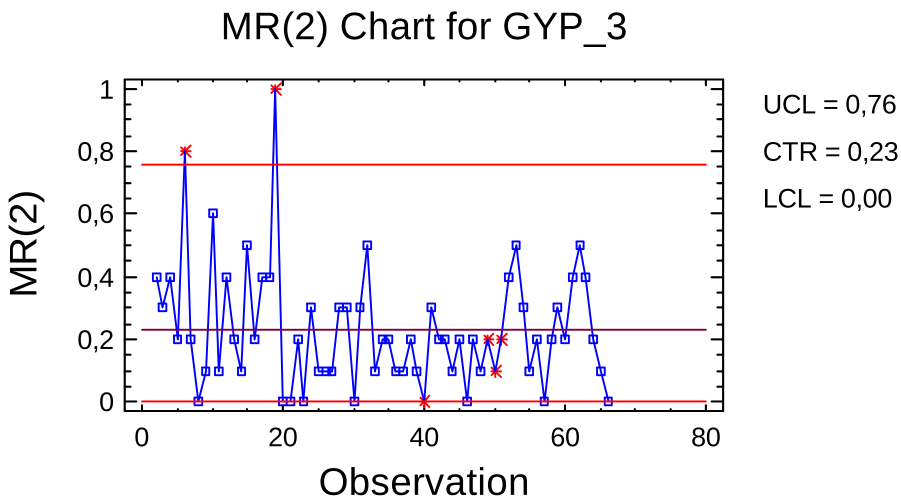
2 beyond limits

Estimates
---------
Process mean = 3,58939
Process sigma = 0,205947
Mean MR(2) = 0,232308



The StatAdvisor
---------------
   This procedure creates an individuals chart for GYP_3.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 3,58939 and a standard
deviation equal to 0,205947.  These parameters were estimated from the
data.  Of the 66 nonexcluded points shown on the charts, 1 is beyond
the control limits on the first chart while 2 are beyond the limits on
the second chart.  Since the probability of seeing 2 or more points
beyond the limits just by chance is 0,00000156182 if the data comes
from the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```





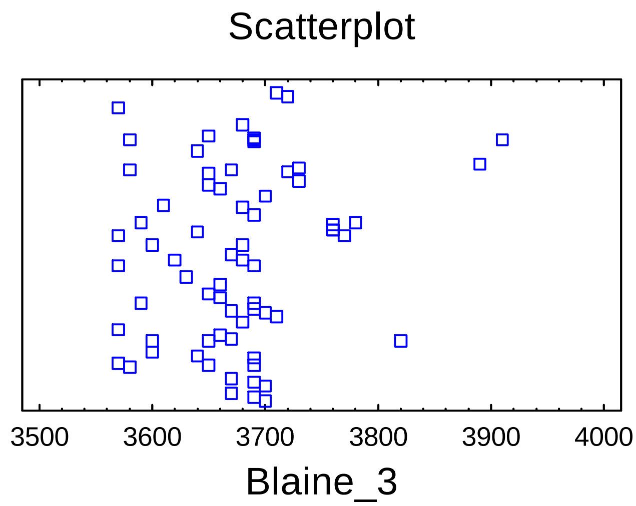

```
One-Variable Analysis - Blaine_3

Analysis Summary

Data variable: Blaine_3

69 values ranging from 3570,0 to 3910,0

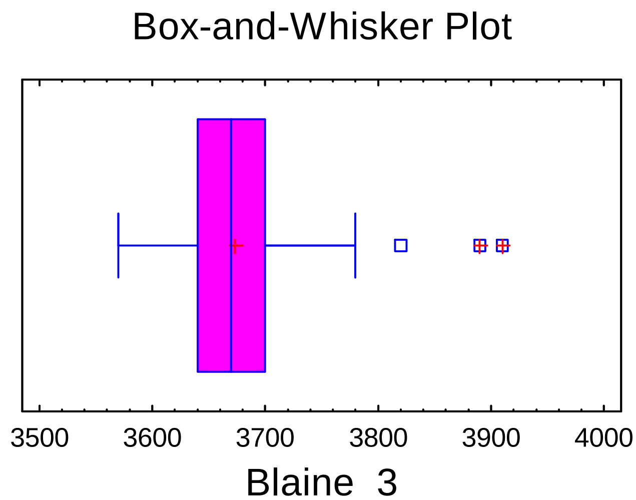

The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```

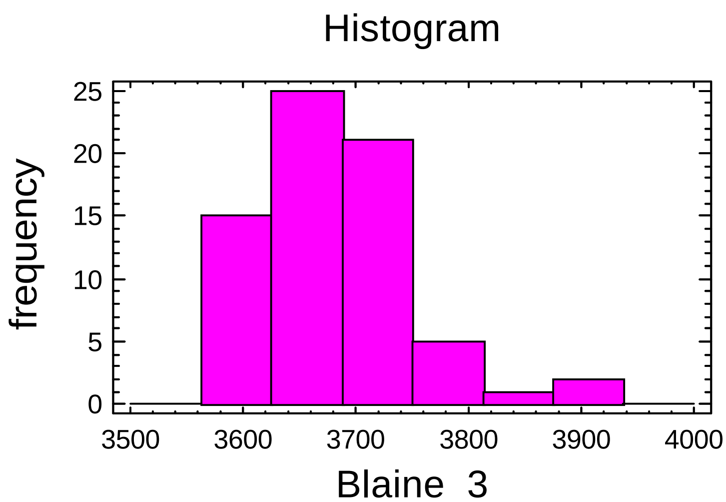



```
Summary Statistics for Blaine_3

Count = 69
Average = 3673,48
Variance = 4602,43
Standard deviation = 67,8412
Minimum = 3570,0
Maximum = 3910,0
Range = 340,0
Stnd. skewness = 3,34393
Stnd. kurtosis = 3,97549


The StatAdvisor
---------------
   This table shows summary statistics for Blaine_3.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is not within the range expected for data from a normal
distribution.  The standardized kurtosis value is not within the range
expected for data from a normal distribution.
```






```
Uncensored Data - Blaine_3

Analysis Summary

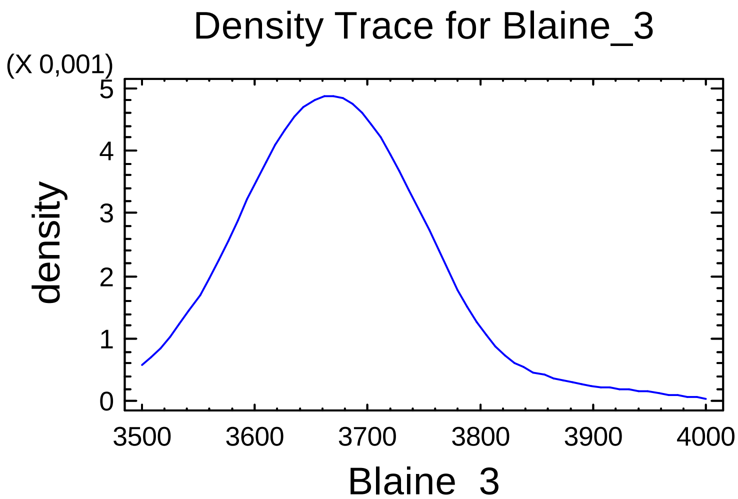
Data variable: Blaine_3

69 values ranging from 3570,0 to 3910,0

Fitted normal distribution:
     mean = 3673,48
     standard deviation = 67,8412


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Blaine_3.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
```

press the alternate mouse button and select Analysis Options.




```
Tests for Normality for Blaine_3

Computed Chi-Square goodness-of-fit statistic = 48,1739
P-Value = 0,000141856

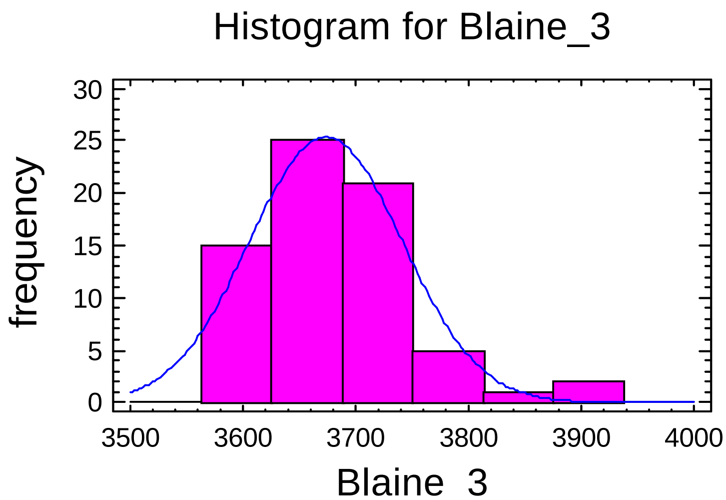
Shapiro-Wilks W statistic = 0,914866
P-Value = 0,0000751461

Z score for skewness = 2,21041
P-Value = 0,0270764

Z score for kurtosis = 2,65365
P-Value = 0,00796263



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Blaine_3 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Blaine_3 into 21 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,0000751461.
Because the P-value for this test is less than 0.01, we can reject the
idea that Blaine_3 comes from a normal distribution with 99%
confidence.
```



Goodness-of-Fit Tests for Blaine_3

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	3595,44	10	8,62	0,22
	3595,44	3627,72	5	8,62	1,52
	3627,72	3651,86	10	8,62	0,22
	3651,86	3673,48	10	8,63	0,22
	3673,48	3695,1	16	8,63	6,31
	3695,1	3719,24	6	8,62	0,80
	3719,24	3751,52	4	8,62	2,48
above	3751,52		8	8,62	0,05

Chi-Square = 11,811 with 5 d.f.   P-Value = 0,0374712

Estimated Kolmogorov statistic DPLUS = 0,145021
Estimated Kolmogorov statistic DMINUS = 0,0892784
Estimated overall statistic DN = 0,145021
Approximate P-Value = 0,109804

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,145021	1,21802	<0.01*
Anderson-Darling A^2	1,38244	1,39812	0,0013*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Blaine_3 can be adequately modeled by a normal distribution. The chi-square test divides the range of Blaine_3 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Blaine_3 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,145021. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.01, we can reject the idea that Blaine_3 comes from a normal distribution with 99% confidence.

One-Variable Analysis - Est1_3

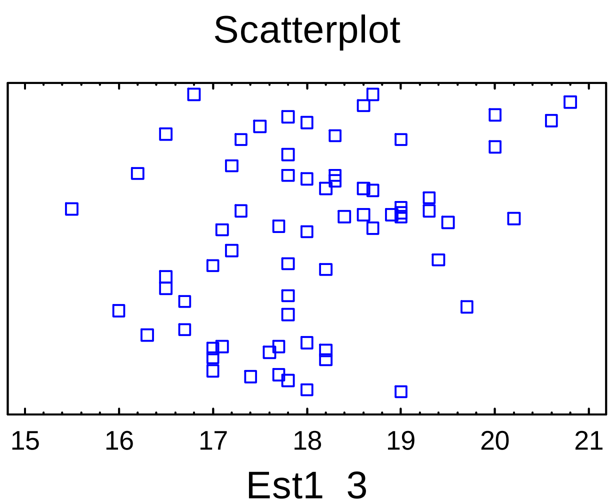
Analysis Summary

Data variable: Est1_3

68 values ranging from 15,5 to 20,8

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.



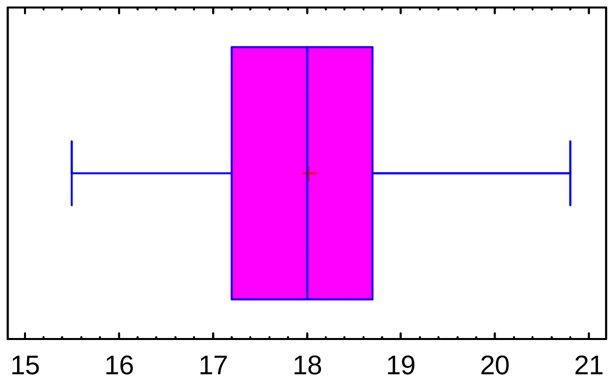
Summary Statistics for Est1_3

Count = 68
Average = 18,0265
Variance = 1,25332
Standard deviation = 1,11952
Minimum = 15,5
Maximum = 20,8
Range = 5,3
Stnd. skewness = 0,892448
Stnd. kurtosis = -0,154937

The StatAdvisor

This table shows summary statistics for Est1_3. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.

Box-and-Whisker Plot



One-Variable Analysis - Est2_3

Analysis Summary

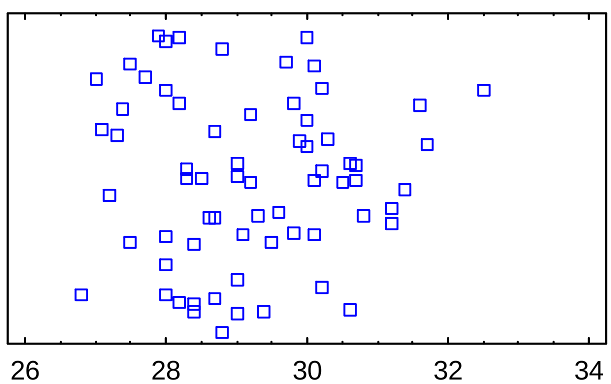
Data variable: Est2_3

67 values ranging from 26,8 to 32,5

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

Scatterplot



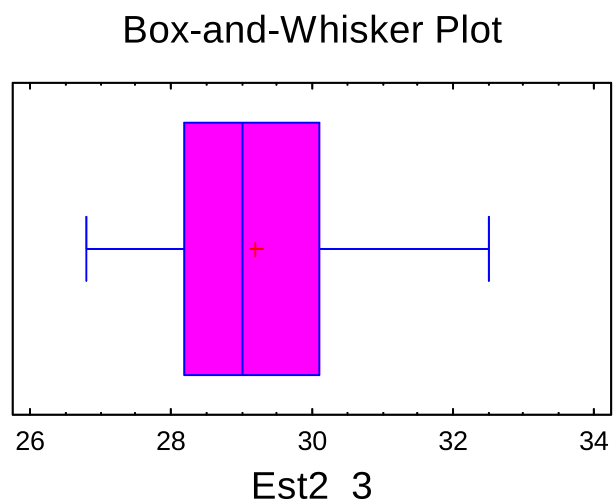
Summary Statistics for Est2_3

Count = 67
Average = 29,191
Variance = 1,66871

```
Standard deviation = 1,29178
Minimum = 26,8
Maximum = 32,5
Range = 5,7
Stnd. skewness = 0,896451
Stnd. kurtosis = -0,870309
```

The StatAdvisor

This table shows summary statistics for Est2_3. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



One-Variable Analysis - Est7_3

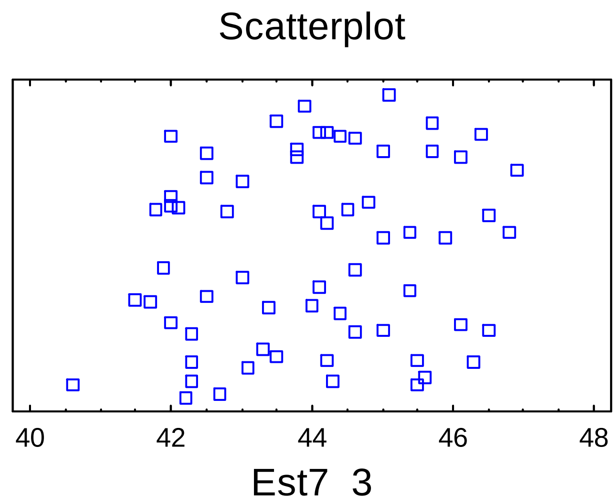
Analysis Summary

Data variable: Est7_3

64 values ranging from 40,6 to 46,9

The StatAdvisor

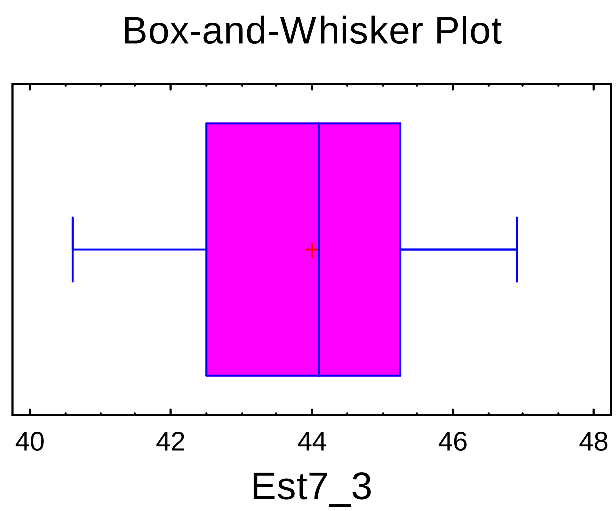
This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.




```
Summary Statistics for Est7_3

Count = 64
Average = 43,9922
Variance = 2,4401
Standard deviation = 1,56208
Minimum = 40,6
Maximum = 46,9
Range = 6,3
Stnd. skewness = 0,00679492
Stnd. kurtosis = -1,55348


The StatAdvisor
---------------
   This table shows summary statistics for Est7_3.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```



One-Variable Analysis - Est28_3

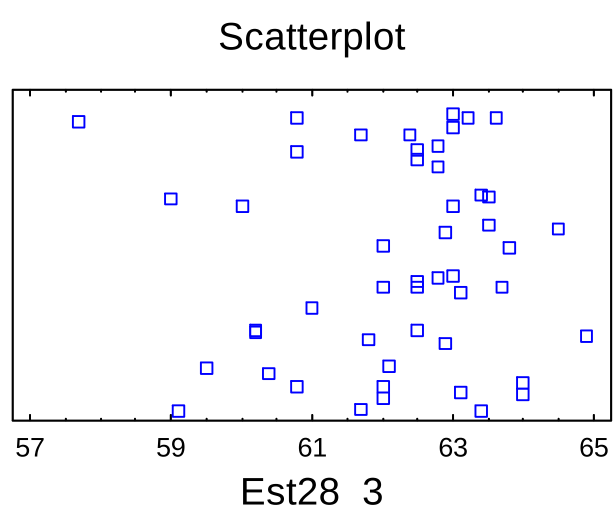
Analysis Summary

Data variable: Est28_3

49 values ranging from 57,7 to 64,9

The StatAdvisor

   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.



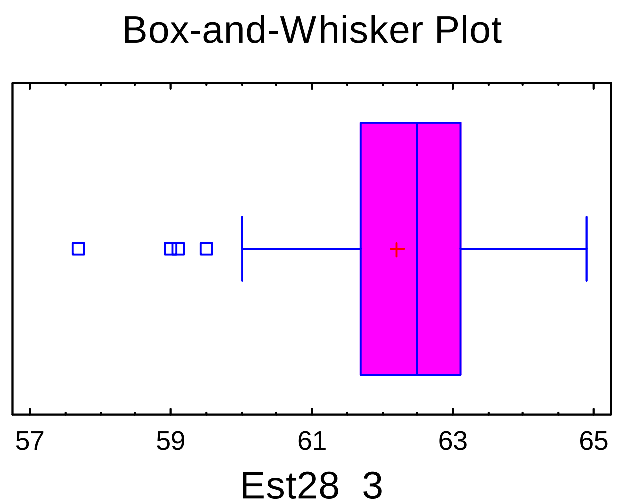
Summary Statistics for Est28_3

Count = 49
Average = 62,1959
Variance = 2,32165

Standard deviation = 1,5237
Minimum = 57,7
Maximum = 64,9
Range = 7,2
Stnd. skewness = -2,58329
Stnd. kurtosis = 0,876608

The StatAdvisor

This table shows summary statistics for Est28_3. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is not within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Uncensored Data - Est28_3

Analysis Summary

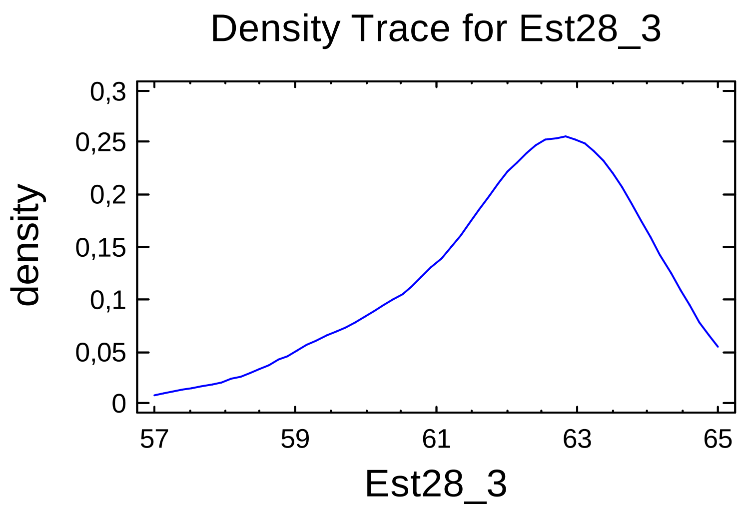
Data variable: Est28_3

49 values ranging from 57,7 to 64,9

Fitted normal distribution:
mean = 62,1959
standard deviation = 1,5237

The StatAdvisor

This analysis shows the results of fitting a normal distribution to the data on Est28_3. The estimated parameters of the fitted distribution are shown above. You can test whether the normal distribution fits the data adequately by selecting Goodness-of-Fit Tests from the list of Tabular Options. You can also assess visually how well the normal distribution fits by selecting Frequency Histogram from the list of Graphical Options. Other options within the procedure allow you to compute and display tail areas and critical values for the distribution. To select a different distribution, press the alternate mouse button and select Analysis Options.




```
Tests for Normality for Est28_3

Computed Chi-Square goodness-of-fit statistic = 22,6327
P-Value = 0,0922569

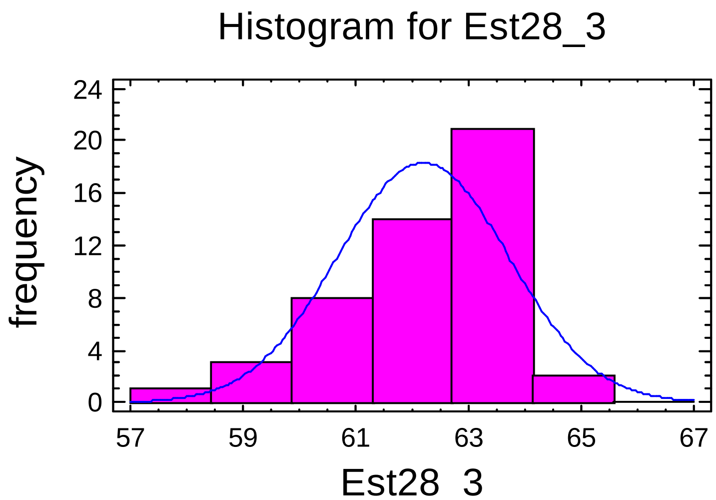
Shapiro-Wilks W statistic = 0,935966
P-Value = 0,0144441

Z score for skewness = 1,7851
P-Value = 0,074244

Z score for kurtosis = 1,03262
P-Value = 0,301779



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est28_3 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est28_3 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,0144441.
Because the P-value for this test is less than 0.05, we can reject the
idea that Est28_3 comes from a normal distribution with 95% confidence.
```



Goodness-of-Fit Tests for Est28_3

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	60,5693	8	7,00	0,14
	60,5693	61,3336	4	7,00	1,29
	61,3336	61,9216	3	7,00	2,29
	61,9216	62,4702	6	7,00	0,14
	62,4702	63,0583	14	7,00	7,00
	63,0583	63,8226	10	7,00	1,29
above	63,8226		4	7,00	1,29

Chi-Square = 13,4287 with 4 d.f.   P-Value = 0,00936024

Estimated Kolmogorov statistic DPLUS = 0,0773865
Estimated Kolmogorov statistic DMINUS = 0,150522
Estimated overall statistic DN = 0,150522
Approximate P-Value = 0,217277

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,150522	1,07043	<0.01*
Anderson-Darling A^2	1,18464	1,20388	0,0039*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est28_3 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est28_3 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est28_3 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,150522. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.01, we can reject the idea that Est28_3 comes from a normal distribution with 99% confidence.

Multiple Regression - Est1_3

Multiple Regression Analysis

Dependent variable: Est1_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	16,5879	51,8701	0,319797	0,7501
CLK_3	-0,120695	0,545627	-0,221204	0,8256
Blaine_3	0,00355834	0,00203216	1,75102	0,0847

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,7893	2	1,89465	1,54	0,2230
Residual	80,1831	65	1,23359		
Total (Corr.)	83,9724	67			

R-squared = 4,51256 percent
R-squared (adjusted for d.f.) = 1,57448 percent
Standard Error of Est. = 1,11067
Mean absolute error = 0,853729
Durbin-Watson statistic = 1,13485 (P=0,0001)
Lag 1 residual autocorrelation = 0,427979

The StatAdvisor

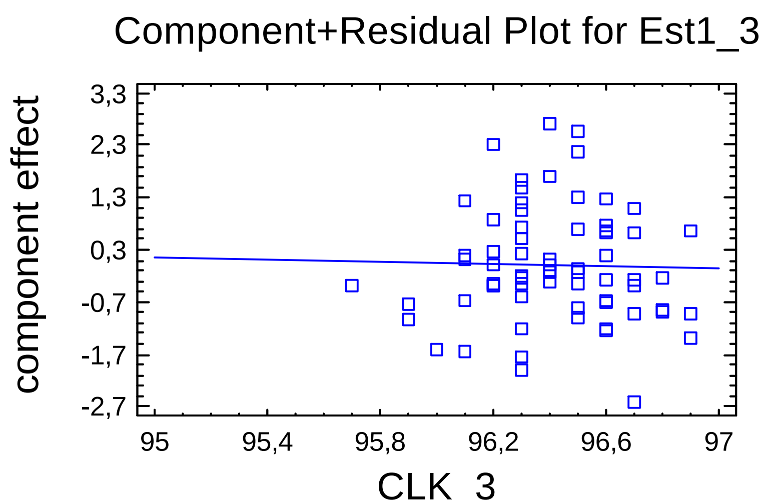
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1_3 and 2 independent variables. The equation of the fitted model is

Est1_3 = 16,5879 - 0,120695*CLK_3 + 0,00355834*Blaine_3

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 4,51256% of the variability in Est1_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 1,57448%. The standard error of the estimate shows the standard deviation of the residuals to be 1,11067. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,853729 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,8256, belonging to CLK_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing CLK_3 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_3	Blaine_3
CONSTANT	1,0000	-0,9899	0,0273
CLK_3	-0,9899	1,0000	-0,1689
Blaine_3	0,0273	-0,1689	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est1_3

Multiple Regression Analysis

Dependent variable: Est1_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	18,0265	0,135761	132,781	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0	0			
Residual	83,9724	67	1,25332		
Total (Corr.)	83,9724	67			

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,11952
Mean absolute error = 0,879585
Durbin-Watson statistic = 1,17134 (P=0,0002)
Lag 1 residual autocorrelation = 0,406099

Stepwise regression

```
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  67 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,25332

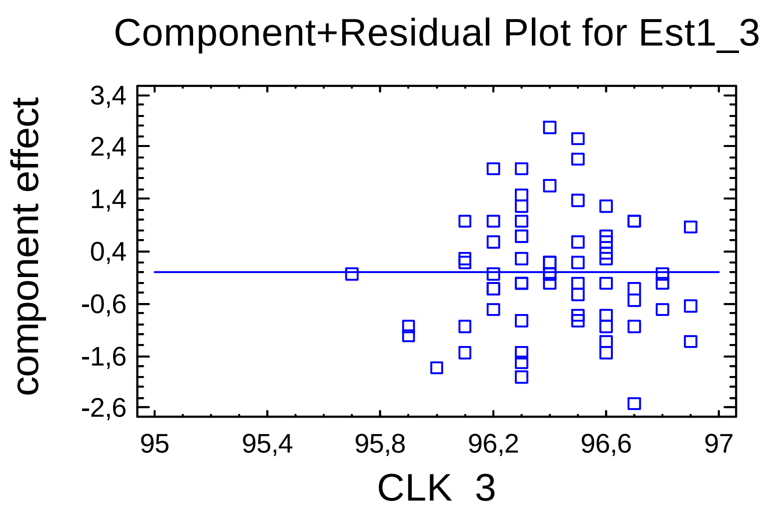
     Final model selected.
```

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1_3 and 2 independent variables. The equation of the fitted model is

Est1_3 = 18,0265

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est1_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,11952. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,879585 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in

the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est2_3

Multiple Regression Analysis

Dependent variable: Est2_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	29,191	0,157817	184,968	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0	0			
Residual	110,135	66	1,66871		
Total (Corr.)	110,135	66			

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,29178
Mean absolute error = 1,07423
Durbin-Watson statistic = 1,44532 (P=0,0110)
Lag 1 residual autocorrelation = 0,271197

Stepwise regression

Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

Step 0:
----
0 variables in the model. 66 d.f. for error.
R-squared =   0,00%   Adjusted R-squared =   0,00%   MSE = 1,66871

Final model selected.

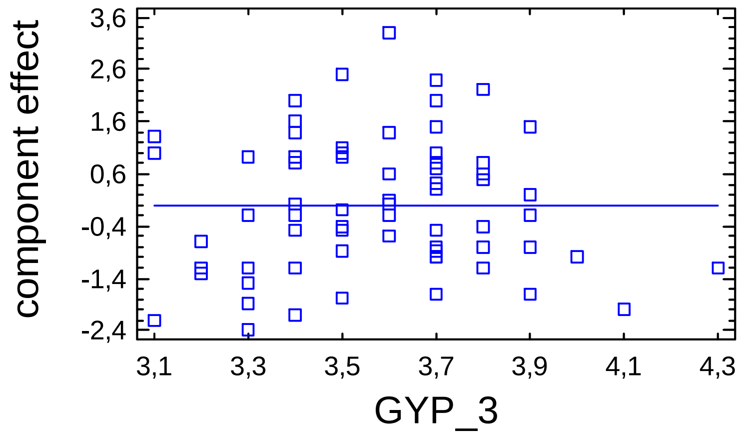
The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2_3 and 3 independent variables. The equation of the fitted model is

Est2_3 = 29,191

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est2_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,29178. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,07423 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

Component+Residual Plot for Est2_3




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est2_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic         P-Value
-----------------------------------------------------------------------------
CONSTANT                 41,5619       62,5487        0,664473          0,5088
CLK_3                  -0,237812      0,655206       -0,362957          0,7178
Blaine_3              0,00287281    0,00238408           1,205          0,2326
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     2,50606      2      1,25303       0,75       0,4788
Residual                  107,629     64       1,6817
-----------------------------------------------------------------------------
Total (Corr.)             110,135     66

R-squared = 2,27545 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,2968
Mean absolute error = 1,06241
Durbin-Watson statistic = 1,41673 (P=0,0054)
Lag 1 residual autocorrelation = 0,287393
```

The StatAdvisor

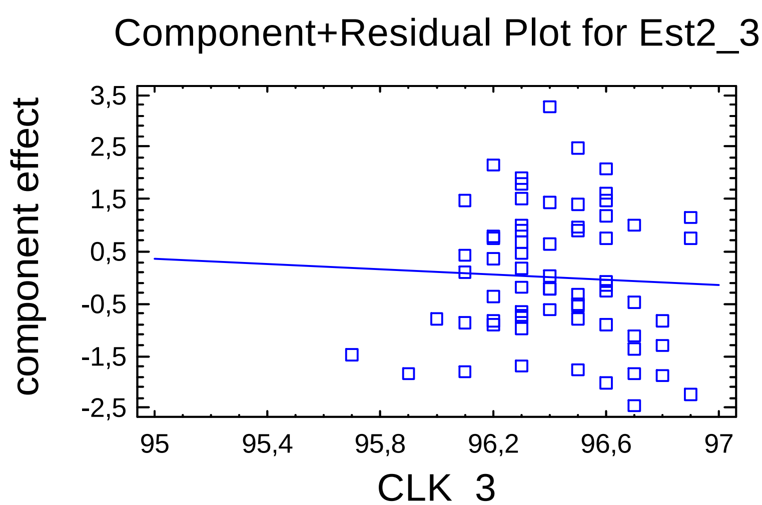
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2_3 and 2 independent variables. The equation of the fitted model is

Est2_3 = 41,5619 - 0,237812*CLK_3 + 0,00287281*Blaine_3

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 2,27545% of the variability in Est2_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,2968. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,06241 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7178, belonging to CLK_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing CLK_3 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_3	Blaine_3
CONSTANT	1,0000	-0,9903	0,0020
CLK_3	-0,9903	1,0000	-0,1407
Blaine_3	0,0020	-0,1407	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est7_3

Multiple Regression Analysis

Dependent variable: Est7_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	103,579	78,0255	1,3275	0,1893
CLK_3	-0,747787	0,814227	-0,918401	0,3620
Blaine_3	0,00340307	0,00298395	1,14046	0,2586

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	4,71377	2	2,35688	0,96	0,3868
Residual	149,012	61	2,44283		
Total (Corr.)	153,726	63			

R-squared = 3,06634 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,56295
Mean absolute error = 1,27755
Durbin-Watson statistic = 1,20556 (P=0,0003)
Lag 1 residual autocorrelation = 0,39444

The StatAdvisor

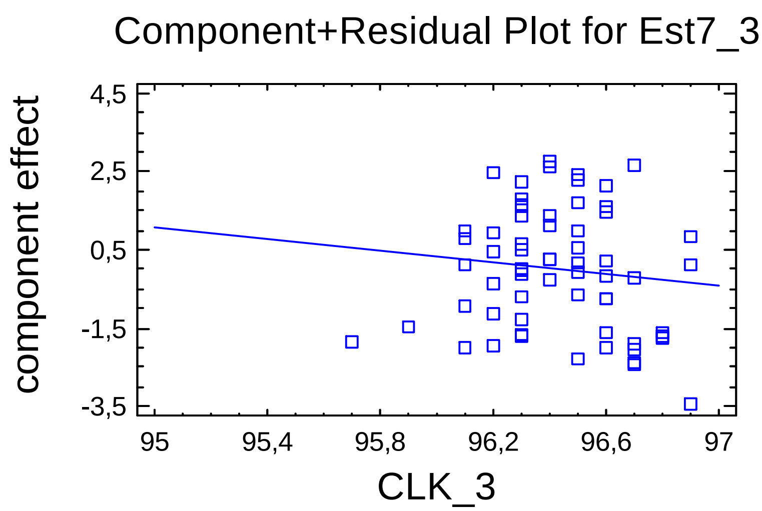
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7_3 and 2 independent variables. The equation of the fitted model is

Est7_3 = 103,579 - 0,747787*CLK_3 + 0,00340307*Blaine_3

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 3,06634% of the variability in Est7_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,56295. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,27755 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,3620, belonging to CLK_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing CLK_3 from the model.




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT           CLK_3       Blaine_3
CONSTANT                  1,0000         -0,9902        -0,0256
CLK_3                    -0,9902          1,0000        -0,1144
Blaine_3                 -0,0256         -0,1144         1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est7_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 43,9922        0,19526          225,3         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square     F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  153,726     63       2,4401
-----------------------------------------------------------------------------
Total (Corr.)             153,726     63

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,56208
Mean absolute error = 1,30542
Durbin-Watson statistic = 1,30837 (P=0,0024)
Lag 1 residual autocorrelation = 0,344588


Stepwise regression
-------------------
```

```
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  63 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 2,4401

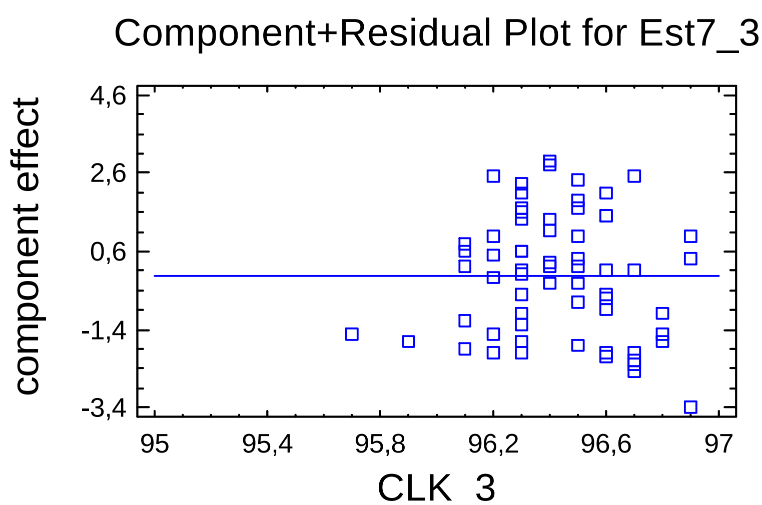
     Final model selected.
```

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7_3 and 2 independent variables. The equation of the fitted model is

Est7_3 = 43,9922

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est7_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,56208. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,30542 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in

the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est28_3

Multiple Regression Analysis

Dependent variable: Est28_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	62,1959	0,217671	285,734	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0	0			
Residual	111,439	48	2,32165		
Total (Corr.)	111,439	48			

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,5237
Mean absolute error = 1,1885
Durbin-Watson statistic = 1,53887 (P=0,0536)
Lag 1 residual autocorrelation = 0,208333

Stepwise regression

Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

Step 0:

0 variables in the model. 48 d.f. for error.
R-squared =   0,00%   Adjusted R-squared =   0,00%   MSE = 2,32165

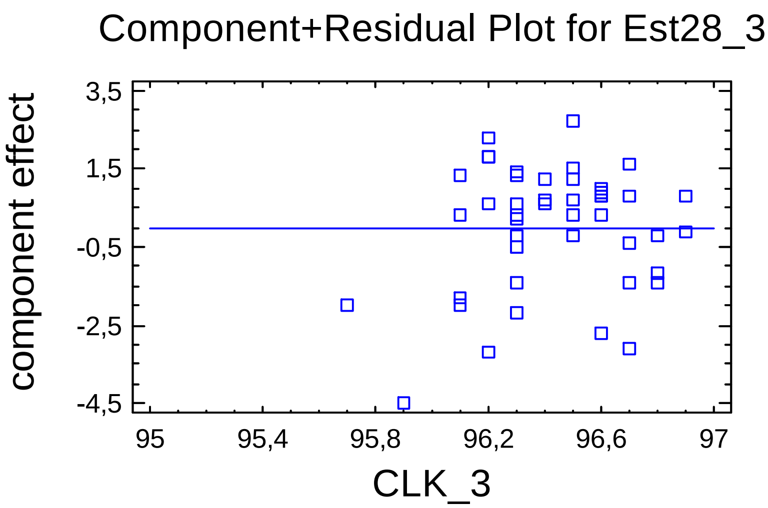
Final model selected.

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_3 and 2 independent variables. The equation of the fitted model is

Est28_3 = 62,1959

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est28_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,5237. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,1885 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est28_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est28_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                -38,4727       82,8004       -0,464644         0,6444
CLK_3                   0,970306      0,862756         1,12466         0,2666
Blaine_3              0,00192984    0,00313476        0,615627         0,5412
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     4,20913      2      2,10456       0,90       0,4125
Residual                   107,23     46      2,33109
-----------------------------------------------------------------------------
Total (Corr.)             111,439     48

R-squared = 3,77706 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,52679
Mean absolute error = 1,18122
Durbin-Watson statistic = 1,5605 (P=0,0460)
Lag 1 residual autocorrelation = 0,193327
```

The StatAdvisor

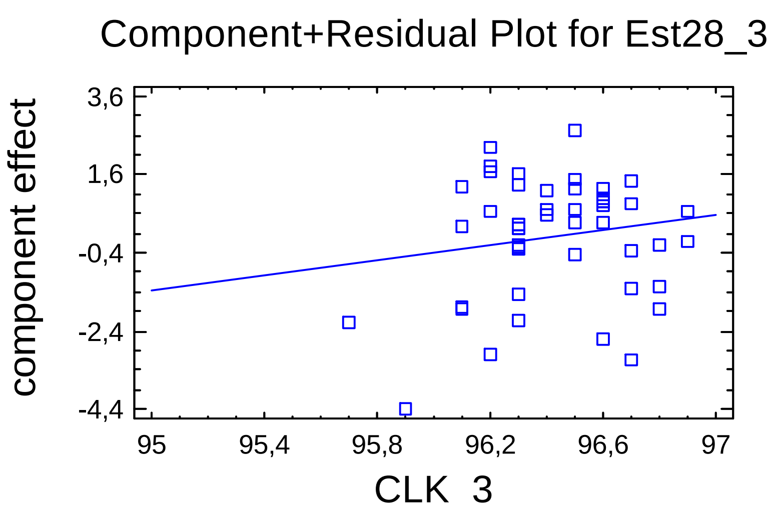
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_3 and 2 independent variables. The equation of the fitted model is

Est28_3 = -38,4727 + 0,970306*CLK_3 + 0,00192984*Blaine_3

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 3,77706% of the variability in Est28_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,52679. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,18122 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,5412, belonging to Blaine_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_3 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_3	Blaine_3
CONSTANT	1,0000	-0,9903	-0,0360
CLK_3	-0,9903	1,0000	-0,1030
Blaine_3	-0,0360	-0,1030	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).

Στατιστική ανάλυση δεδομένων ποιότητα τσιμέντου OPC - μύλος 4

One-Variable Analysis - CLK_4

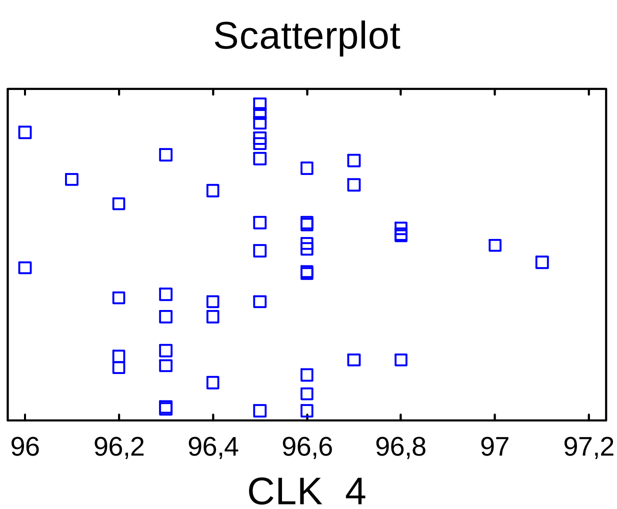
Analysis Summary

Data variable: CLK_4

47 values ranging from 96,0 to 97,1

The StatAdvisor

   This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.



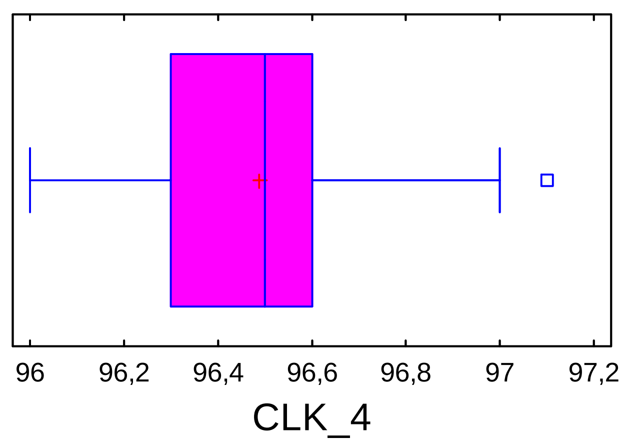
Summary Statistics for CLK_4

Count = 47
Average = 96,4894
Variance = 0,0548844
Standard deviation = 0,234274
Minimum = 96,0
Maximum = 97,1
Range = 1,1
Stnd. skewness = 0,403446
Stnd. kurtosis = 0,422985

The StatAdvisor

   This table shows summary statistics for CLK_4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized

skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Individuals Charts - CLK_4

```
X and MR(2) - Initial Study for CLK_4

Number of observations = 44
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 97,0606
Centerline      = 96,4977
LCL: -3,0 sigma = 95,9349

1 beyond limits

MR(2) Chart
-----------
UCL: +3,0 sigma = 0,691731
Centerline      = 0,211628
LCL: -3,0 sigma = 0,0

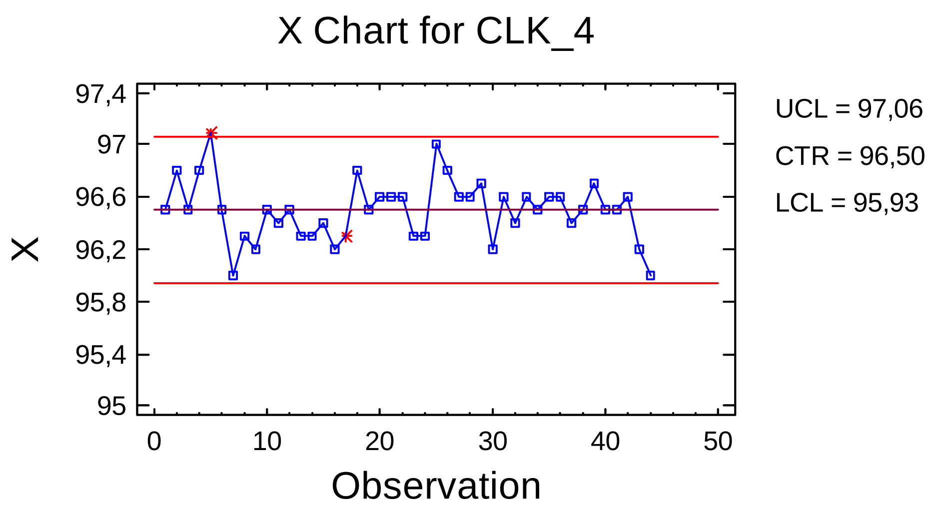
1 beyond limits

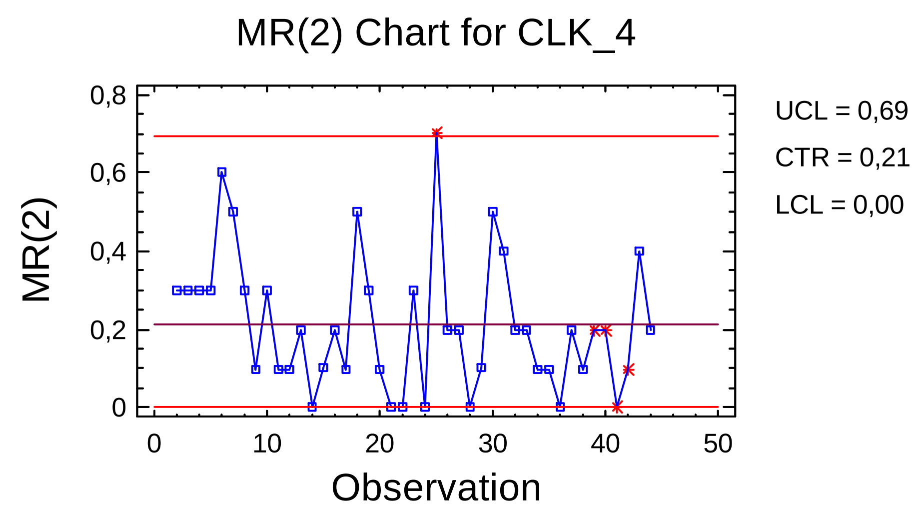
Estimates
---------
Process mean = 96,4977
Process sigma = 0,187613
Mean MR(2) = 0,211628
```

The StatAdvisor

This procedure creates an individuals chart for CLK_4. It is designed to allow you to determine whether the data come from a process which is in a state of statistical control. The control charts are constructed under the assumption that the data come from a normal distribution with a mean equal to 96,4977 and a standard deviation equal to 0,187613. These parameters were estimated from the data. Of the 44 nonexcluded points shown on the charts, 1 is beyond

the control limits on the first chart while 1 is beyond the limits on
the second chart. Since the probability of seeing 1 or more points
beyond the limits just by chance is 0,00118728 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.





One-Variable Analysis - GYP_4

Analysis Summary

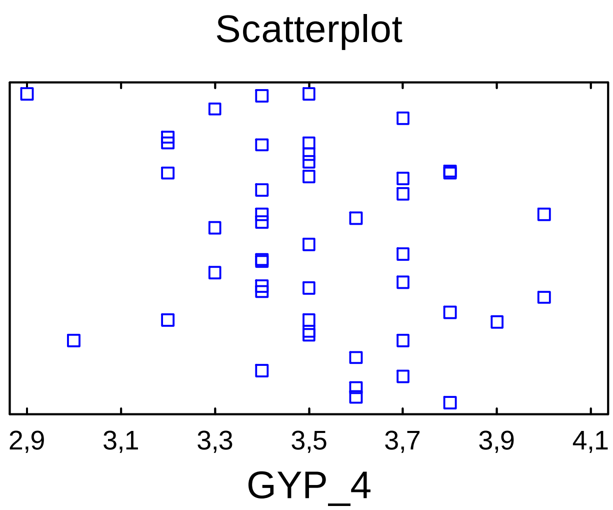
Data variable: GYP_4

47 values ranging from 2,9 to 4,0

The StatAdvisor

This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs. Also included in the
procedure are confidence intervals and hypothesis tests. Use the

Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.

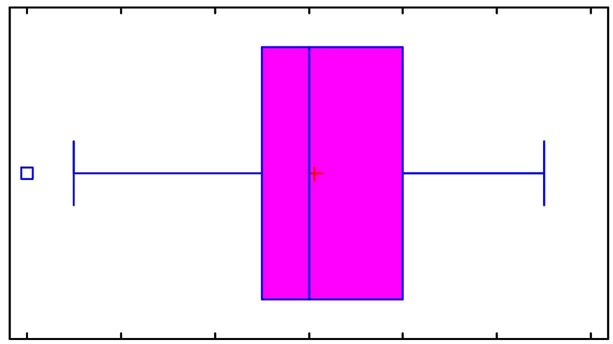



```
Summary Statistics for GYP_4

Count = 47
Average = 3,51064
Variance = 0,0548844
Standard deviation = 0,234274
Minimum = 2,9
Maximum = 4,0
Range = 1,1
Stnd. skewness = -0,403446
Stnd. kurtosis = 0,422985


The StatAdvisor
---------------
   This table shows summary statistics for GYP_4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```

Box-and-Whisker Plot



Individuals Charts - GYP_4

```
X and MR(2) - Initial Study for GYP_4

Number of observations = 44
0 observations excluded

X Chart
-------
UCL: +3,0 sigma = 4,06511
Centerline      = 3,50227
LCL: -3,0 sigma = 2,93943

1 beyond limits

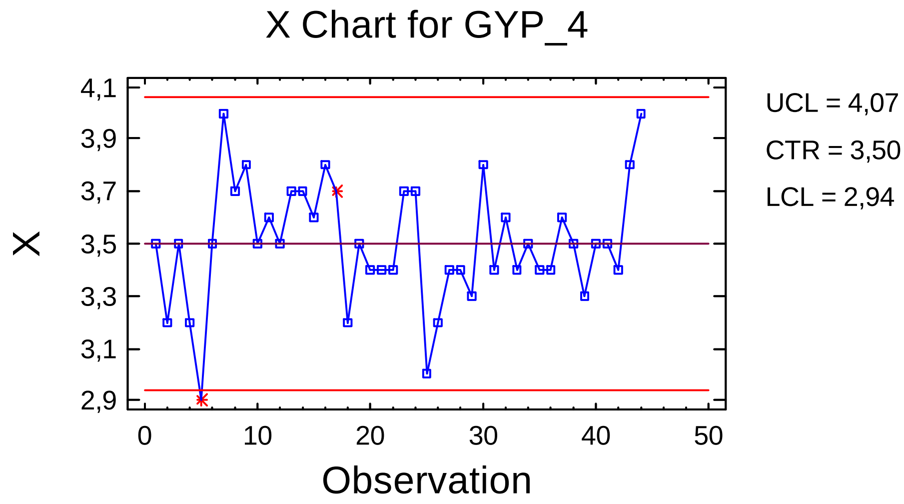
MR(2) Chart
-----------
UCL: +3,0 sigma = 0,691731
Centerline      = 0,211628
LCL: -3,0 sigma = 0,0

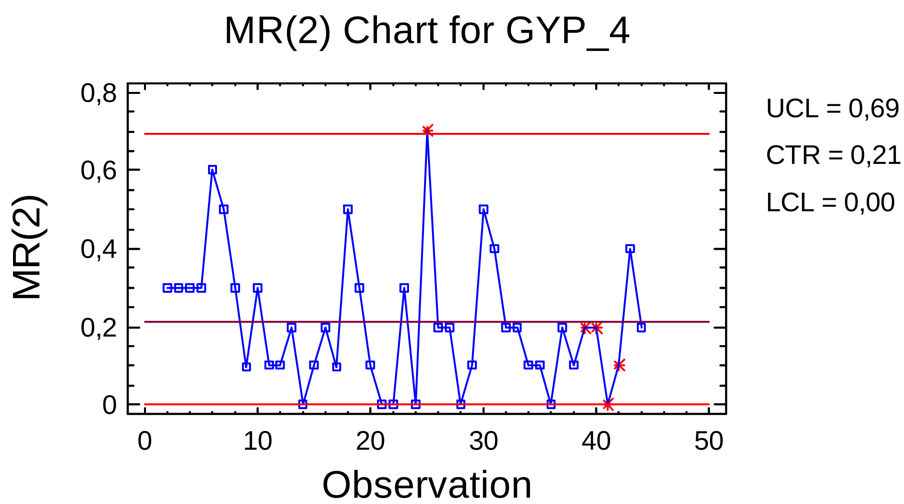
1 beyond limits

Estimates
---------
Process mean = 3,50227
Process sigma = 0,187613
Mean MR(2) = 0,211628



The StatAdvisor
---------------
   This procedure creates an individuals chart for GYP_4.  It is
designed to allow you to determine whether the data come from a
process which is in a state of statistical control.  The control
charts are constructed under the assumption that the data come from a
normal distribution with a mean equal to 3,50227 and a standard
deviation equal to 0,187613.  These parameters were estimated from the
data.  Of the 44 nonexcluded points shown on the charts, 1 is beyond
the control limits on the first chart while 1 is beyond the limits on
the second chart.  Since the probability of seeing 1 or more points
beyond the limits just by chance is 0,00118728 if the data comes from
the assumed distribution, we can declare the process to be out of
control at the 99% confidence level.
```






```
One-Variable Analysis - Blaine_4

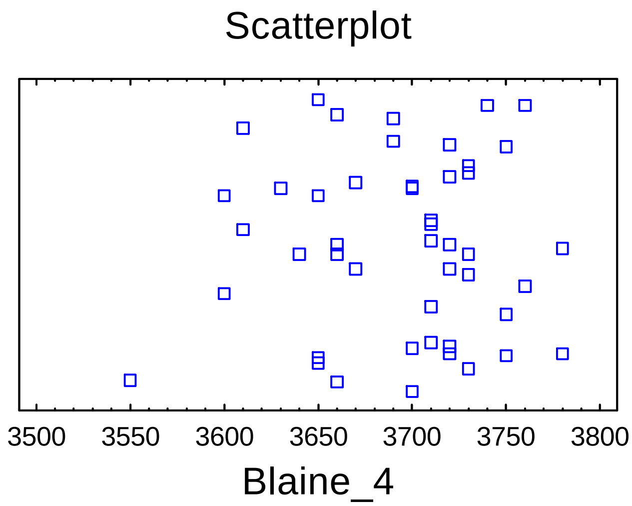
Analysis Summary

Data variable: Blaine_4

47 values ranging from 3550,0 to 3780,0


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
```

to access these different procedures.

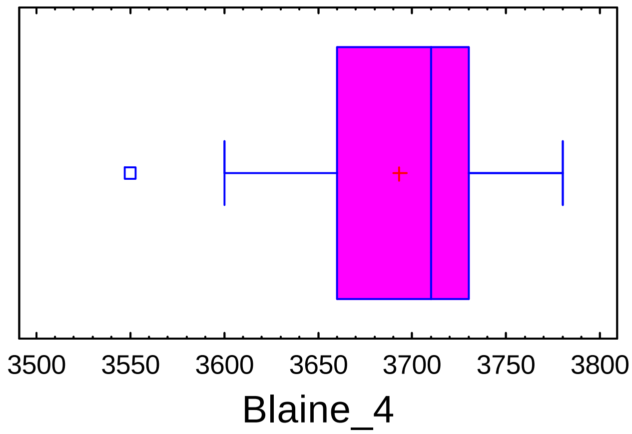



```
Summary Statistics for Blaine_4

Count = 47
Average = 3693,4
Variance = 2609,9
Standard deviation = 51,0872
Minimum = 3550,0
Maximum = 3780,0
Range = 230,0
Stnd. skewness = -1,77869
Stnd. kurtosis = 0,172919


The StatAdvisor
---------------
   This table shows summary statistics for Blaine_4.  It includes
measures of central tendency, measures of variability, and measures of
shape.  Of particular interest here are the standardized skewness and
standardized kurtosis, which can be used to determine whether the
sample comes from a normal distribution.  Values of these statistics
outside the range of -2 to +2 indicate significant departures from
normality, which would tend to invalidate any statistical test
regarding the standard deviation.  In this case, the standardized
skewness value is within the range expected for data from a normal
distribution.  The standardized kurtosis value is within the range
expected for data from a normal distribution.
```

Box-and-Whisker Plot




```
One-Variable Analysis - Est1_4

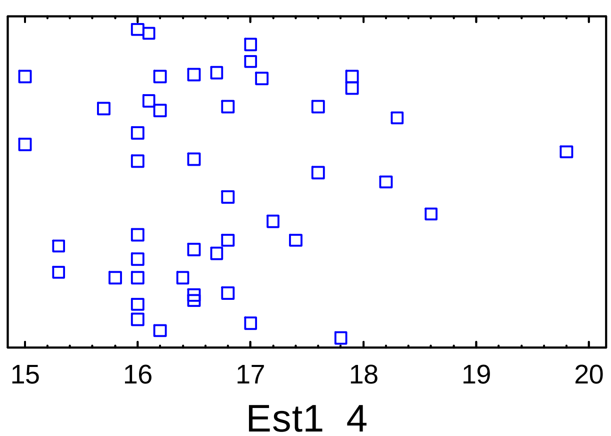
Analysis Summary

Data variable: Est1_4

46 values ranging from 15,0 to 19,8


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```

Scatterplot



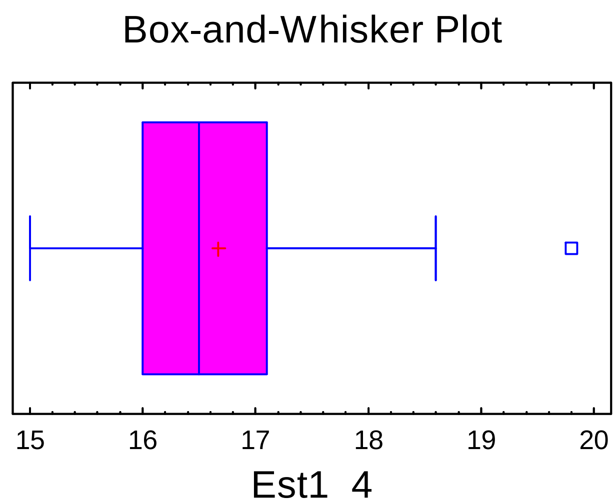

```
Summary Statistics for Est1_4

Count = 46
Average = 16,6696
Variance = 0,935498
```

```
Standard deviation = 0,967211
Minimum = 15,0
Maximum = 19,8
Range = 4,8
Stnd. skewness = 2,42906
Stnd. kurtosis = 1,84664
```

The StatAdvisor

This table shows summary statistics for Est1_4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is not within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Uncensored Data - Est1_4

Analysis Summary

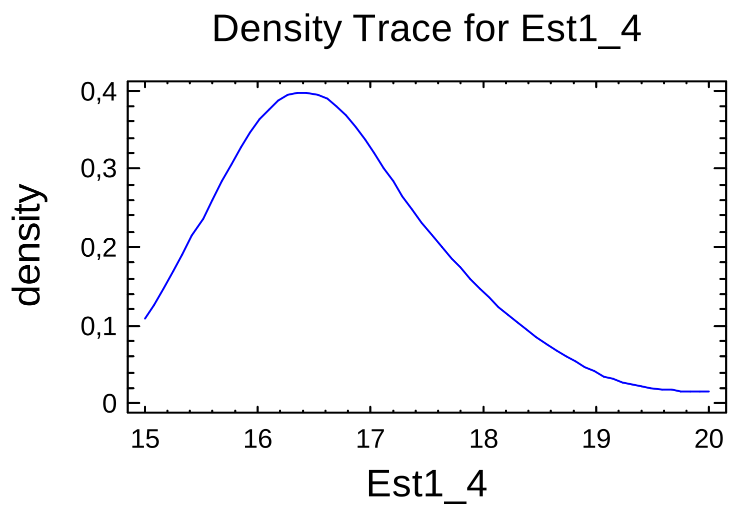
Data variable: Est1_4

46 values ranging from 15,0 to 19,8

```
Fitted normal distribution:
     mean = 16,6696
     standard deviation = 0,967211
```

The StatAdvisor

This analysis shows the results of fitting a normal distribution to the data on Est1_4. The estimated parameters of the fitted distribution are shown above. You can test whether the normal distribution fits the data adequately by selecting Goodness-of-Fit Tests from the list of Tabular Options. You can also assess visually how well the normal distribution fits by selecting Frequency Histogram from the list of Graphical Options. Other options within the procedure allow you to compute and display tail areas and critical values for the distribution. To select a different distribution, press the alternate mouse button and select Analysis Options.




```
Tests for Normality for Est1_4

Computed Chi-Square goodness-of-fit statistic = 35,3913
P-Value = 0,00216224

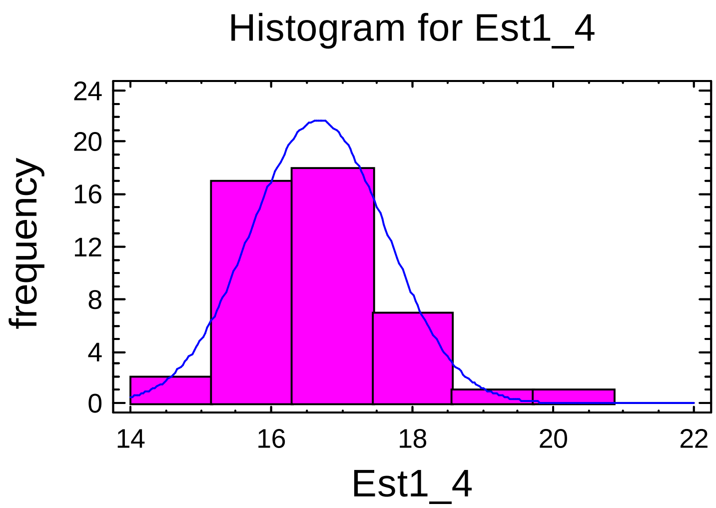
Shapiro-Wilks W statistic = 0,947304
P-Value = 0,0575996

Z score for skewness = 1,69611
P-Value = 0,0898646

Z score for kurtosis = 1,68636
P-Value = 0,0917257



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est1_4 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est1_4 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,00216224.
Because the P-value for this test is less than 0.01, we can reject the
idea that Est1_4 comes from a normal distribution with 99% confidence.
```



Goodness-of-Fit Tests for Est1_4

Chi-Square Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chi-Square
	at or below	15,637	4	6,57	1,01
	15,637	16,1222	12	6,57	4,48
	16,1222	16,4955	4	6,57	1,01
	16,4955	16,8437	11	6,57	2,98
	16,8437	17,217	5	6,57	0,38
	17,217	17,7021	3	6,57	1,94
above	17,7021		7	6,57	0,03

Chi-Square = 11,8256 with 4 d.f.   P-Value = 0,0186964

Estimated Kolmogorov statistic DPLUS = 0,120273
Estimated Kolmogorov statistic DMINUS = 0,11395
Estimated overall statistic DN = 0,120273
Approximate P-Value = 0,533381

EDF Statistic	Value	Modified Form	P-Value
Kolmogorov-Smirnov D	0,120273	0,829603	<0.10*
Anderson-Darling A^2	0,781327	0,794897	0,0395*

*Indicates that the P-Value has been compared to tables of critical values specially constructed for fitting the currently selected distribution. Other P-values are based on general tables and may be very conservative.

The StatAdvisor

This pane shows the results of tests run to determine whether Est1_4 can be adequately modeled by a normal distribution. The chi-square test divides the range of Est1_4 into nonoverlapping intervals and compares the number of observations in each class to the number expected based on the fitted distribution. The Kolmogorov-Smirnov test computes the maximum distance between the cumulative distribution of Est1_4 and the CDF of the fitted normal distribution. In this case, the maximum distance is 0,120273. The other EDF statistics compare the empirical distribution function to the fitted CDF in different ways.

Since the smallest P-value amongst the tests performed is less than 0.05, we can reject the idea that Est1_4 comes from a normal distribution with 95% confidence.

One-Variable Analysis - Est2_4

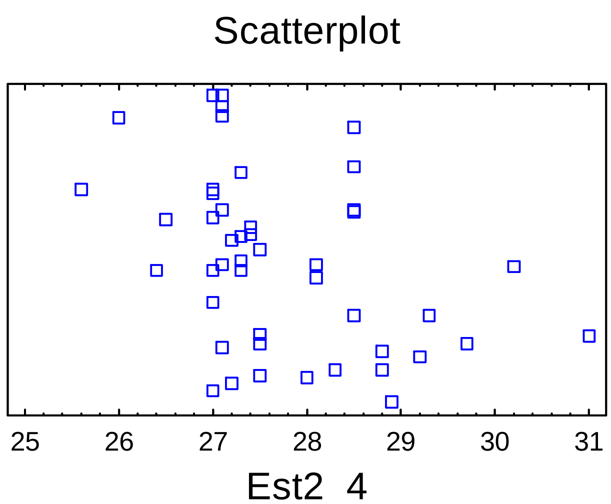
Analysis Summary

Data variable: Est2_4

46 values ranging from 25,6 to 31,0

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

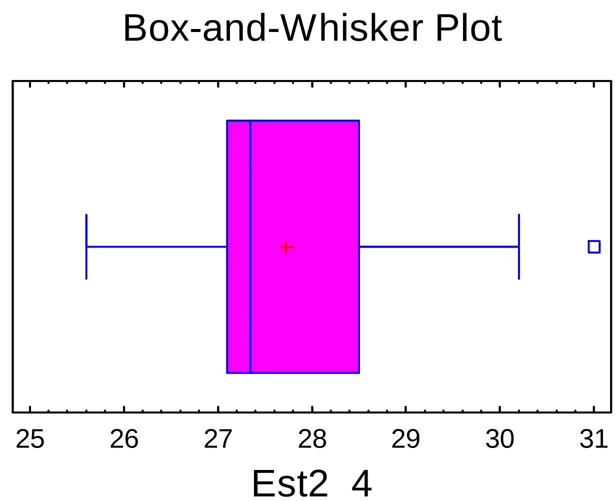


Summary Statistics for Est2_4

Count = 46
Average = 27,7261
Variance = 1,13886
Standard deviation = 1,06717
Minimum = 25,6
Maximum = 31,0
Range = 5,4
Stnd. skewness = 2,53816
Stnd. kurtosis = 1,59202

The StatAdvisor

This table shows summary statistics for Est2_4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is not within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.




```
Uncensored Data - Est2_4

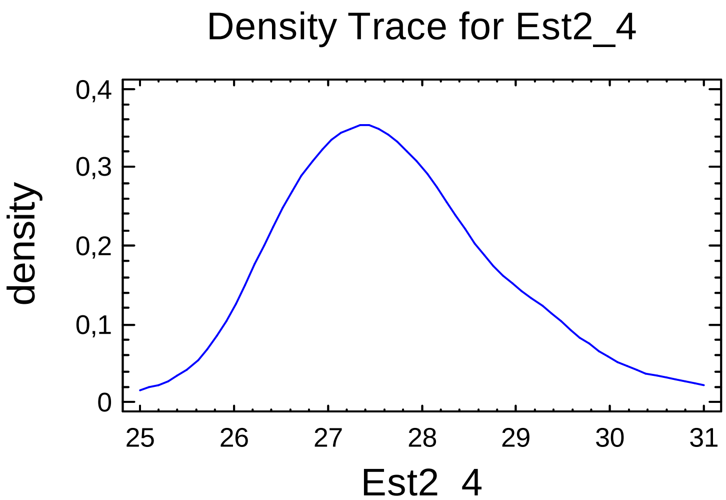
Analysis Summary

Data variable: Est2_4

46 values ranging from 25,6 to 31,0

Fitted normal distribution:
     mean = 27,7261
     standard deviation = 1,06717


The StatAdvisor
---------------
   This analysis shows the results of fitting a normal distribution to
the data on Est2_4.  The estimated parameters of the fitted
distribution are shown above.  You can test whether the normal
distribution fits the data adequately by selecting Goodness-of-Fit
Tests from the list of Tabular Options.  You can also assess visually
how well the normal distribution fits by selecting Frequency Histogram
from the list of Graphical Options.  Other options within the
procedure allow you to compute and display tail areas and critical
values for the distribution.  To select a different distribution,
press the alternate mouse button and select Analysis Options.
```




```
Tests for Normality for Est2_4

Computed Chi-Square goodness-of-fit statistic = 41,6522
P-Value = 0,00025418

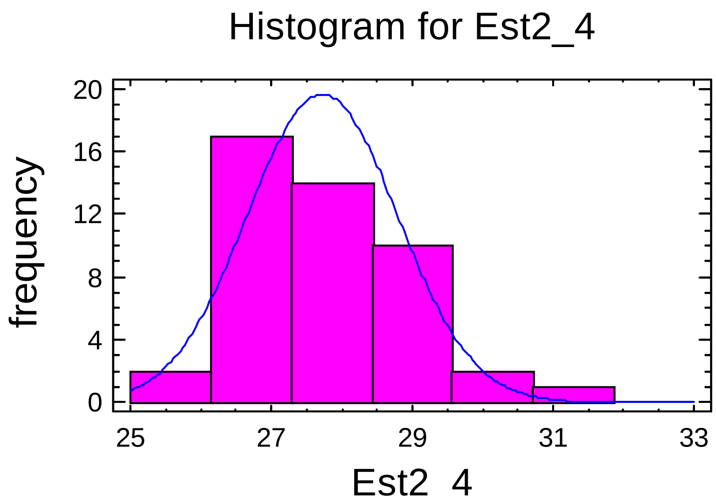
Shapiro-Wilks W statistic = 0,921587
P-Value = 0,00463415

Z score for skewness = 1,75972
P-Value = 0,0784556

Z score for kurtosis = 1,53445
P-Value = 0,124918



The StatAdvisor
---------------
   This pane shows the results of several tests run to determine
whether Est2_4 can be adequately modeled by a normal distribution.
The chi-square test divides the range of Est2_4 into 18 equally
probable classes and compares the number of observations in each class
to the number expected.  The Shapiro-Wilks test is based upon
comparing the quantiles of the fitted normal distribution to the
quantiles of the data.  The standardized skewness test looks for lack
of symmetry in the data.  The standardized kurtosis test looks for
distributional shape which is either flatter or more peaked than the
normal distribution.
   The lowest P-value amongst the tests performed equals 0,00025418.
Because the P-value for this test is less than 0.01, we can reject the
idea that Est2_4 comes from a normal distribution with 99% confidence.
```




```
Goodness-of-Fit Tests for Est2_4

                              Chi-Square Test
----------------------------------------------------------------------------
               Lower          Upper       Observed       Expected
               Limit          Limit      Frequency      Frequency    Chi-Square
----------------------------------------------------------------------------
         at or below        26,5868              4           6,57          1,01
             26,5868        27,1221             13           6,57          6,29
             27,1221         27,534             12           6,57          4,48
              27,534        27,9182              0           6,57          6,57
             27,9182        28,3301              4           6,57          1,01
             28,3301        28,8654              7           6,57          0,03
above        28,8654                             6           6,57          0,05
----------------------------------------------------------------------------
Chi-Square = 19,4352 with 4 d.f.   P-Value = 0,000645347

Estimated Kolmogorov statistic DPLUS = 0,214327
Estimated Kolmogorov statistic DMINUS = 0,161173
Estimated overall statistic DN = 0,214327
Approximate P-Value = 0,0292177

EDF Statistic          Value          Modified Form   P-Value
---------------------------------------------------------------------
Kolmogorov-Smirnov D   0,214327       1,47836         <0.01*
Anderson-Darling A^2   1,61297        1,64099         0,0003*
---------------------------------------------------------------------
*Indicates that the P-Value has been compared to tables of critical values
specially constructed for fitting the currently selected distribution.
Other P-values are based on general tables and may be very conservative.


The StatAdvisor
---------------
   This pane shows the results of tests run to determine whether
Est2_4 can be adequately modeled by a normal distribution.  The
chi-square test divides the range of Est2_4 into nonoverlapping
intervals and compares the number of observations in each class to the
number expected based on the fitted distribution.  The
Kolmogorov-Smirnov test computes the maximum distance between the
cumulative distribution of Est2_4 and the CDF of the fitted normal
distribution.  In this case, the maximum distance is 0,214327.  The
other EDF statistics compare the empirical distribution function to
the fitted CDF in different ways.
   Since the smallest P-value amongst the tests performed is less than
0.01, we can reject the idea that Est2_4 comes from a normal
distribution with 99% confidence.
```

One-Variable Analysis - Est7_4

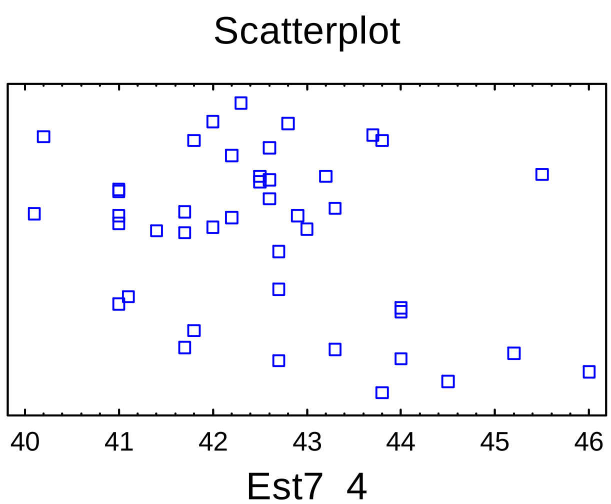
Analysis Summary

Data variable: Est7_4

43 values ranging from 40,1 to 46,0

The StatAdvisor

This procedure is designed to summarize a single sample of data. It will calculate various statistics and graphs. Also included in the procedure are confidence intervals and hypothesis tests. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

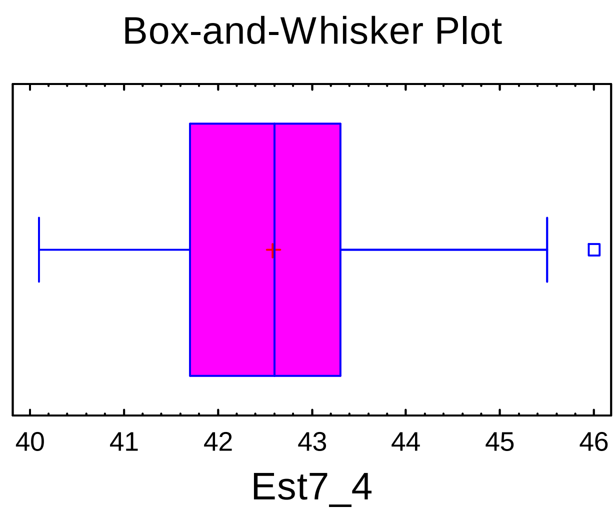


Summary Statistics for Est7_4

Count = 43
Average = 42,5837
Variance = 1,7933
Standard deviation = 1,33914
Minimum = 40,1
Maximum = 46,0
Range = 5,9
Stnd. skewness = 1,30825
Stnd. kurtosis = 0,243184

The StatAdvisor

This table shows summary statistics for Est7_4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



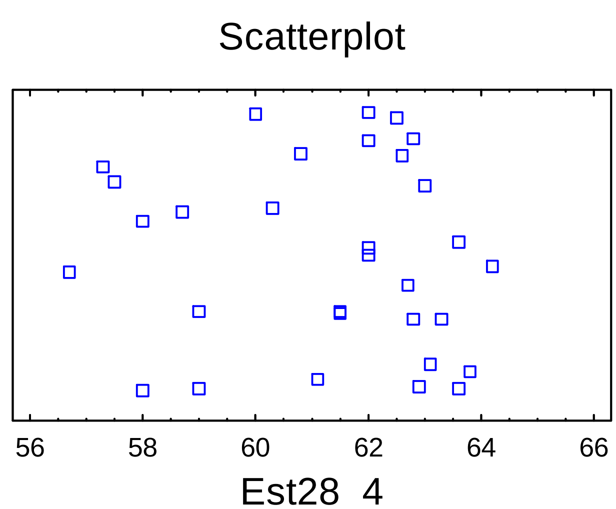

```
One-Variable Analysis - Est28_4

Analysis Summary

Data variable: Est28_4

31 values ranging from 56,7 to 64,2


The StatAdvisor
---------------
   This procedure is designed to summarize a single sample of data.
It will calculate various statistics and graphs.  Also included in the
procedure are confidence intervals and hypothesis tests.  Use the
Tabular Options and Graphical Options buttons on the analysis toolbar
to access these different procedures.
```



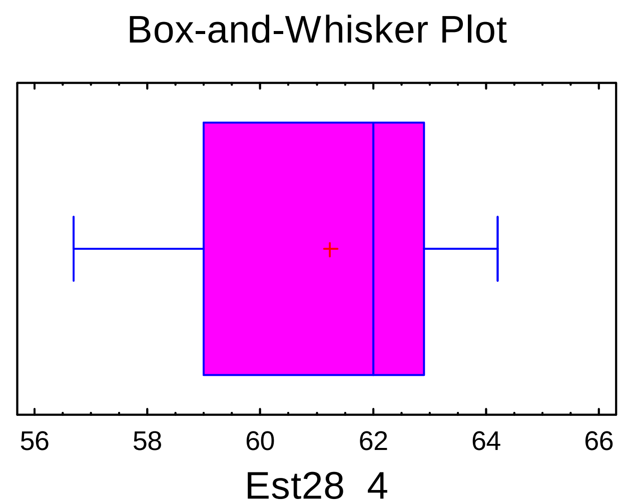

```
Summary Statistics for Est28_4

Count = 31
Average = 61,2355
Variance = 4,77103
```

```
Standard deviation = 2,18427
Minimum = 56,7
Maximum = 64,2
Range = 7,5
Stnd. skewness = -1,58248
Stnd. kurtosis = -0,879819
```

The StatAdvisor

This table shows summary statistics for Est28_4. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. In this case, the standardized skewness value is within the range expected for data from a normal distribution. The standardized kurtosis value is within the range expected for data from a normal distribution.



Multiple Regression - Est1_4

Multiple Regression Analysis

Dependent variable: Est1_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-46,5083	62,5817	-0,74316	0,4614
CLK_4	0,75	0,639456	1,17287	0,2473
Blaine_4	-0,00248938	0,00282113	-0,882404	0,3825

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	2,00842	2	1,00421	1,08	0,3496
Residual	40,089	43	0,932302		
Total (Corr.)	42,0974	45			

```
R-squared = 4,7709 percent
R-squared (adjusted for d.f.) = 0,341637 percent
Standard Error of Est. = 0,965558
```

```
Mean absolute error = 0,741182
Durbin-Watson statistic = 1,17854 (P=0,0013)
Lag 1 residual autocorrelation = 0,383286
```

The StatAdvisor

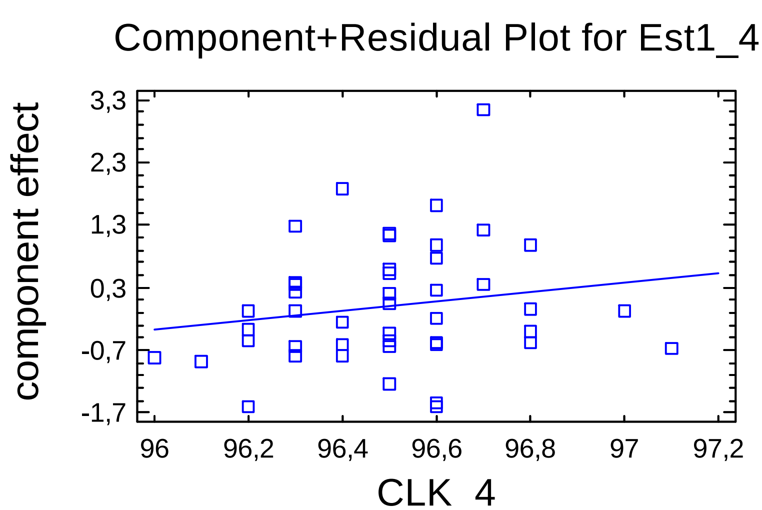
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1_4 and 2 independent variables. The equation of the fitted model is

Est1_4 = -46,5083 + 0,75*CLK_4 - 0,00248938*Blaine_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 4,7709% of the variability in Est1_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,341637%. The standard error of the estimate shows the standard deviation of the residuals to be 0,965558. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,741182 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,3825, belonging to Blaine_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_4 from the model.



Multiple Regression - Est1_4

Multiple Regression Analysis

Dependent variable: Est1_4

Parameter	Estimate	Standard Error	T Statistic	P-Value

```
CONSTANT                16,6696       0,142608        116,891         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  42,0974     45     0,935498
-----------------------------------------------------------------------------
Total (Corr.)             42,0974     45

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,967211
Mean absolute error = 0,736484
Durbin-Watson statistic = 1,08914 (P=0,0006)
Lag 1 residual autocorrelation = 0,429809


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  45 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 0,935498

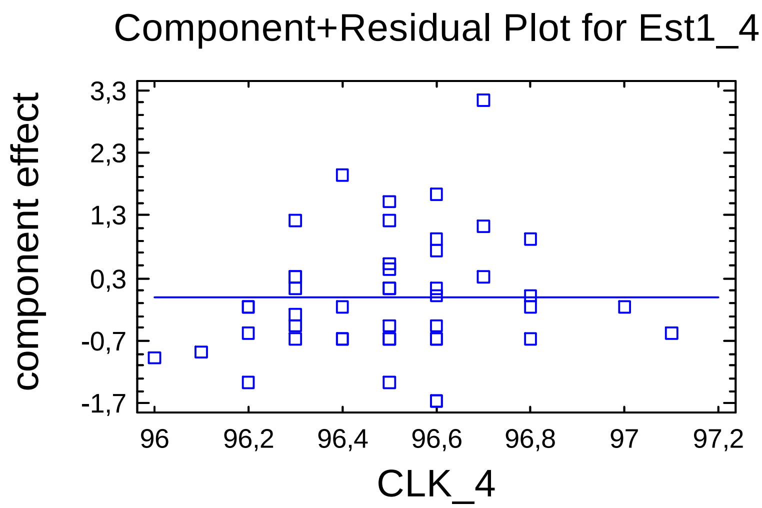
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est1_4 and 2
independent variables.  The equation of the fitted model is

Est1_4 = 16,6696

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est1_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 0,967211.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 0,736484 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.
```



Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est2_4

Multiple Regression Analysis

Dependent variable: Est2_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	27,7261	0,157346	176,211	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0	0			
Residual	51,2487	45	1,13886		
Total (Corr.)	51,2487	45			

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,06717
Mean absolute error = 0,850284
Durbin-Watson statistic = 1,32218 (P=0,0099)
Lag 1 residual autocorrelation = 0,32103

Stepwise regression

Method: forward selection
F-to-enter: 4,0

```
F-to-remove: 4,0

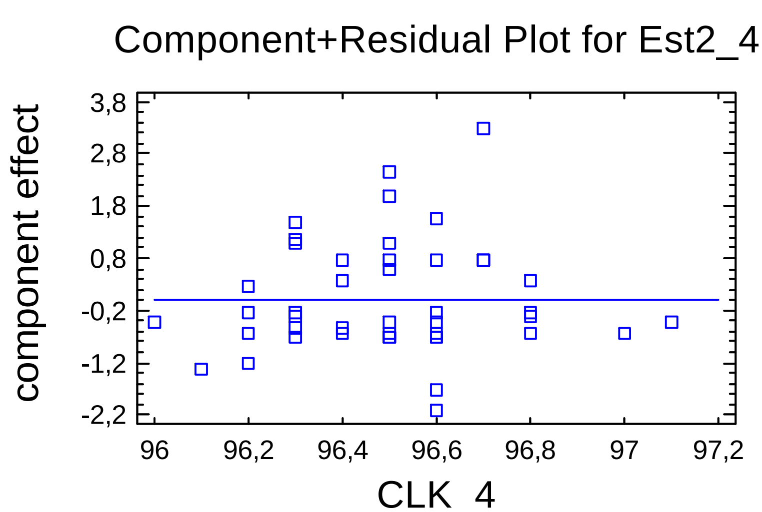
     Step 0:
     ---------
     0 variables in the model.  45 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,13886

     Final model selected.
```

```
The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2_4 and 2
independent variables.  The equation of the fitted model is

Est2_4 = 27,7261

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est2_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 1,06717.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 0,850284 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.
```




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
-----------------------------------------------------------------------------
```

```
The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
```

predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est2_4

Multiple Regression Analysis

Dependent variable: Est2_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	0,507005	70,5897	0,00718242	0,9943
CLK_4	0,245614	0,721281	0,340525	0,7351
Blaine_4	0,000952027	0,00318212	0,29918	0,7662

Analysis of Variance

Source	Sum of Squares	PDF	Mean Square	F-Ratio	P-Value
Model	0,243716	2	0,121858	0,10	0,9026
Residual	51,005	43	1,18616		
Total (Carr.)	51,2487	45			

R-squared = 0,475555 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,08911
Mean absolute error = 0,843562
Durbin-Watson statistic = 1,33937 (P=0,0082)
Lag 1 residual autocorrelation = 0,316082

The StatAdvisor

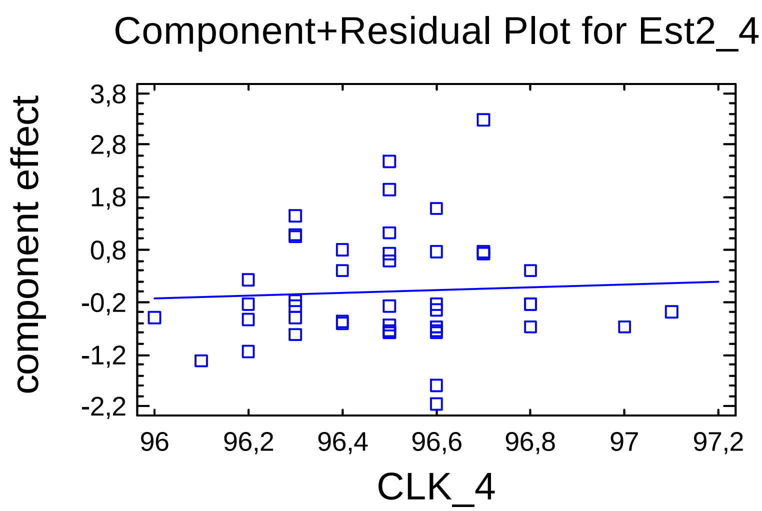
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2_4 and 2 independent variables. The equation of the fitted model is

Est2_4 = 0,507005 + 0,245614*CLK_4 + 0,000952027*Blaine_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 0,475555% of the variability in Est2_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,08911. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,843562 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7662, belonging to Blaine_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_4	Blaine_4
CONSTANT	1,0000	-0,9860	-0,1665
CLK_4	-0,9860	1,0000	0,0000
Blaine_4	-0,1665	0,0000	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est7_4

Multiple Regression Analysis

Dependent variable: Est7_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	94,9098	91,4316	1,03804	0,3055
CLK_4	-0,580835	0,925196	-0,627797	0,5337
Blaine_4	0,00100749	0,00434521	0,231863	0,8178

Analysis of Variance

Source	Sum of Squares	PDF	Mean Square	F-Ratio	P-Value
Model	0,859898	2	0,429949	0,23	0,7948
Residual	74,4587	40	1,86147		
Total (Carr.)	75,3186	42			

R-squared = 1,14168 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,36436
Mean absolute error = 1,00733
Durbin-Watson statistic = 0,944078 (P=0,0001)
Lag 1 residual autocorrelation = 0,506766

The StatAdvisor

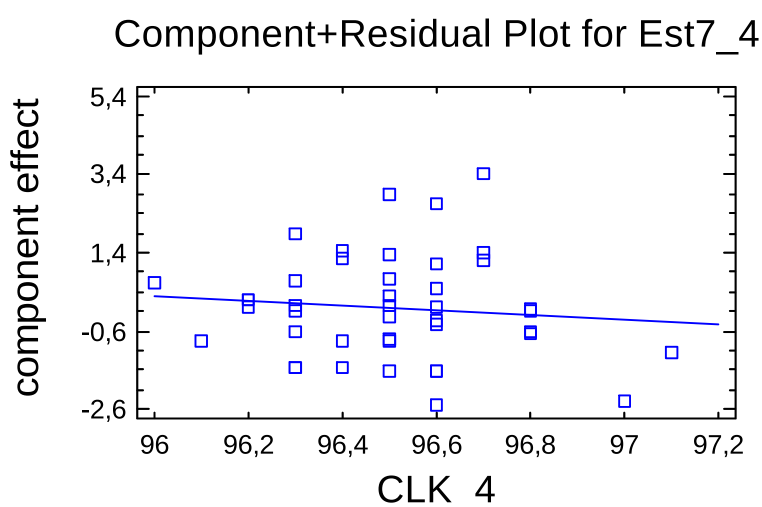
   The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7_4 and 2 independent variables. The equation of the fitted model is

Est7_4 = 94,9098 - 0,580835*CLK_4 + 0,00100749*Blaine_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

     The R-Squared statistic indicates that the model as fitted explains 1,14168% of the variability in Est7_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,36436. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,00733 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

   In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,8178, belonging to Blaine_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_4	Blaine_4
CONSTANT	1,0000	-0,9845	-0,2198
CLK_4	-0,9845	1,0000	0,0451
Blaine_4	-0,2198	0,0451	1,0000

The StatAdvisor

   This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).

```
Multiple Regression - Est7_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 42,5837       0,204217        208,522         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     PDF  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  75,3186     42       1,7933
-----------------------------------------------------------------------------
Total (Carr.)             75,3186     42

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,33914
Mean absolute error = 1,02596
Durbin-Watson statistic = 0,98236 (P=0,0002)
Lag 1 residual autocorrelation = 0,488764


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,7933

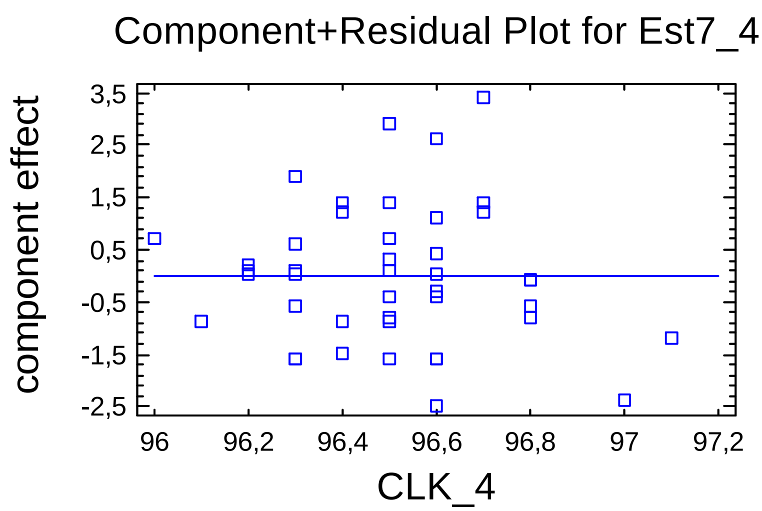
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est7_4 and 2
independent variables.  The equation of the fitted model is

Est7_4 = 42,5837

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est7_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 1,33914.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 1,02596 is the average value of the
residuals.  The Durbin-Watson (DEW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.
```




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est28_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est28_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 61,2355       0,392306        156,091         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     PDF  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  143,131     30      4,77103
-----------------------------------------------------------------------------
Total (Carr.)             143,131     30

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 2,18427
Mean absolute error = 1,83392
Durbin-Watson statistic = 1,93012 (P=0,4247)
Lag 1 residual autocorrelation = 0,0251971


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
```

```
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  30 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 4,77103

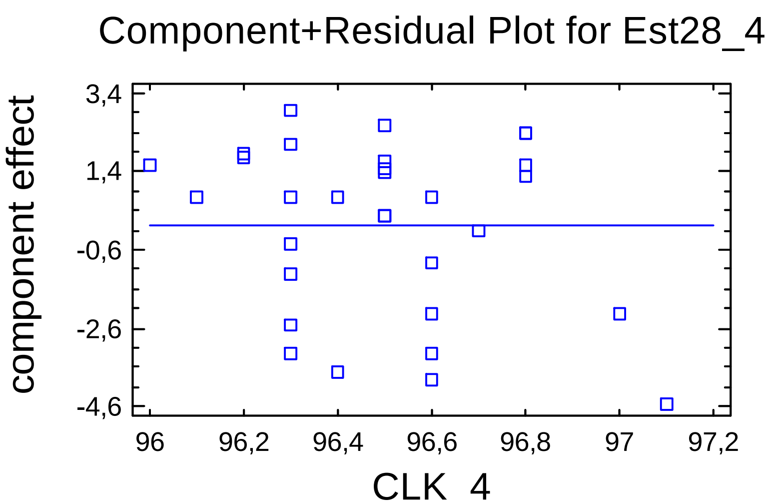
     Final model selected.
```

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_4 and 2 independent variables. The equation of the fitted model is

Est28_4 = 61,2355

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est28_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 2,18427. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,83392 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.



Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est28_4

Multiple Regression Analysis

Dependent variable: Est28_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	326,238	148,02	2,20401	0,0359
CLK_4	-2,2631	1,49255	-1,51626	0,1407
Blaine_4	-0,0126088	0,00719099	-1,75342	0,0905

Analysis of Variance

Source	Sum of Squares	PDF	Mean Square	F-Ratio	P-Value
Model	21,9546	2	10,9773	2,54	0,0972
Residual	121,176	28	4,32773		
Total (Carr.)	143,131	30			

R-squared = 15,3388 percent
R-squared (adjusted for d.f.) = 9,2916 percent
Standard Error of Est. = 2,08032
Mean absolute error = 1,68222
Durbin-Watson statistic = 1,97808 (P=0,4344)
Lag 1 residual autocorrelation = -0,00155419

The StatAdvisor

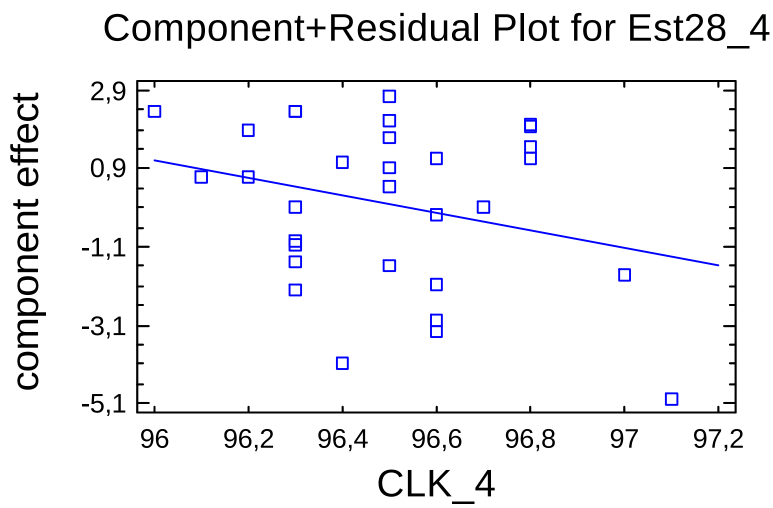
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_4 and 2 independent variables. The equation of the fitted model is

Est28_4 = 326,238 - 2,2631*CLK_4 - 0,0126088*Blaine_4

Since the P-value in the ANOVA table is less than 0.10, there is a statistically significant relationship between the variables at the 90% confidence level.

The R-Squared statistic indicates that the model as fitted explains 15,3388% of the variability in Est28_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 9,2916%. The standard error of the estimate shows the standard deviation of the residuals to be 2,08032. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,68222 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,1407, belonging to CLK_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing CLK_4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_4	Blaine_4
CONSTANT	1,0000	-0,9838	-0,2380
CLK_4	-0,9838	1,0000	0,0599
Blaine_4	-0,2380	0,0599	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est2 to Est7_4

Multiple Regression Analysis

Dependent variable: Est2 to Est7_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-0,429942	1,15272	-0,372981	0,7111
CLK_4	0,0113891	0,0116643	0,976406	0,3347
Blaine_4	-0,00000497606	0,000054782	-0,0908337	0,9281

Analysis of Variance

Source	Sum of Squares	PDF	Mean Square	F-Ratio	P-Value
Model	0,000287468	2	0,000143734	0,49	0,6188
Residual	0,011835	40	0,000295876		
Total (Carr.)	0,0121225	42			

R-squared = 2,37136 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,017201
Mean absolute error = 0,0131124
Durbin-Watson statistic = 1,29888 (P=0,0069)
Lag 1 residual autocorrelation = 0,347481

The StatAdvisor

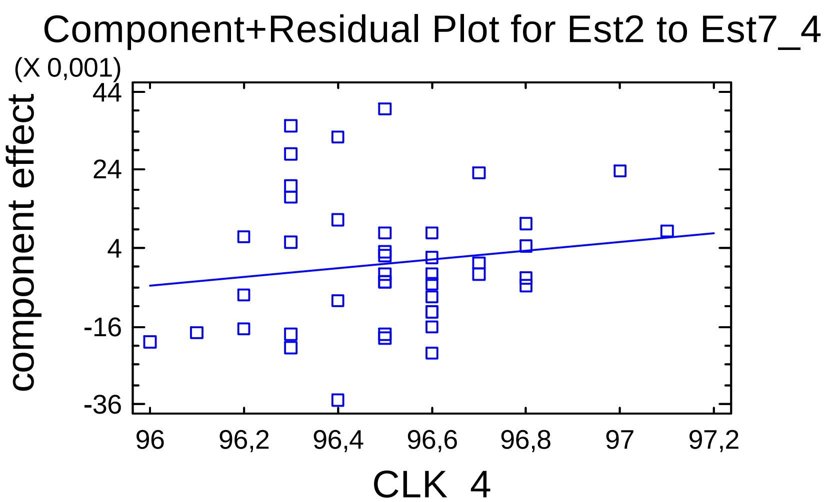
   The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2 to Est7_4 and 2 independent variables. The equation of the fitted model is

Est2 to Est7_4 = -0,429942 + 0,0113891*CLK_4 - 0,00000497606*Blaine_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

     The R-Squared statistic indicates that the model as fitted explains 2,37136% of the variability in Est2 to Est7_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 0,017201. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,0131124 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

   In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9281, belonging to Blaine_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_4	Blaine_4
CONSTANT	1,0000	-0,9845	-0,2198
CLK_4	-0,9845	1,0000	0,0451
Blaine_4	-0,2198	0,0451	1,0000

The StatAdvisor

   This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).

```
Multiple Regression - Est2 to Est7_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2 to Est7_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                0,650754     0,00259082        251,177         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     PDF  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                        0,0      0
Residual                0,0121225     42  0,000288631
-----------------------------------------------------------------------------
Total (Carr.)           0,0121225     42

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,0169891
Mean absolute error = 0,0133906
Durbin-Watson statistic = 1,20838 (P=0,0039)
Lag 1 residual autocorrelation = 0,392981


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 0,000288631

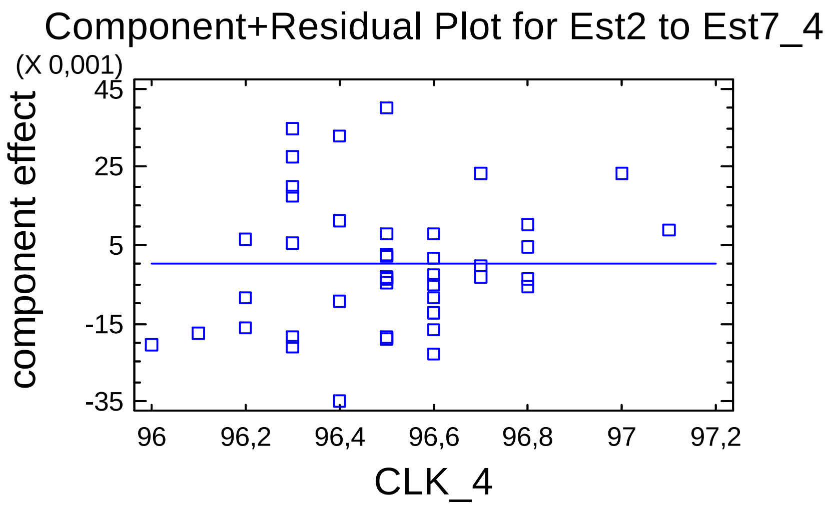
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2 to Est7_4
and 2 independent variables.  The equation of the fitted model is

Est2 to Est7_4 = 0,650754

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est2 to Est7_4.  The adjusted
R-squared statistic, which is more suitable for comparing models with
different numbers of independent variables, is 0,0%.  The standard
error of the estimate shows the standard deviation of the residuals to
be 0,0169891.  This value can be used to construct prediction limits
for new observations by selecting the Reports option from the text
menu.  The mean absolute error (MAE) of 0,0133906 is the average value
of the residuals.  The Durbin-Watson (DEW) statistic tests the
residuals to determine if there is any significant correlation based
on the order in which they occur in your data file.  Since the P-value
is less than 0.05, there is an indication of possible serial
correlation.  Plot the residuals versus row order to see if there is
any pattern which can be seen.
```




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est7 to Est 28_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7 to Est 28_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                0,109223       0,269512       0,405262         0,6883
Blaine_4              0,00015669   0,0000728846        2,14983         0,0400
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     PDF  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  0,00206218      1   0,00206218       4,62        0,0400
Residual                0,0129394     29  0,000446188
-----------------------------------------------------------------------------
Total (Carr.)           0,0150016     30

R-squared = 13,7464 percent
R-squared (adjusted for d.f.) = 10,7721 percent
Standard Error of Est. = 0,0211232
Mean absolute error = 0,0172772
Durbin-Watson statistic = 1,936 (P=0,4182)
Lag 1 residual autocorrelation = 0,0019443


Stepwise regression
-------------------
Method: forward selection
```

```
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  30 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 0,000500054

     Step 1:
     ---------
     Adding variable Blaine_4 with F-to-enter = 4,62178
     1 variables in the model.  29 d.f. for error.
     R-squared =  13,75%     Adjusted R-squared =  10,77%     MSE = 0,000446188

     Final model selected.
```

The StatAdvisor

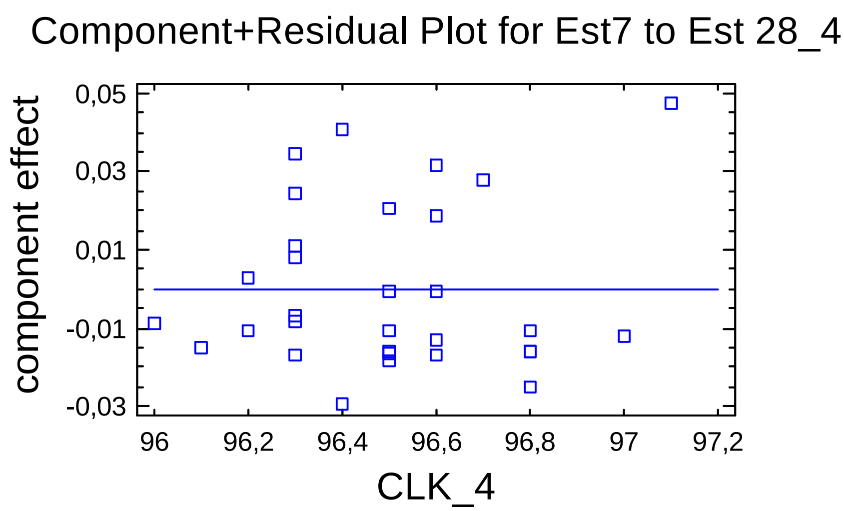
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7 to Est 28_4 and 2 independent variables. The equation of the fitted model is

Est7 to Est 28_4 = 0,109223 + 0,00015669*Blaine_4

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between the variables at the 95% confidence level.

The R-Squared statistic indicates that the model as fitted explains 13,7464% of the variability in Est7 to Est 28_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 10,7721%. The standard error of the estimate shows the standard deviation of the residuals to be 0,0211232. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,0172772 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0400, belonging to Blaine_4. Since the P-value is less than 0.05, that term is statistically significant at the 95% confidence level. Consequently, you probably don't want to remove any variables from the model.




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT       Blaine_4
CONSTANT                  1,0000        -0,9999
Blaine_4                 -0,9999         1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).



Multiple Regression - Est7 to Est 28_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7 to Est 28_4
-----------------------------------------------------------------------------
                                        Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT               -0,490017        1,52523      -0,321274         0,7504
CLK_4                 0,00614198      0,0153796       0,399358         0,6927
Blaine_4             0,000158464   0,0000740976        2,13858         0,0413
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     PDF  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  0,00213547       2   0,00106773       2,32       0,1165
Residual                0,0128662      28  0,000459506
-----------------------------------------------------------------------------
Total (Carr.)           0,0150016      30

R-squared = 14,2349 percent
R-squared (adjusted for d.f.) = 8,10883 percent
Standard Error of Est. = 0,0214361
Mean absolute error = 0,0173449
Durbin-Watson statistic = 1,97241 (P=0,4280)
Lag 1 residual autocorrelation = -0,0137776
```

The StatAdvisor

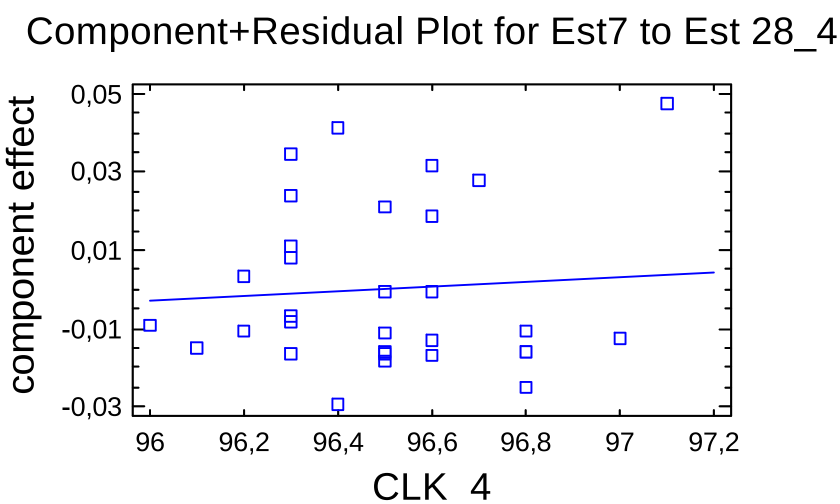
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7 to Est 28_4 and 2 independent variables. The equation of the fitted model is

Est7 to Est 28_4 = -0,490017 + 0,00614198*CLK_4 + 0,000158464*Blaine_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 14,2349% of the variability in Est7 to Est 28_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 8,10883%. The standard error of the estimate shows the standard deviation of the residuals to be 0,0214361. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,0173449 is the average value of the residuals. The Durbin-Watson (DEW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,6927, belonging to CLK_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing CLK_4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	CLK_4	Blaine_4
CONSTANT	1,0000	-0,9838	-0,2380
CLK_4	-0,9838	1,0000	0,0599
Blaine_4	-0,2380	0,0599	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

ΠΑΡΑΡΤΗΜΑ Β

Ανάλυση ικανότητας- ποιότητα τσιμέντου CEM II 42,5 –μύλος 1

Process Capability Analysis - Est2MT1

```
Analysis Summary

Data variable: Est2MT1

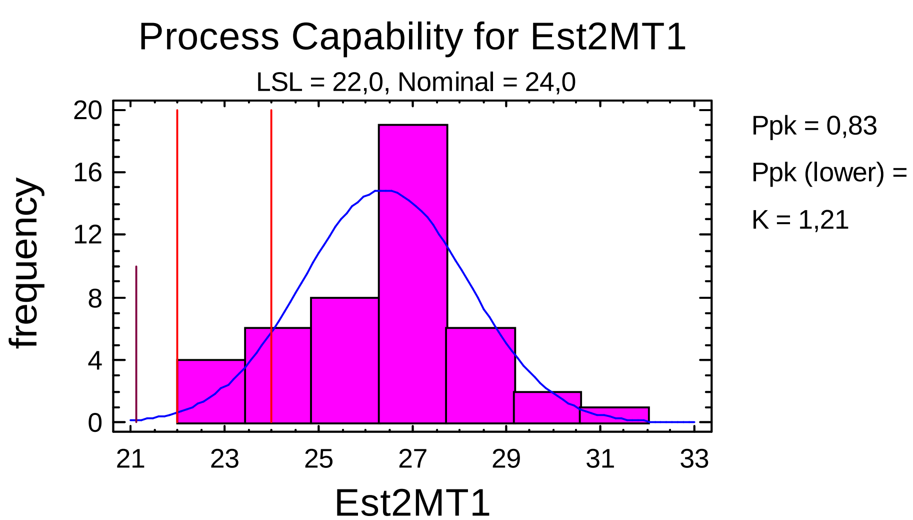
Distribution: Normal
     sample size = 46
     mean = 26,4109
     standard deviation = 1,76399

6,0 Sigma Limits
     +3,0 sigma = 31,7028
     mean = 26,4109
     -3,0 sigma = 21,1189
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 24,0				
LSL = 22,0	0,000000%	-2,50	0,620075%	6200,75
Total	0,000000%		0,620075%	6200,75

```
The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 46 observations in the variable Est2MT1.
0,620075% of the fitted distribution lies outside the specification
limits.  If the normal distribution is appropriate for the data, this
estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for Est2MT1

Pp =
```

Ppk = 0,833503
Ppk (upper) =
Ppk (lower) = 0,833503
K = 1,20543

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,833503. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 1,20543, the mean is located 120,543% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est7MT1

Analysis Summary

Data variable: Est7MT1

Distribution: Normal
sample size = 46
mean = 40,7304
standard deviation = 2,05306

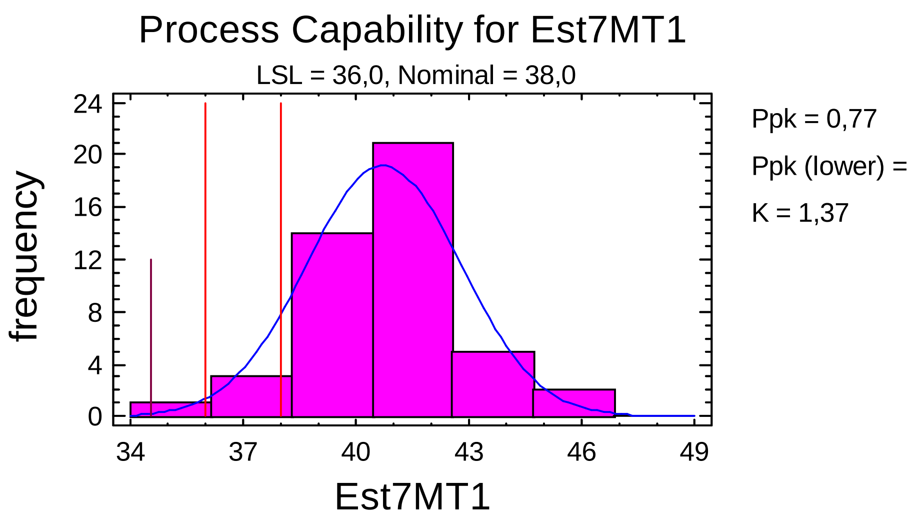
6,0 Sigma Limits
+3,0 sigma = 46,8896
mean = 40,7304
-3,0 sigma = 34,5713

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 38,0				
LSL = 36,0	2,173913%	-2,30	1,060872%	10608,72
Total	2,173913%		1,060872%	10608,72

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 46 observations in the variable Est7MT1. 1,06087% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Est7MT1

Pp =
Ppk = 0,76803
Ppk (upper) =
Ppk (lower) = 0,76803
K = 1,36522

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,76803.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals 1,36522, the
mean is located 136,522% of the way from the center of the specs
toward the upper specification limit.
```

```
Process Capability Analysis - Est28MT1

Analysis Summary

Data variable: Est28MT1

Distribution: Normal
     sample size = 37
     mean = 53,4351
     standard deviation = 1,49243

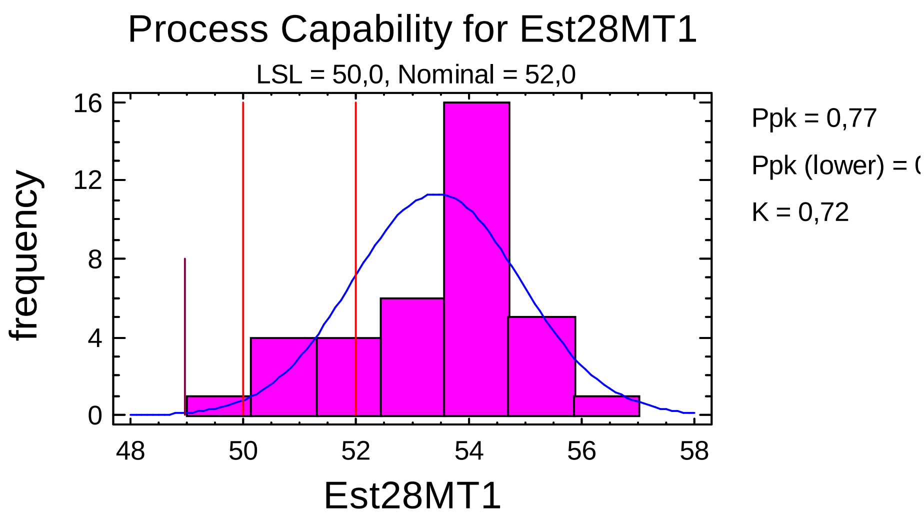
6,0 Sigma Limits
     +3,0 sigma = 57,9124
     mean = 53,4351
     -3,0 sigma = 48,9579
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 52,0				
LSL = 50,0	0,000000%	-2,30	1,067575%	10675,75
Total	0,000000%		1,067575%	10675,75

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 37 observations in the variable Est28MT1. 1,06757% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Est28MT1

Pp =
Ppk = 0,767236
Ppk (upper) =
Ppk (lower) = 0,767236
K = 0,717568

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,767236. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 0,717568, the mean is located 71,7568% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est2MT4

Analysis Summary

```
Data variable: Est2MT4

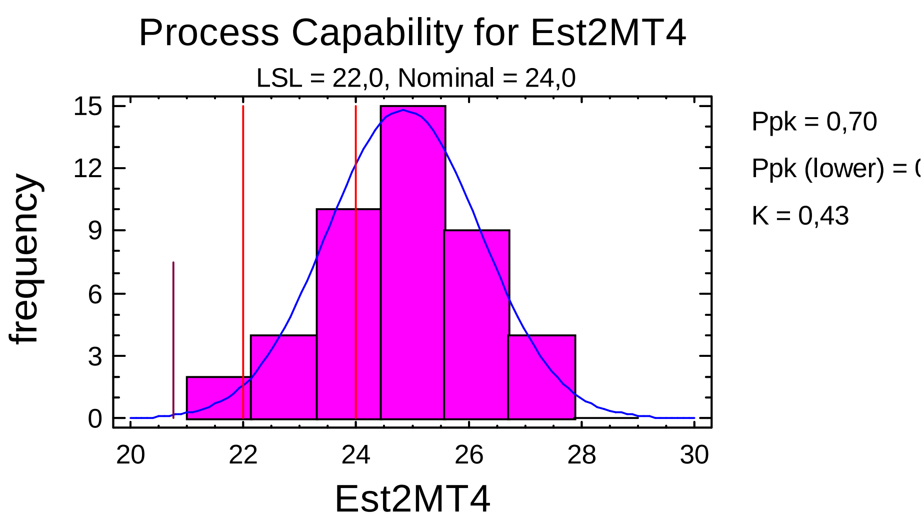
Distribution: Normal
     sample size = 44
     mean = 24,85
     standard deviation = 1,35724

6,0 Sigma Limits
     +3,0 sigma = 28,9217
     mean = 24,85
     -3,0 sigma = 20,7783

                     Observed                   Estimated       Defects
Specifications       Beyond Spec.    Z-Score    Beyond Spec.    Per Million
---------------------------------------------------------------------------
Nominal = 24,0
LSL =      22,0         2,272727%      -2,10       1,787073%       17870,73
---------------------------------------------------------------------------
Total                   2,272727%                  1,787073%       17870,73
```

```
The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 44 observations in the variable Est2MT4.  1,78707%
of the fitted distribution lies outside the specification limits.  If
the normal distribution is appropriate for the data, this estimates
the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for Est2MT4

Pp =
Ppk = 0,699951
Ppk (upper) =
Ppk (lower) = 0,699951
K = 0,425

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,699951. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 0,425, the mean is located 42,5% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est7MT4

Analysis Summary

Data variable: Est7MT4

Distribution: Normal
sample size = 45
mean = 40,1
standard deviation = 2,29059

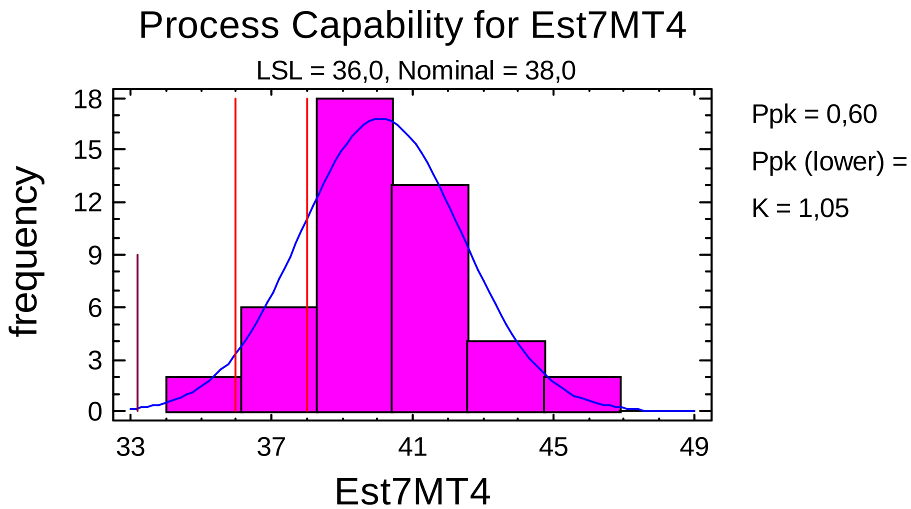
6,0 Sigma Limits
+3,0 sigma = 46,9718
mean = 40,1
-3,0 sigma = 33,2282

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 38,0				
LSL = 36,0	2,222222%	-1,79	3,673247%	36732,47
Total	2,222222%		3,673247%	36732,47

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 45 observations in the variable Est7MT4. 3,67325% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Est7MT4

Pp =
Ppk = 0,596643
Ppk (upper) =
Ppk (lower) = 0,596643
K = 1,05

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,596643. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 1,05, the mean is located 105,0% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est28MT4

Analysis Summary

Data variable: Est28MT4

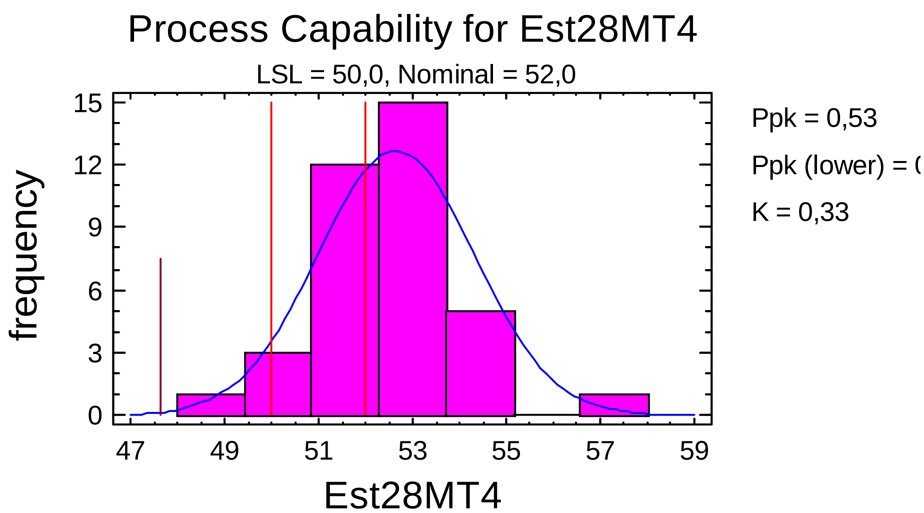
Distribution: Normal
    sample size = 37
    mean = 52,6514
    standard deviation = 1,66927

6,0 Sigma Limits
    +3,0 sigma = 57,6592
    mean = 52,6514
    -3,0 sigma = 47,6435

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 52,0				
LSL = 50,0	5,405405%	-1,59	5,610550%	56105,50
Total	5,405405%		5,610550%	56105,50

```
The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 37 observations in the variable Est28MT4.
5,61055% of the fitted distribution lies outside the specification
limits.  If the normal distribution is appropriate for the data, this
estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for Est28MT4

Pp =
Ppk = 0,529444
Ppk (upper) =
Ppk (lower) = 0,529444
K = 0,325676

Based on 6,0 sigma limits.


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,529444.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals 0,325676, the
mean is located 32,5676% of the way from the center of the specs
toward the upper specification limit.
```

Process Capability Analysis - Al2O3_2

```
Analysis Summary

Data variable: Al2O3_2

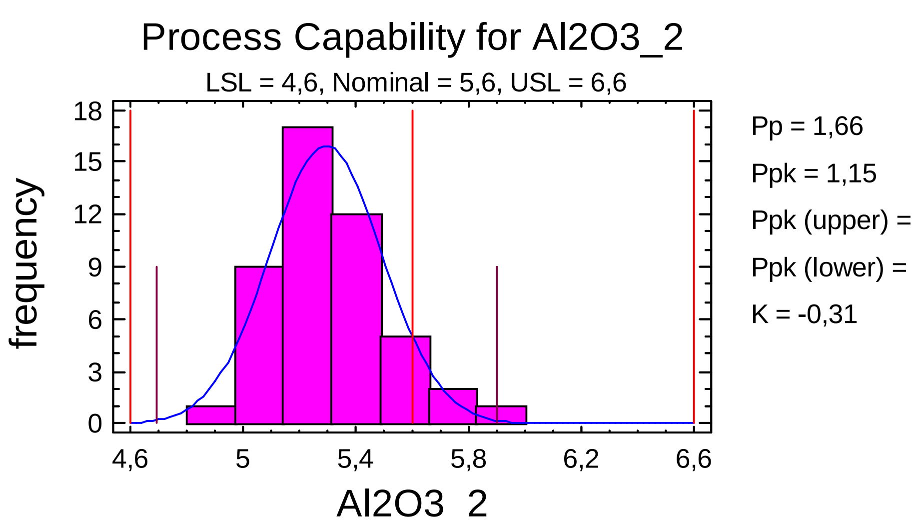
Distribution: Normal
     sample size = 47
     mean = 5,29447
     standard deviation = 0,201276

6,0 Sigma Limits
     +3,0 sigma = 5,8983
     mean = 5,29447
     -3,0 sigma = 4,69064
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,6	0,000000%	6,49	0,000000%	0,00
Nominal = 5,6				
LSL = 4,6	0,000000%	-3,45	0,028001%	280,01
Total	0,000000%		0,028001%	280,01

```
The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 47 observations in the variable Al2O3_2.
0,0280009% of the fitted distribution lies outside the specification
limits.  If the normal distribution is appropriate for the data, this
estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for Al2O3_2

Pp = 1,6561
Ppk = 1,15011
Ppk (upper) = 2,16209
```

Ppk (lower) = 1,15011
K = -0,305532

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (1,31856, 1,99296)
   Ppk: (0,896507, 1,40371)

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 1,6561, which is usually considered to be good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 1,15011. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,305532, the mean is located 30,5532% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 47 observations were taken.

.

Process Capability Analysis - Al2O3_2

Analysis Summary

Data variable: Al2O3_2

Distribution: Normal
     sample size = 47
     mean = 5,29447
     standard deviation = 0,201276Process Capability Analysis - SiO2MT1

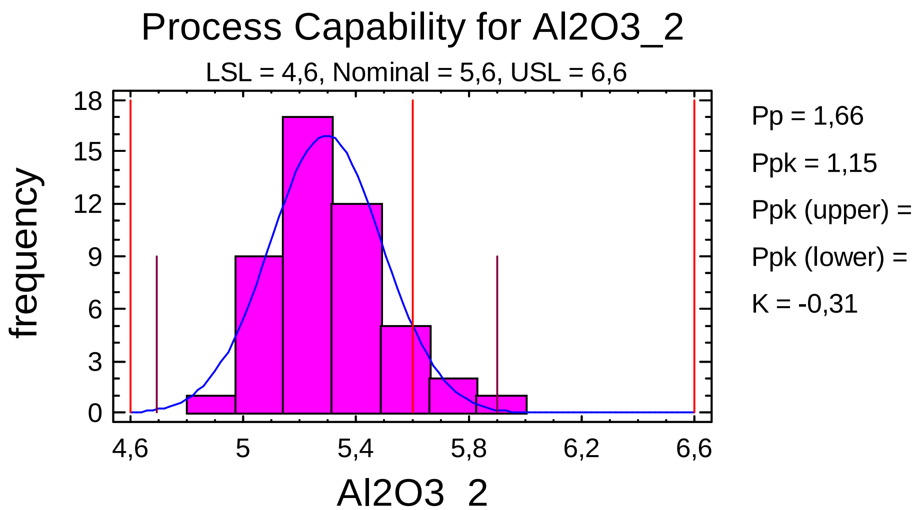
6,0 Sigma Limits
     +3,0 sigma = 5,8983
     mean = 5,29447
     -3,0 sigma = 4,69064

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,6	0,000000%	6,49	0,000000%	0,00
Nominal = 5,6				
LSL = 4,6	0,000000%	-3,45	0,028001%	280,01
Total	0,000000%		0,028001%	280,01

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable Al2O3_2. 0,0280009% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Al2O3_2

Pp = 1,6561
Ppk = 1,15011
Ppk (upper) = 2,16209
Ppk (lower) = 1,15011
K = -0,305532

Based on 6,0 sigma limits.

95,0% Confidence Intervals
Pp: (1,31856, 1,99296)
Ppk: (0,896507, 1,40371)

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 1,6561, which is usually considered to be good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 1,15011. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,305532, the mean is located 30,5532% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 47 observations were taken.

Process Capability Analysis - SiO2MT1

Analysis Summary

```
Data variable: SiO2MT1

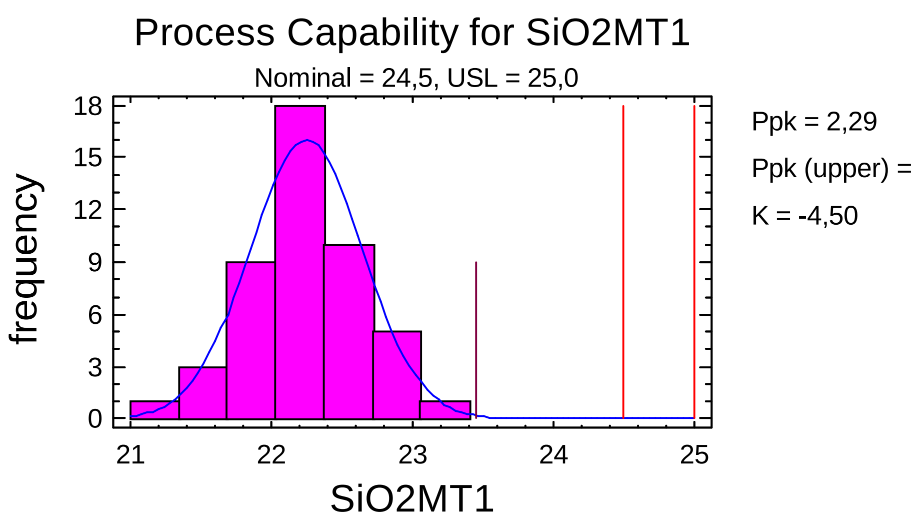
Distribution: Normal
     sample size = 47
     mean = 22,2479
     standard deviation = 0,401188

6,0 Sigma Limits
     +3,0 sigma = 23,4514
     mean = 22,2479
     -3,0 sigma = 21,0443

                     Observed                        Estimated       Defects
Specifications       Beyond Spec.    Z-Score      Beyond Spec.    Per Million
---------------------------------------------------------------------------
USL =      25,0         0,000000%       6,86        0,000000%            0,00
Nominal = 24,5
---------------------------------------------------------------------------
Total                   0,000000%                   0,000000%            0,00


The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 47 observations in the variable SiO2MT1.
3,46523E-10% of the fitted distribution lies outside the specification
limits.  If the normal distribution is appropriate for the data, this
estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for SiO2MT1

Pp =
Ppk = 2,28665
Ppk (upper) = 2,28665
Ppk (lower) =
K = -4,50426

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,28665. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -4,50426, the mean is located 450,426% of the way from the center of the specs toward the lower specification limit.

Process Capability Analysis - BLAINEMT1

Analysis Summary

Data variable: BLAINEMT1

Distribution: Normal
sample size = 47
mean = 4778,81
standard deviation = 35,2967

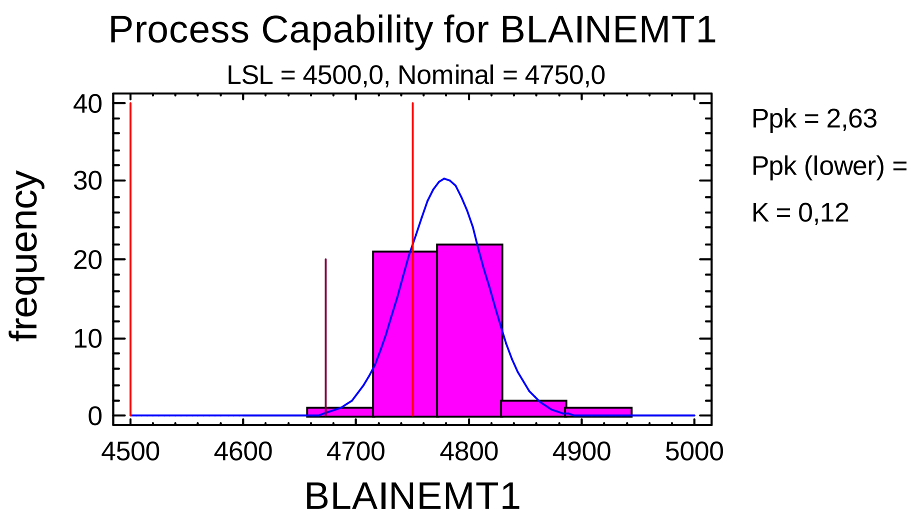
6,0 Sigma Limits
+3,0 sigma = 4884,7
mean = 4778,81
-3,0 sigma = 4672,92

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 4750,0				
LSL = 4500,0	0,000000%	-7,90	0,000000%	0,00
Total	0,000000%		0,000000%	0,00

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable BLAINEMT1. 1,44329E-13% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for BLAINEMT1

Pp =
Ppk = 2,633
Ppk (upper) =
Ppk (lower) = 2,633
K = 0,115234

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 2,633.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals 0,115234, the
mean is located 11,5234% of the way from the center of the specs
toward the upper specification limit.



Nonnormal Capability Indices for BLAINEMT1

Pp =
Ppk = 3,2546
Ppk (upper) =
Ppk (lower) = 3,2546
Pr =
K =

50 percentile = 4774,96
0.135 percentile = 4690,48

Nominal = 4750,0
LSL = 4500,0


The StatAdvisor
---------------
   This pane produces estimates of the usual capability indices
without assuming that BLAINEMT1 comes from a normal distribution.  To
compute the indices, the sample skewness and kurtosis of BLAINEMT1 are
first calculated.  Based on the estimated skewness and kurtosis, a
distribution is selected from the general class of Pearson curves.
Estimates of the center, lower limit and upper limit for the
```

distribution are then calculated and used to estimate the capability indices. These indices should be used in place of the normal capability indices if the goodness-of-fit tests are not satisfied.

Process Capability Analysis - BLAINEMT1

Analysis Summary

Data variable: BLAINEMT1

Distribution: Normal
    sample size = 47
    mean = 4778,81
    standard deviation = 35,2967

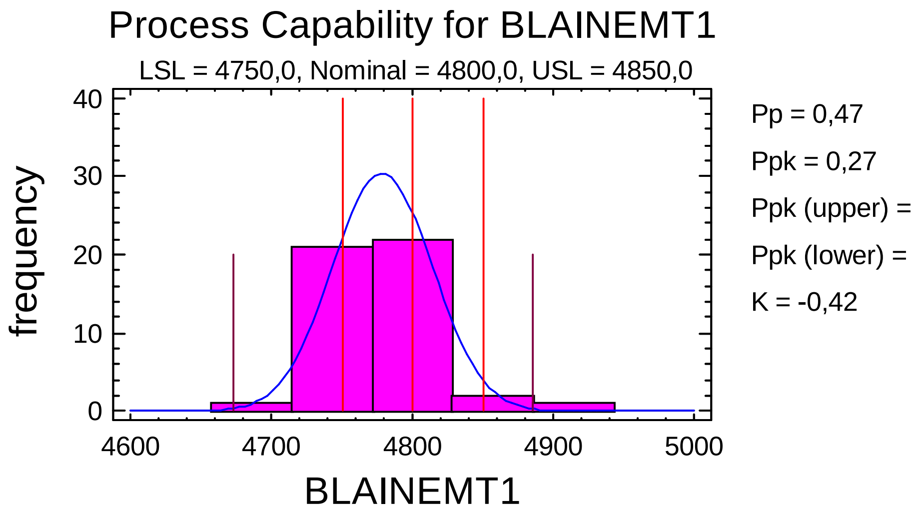
6,0 Sigma Limits
    +3,0 sigma = 4884,7
    mean = 4778,81
    -3,0 sigma = 4672,92

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 4850,0	4,255319%	2,02	2,185037%	21850,37
Nominal = 4800,0				
LSL = 4750,0	12,765957%	-0,82	20,719689%	207196,89
Total	17,021277%		22,904726%	229047,26

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable BLAINEMT1. 22,9047% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for BLAINEMT1

Pp = 0,472188
Ppk = 0,272061
Ppk (upper) = 0,672316
Ppk (lower) = 0,272061
K = -0,42383

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (0,37595, 0,568234)
   Ppk: (0,161734, 0,382388)


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.  One
common index is Pp, which in the case of the normal distribution
equals the distance between the specification limits divided by 6
times the standard deviation.  In this case, Pp equals 0,472188, which
is usually considered to be not good.  Ppk is a one-sided capability
index, which in the case of the normal distribution divides the
distance from the mean to the nearer specification limit by 3 times
the standard deviation.  In this case, Ppk equals 0,272061.  The
rather large difference between Pp and Ppk is a sign that the
distribution is not centered well between the specification limits.  K
equals the mean minus the nominal, divided by one-half the distance
between the specs.  Since K equals -0,42383, the mean is located
42,383% of the way from the center of the specs toward the lower
specification limit.
   Since capability indices are statistics, they will vary from one
sample of data to another.  The 95,0% confidence intervals show how
much these statistics might vary from the true values given the fact
that only 47 observations were taken.



Nonnormal Capability Indices for BLAINEMT1

Pp = 0,39508
Ppk = 0,295462
Ppk (upper) = 0,444989
Ppk (lower) = 0,295462
Pr = 2,53113
K = -0,500763

99.865 percentile = 4943,59
50 percentile = 4774,96
0.135 percentile = 4690,48
```

USL = 4850,0
Nominal = 4800,0
LSL = 4750,0

The StatAdvisor

This pane produces estimates of the usual capability indices without assuming that BLAINEMT1 comes from a normal distribution. To compute the indices, the sample skewness and kurtosis of BLAINEMT1 are first calculated. Based on the estimated skewness and kurtosis, a distribution is selected from the general class of Pearson curves. Estimates of the center, lower limit and upper limit for the distribution are then calculated and used to estimate the capability indices. These indices should be used in place of the normal capability indices if the goodness-of-fit tests are not satisfied.

Process Capability Analysis - SiO2MT1

Analysis Summary

Process Capability Analysis - LOIMT4

Analysis Summary

Data variable: LOIMT4

Distribution: Normal
sample size = 49
mean = 4,81163
standard deviation = 0,569339

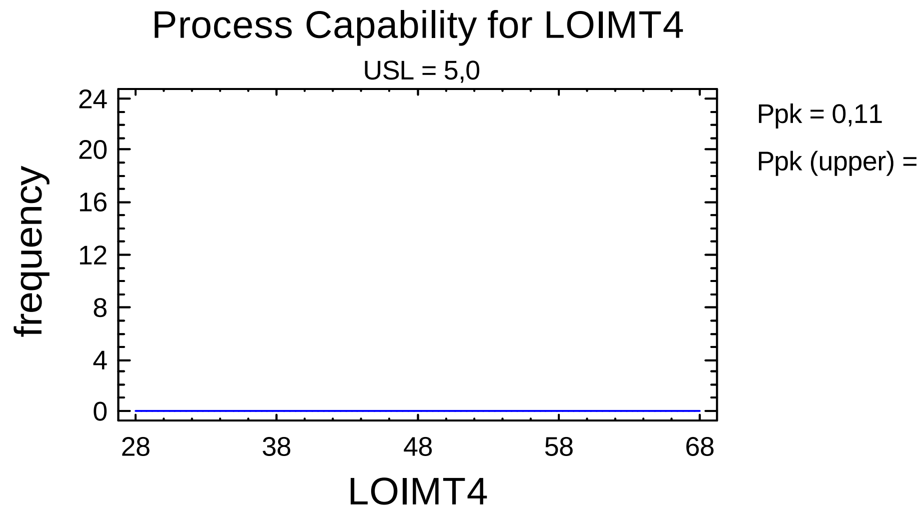
6,0 Sigma Limits
+3,0 sigma = 6,51965
mean = 4,81163
-3,0 sigma = 3,10361

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	36,734694%	0,33	37,037605%	370376,05
Total	36,734694%		37,037605%	370376,05

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable LOIMT4. 37,0376% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for LOIMT4

Pp =
Ppk = 0,110284
Ppk (upper) = 0,110284
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,110284.




Process Capability Analysis - SIO2MT4

Analysis Summary

Data variable: SIO2MT4

Distribution: Normal
     sample size = 49
     mean = 21,9122
     standard deviation = 0,485503

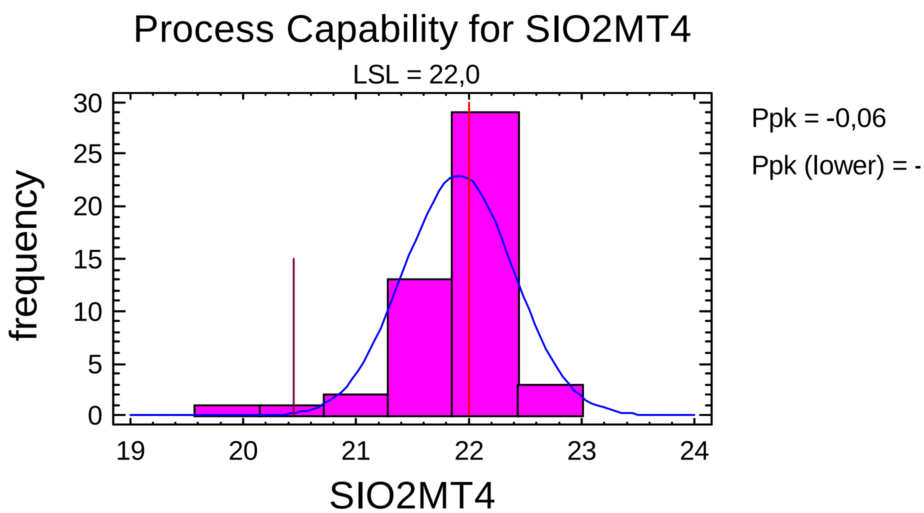
6,0 Sigma Limits
     +3,0 sigma = 23,3688
     mean = 21,9122
     -3,0 sigma = 20,4557

                     Observed                         Estimated       Defects
Specifications       Beyond Spec.    Z-Score    Beyond Spec.    Per Million
---------------------------------------------------------------------------
LSL =     22,0         53,061224%       0,18       57,172074%      571720,74
---------------------------------------------------------------------------
Total                  53,061224%                  57,172074%      571720,74


The StatAdvisor
---------------
```

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable SIO2MT4. 57,1721% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for SIO2MT4

Pp =
Ppk = -0,0602502
Ppk (upper) =
Ppk (lower) = -0,0602502
K =

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals -0,0602502.

Process Capability Analysis - BLAINEMT4

Analysis Summary

Data variable: BLAINEMT4

Distribution: Normal
sample size = 49
mean = 4255,1
standard deviation = 53,6238

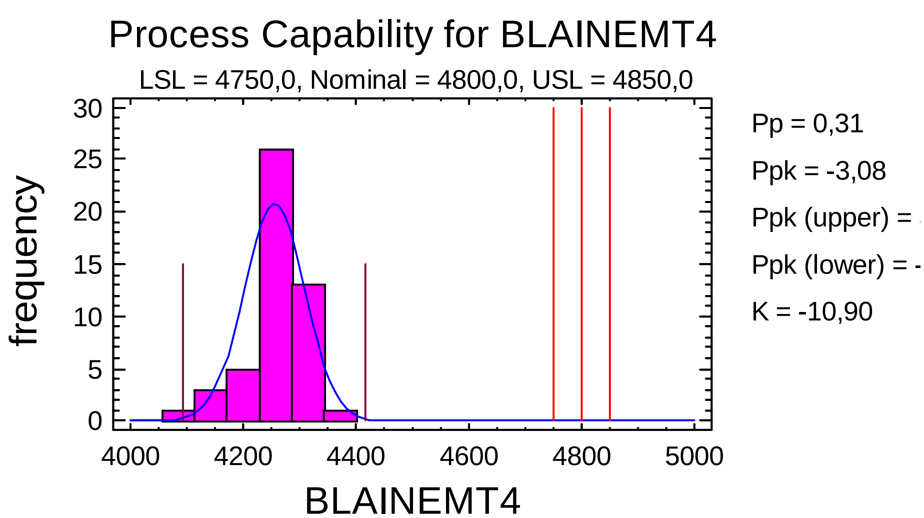
```
6,0 Sigma Limits
     +3,0 sigma = 4415,97
     mean = 4255,1
     -3,0 sigma = 4094,23
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 4850,0	0,000000%	11,09	0,000000%	0,00
Nominal = 4800,0				
LSL = 4750,0	100,000000%	9,23	100,000000%	1000000,00
Total	100,000000%		100,000000%	1000000,00

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable BLAINEMT4. 100,0% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for BLAINEMT4

```
Pp = 0,310807
Ppk = -3,07636
Ppk (upper) = 3,69797
Ppk (lower) = -3,07636
K = -10,898
```

Based on 6,0 sigma limits.

```
95,0% Confidence Intervals
   Pp: (0,248785, 0,372706)
   Ppk: (-3,69879, -2,45393)
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 0,310807, which is usually considered to be not good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals -3,07636. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -10,898, the mean is located 1089,8% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 49 observations were taken.

Process Capability Analysis - SIO2MT4

Process Capability Analysis - SIO2MT4

Analysis Summary

Data variable: SIO2MT4

Distribution: Normal
sample size = 49
mean = 21,9122
standard deviation = 0,485503

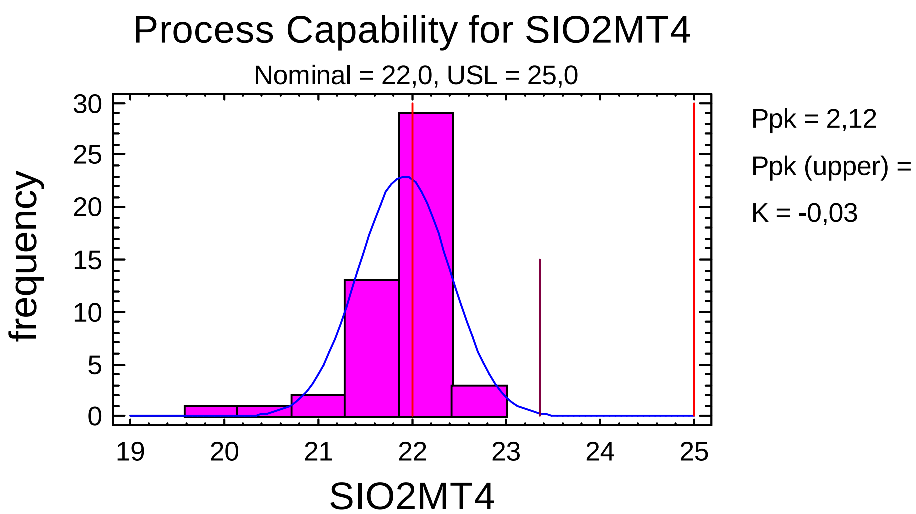
6,0 Sigma Limits
+3,0 sigma = 23,3688
mean = 21,9122
-3,0 sigma = 20,4557

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 25,0	0,000000%	6,36	0,000000%	0,00
Nominal = 22,0				
Total	0,000000%		0,000000%	0,00

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable SIO2MT4. 1,01397E-8% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for SIO2MT4

Pp =
Ppk = 2,11997
Ppk (upper) = 2,11997
Ppk (lower) =
K = -0,0292517

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,11997. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,0292517, the mean is located 2,92517% of the way from the center of the specs toward the lower specification limit.

```
Process Capability Analysis - SIO2MT4

Analysis Summary

Data variable: SIO2MT4

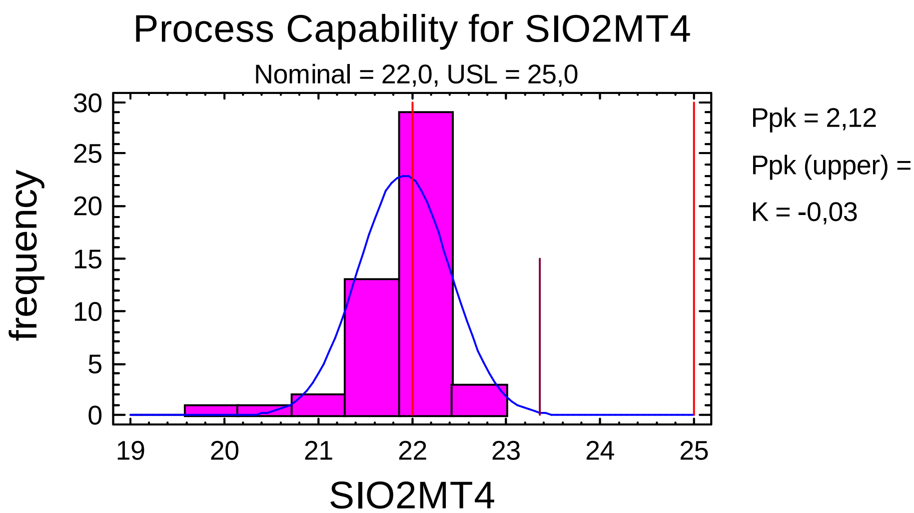
Distribution: Normal
     sample size = 49
     mean = 21,9122
     standard deviation = 0,485503

6,0 Sigma Limits
     +3,0 sigma = 23,3688
     mean = 21,9122
     -3,0 sigma = 20,4557
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 25,0	0,000000%	6,36	0,000000%	0,00
Nominal = 22,0				
Total	0,000000%		0,000000%	0,00

```
The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 49 observations in the variable SIO2MT4.
1,01397E-8% of the fitted distribution lies outside the specification
limits.  If the normal distribution is appropriate for the data, this
estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for SIO2MT4

Pp =
Ppk = 2,11997
Ppk (upper) = 2,11997
Ppk (lower) =
K = -0,0292517

Based on 6,0 sigma limits.


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 2,11997.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals -0,0292517,
the mean is located 2,92517% of the way from the center of the specs
toward the lower specification limit.
```

Process Capability Analysis - BLAINEMT4

Analysis Summary

Data variable: BLAINEMT4

Distribution: Normal
     sample size = 49
     mean = 4255,1
     standard deviation = 53,6238

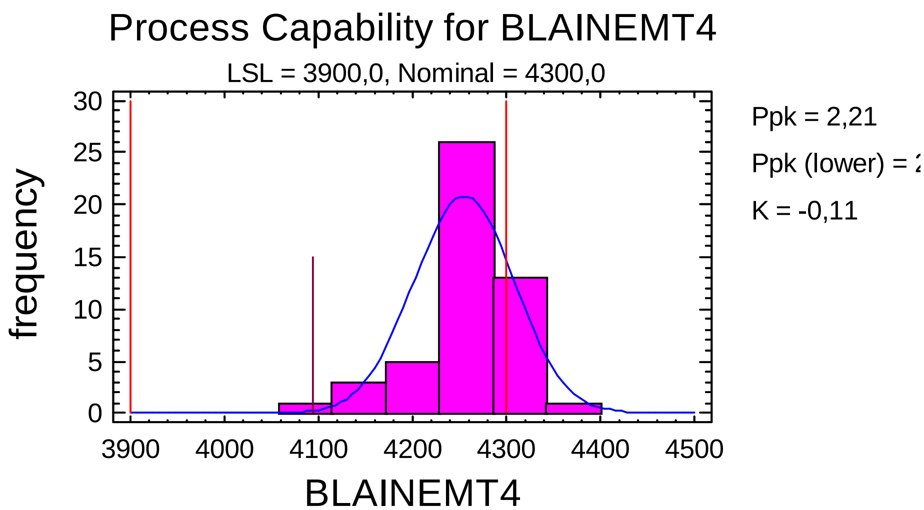
6,0 Sigma Limits
     +3,0 sigma = 4415,97
     mean = 4255,1
     -3,0 sigma = 4094,23

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 4300,0				
LSL = 3900,0	0,000000%	-6,62	0,000000%	0,00
Total	0,000000%		0,000000%	0,00

The StatAdvisor

   This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable BLAINEMT4. 1,78003E-9% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for BLAINEMT4

Pp =
Ppk = 2,20737
Ppk (upper) =
Ppk (lower) = 2,20737
K = -0,112245

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,20737. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,112245, the mean is located 11,2245% of the way from the center of the specs toward the lower specification limit.

Process Capability Analysis - IRMT4

Analysis Summary

Data variable: IRMT4

Distribution: Normal
  sample size = 48
  mean = 5,38812
  standard deviation = 0,827099

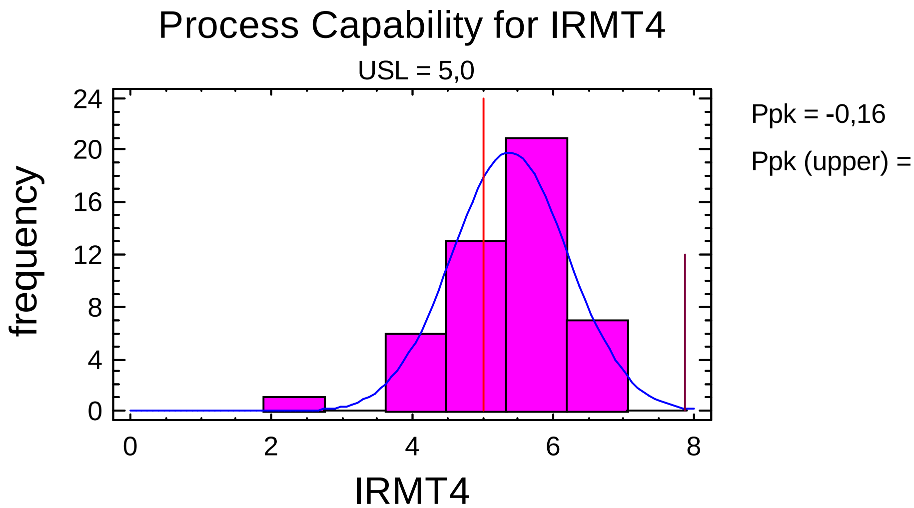
6,0 Sigma Limits
  +3,0 sigma = 7,86942
  mean = 5,38812
  -3,0 sigma = 2,90683

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	72,916667%	-0,47	68,056001%	680560,01
Total	72,916667%		68,056001%	680560,01

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 48 observations in the variable IRMT4. 68,056% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for IRMT4

Pp =
Ppk = -0,15642
Ppk (upper) = -0,15642
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals -0,15642.
```

Process Capability Analysis - AMT4l2O3

```
Analysis Summary

Data variable: AMT4l2O3

Distribution: Normal
     sample size = 49
     mean = 4,99735
     standard deviation = 0,167913

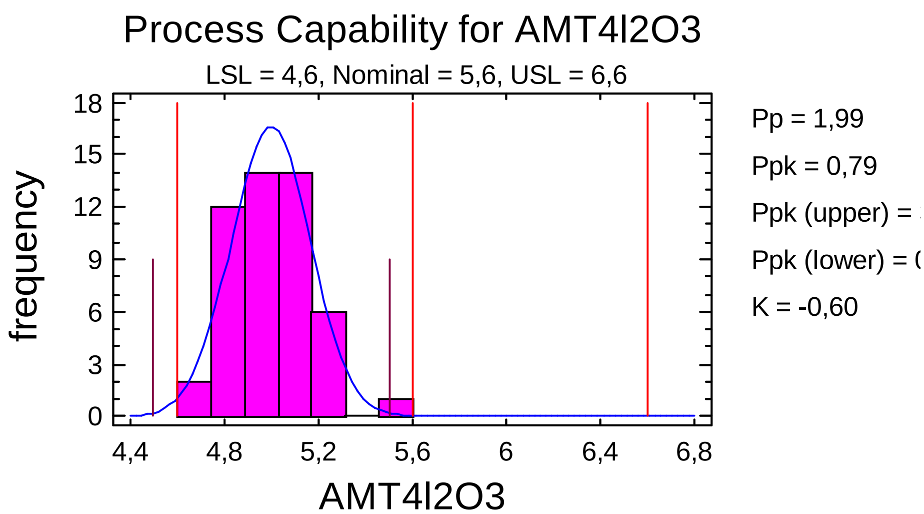
6,0 Sigma Limits
     +3,0 sigma = 5,50109
     mean = 4,99735
     -3,0 sigma = 4,49361
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,6	0,000000%	9,54	0,000000%	0,00
Nominal = 5,6				
LSL = 4,6	0,000000%	-2,37	0,898144%	8981,44
Total	0,000000%		0,898144%	8981,44

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable AMT4l2O3. 0,898144% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for AMT4l2O3

Pp = 1,98515
Ppk = 0,788794
Ppk (upper) = 3,18151
Ppk (lower) = 0,788794
K = -0,602653

Based on 6,0 sigma limits.

95,0% Confidence Intervals
Pp: (1,58901, 2,3805)
Ppk: (0,605468, 0,972119)

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 1,98515, which is usually considered to be good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,788794. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,602653, the mean is located 60,2653% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 49 observations were taken.

Ανάλυση ικανότητας –ποιότητα τσιμέντου CEM II 42,5-μύλος 4

Process Capability Analysis - IR_2

Analysis Summary

Data variable: IR_2

Distribution: Normal
sample size = 47
mean = 6,04468
standard deviation = 0,759198

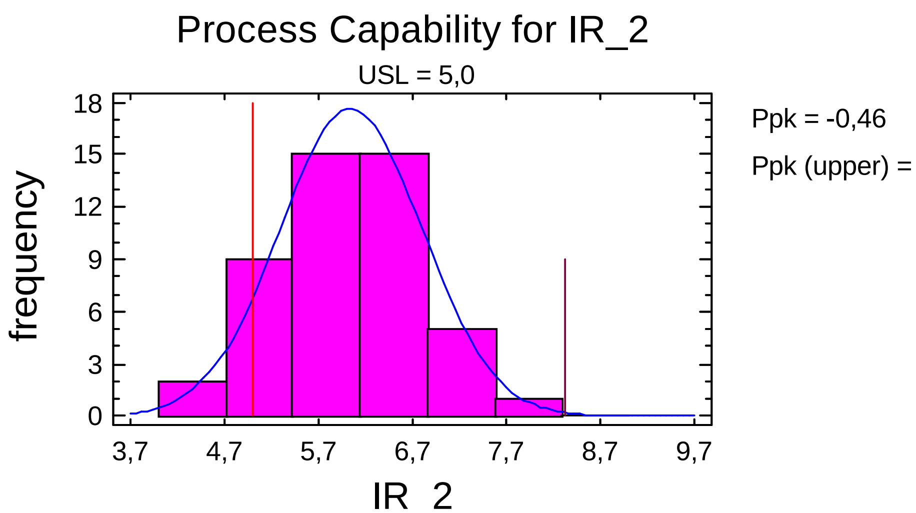
6,0 Sigma Limits
+3,0 sigma = 8,32228
mean = 6,04468
-3,0 sigma = 3,76709

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	91,489362%	-1,38	91,559436%	915594,36
Total	91,489362%		91,559436%	915594,36

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable IR_2. 91,5594% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for IR_2

Pp =
Ppk = -0,458677
Ppk (upper) = -0,458677
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals -0,458677.




Process Capability Analysis - Al2O3_2

Analysis Summary

Data variable: Al2O3_2

Distribution: Normal
     sample size = 47
     mean = 5,29447
     standard deviation = 0,201276

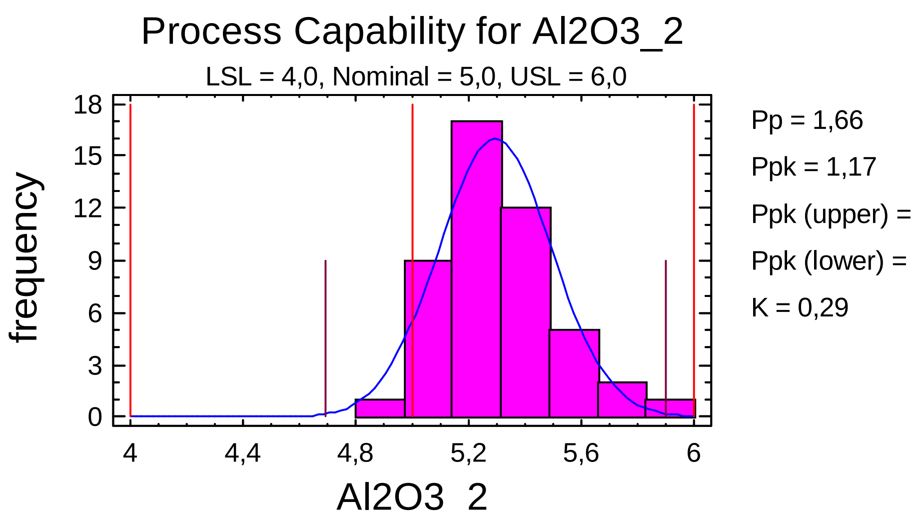
6,0 Sigma Limits
     +3,0 sigma = 5,8983
     mean = 5,29447
     -3,0 sigma = 4,69064
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,0	0,000000%	3,51	0,022810%	228,10
Nominal = 5,0				
LSL = 4,0	0,000000%	-6,43	0,000000%	0,00
Total	0,000000%		0,022810%	228,10

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable Al2O3_2. 0,02281% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Al2O3_2

Pp = 1,6561
Ppk = 1,16843
Ppk (upper) = 1,16843
Ppk (lower) = 2,14376
K = 0,294468

Based on 6,0 sigma limits.

95,0% Confidence Intervals
Pp: (1,31856, 1,99296)
Ppk: (0,911356, 1,4255)

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 1,6561, which is usually considered to be good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 1,16843. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 0,294468, the mean is located 29,4468% of the way from the center of the specs toward the upper specification limit.
Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how

much these statistics might vary from the true values given the fact that only 47 observations were taken.

Process Capability Analysis - SiO2MT1

Analysis Summary

Data variable: SiO2MT1

Distribution: Normal
sample size = 47
mean = 22,2479
standard deviation = 0,401188

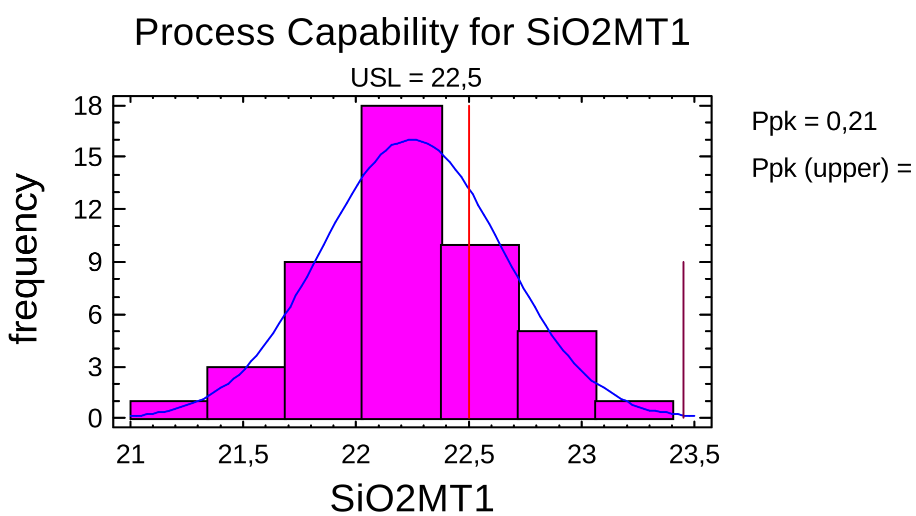
6,0 Sigma Limits
+3,0 sigma = 23,4514
mean = 22,2479
-3,0 sigma = 21,0443

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 22,5	23,404255%	0,63	26,485244%	264852,44
Total	23,404255%		26,485244%	264852,44

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable SiO2MT1. 26,4852% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for SiO2MT1

Pp =

Ppk = 0,209484
Ppk (upper) = 0,209484
Ppk (lower) =
K =

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,209484.

Process Capability Analysis - BLAINEMT1

Analysis Summary

Data variable: BLAINEMT1

Distribution: Normal
sample size = 47
mean = 4778,81
standard deviation = 35,2967

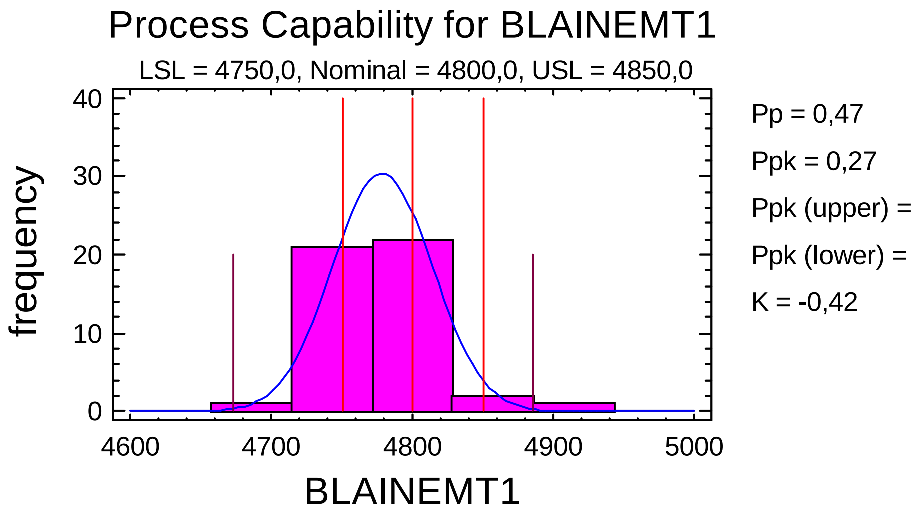
6,0 Sigma Limits
+3,0 sigma = 4884,7
mean = 4778,81
-3,0 sigma = 4672,92

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 4850,0	4,255319%	2,02	2,185037%	21850,37
Nominal = 4800,0				
LSL = 4750,0	12,765957%	-0,82	20,719689%	207196,89
Total	17,021277%		22,904726%	229047,26

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable BLAINEMT1. 22,9047% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for BLAINEMT1

Pp = 0,472188
Ppk = 0,272061
Ppk (upper) = 0,672316
Ppk (lower) = 0,272061
K = -0,42383

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (0,37595, 0,568234)
   Ppk: (0,161734, 0,382388)


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.  One
common index is Pp, which in the case of the normal distribution
equals the distance between the specification limits divided by 6
times the standard deviation.  In this case, Pp equals 0,472188, which
is usually considered to be not good.  Ppk is a one-sided capability
index, which in the case of the normal distribution divides the
distance from the mean to the nearer specification limit by 3 times
the standard deviation.  In this case, Ppk equals 0,272061.  The
rather large difference between Pp and Ppk is a sign that the
distribution is not centered well between the specification limits.  K
equals the mean minus the nominal, divided by one-half the distance
between the specs.  Since K equals -0,42383, the mean is located
42,383% of the way from the center of the specs toward the lower
specification limit.
   Since capability indices are statistics, they will vary from one
sample of data to another.  The 95,0% confidence intervals show how
much these statistics might vary from the true values given the fact
that only 47 observations were taken.



Nonnormal Capability Indices for BLAINEMT1

Pp = 0,39508
Ppk = 0,295462
Ppk (upper) = 0,444989
Ppk (lower) = 0,295462
Pr = 2,53113
K = -0,500763

99.865 percentile = 4943,59
50 percentile = 4774,96
0.135 percentile = 4690,48
```

USL = 4850,0
Nominal = 4800,0
LSL = 4750,0

The StatAdvisor

This pane produces estimates of the usual capability indices without assuming that BLAINEMT1 comes from a normal distribution. To compute the indices, the sample skewness and kurtosis of BLAINEMT1 are first calculated. Based on the estimated skewness and kurtosis, a distribution is selected from the general class of Pearson curves. Estimates of the center, lower limit and upper limit for the distribution are then calculated and used to estimate the capability indices. These indices should be used in place of the normal capability indices if the goodness-of-fit tests are not satisfied.

Process Capability Analysis - LOIMT1

Analysis Summary

Data variable: LOIMT1

Distribution: Normal
sample size = 47
mean = 5,09128
standard deviation = 0,388932

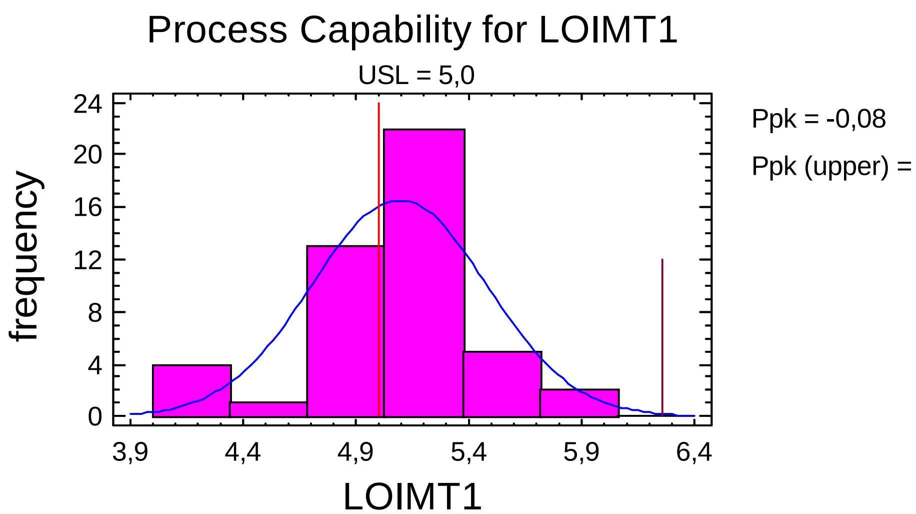
6,0 Sigma Limits
+3,0 sigma = 6,25807
mean = 5,09128
-3,0 sigma = 3,92448

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	63,829787%	-0,23	59,277571%	592775,71
Total	63,829787%		59,277571%	592775,71

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 47 observations in the variable LOIMT1. 59,2776% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for LOIMT1

Pp =
Ppk = -0,0782285
Ppk (upper) = -0,0782285
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals -0,0782285.




Nonnormal Capability Indices for LOIMT1

Pp =
Ppk = -0,115612
Ppk (upper) = -0,115612
Ppk (lower) =
Pr =
K =

99.865 percentile = 6,15013
50 percentile = 5,11919

USL = 5,0


The StatAdvisor
---------------
   This pane produces estimates of the usual capability indices
without assuming that LOIMT1 comes from a normal distribution.  To
compute the indices, the sample skewness and kurtosis of LOIMT1 are
first calculated.  Based on the estimated skewness and kurtosis, a
distribution is selected from the general class of Pearson curves.
Estimates of the center, lower limit and upper limit for the
distribution are then calculated and used to estimate the capability
indices.  These indices should be used in place of the normal
capability indices if the goodness-of-fit tests are not satisfied.
```

```
Process Capability Analysis - IRMT4

Analysis Summary

Data variable: IRMT4

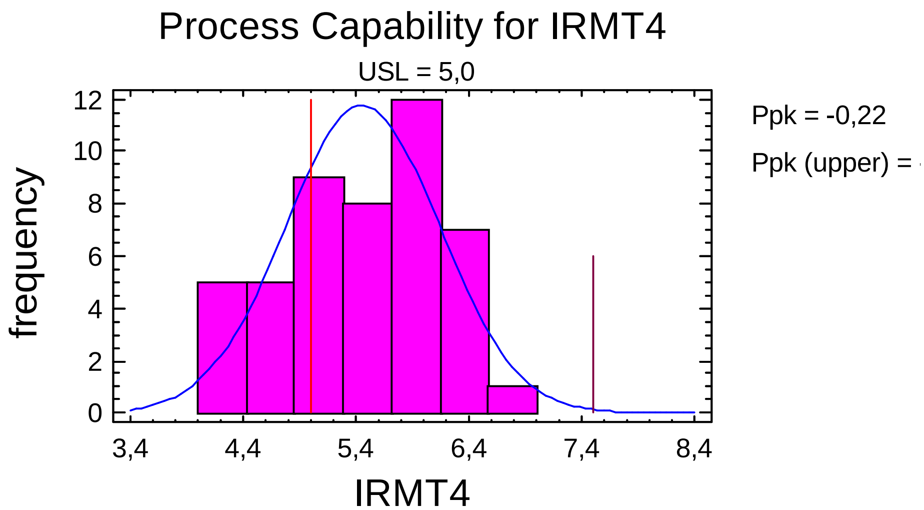
Distribution: Normal
     sample size = 47
     mean = 5,45681
     standard deviation = 0,683816

6,0 Sigma Limits
     +3,0 sigma = 7,50826
     mean = 5,45681
     -3,0 sigma = 3,40536

                     Observed                     Estimated       Defects
Specifications       Beyond Spec.    Z-Score      Beyond Spec.    Per Million
---------------------------------------------------------------------------
USL =      5,0         74,468085%      -0,67        74,794343%      747943,43
---------------------------------------------------------------------------
Total                  74,468085%                   74,794343%      747943,43


The StatAdvisor
---------------
   This procedure is designed to compare a set of data against a set
of specifications.  The goal of the analysis is to estimate the
proportion of the population from which that data comes which falls
outside the specification limits.  In this case, a normal distribution
was fit to a set of 47 observations in the variable IRMT4.  74,7943%
of the fitted distribution lies outside the specification limits.  If
the normal distribution is appropriate for the data, this estimates
the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for
this data, select Goodness-of-Fit Tests from the list of Tabular
Options.  You can assess the fit visually by selecting Capability Plot
from the list of Graphical Options.
```




```
Capability Indices for IRMT4

Pp =
Ppk = -0,222676
Ppk (upper) = -0,222676
Ppk (lower) =
```

K =

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals -0,222676.

Process Capability Analysis - SIO2MT4

Analysis Summary

Data variable: SIO2MT4

Distribution: Normal
sample size = 49
mean = 21,9122
standard deviation = 0,485503

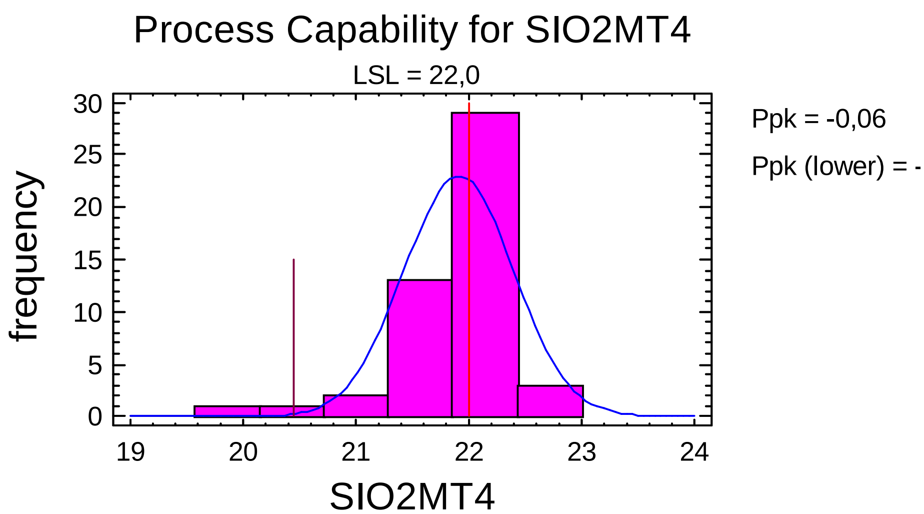
6,0 Sigma Limits
+3,0 sigma = 23,3688
mean = 21,9122
-3,0 sigma = 20,4557

Specifications		Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
LSL =	22,0	53,061224%	0,18	57,172074%	571720,74
Total		53,061224%		57,172074%	571720,74

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable SIO2MT4. 57,1721% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for SIO2MT4

Pp =
Ppk = -0,0602502
Ppk (upper) =
Ppk (lower) = -0,0602502
K =

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications.   Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals -0,0602502.

```
Process Capability Analysis - AMT4l2O3

Analysis Summary

Data variable: AMT4l2O3

Distribution: Normal
     sample size = 48
     mean = 4,9875
     standard deviation = 0,154734

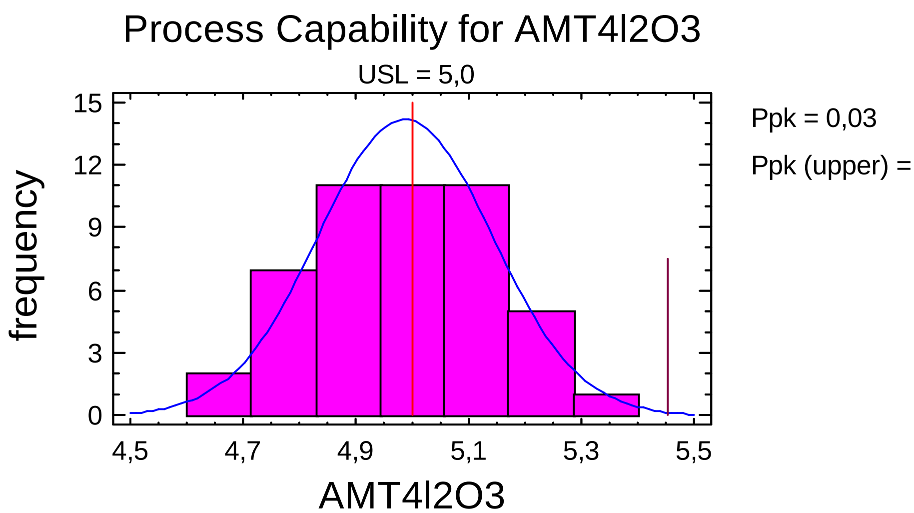
6,0 Sigma Limits
     +3,0 sigma = 5,4517
     mean = 4,9875
     -3,0 sigma = 4,5233
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	47,916667%	0,08	46,780418%	467804,18
Total	47,916667%		46,780418%	467804,18

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 48 observations in the variable AMT4l2O3. 46,7804% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for AMT4l2O3

Pp =
Ppk = 0,026928
Ppk (upper) = 0,026928
Ppk (lower) =
K =

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,026928.

Process Capability Analysis - BLAINEMT4

Analysis Summary

Data variable: BLAINEMT4

Distribution: Normal
sample size = 48
mean = 4258,13
standard deviation = 49,7935

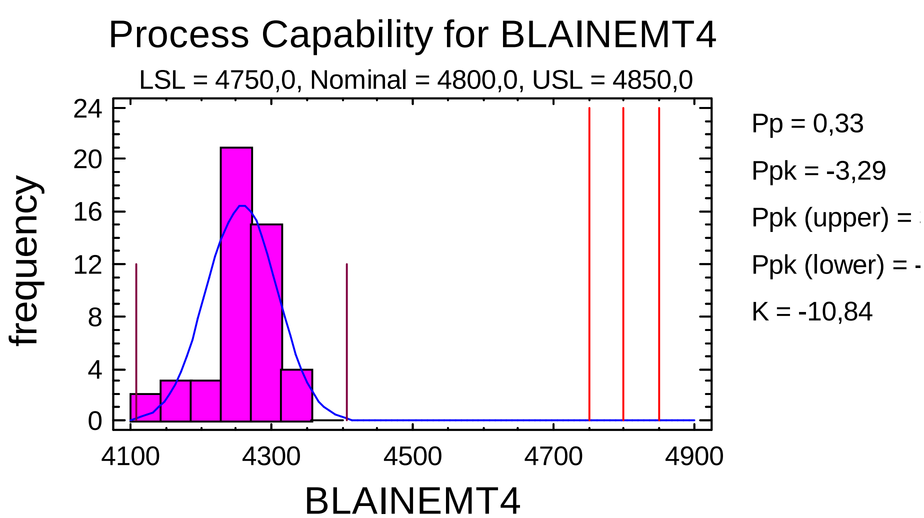
```
6,0 Sigma Limits
     +3,0 sigma = 4407,51
     mean = 4258,13
     -3,0 sigma = 4108,74
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 4850,0	0,000000%	11,89	0,000000%	0,00
Nominal = 4800,0				
LSL = 4750,0	100,000000%	9,88	100,000000%	1000000,00
Total	100,000000%		100,000000%	1000000,00

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 48 observations in the variable BLAINEMT4. 100,0% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for BLAINEMT4

```
Pp = 0,334716
Ppk = -3,29277
Ppk (upper) = 3,9622
Ppk (lower) = -3,29277
K = -10,8375
```

Based on 6,0 sigma limits.

```
95,0% Confidence Intervals
   Pp: (0,267221, 0,402076)
   Ppk: (-3,96507, -2,62047)
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 0,334716, which is usually considered to be not good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals -3,29277. The rather large difference between Pp and Ppk is a sign that the distribution is not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -10,8375, the mean is located 1083,75% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 48 observations were taken.

Process Capability Analysis - LOIMT4

Analysis Summary

Data variable: LOIMT4

Distribution: Normal
sample size = 49
mean = 4,81163
standard deviation = 0,569339

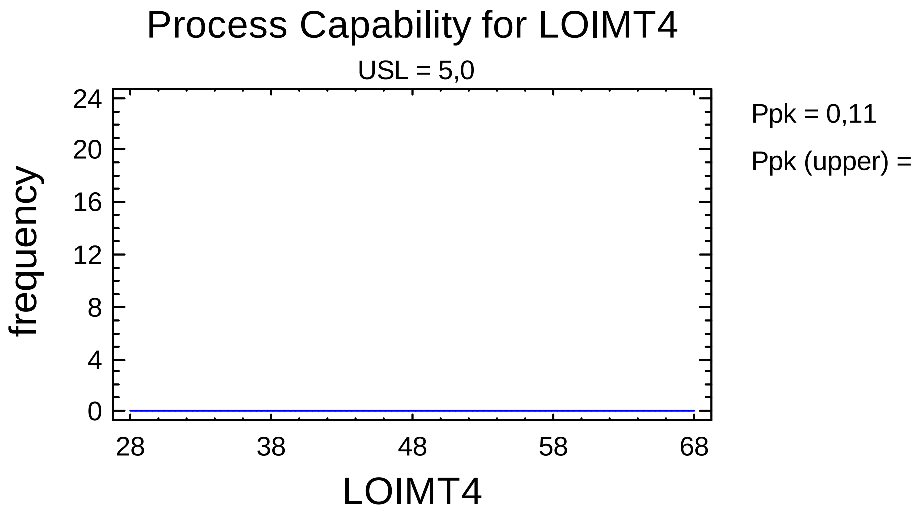
6,0 Sigma Limits
+3,0 sigma = 6,51965
mean = 4,81163
-3,0 sigma = 3,10361

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 5,0	36,734694%	0,33	37,037605%	370376,05
Total	36,734694%		37,037605%	370376,05

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 49 observations in the variable LOIMT4. 37,0376% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for LOIMT4

Pp =
Ppk = 0,110284
Ppk (upper) = 0,110284
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,110284.
```

Ανάλυση ικανότητας- ποιότητα τσιμέντου OPC- μύλος 1

Process Capability Analysis - Al2O3_3

```
Analysis Summary

Data variable: Al2O3_3

Distribution: Normal
     sample size = 66
     mean = 4,77712
     standard deviation = 0,108653

6,0 Sigma Limits
     +3,0 sigma = 5,10308
     mean = 4,77712
     -3,0 sigma = 4,45116
```

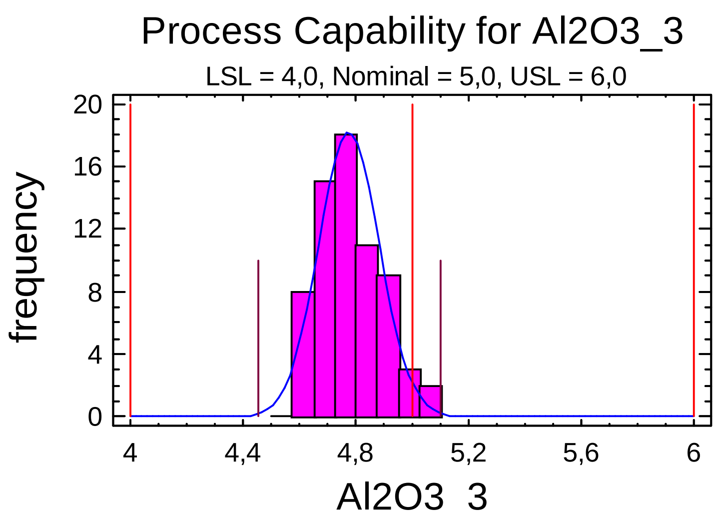
Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,0	0,000000%	11,25	0,000000%	0,00
Nominal = 5,0				
LSL = 4,0	0,000000%	-7,15	0,000000%	0,00

```
------------------------------------------------------------------------------
Total                    0,000000%                   0,000000%          0,00
```

The StatAdvisor

   This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 66 observations in the variable Al2O3_3. 4,29545E-11% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Al2O3_3

Pp = 3,06788
Ppk = 2,38411
Ppk (upper) = 3,75164
Ppk (lower) = 2,38411
K = -0,222879

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (2,54134, 3,59342)
   Ppk: (1,96647, 2,80176)

The StatAdvisor

   Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 3,06788, which is usually considered to be very good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,38411. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,222879, the mean is located 22,2879% of the way from the center of the specs toward the lower specification

limit.
Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 66 observations were taken.

Process Capability Analysis - Blaine_3

Analysis Summary

Data variable: Blaine_3

Distribution: Normal
sample size = 66
mean = 3667,42
standard deviation = 56,1402

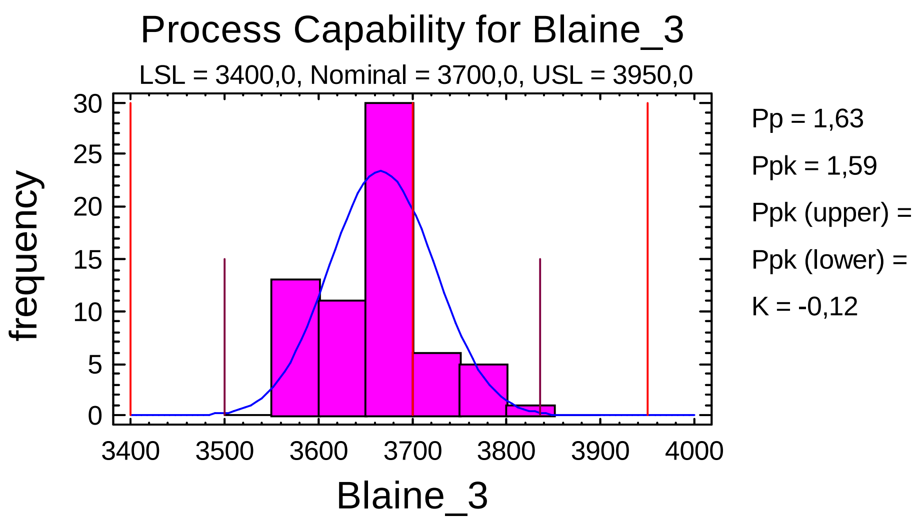
6,0 Sigma Limits
+3,0 sigma = 3835,84
mean = 3667,42
-3,0 sigma = 3499,0

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 3950,0	0,000000%	5,03	0,000024%	0,24
Nominal = 3700,0				
LSL = 3400,0	0,000000%	-4,76	0,000095%	0,95
Total	0,000000%		0,000119%	1,19

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 66 observations in the variable Blaine_3. 0,000119381% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Blaine_3

Pp = 1,63282
Ppk = 1,58783
Ppk (upper) = 1,6778
Ppk (lower) = 1,58783
K = -0,118457

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (1,35258, 1,91253)
   Ppk: (1,30329, 1,87238)


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.  One
common index is Pp, which in the case of the normal distribution
equals the distance between the specification limits divided by 6
times the standard deviation.  In this case, Pp equals 1,63282, which
is usually considered to be good.  Ppk is a one-sided capability
index, which in the case of the normal distribution divides the
distance from the mean to the nearer specification limit by 3 times
the standard deviation.  In this case, Ppk equals 1,58783.  K equals
the mean minus the nominal, divided by one-half the distance between
the specs.  Since K equals -0,118457, the mean is located 11,8457% of
the way from the center of the specs toward the lower specification
limit.
   Since capability indices are statistics, they will vary from one
sample of data to another.  The 95,0% confidence intervals show how
much these statistics might vary from the true values given the fact
that only 66 observations were taken.




Process Capability Analysis - Al2O3_4


Process Capability Analysis - SiO2_3

Analysis Summary

Data variable: SiO2_3
```

```
Distribution: Normal
     sample size = 66
     mean = 20,6514
     standard deviation = 0,217736

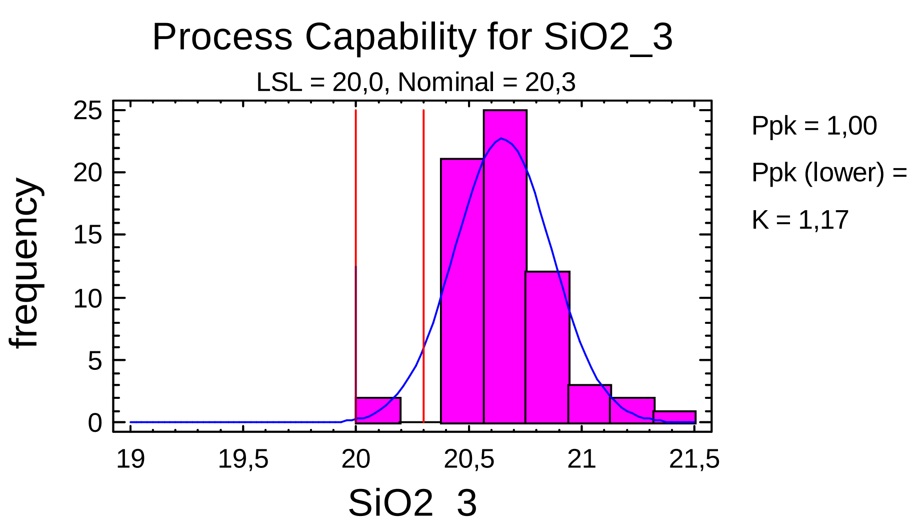
6,0 Sigma Limits
     +3,0 sigma = 21,3046
     mean = 20,6514
     -3,0 sigma = 19,9982
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 20,3				
LSL = 20,0	0,000000%	-2,99	0,138797%	1387,97
Total	0,000000%		0,138797%	1387,97

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 66 observations in the variable SiO2_3. 0,138797% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for SiO2_3

Pp =
Ppk = 0,997177
Ppk (upper) =
Ppk (lower) = 0,997177
K = 1,17121

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,997177. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 1,17121, the mean is located 117,121% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - LOI_3

Analysis Summary

Data variable: LOI_3

Distribution: Normal
sample size = 66
mean = 1,14939
standard deviation = 0,150311

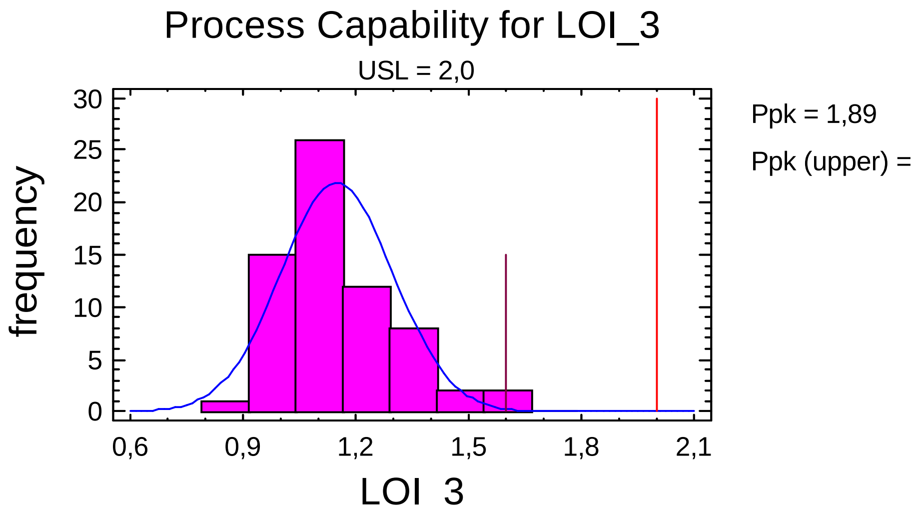
6,0 Sigma Limits
+3,0 sigma = 1,60033
mean = 1,14939
-3,0 sigma = 0,69846

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 2,0	0,000000%	5,66	0,000001%	0,01
Total	0,000000%		0,000001%	0,01

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 66 observations in the variable LOI_3. 7,63573E-7% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for LOI_3

Pp =
Ppk = 1,88632
Ppk (upper) = 1,88632
Ppk (lower) =
K =

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 1,88632.
```

Process Capability Analysis - Est2_3

```
Analysis Summary

Data variable: Est2_3

Distribution: Normal
     sample size = 64
     mean = 29,2031
     standard deviation = 1,25318

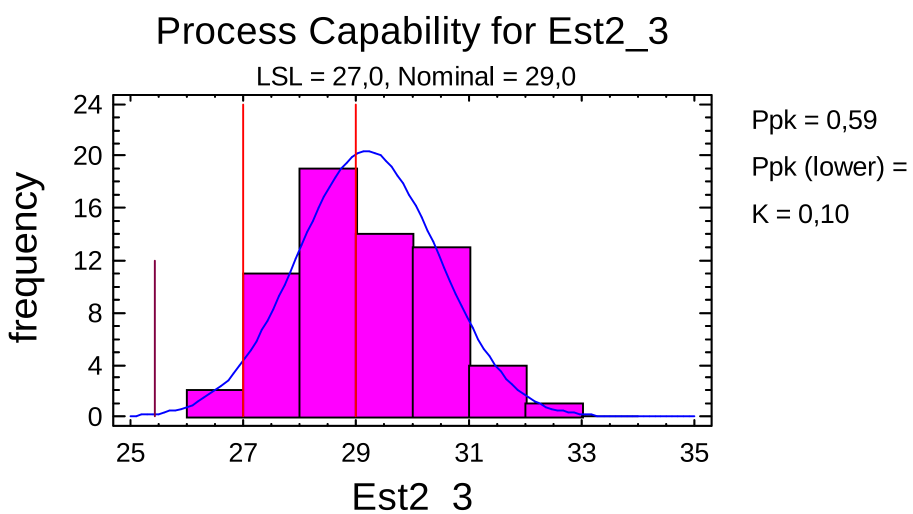
6,0 Sigma Limits
     +3,0 sigma = 32,9627
     mean = 29,2031
     -3,0 sigma = 25,4436
```

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 29,0				
LSL = 27,0	1,562500%	-1,76	3,937152%	39371,52
Total	1,562500%		3,937152%	39371,52

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 64 observations in the variable Est2_3. 3,93715% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Est2_3

Pp =
Ppk = 0,586008
Ppk (upper) =
Ppk (lower) = 0,586008
K = 0,101562

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,586008. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 0,101562, the mean is located 10,1562% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est7_3

Analysis Summary

Data variable: Est7_3

```
Distribution: Normal
     sample size = 61
     mean = 43,9984
     standard deviation = 1,55215

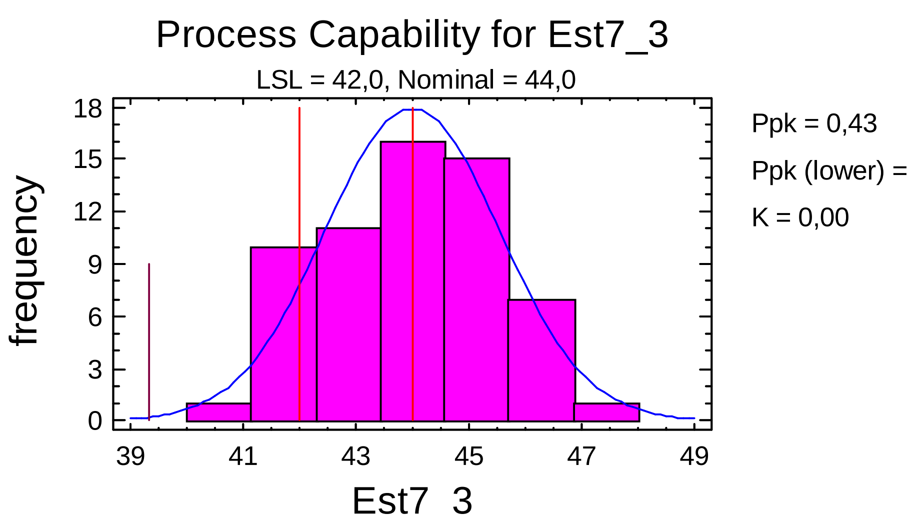
6,0 Sigma Limits
     +3,0 sigma = 48,6548
     mean = 43,9984
     -3,0 sigma = 39,3419

                     Observed                    Estimated        Defects
Specifications       Beyond Spec.    Z-Score     Beyond Spec.     Per Million
---------------------------------------------------------------------------
Nominal = 44,0
LSL =      42,0         8,196721%      -1,29        9,896309%       98963,09
---------------------------------------------------------------------------
Total                   8,196721%                   9,896309%       98963,09
```

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 61 observations in the variable Est7_3. 9,89631% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Est7_3

Pp =
Ppk = 0,42916
Ppk (upper) =
Ppk (lower) = 0,42916
K = -0,000819672

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,42916. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,000819672, the mean is located 0,0819672% of the way from the center of the specs toward the lower specification limit.

Process Capability Analysis - Est28_3

Analysis Summary

Data variable: Est28_3

Distribution: Normal
sample size = 46
mean = 62,3109
standard deviation = 1,40083

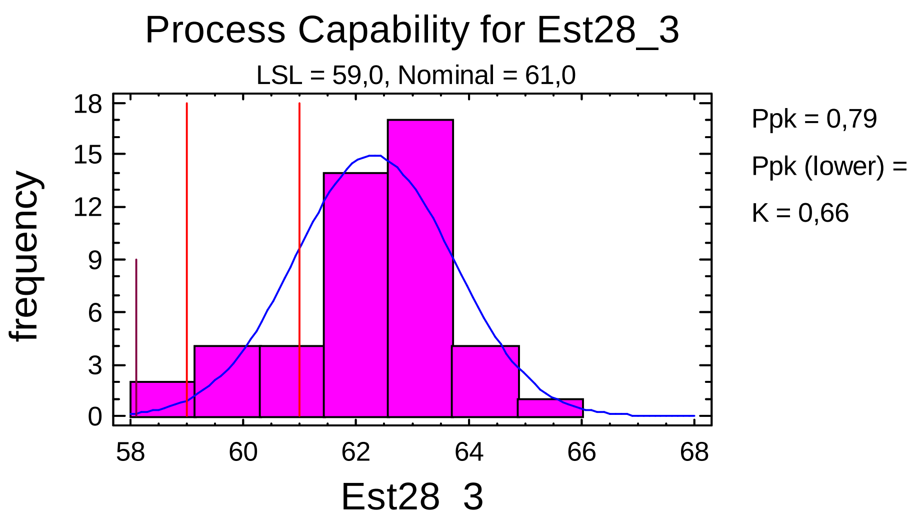
6,0 Sigma Limits
+3,0 sigma = 66,5134
mean = 62,3109
-3,0 sigma = 58,1084

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 61,0				
LSL = 59,0	0,000000%	-2,36	0,905142%	9051,42
Total	0,000000%		0,905142%	9051,42

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 46 observations in the variable Est28_3. 0,905142% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Est28_3

Pp =
Ppk = 0,787835
Ppk (upper) =
Ppk (lower) = 0,787835
K = 0,655435

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,787835.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals 0,655435, the
mean is located 65,5435% of the way from the center of the specs
toward the upper specification limit.
```

Ανάλυση ικανότητας- ποιότητα τσιμέντου OPC – μύλος 4

```
Analysis Summary

Data variable: Al2O3_4

Distribution: Normal
     sample size = 44
     mean = 4,69409
     standard deviation = 0,0962148

6,0 Sigma Limits
     +3,0 sigma = 4,98274
     mean = 4,69409
     -3,0 sigma = 4,40545
```

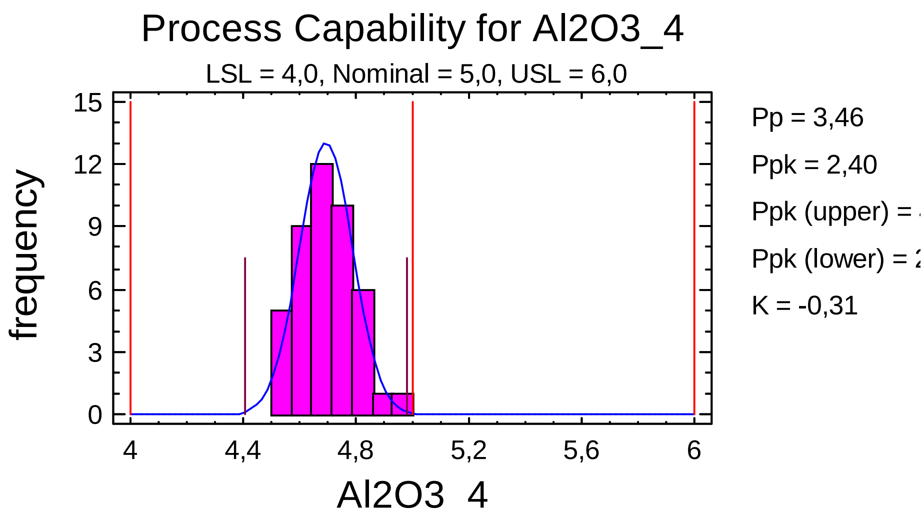
Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 6,0	0,000000%	13,57	0,000000%	0,00

```
Nominal = 5,0
LSL =     4,0          0,000000%      -7,21       0,000000%           0,00
---------------------------------------------------------------------------
Total                  0,000000%                  0,000000%           0,00
```

The StatAdvisor

   This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 44 observations in the variable Al2O3_4. 2,7367E-11% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Al2O3_4

Pp = 3,46447
Ppk = 2,40466
Ppk (upper) = 4,52428
Ppk (lower) = 2,40466
K = -0,305909

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (2,73433, 4,19314)
   Ppk: (1,88698, 2,92233)

The StatAdvisor

   Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. One common index is Pp, which in the case of the normal distribution equals the distance between the specification limits divided by 6 times the standard deviation. In this case, Pp equals 3,46447, which is usually considered to be very good. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,40466. The rather large difference between Pp and Ppk is a sign that the distribution is

not centered well between the specification limits. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals -0,305909, the mean is located 30,5909% of the way from the center of the specs toward the lower specification limit.

Since capability indices are statistics, they will vary from one sample of data to another. The 95,0% confidence intervals show how much these statistics might vary from the true values given the fact that only 44 observations were taken.

Process Capability Analysis - Blaine_4

Analysis Summary

Data variable: Blaine_4

Distribution: Normal
sample size = 44
mean = 3691,36
standard deviation = 51,1082

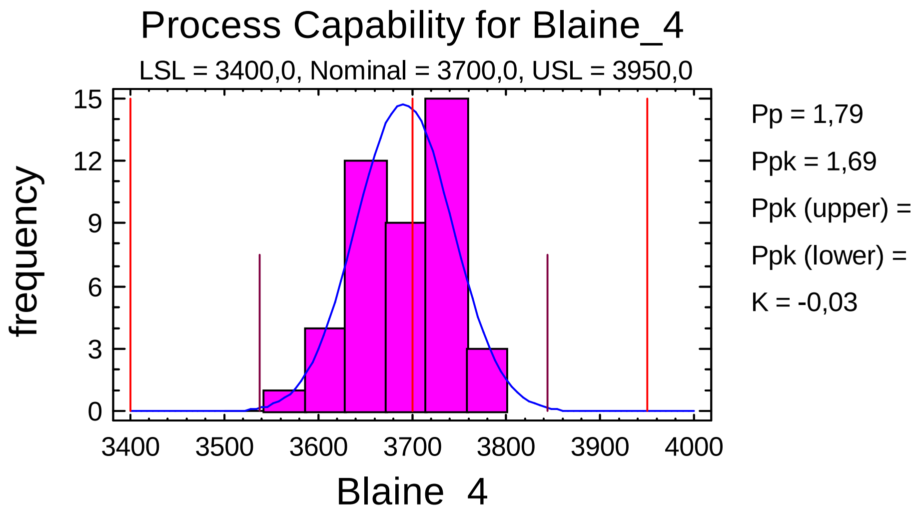
6,0 Sigma Limits
+3,0 sigma = 3844,69
mean = 3691,36
-3,0 sigma = 3538,04

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
USL = 3950,0	0,000000%	5,06	0,000021%	0,21
Nominal = 3700,0				
LSL = 3400,0	0,000000%	-5,70	0,000001%	0,01
Total	0,000000%		0,000022%	0,22

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 44 observations in the variable Blaine_4. 0,0000215337% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Blaine_4

Pp = 1,79358
Ppk = 1,68685
Ppk (upper) = 1,68685
Ppk (lower) = 1,9003
K = -0,031405

Based on 6,0 sigma limits.

95,0% Confidence Intervals
   Pp: (1,41558, 2,17082)
   Ppk: (1,31698, 2,05672)


The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.  One
common index is Pp, which in the case of the normal distribution
equals the distance between the specification limits divided by 6
times the standard deviation.  In this case, Pp equals 1,79358, which
is usually considered to be good.  Ppk is a one-sided capability
index, which in the case of the normal distribution divides the
distance from the mean to the nearer specification limit by 3 times
the standard deviation.  In this case, Ppk equals 1,68685.  K equals
the mean minus the nominal, divided by one-half the distance between
the specs.  Since K equals -0,031405, the mean is located 3,1405% of
the way from the center of the specs toward the lower specification
limit.
   Since capability indices are statistics, they will vary from one
sample of data to another.  The 95,0% confidence intervals show how
much these statistics might vary from the true values given the fact
that only 44 observations were taken.




Process Capability Analysis - LOI_4

Analysis Summary

Data variable: LOI_4

Distribution: Normal
     sample size = 44
     mean = 1,19886
     standard deviation = 0,12397
```

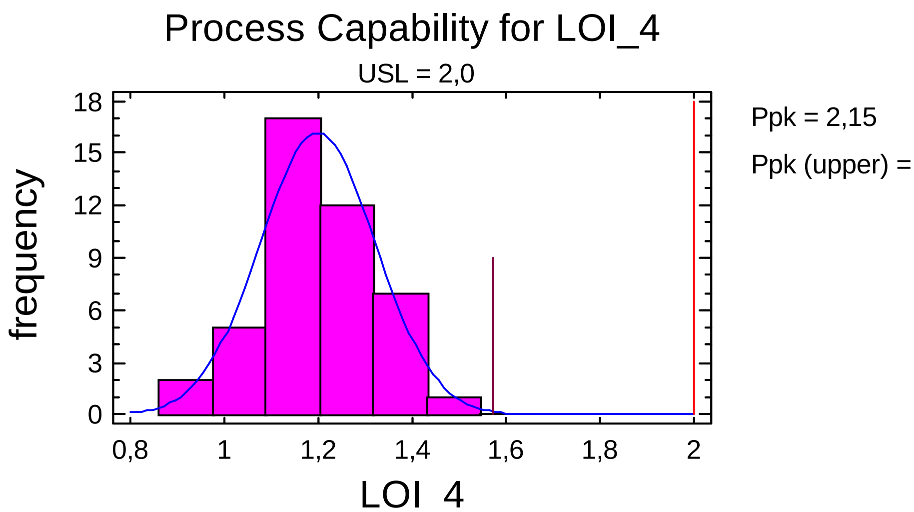
```
6,0 Sigma Limits
     +3,0 sigma = 1,57077
     mean = 1,19886
     -3,0 sigma = 0,826955

                     Observed                          Estimated        Defects
Specifications       Beyond Spec.     Z-Score          Beyond Spec.     Per Million
---------------------------------------------------------------------------
USL =      2,0          0,000000%        6,46          0,000000%            0,00
---------------------------------------------------------------------------
Total                   0,000000%                      0,000000%            0,00
```

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 44 observations in the variable LOI_4. 5,17879E-9% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for LOI_4

Pp =
Ppk = 2,15412
Ppk (upper) = 2,15412
Ppk (lower) =
K =

Based on 6,0 sigma limits.
```

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 2,15412.

Process Capability Analysis - sio2_4

Analysis Summary

Data variable: sio2_4

Distribution: Normal
sample size = 44
mean = 20,6209
standard deviation = 0,177631

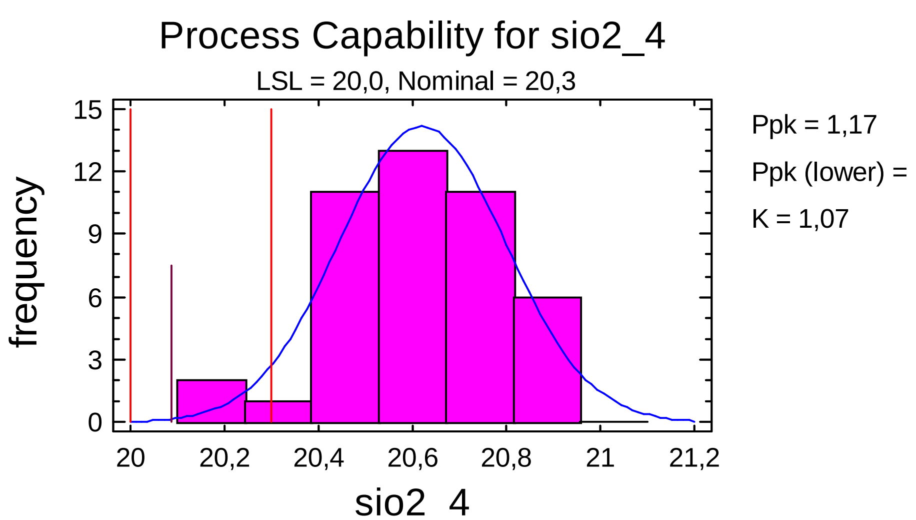
6,0 Sigma Limits
+3,0 sigma = 21,1538
mean = 20,6209
-3,0 sigma = 20,088

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 20,3				
LSL = 20,0	0,000000%	-3,50	0,023663%	236,63
Total	0,000000%		0,023663%	236,63

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 44 observations in the variable sio2_4. 0,0236625% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for sio2_4

Pp =
Ppk = 1,16517
Ppk (upper) =
Ppk (lower) = 1,16517
K = 1,0697

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications. Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 1,16517. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 1,0697, the mean is located 106,97% of the way from the center of the specs toward the upper specification limit.

Process Capability Analysis - Est2_4

Analysis Summary

Data variable: Est2_4

Distribution: Normal
sample size = 43
mean = 27,6535
standard deviation = 0,940706

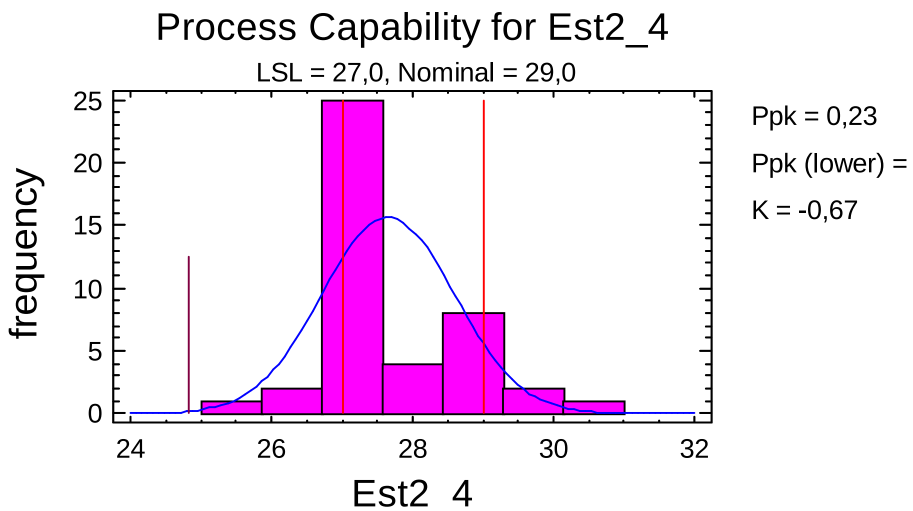
6,0 Sigma Limits
+3,0 sigma = 30,4756
mean = 27,6535
-3,0 sigma = 24,8314

Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 29,0				
LSL = 27,0	6,976744%	-0,69	24,362716%	243627,16
Total	6,976744%		24,362716%	243627,16

The StatAdvisor

This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 43 observations in the variable Est2_4. 24,3627% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.




```
Capability Indices for Est2_4

Pp =
Ppk = 0,23156
Ppk (upper) =
Ppk (lower) = 0,23156
K = -0,673256

Based on 6,0 sigma limits.



The StatAdvisor
---------------
   Several capability indices have been computed to summarize the
comparison of the fitted distribution to the specifications.    Ppk is
a one-sided capability index, which in the case of the normal
distribution divides the distance from the mean to the nearer
specification limit by 3 times the standard deviation.  In this case,
Ppk equals 0,23156.  K equals the mean minus the nominal, divided by
one-half the distance between the specs.  Since K equals -0,673256,
the mean is located 67,3256% of the way from the center of the specs
toward the lower specification limit.




Process Capability Analysis - Est7_4

Analysis Summary

Data variable: Est7_4

Distribution: Normal
     sample size = 40
     mean = 42,52
     standard deviation = 1,26799

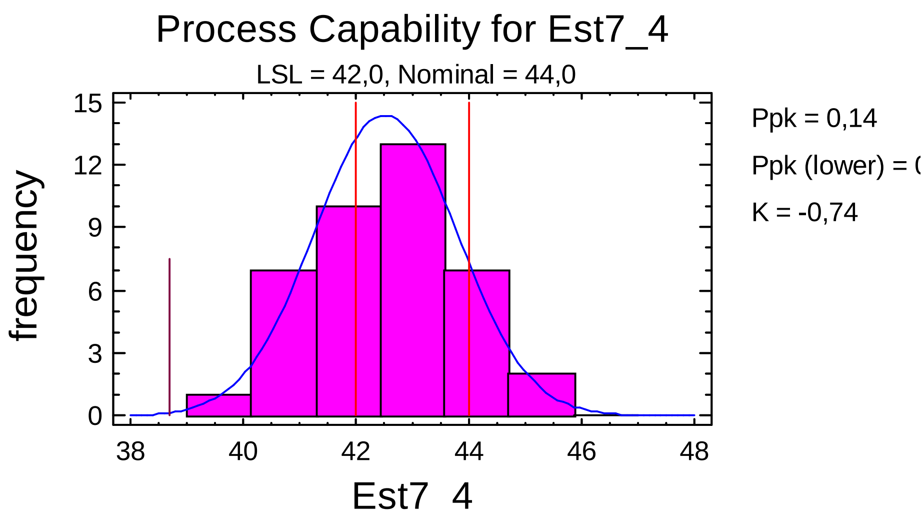
6,0 Sigma Limits
     +3,0 sigma = 46,324
     mean = 42,52
     -3,0 sigma = 38,716

                     Observed                     Estimated       Defects
Specifications       Beyond Spec.    Z-Score     Beyond Spec.    Per Million
---------------------------------------------------------------------------
Nominal = 44,0
LSL =      42,0        32,500000%      -0,41       34,086518%      340865,18
---------------------------------------------------------------------------
Total                  32,500000%                  34,086518%      340865,18
```

The StatAdvisor

   This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls outside the specification limits. In this case, a normal distribution was fit to a set of 40 observations in the variable Est7_4. 34,0865% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

   To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Process Capability Analysis - Est28_4

Analysis Summary

Data variable: Est28_4

Distribution: Normal
     sample size = 29
     mean = 61,2966
     standard deviation = 2,20397

6,0 Sigma Limits
     +3,0 sigma = 67,9085
     mean = 61,2966
     -3,0 sigma = 54,6846

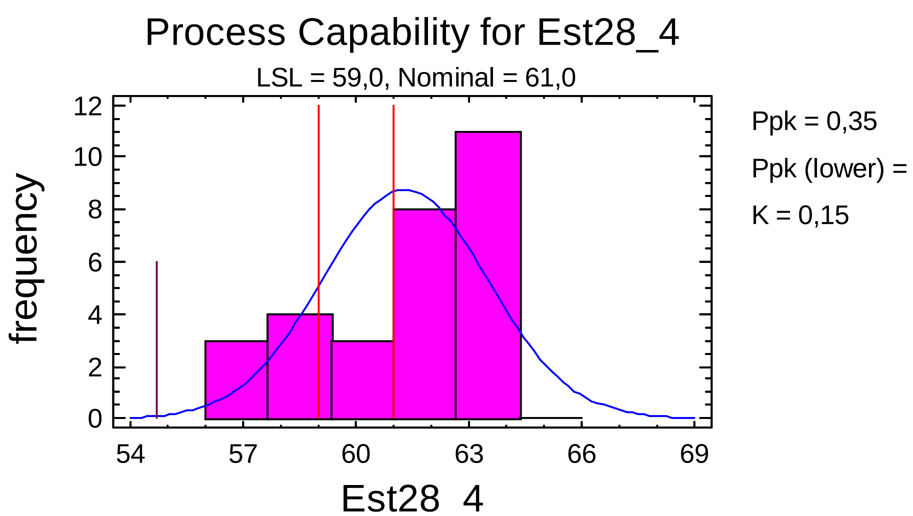
Specifications	Observed Beyond Spec.	Z-Score	Estimated Beyond Spec.	Defects Per Million
Nominal = 61,0				
LSL = 59,0	17,241379%	-1,04	14,870375%	148703,75
Total	17,241379%		14,870375%	148703,75

The StatAdvisor

   This procedure is designed to compare a set of data against a set of specifications. The goal of the analysis is to estimate the proportion of the population from which that data comes which falls

outside the specification limits. In this case, a normal distribution was fit to a set of 29 observations in the variable Est28_4. 14,8704% of the fitted distribution lies outside the specification limits. If the normal distribution is appropriate for the data, this estimates the percent of the population which lies outside the spec.

To determine whether the normal distribution is appropriate for this data, select Goodness-of-Fit Tests from the list of Tabular Options. You can assess the fit visually by selecting Capability Plot from the list of Graphical Options.



Capability Indices for Est28_4

Pp =
Ppk = 0,347335
Ppk (upper) =
Ppk (lower) = 0,347335
K = 0,148276

Based on 6,0 sigma limits.

The StatAdvisor

Several capability indices have been computed to summarize the comparison of the fitted distribution to the specifications.   Ppk is a one-sided capability index, which in the case of the normal distribution divides the distance from the mean to the nearer specification limit by 3 times the standard deviation. In this case, Ppk equals 0,347335. K equals the mean minus the nominal, divided by one-half the distance between the specs. Since K equals 0,148276, the mean is located 14,8276% of the way from the center of the specs toward the upper specification limit.

ΠΑΡΑΡΤΗΜΑ Γ

Συσχέτιση ιδιοτήτων- ποιότητα τσιμέντου CEM II 42,5- μύλος 1

Multiple-Variable Analysis

Analysis Summary

Data variables:
Est1_1

```
     Blaine_1
     IR_1
     LOI_1
     SiO2_1
     Al2O3_1

There are 47 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

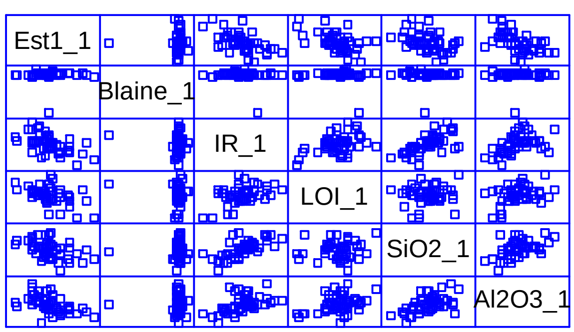
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```




```
Correlations
```

	Est1_1	Blaine_1	IR_1	LOI_1
Est1_1		0,0178 (47) 0,9053	-0,5742 (47) 0,0000	-0,5186 (47) 0,0002
Blaine_1	0,0178 (47) 0,9053		-0,1173 (47) 0,4324	-0,1539 (47) 0,3017
IR_1	-0,5742 (47) 0,0000	-0,1173 (47) 0,4324		0,4478 (47) 0,0016
LOI_1	-0,5186 (47) 0,0002	-0,1539 (47) 0,3017	0,4478 (47) 0,0016	
SiO2_1	-0,4523 (47) 0,0014	0,0104 (47) 0,9447	0,6708 (47) 0,0000	0,0916 (47) 0,5404
Al2O3_1	-0,5316 (47) 0,0001	0,0005 (47) 0,9975	0,4977 (47) 0,0004	0,3858 (47) 0,0074

	SiO2_1	Al2O3_1
Est1_1	-0,4523 (47) 0,0014	-0,5316 (47) 0,0001
Blaine_1	0,0104 (47) 0,9447	0,0005 (47) 0,9975
IR_1	0,6708 (47) 0,0000	0,4977 (47) 0,0004
LOI_1	0,0916 (47) 0,5404	0,3858 (47) 0,0074
SiO2_1		0,5471 (47) 0,0001
Al2O3_1	0,5471 (47) 0,0001	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est1_1 and IR_1
Est1_1 and LOI_1
Est1_1 and SiO2_1
Est1_1 and Al2O3_1
IR_1 and LOI_1
IR_1 and SiO2_1
IR_1 and Al2O3_1
LOI_1 and Al2O3_1
SiO2_1 and Al2O3_1

Multiple-Variable Analysis

Analysis Summary

Data variables:
Est2_1
Blaine_1
IR_1
LOI_1
SiO2_1
Al2O3_1

There are 47 complete cases for use in the calculations.

The StatAdvisor

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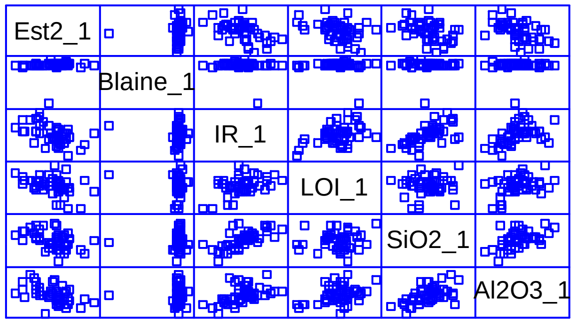
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to

each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est2_1	Blaine_1	IR_1	LOI_1
Est2_1		0,0742	-0,5274	-0,3989
		(47)	(47)	(47)
		0,6200	0,0001	0,0055
Blaine_1	0,0742		-0,1173	-0,1539
	(47)		(47)	(47)
	0,6200		0,4324	0,3017
IR_1	-0,5274	-0,1173		0,4478
	(47)	(47)		(47)
	0,0001	0,4324		0,0016
LOI_1	-0,3989	-0,1539	0,4478	
	(47)	(47)	(47)	
	0,0055	0,3017	0,0016	
SiO2_1	-0,4182	0,0104	0,6708	0,0916
	(47)	(47)	(47)	(47)
	0,0034	0,9447	0,0000	0,5404
Al2O3_1	-0,5201	0,0005	0,4977	0,3858
	(47)	(47)	(47)	(47)
	0,0002	0,9975	0,0004	0,0074

	SiO2_1	Al2O3_1
Est2_1	-0,4182	-0,5201
	(47)	(47)
	0,0034	0,0002
Blaine_1	0,0104	0,0005
	(47)	(47)
	0,9447	0,9975
IR_1	0,6708	0,4977
	(47)	(47)
	0,0000	0,0004
LOI_1	0,0916	0,3858
	(47)	(47)
	0,5404	0,0074
SiO2_1		0,5471
		(47)
		0,0001
Al2O3_1	0,5471	
	(47)	
	0,0001	

Correction
(Sample Size)
P-Value

The StatAdvisor

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   Est2_1 and IR_1
   Est2_1 and LOI_1
   Est2_1 and SiO2_1
   Est2_1 and Al2O3_1
   IR_1 and LOI_1
   IR_1 and SiO2_1
   IR_1 and Al2O3_1
   LOI_1 and Al2O3_1
   SiO2_1 and Al2O3_1

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Al2O3_2
     BLAINEMT1
     IR_2
     LOIMT1
     SiO2MT1
     Est7MT1

There are 46 complete cases for use in the calculations.

The StatAdvisor

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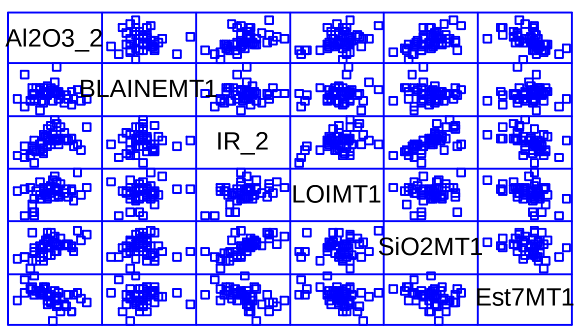
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

```
                    Al2O3_2             BLAINEMT1           IR_2                LOIMT1
--------------------------------------------------------------------------------------
--------------
Al2O3_2                                 -0,0763             0,5048
0,3972
                                        (    46)            (    46)            (
46)
                                         0,6141             0,0003
0,0063

BLAINEMT1           -0,0763                                 0,0661
0,1737
```

```
                    (   46)                                     (   46)             (
46)
                     0,6141                                      0,6624
0,2484

IR_2                 0,5048              0,0661
0,4336
                    (   46)             (   46)                                     (
46)
                     0,0003              0,6624
0,0026

LOIMT1               0,3972              0,1737              0,4336
                    (   46)             (   46)             (   46)
                     0,0063              0,2484              0,0026

SiO2MT1              0,5469             -0,0494              0,6802
0,0978
                    (   46)             (   46)             (   46)             (
46)
                     0,0001              0,7443              0,0000
0,5177

Est7MT1             -0,5257              0,0394             -0,4824             -
0,4267
                    (   46)             (   46)             (   46)             (
46)
                     0,0002              0,7950              0,0007
0,0031
--------------------------------------------------------------------------------------
--------------

                    SiO2MT1             Est7MT1
--------------------------------------------------------------------------------------
--------------
Al2O3_2              0,5469             -0,5257
                    (   46)             (   46)
                     0,0001              0,0002

BLAINEMT1           -0,0494              0,0394
                    (   46)             (   46)
                     0,7443              0,7950

IR_2                 0,6802             -0,4824
                    (   46)             (   46)
                     0,0000              0,0007

LOIMT1               0,0978             -0,4267
                    (   46)             (   46)
                     0,5177              0,0031

SiO2MT1                                 -0,3159
                                        (   46)
                                         0,0325

Est7MT1             -0,3159
                    (   46)
                     0,0325
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
```

```
below 0.05:
   Al2O3_2 and IR_2
   Al2O3_2 and LOIMT1
   Al2O3_2 and SiO2MT1
   Al2O3_2 and Est7MT1
   IR_2 and LOIMT1
   IR_2 and SiO2MT1
   IR_2 and Est7MT1
   LOIMT1 and Est7MT1
   SiO2MT1 and Est7MT1
```

Multiple-Variable Analysis

Analysis Summary

```
Data variables:
     Est28_1
     Blaine_1
     IR_1
     LOI_1
     SiO2_1
     Al2O3_1
```

There are 38 complete cases for use in the calculations.

The StatAdvisor

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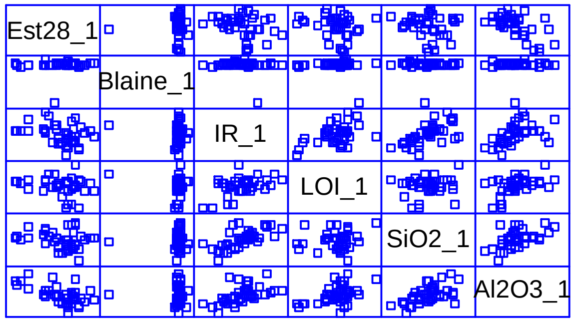
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations




```
Correlations

                    Est28_1             Blaine_1            IR_1                LOI_1
-------------------------------------------------------------------------------------
--------------
Est28_1                                  0,0628             -0,3185              -
0,2207
                                        (    38)            (    38)            (
38)
                                         0,7081              0,0513
0,1831

Blaine_1             0,0628                                 -0,1240              -
0,1844
                    (    38)                                (    38)            (
38)
                     0,7081                                  0,4584
0,2679

IR_1                -0,3185             -0,1240
0,4740
                    (    38)            (    38)                                (
38)
                     0,0513              0,4584
0,0026

LOI_1               -0,2207             -0,1844              0,4740
                    (    38)            (    38)            (    38)
                     0,1831              0,2679              0,0026

SiO2_1              -0,1823              0,0089              0,6542
0,1483
                    (    38)            (    38)            (    38)            (
38)
                     0,2733              0,9577              0,0000
0,3744

Al2O3_1             -0,5807             -0,0141              0,5264
0,4955
                    (    38)            (    38)            (    38)            (
38)
                     0,0001              0,9331              0,0007
0,0016
-------------------------------------------------------------------------------------
--------------

                    SiO2_1              Al2O3_1
-------------------------------------------------------------------------------------
--------------
Est28_1             -0,1823             -0,5807
                    (    38)            (    38)
```

```
                    0,2733              0,0001

Blaine_1            0,0089             -0,0141
                   (   38)             (   38)
                    0,9577              0,9331

IR_1                0,6542              0,5264
                   (   38)             (   38)
                    0,0000              0,0007

LOI_1               0,1483              0,4955
                   (   38)             (   38)
                    0,3744              0,0016

SiO2_1                                  0,5770
                                       (   38)
                                        0,0001

Al2O3_1             0,5770
                   (   38)
                    0,0001
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est28_1 and Al2O3_1
   IR_1 and LOI_1
   IR_1 and SiO2_1
   IR_1 and Al2O3_1
   LOI_1 and Al2O3_1
   SiO2_1 and Al2O3_1
```

Συσχέτιση ιδιοτήτων-ποιότητα τσιμέντου CEM II 42,5- μύλος 4

Multiple-Variable Analysis

```
Analysis Summary

Data variables:
     Est7_2
     Blaine_2
     IR_2
     LOI_2
     SiO2_2
     Al2O3_2

There are 43 complete cases for use in the calculations.


The StatAdvisor
---------------
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```

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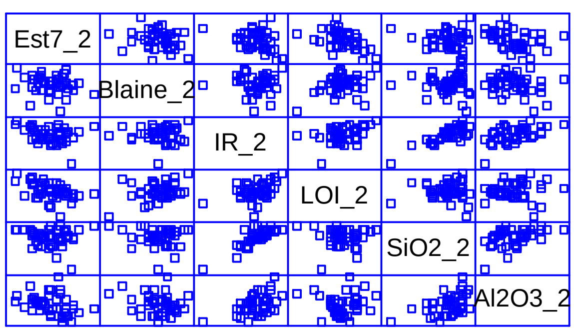
GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est7_2	Blaine_2	IR_2	LOI_2
Est7_2		-0,1903	-0,3106	-0,4713
		(43)	(43)	(43)
		0,2216	0,0426	0,0014
Blaine_2	-0,1903		0,0139	0,3634
	(43)		(43)	(43)

```
                    0,2216                                  0,9296
0,0166

IR_2               -0,3106              0,0139
0,4005
                   (    43)            (    43)                                 (
43)
                    0,0426              0,9296
0,0078

LOI_2              -0,4713              0,3634              0,4005
                   (    43)            (    43)            (    43)
                    0,0014              0,0166              0,0078

SiO2_2             -0,1014             -0,1028              0,8383              -
0,0180
                   (    43)            (    43)            (    43)            (
43)
                    0,5176              0,5118              0,0000
0,9088

Al2O3_2            -0,3498             -0,2101              0,4940
0,0652
                   (    43)            (    43)            (    43)            (
43)
                    0,0215              0,1764              0,0008
0,6779
--------------------------------------------------------------------------------------
--------------

                   SiO2_2              Al2O3_2
--------------------------------------------------------------------------------------
--------------
Est7_2             -0,1014             -0,3498
                   (    43)            (    43)
                    0,5176              0,0215

Blaine_2           -0,1028             -0,2101
                   (    43)            (    43)
                    0,5118              0,1764

IR_2                0,8383              0,4940
                   (    43)            (    43)
                    0,0000              0,0008

LOI_2              -0,0180              0,0652
                   (    43)            (    43)
                    0,9088              0,6779

SiO2_2                                  0,4525
                                       (    43)
                                        0,0023

Al2O3_2             0,4525
                   (    43)
                    0,0023
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
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significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est7_2 and IR_2
```

Est7_2 and LOI_2
Est7_2 and Al2O3_2
Blaine_2 and LOI_2
IR_2 and LOI_2
IR_2 and SiO2_2
IR_2 and Al2O3_2
SiO2_2 and Al2O3_2

Multiple-Variable Analysis

Analysis Summary

Data variables:
Est28_2
Blaine_2
IR_2
LOI_2
SiO2_2
Al2O3_2

There are 36 complete cases for use in the calculations.

The StatAdvisor

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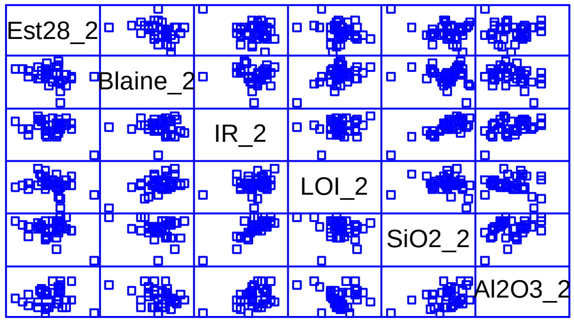
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est28_2	Blaine_2	IR_2	LOI_2
Est28_2		-0,3155 (36) 0,0609	-0,3272 (36) 0,0514	-0,2558 (36) 0,1321
Blaine_2	-0,3155 (36) 0,0609		-0,0830 (36) 0,6305	0,5252 (36) 0,0010
IR_2	-0,3272 (36) 0,0514	-0,0830 (36) 0,6305		0,2542 (36) 0,1346
LOI_2	-0,2558 (36) 0,1321	0,5252 (36) 0,0010	0,2542 (36) 0,1346	
SiO2_2	-0,2765 (36) 0,1026	-0,2025 (36) 0,2363	0,8345 (36) 0,0000	-0,1550 (36) 0,3667
Al2O3_2	0,0243 (36) 0,8879	-0,3030 (36) 0,0724	0,3836 (36) 0,0209	-0,1410 (36) 0,4120

	SiO2_2	Al2O3_2
Est28_2	-0,2765 (36)	0,0243 (36)

	0,1026	0,8879
Blaine_2	-0,2025	-0,3030
	(36)	(36)
	0,2363	0,0724
IR_2	0,8345	0,3836
	(36)	(36)
	0,0000	0,0209
LOI_2	-0,1550	-0,1410
	(36)	(36)
	0,3667	0,4120
SiO2_2		0,3758
		(36)
		0,0239
Al2O3_2	0,3758	
	(36)	
	0,0239	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Blaine_2 and LOI_2
IR_2 and SiO2_2
IR_2 and Al2O3_2
SiO2_2 and Al2O3_2

Multiple-Variable Analysis

Analysis Summary

Data variables:
Est1_2
Blaine_2
IR_2
LOI_2
SiO2_2
Al2O3_2

There are 44 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one

of several procedures may be appropriate. Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

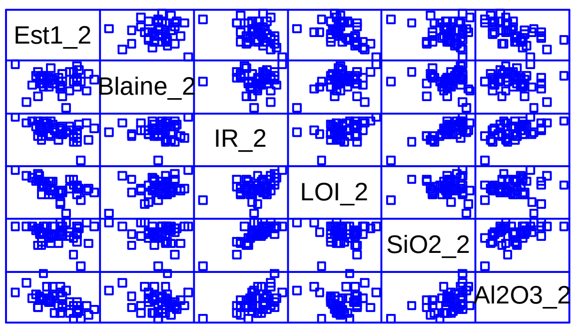
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

```
                    Est1_2              Blaine_2            IR_2                LOI_2
--------------------------------------------------------------------------------------
--------------
Est1_2                                   0,0296             -0,4493              -
0,5183
                                        (    44)            (    44)            (
44)
                                         0,8489              0,0022
0,0003

Blaine_2             0,0296                                  0,0194
0,3640
                    (    44)                                (    44)            (
44)
                     0,8489                                  0,9006
0,0151

IR_2                -0,4493              0,0194
0,4140
                    (    44)            (    44)                                (
44)
```

```
                    0,0022              0,9006
0,0052

LOI_2               -0,5183             0,3640              0,4140
                    (    44)            (    44)            (    44)
                     0,0003             0,0151              0,0052

SiO2_2              -0,1685             -0,1030              0,8192              -
0,0188
                    (    44)            (    44)            (    44)            (
44)
                     0,2743              0,5060              0,0000
0,9037

Al2O3_2             -0,5943             -0,2098              0,4851
0,0656
                    (    44)            (    44)            (    44)            (
44)
                     0,0000              0,1717              0,0008
0,6723
----------------------------------------------------------------------------------------
--------------

                    SiO2_2              Al2O3_2
----------------------------------------------------------------------------------------
--------------
Est1_2              -0,1685             -0,5943
                    (    44)            (    44)
                     0,2743              0,0000

Blaine_2            -0,1030             -0,2098
                    (    44)            (    44)
                     0,5060              0,1717

IR_2                 0,8192              0,4851
                    (    44)            (    44)
                     0,0000              0,0008

LOI_2               -0,0188              0,0656
                    (    44)            (    44)
                     0,9037              0,6723

SiO2_2                                   0,4524
                                        (    44)
                                         0,0020

Al2O3_2              0,4524
                    (    44)
                     0,0020
----------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est1_2 and IR_2
   Est1_2 and LOI_2
   Est1_2 and Al2O3_2
   Blaine_2 and LOI_2
   IR_2 and LOI_2
   IR_2 and SiO2_2
   IR_2 and Al2O3_2
   SiO2_2 and Al2O3_2
```

Multiple-Variable Analysis

Analysis Summary

Data variables:
- Est2_2
- Blaine_2
- IR_2
- LOI_2
- SiO2_2
- Al2O3_2

There are 43 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
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GOAL: reduce the number of columns to a small set of meaningful measures.
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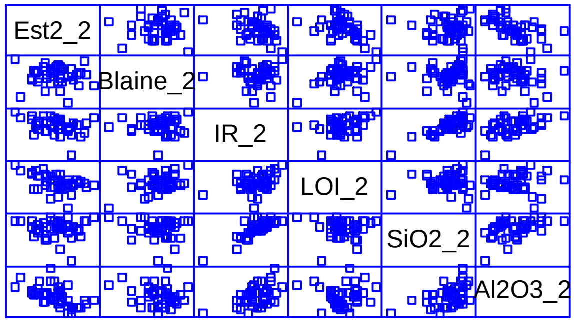
GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est2_2	Blaine_2	IR_2	LOI_2
Est2_2		-0,0613 (43) 0,6961	-0,3493 (43) 0,0217	-0,4933 (43) 0,0008
Blaine_2	-0,0613 (43) 0,6961		0,0139 (43) 0,9296	0,3634 (43) 0,0166
IR_2	-0,3493 (43) 0,0217	0,0139 (43) 0,9296		0,4005 (43) 0,0078
LOI_2	-0,4933 (43) 0,0008	0,3634 (43) 0,0166	0,4005 (43) 0,0078	
SiO2_2	-0,0651 (43) 0,6783	-0,1028 (43) 0,5118	0,8383 (43) 0,0000	-0,0180 (43) 0,9088
Al2O3_2	-0,5781 (43) 0,0000	-0,2101 (43) 0,1764	0,4940 (43) 0,0008	0,0652 (43) 0,6779

	SiO2_2	Al2O3_2
Est2_2	-0,0651 (43)	-0,5781 (43)

```
                     0,6783              0,0000

Blaine_2            -0,1028             -0,2101
                    (   43)             (   43)
                     0,5118              0,1764

IR_2                 0,8383              0,4940
                    (   43)             (   43)
                     0,0000              0,0008

LOI_2               -0,0180              0,0652
                    (   43)             (   43)
                     0,9088              0,6779

SiO2_2                                   0,4525
                                        (   43)
                                         0,0023

Al2O3_2              0,4525
                    (   43)
                     0,0023
-----------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est2_2 and IR_2
   Est2_2 and LOI_2
   Est2_2 and Al2O3_2
   Blaine_2 and LOI_2
   IR_2 and LOI_2
   IR_2 and SiO2_2
   IR_2 and Al2O3_2
   SiO2_2 and Al2O3_2
```

Απλή παλινδρομική ιδιοτήτων που συσχετίζονται μεταξύ τους-ποιότητα CEM II 42,5

Simple Regression - IR_2 vs. LOIMT1

```
Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)
-----------------------------------------------------------------------------
Dependent variable: IR_2
Independent variable: LOIMT1
-----------------------------------------------------------------------------
                               Standard          T
Parameter       Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
Intercept      0,0324261      0,0345356      0,938918         0,3528
Slope           0,686419       0,174205        3,9403         0,0003
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  0,00560708      1   0,00560708      15,53       0,0003
Residual                0,0162514     45  0,000361142
```

```
-----------------------------------------------------------------------------
Total (Corr.)          0,0218584     46

Correlation Coefficient = 0,506476
R-squared = 25,6518 percent
R-squared (adjusted for d.f.) = 23,9996 percent
Standard Error of Est. = 0,0190037
Mean absolute error = 0,0150631
Durbin-Watson statistic = 1,52243 (P=0,0397)
Lag 1 residual autocorrelation = 0,184929

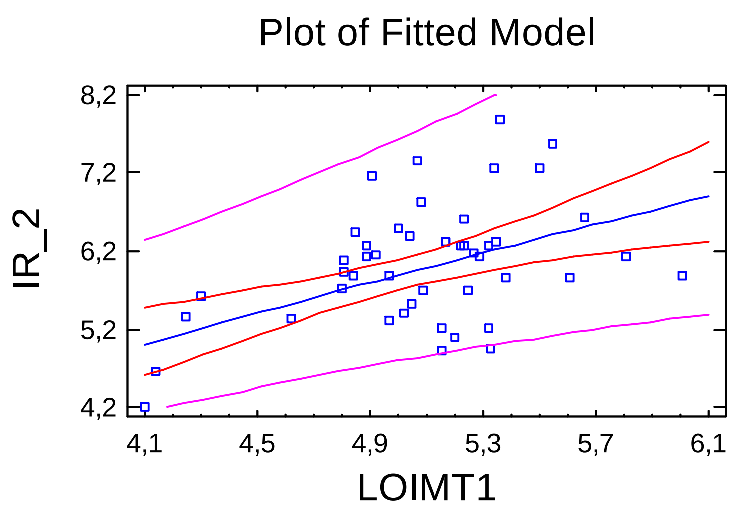
The StatAdvisor
---------------
   The output shows the results of fitting a double reciprocal model
to describe the relationship between IR_2 and LOIMT1.  The equation of
the fitted model is

   Simple Regression - IR_2 vs. Al2O3_2

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between IR_2 and LOIMT1 at the
99% confidence level.

   The R-Squared statistic indicates that the model as fitted explains
25,6518% of the variability in IR_2 after transforming to a reciprocal
scale to linearize the model.  The correlation coefficient equals
0,506476, indicating a moderately strong relationship between the
variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 0,0190037.  This value can be used to
construct prediction limits for new observations by selecting the
Forecasts option from the text menu.

   The mean absolute error (MAE) of 0,0150631 is the average value of
the residuals.  The Durbin-Watson (DW) statistic tests the residuals
to determine if there is any significant correlation based on the
order in which they occur in your data file.  Since the P-value is
less than 0.05, there is an indication of possible serial correlation.
Plot the residuals versus row order to see if there is any pattern
which can be seen.
```




```
Comparison of Alternative Models
--------------------------------------------------
Model                      Correlation       R-Squared
--------------------------------------------------
Double reciprocal               0,5065          25,65%
S-curve                        -0,4852          23,54%
Reciprocal-Y                   -0,4719          22,27%
Multiplicative                  0,4708          22,16%
Reciprocal-X                   -0,4621          21,36%
Exponential                     0,4546          20,67%
```

Logarithmic-X	0,4497	20,22%
Square root-Y	0,4452	19,82%
Square root-X	0,4428	19,61%
Linear	0,4355	18,96%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 25,6518%. This is the currently selected model.

Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)

Dependent variable: IR_2
Independent variable: Al2O3_2

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	-0,139334	0,0737636	-1,88893	0,0654
Slope	1,62526	0,389728	4,17025	0,0001

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,00609287	1	0,00609287	17,39	0,0001
Residual	0,0157656	45	0,000350346		
Total (Corr.)	0,0218584	46			

Correlation Coefficient = 0,52796
R-squared = 27,8742 percent
R-squared (adjusted for d.f.) = 26,2714 percent
Standard Error of Est. = 0,0187175
Mean absolute error = 0,014215
Durbin-Watson statistic = 1,16403 (P=0,0009)
Lag 1 residual autocorrelation = 0,298763

The StatAdvisor

The output shows the results of fitting a double reciprocal model to describe the relationship between IR_2 and Al2O3_2. The equation of the fitted model is

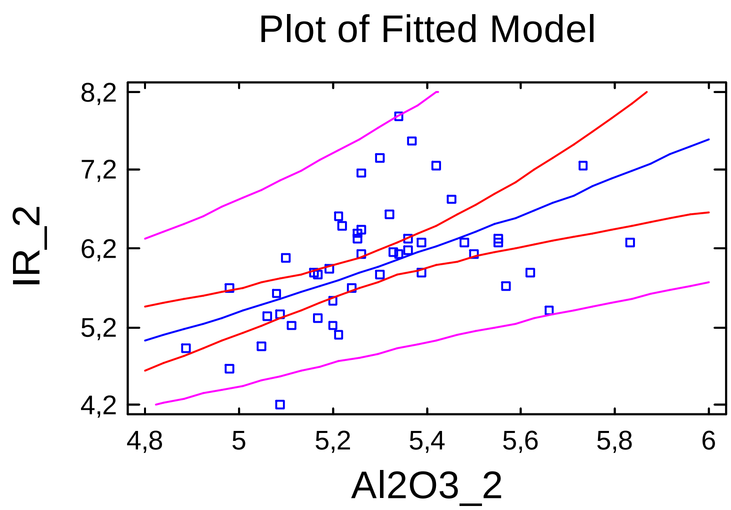
IR_2 = 1/(-0,139334 + 1,62526/Al2O3_2)

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between IR_2 and Al2O3_2 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 27,8742% of the variability in IR_2 after transforming to a reciprocal scale to linearize the model. The correlation coefficient equals 0,52796, indicating a moderately strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,0187175. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,014215 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is

```
less than 0.05, there is an indication of possible serial correlation.
Plot the residuals versus row order to see if there is any pattern
which can be seen.
```




```
Comparison of Alternative Models
--------------------------------------------------
Model                     Correlation      R-Squared
--------------------------------------------------
Double reciprocal              0,5280         27,87%
S-curve                       -0,5169         26,71%
Reciprocal-Y                  -0,5088         25,89%
Multiplicative                 0,5076         25,77%
Reciprocal-X                  -0,4995         24,95%
Exponential                    0,4980         24,80%
Logarithmic-X                  0,4906         24,07%
Square root-Y                  0,4903         24,04%
Square root-X                  0,4860         23,62%
Linear                         0,4813         23,16%
Logistic                              <no fit>
Log probit                            <no fit>
--------------------------------------------------


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the double reciprocal model yields
the highest R-Squared value with 27,8742%.  This is the currently
selected model.
```

Παλινδρόμηση – ποιότητα τσιμέντου CEM II 42,5-μύλος 1

Multiple Regression - Est28MT1Ridge Regression - Est2MT1Multiple Regression - Est2MT1Multiple Regression - Est1MT1

```
Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est1MT1
-----------------------------------------------------------------------------
```

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	-96,0784	42,6785	-2,25121	0,0338
BLAINEMT1	0,0258737	0,00903367	2,86414	0,0085
IR_2	-0,961588	0,295551	-3,25354	0,0034
LOIMT1	-1,40371	0,675116	-2,07922	0,0485

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	36,9057	3	12,3019	9,13	0,0003
Residual	32,3414	24	1,34756		
Total (Corr.)	69,2471	27			

R-squared = 53,2957 percent
R-squared (adjusted for d.f.) = 47,4577 percent
Standard Error of Est. = 1,16084
Mean absolute error = 0,8467
Durbin-Watson statistic = 2,1273 (P=0,3204)
Lag 1 residual autocorrelation = -0,0649478

Stepwise regression

Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

Step 0:
----
0 variables in the model. 27 d.f. for error.
R-squared =   0,00%   Adjusted R-squared =   0,00%   MSE = 2,56471

Step 1:

Adding variable IR_2 with F-to-enter = 12,637
1 variables in the model. 26 d.f. for error.
R-squared = 32,71%   Adjusted R-squared = 30,12%   MSE = 1,79225

Step 2:

Adding variable BLAINEMT1 with F-to-enter = 5,52271
2 variables in the model. 25 d.f. for error.
R-squared = 44,88%   Adjusted R-squared = 40,47%   MSE = 1,52668

Step 3:

Adding variable LOIMT1 with F-to-enter = 4,32315
3 variables in the model. 24 d.f. for error.
R-squared = 53,30%   Adjusted R-squared = 47,46%   MSE = 1,34756

Final model selected.

The StatAdvisor

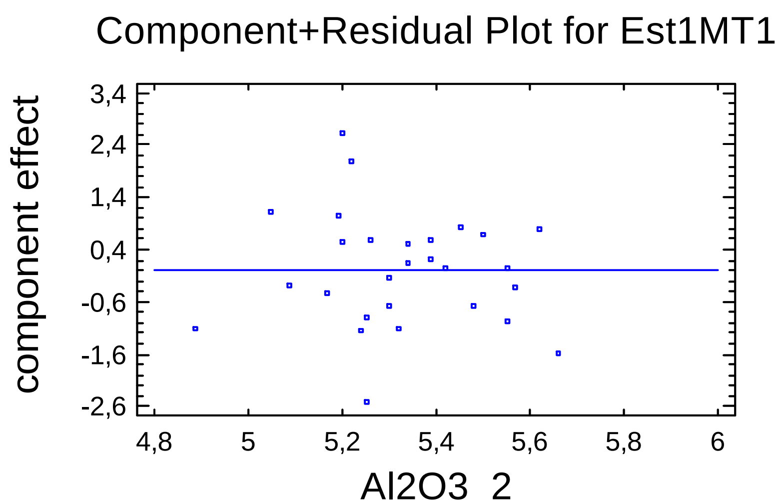
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1MT1 and 6 independent variables. The equation of the fitted model is

Est1MT1 = -96,0784 + 0,0258737*BLAINEMT1 - 0,961588*IR_2 - 1,40371*LOIMT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 53,2957% of the variability in Est1MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 47,4577%. The standard error of the estimate shows the standard deviation of the residuals to be 1,16084. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,8467 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0485, belonging to LOIMT1. Since the P-value is less than 0.05, that term is statistically significant at the 95% confidence level. Consequently, you probably don't want to remove any variables from the model.

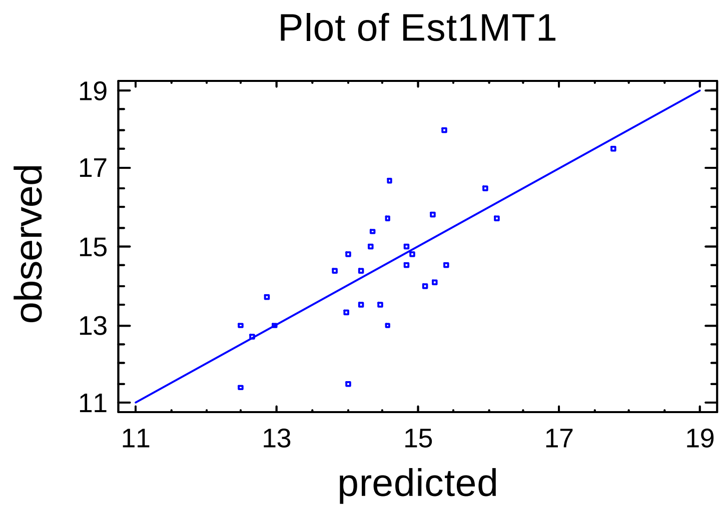


Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
BLAINEMT1	7,73757	1	7,73757	5,74	0,0247
IR_2	23,3425	1	23,3425	17,32	0,0003
LOIMT1	5,8257	1	5,8257	4,32	0,0485
Model	36,9057	3			

The StatAdvisor

This table shows the statistical significance of each variable as it was added to the model. You can use this table to help determine how much the model could be simplified, especially if you are fitting a polynomial.

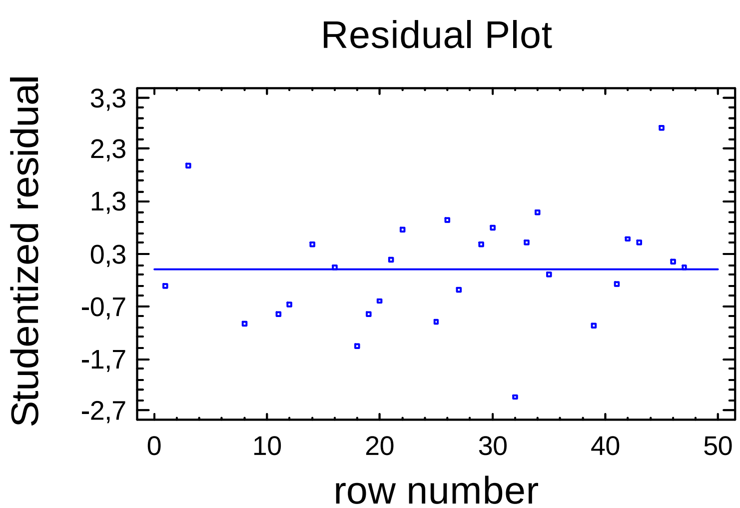


95,0% confidence intervals for coefficient estimates

Parameter	Estimate	Standard Error	Lower Limit	Upper Limit
CONSTANT	-96,0784	42,6785	-184,163	-7,99401
BLAINEMT1	0,0258737	0,00903367	0,00722911	0,0445184
IR_2	-0,961588	0,295551	-1,57158	-0,351599
LOIMT1	-1,40371	0,675116	-2,79709	-0,0103401

The StatAdvisor

This table shows 95,0% confidence intervals for the coefficients in the model. Confidence intervals show how precisely the coefficients can be estimated given the amount of available data and the noise which is present.



Correlation matrix for coefficient estimates

	CONSTANT	BLAINEMT1	IR_2	LOIMT1
CONSTANT	1,0000	-0,9970	-0,0573	0,1330

BLAINEMT1	-0,9970	1,0000	0,0413	-0,1984
IR_2	-0,0573	0,0413	1,0000	-0,3269
LOIMT1	0,1330	-0,1984	-0,3269	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Regression Results for Est1MT1

Row	Fitted Value	Stnd. Error for Forecast	Lower 95,0% CL for Forecast	Upper 95,0% CL for Forecast	Lower 95,0% CL for Mean	Upper 95,0% CL for Mean
49	15,3696	1,2236	12,8442	17,8949	14,5712	16,1679
50	14,8416	1,31392	12,1298	17,5534	13,5713	16,1119
51	12,6474	1,23614	10,0961	15,1986	11,7706	13,5242

The StatAdvisor

This table contains information about Est1MT1 generated using the fitted model. The table includes:
(1) the predicted value of Est1MT1 using the fitted model
(2) the standard error for each predicted value
(3) 95,0% prediction limits for new observations
(4) 95,0% confidence limits for the mean response
Each item corresponds to the values of the independent variables in a specific row of your data file. To generate forecasts for additional combinations of the variables, add additional rows to the bottom of your data file. In each new row, enter values for the independent variables but leave the cell for the dependent variable empty. When you return to this pane, forecasts will be added to the table for the new rows, but the model will be unaffected.

Unusual Residuals

Row	Y	Predicted Y	Residual	Studentized Residual
32	11,5	14,011	-2,51096	-2,43
45	18,0	15,3696	2,63045	2,70

The StatAdvisor

The table of unusual residuals lists all observations which have Studentized residuals greater than 2.0 in absolute value. Studentized residuals measure how many standard deviations each observed value of Est1MT1 deviates from a model fitted using all of the data except that observation. In this case, there are 2 Studentized residuals greater than 2.0, but none greater than 3.0.

Influential Points

Row	Leverage	Mahalanobis Distance	DFITS
1	0,446518	20,0124	-0,290757
45	0,111044	2,28484	0,95426

Average leverage of single data point = 0,142857

The StatAdvisor

The table of influential data points lists all observations which have leverage values greater than 3 times that of an average data point, or which have an unusually large value of DFITS. Leverage is a statistic which measures how influential each observation is in determining the coefficients of the estimated model. DFITS is a statistic which measures how much the estimated coefficients would change if each observation was removed from the data set. In this case, an average data point would have a leverage value equal to 0,142857. There is one data point with more than 3 times the average leverage, but none with more than 5 times. There is one data point with an unusually large value of DFITS.

Multiple-Variable Analysis

Analysis Summary

Data variables:
BLAINEMT1
LOIMT1
IR_2
Est1MT1

There are 46 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
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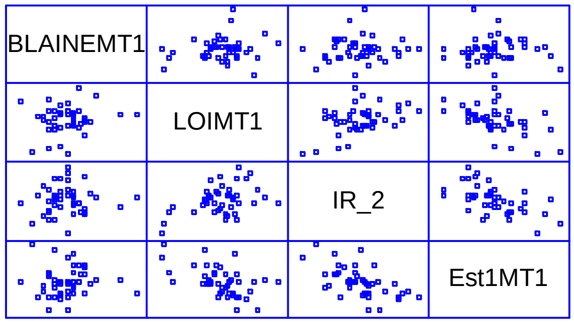
GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.

PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Summary Statistics

	BLAINEMT1	LOIMT1	IR_2	Est1MT1
Count	46	46	46	46
Average	4779,65	5,0863	6,03957	14,7326
Variance	1239,34	0,153442	0,587933	2,69914
Standard deviation	35,2043	0,391716	0,766768	1,6429
Minimum	4700,0	4,1	4,22	11,4
Maximum	4900,0	6,01	7,89	19,0
Range	200,0	1,91	3,67	7,6
Stnd. skewness	2,48878	-1,38515	0,48871	1,45266
Stnd. kurtosis	3,76153	1,51575	0,299014	0,634088

The StatAdvisor

This table shows summary statistics for each of the selected data variables. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate many of the statistical procedures normally applied to this data. In this case, the following variables show standardized skewness values outside the expected range:

BLAINEMT1

The following variables show standardized kurtosis values outside the expected range:

BLAINEMT1

To make the variables more normal, you might try a transformation such as LOG(Y), SQRT(Y), or 1/Y.

95,0 percent confidence intervals

	Mean	Stnd. error	Lower limit	Upper limit
BLAINEMT1	4779,65	5,19059	4769,2	4790,11
LOIMT1	5,0863	0,0577554	4,96998	5,20263
IR_2	6,03957	0,113054	5,81186	6,26727
Est1MT1	14,7326	0,242233	14,2447	15,2205

	Sigma	Lower limit	Upper limit
BLAINEMT1	35,2043	29,1998	44,3406
LOIMT1	0,391716	0,324904	0,493376
IR_2	0,766768	0,635986	0,965762
Est1MT1	1,6429	1,36269	2,06928

The StatAdvisor

This table shows 95,0% confidence intervals for the means and standard deviations of each of the variables. These intervals bound the sampling error in the estimates of the parameters of the populations from which the data come. They can be used to help judge how precisely the population means and standard deviations have been estimated. The intervals assume that the populations from which the samples come can be represented by normal distributions. While the confidence intervals for the means are quite robust and not very sensitive to violations of this assumption, the confidence intervals for the standard deviations are quite sensitive. You can check the assumption of normality in the One Variable Analysis procedure.

Correlations

	BLAINEMT1	LOIMT1	IR_2	Est1MT1
BLAINEMT1		0,1737	0,0661	0,0279
		(46)	(46)	(46)
		0,2484	0,6624	0,8542
LOIMT1	0,1737		0,4336	-0,5266
	(46)		(46)	(46)
	0,2484		0,0026	0,0002
IR_2	0,0661	0,4336		-0,5779
	(46)	(46)		(46)
	0,6624	0,0026		0,0000
Est1MT1	0,0279	-0,5266	-0,5779	
	(46)	(46)	(46)	
	0,8542	0,0002	0,0000	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

LOIMT1 and IR_2
LOIMT1 and Est1MT1
IR_2 and Est1MT1

Spearman Rank Correlations

	BLAINEMT1	LOIMT1	IR_2	Est1MT1
BLAINEMT1		0,1256	0,0332	0,2111
		(46)	(46)	(46)
		0,3994	0,8238	0,1568
LOIMT1	0,1256		0,3322	-0,5056
	(46)		(46)	(46)
	0,3994		0,0258	0,0007
IR_2	0,0332	0,3322		-0,5955
	(46)	(46)		(46)
	0,8238	0,0258		0,0001
Est1MT1	0,2111	-0,5056	-0,5955	
	(46)	(46)	(46)	
	0,1568	0,0007	0,0001	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

LOIMT1 and IR_2
LOIMT1 and Est1MT1
IR_2 and Est1MT1

```
Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2MT1
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 48,3906        6,26672        7,72185         0,0000
Al2O3_2                 -3,22561        1,32854       -2,42793         0,0194
IR_2                   -0,817849       0,323689       -2,52665         0,0153
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                      51,207      2      25,6035      12,40       0,0001
Residual                  88,8176     43      2,06552
-----------------------------------------------------------------------------
Total (Corr.)             140,025     45

R-squared = 36,57 percent
R-squared (adjusted for d.f.) = 33,6198 percent
Standard Error of Est. = 1,43719
Mean absolute error = 1,04148
Durbin-Watson statistic = 1,4573 (P=0,0191)
Lag 1 residual autocorrelation = 0,252017


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  45 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 3,11166

     Step 1:
     ---------
     Adding variable IR_2 with F-to-enter = 17,0047
     1 variables in the model.  44 d.f. for error.
     R-squared =  27,87%     Adjusted R-squared =  26,24%     MSE = 2,29531

     Step 2:
     ---------
     Adding variable Al2O3_2 with F-to-enter = 5,89485
     2 variables in the model.  43 d.f. for error.
     R-squared =  36,57%     Adjusted R-squared =  33,62%     MSE = 2,06552

     Final model selected.



The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2MT1 and 5
independent variables.  The equation of the fitted model is

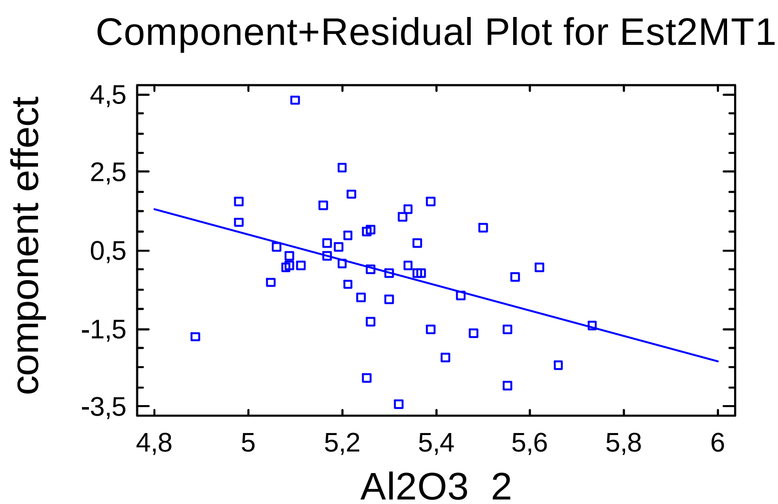
Est2MT1 = 48,3906 - 3,22561*Al2O3_2 - 0,817849*IR_2

Since the P-value in the ANOVA table is less than 0.01, there is a
```

statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 36,57% of the variability in Est2MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 33,6198%. The standard error of the estimate shows the standard deviation of the residuals to be 1,43719. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,04148 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0194, belonging to Al2O3_2. Since the P-value is less than 0.05, that term is statistically significant at the 95% confidence level. Consequently, you probably don't want to remove any variables from the model.

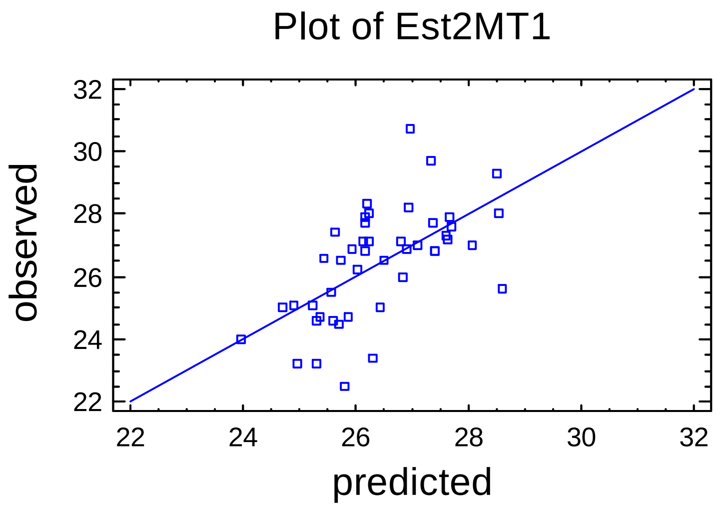


Further ANOVA for Variables in the Order Fitted

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Al2O3_2	38,0208	1	38,0208	18,41	0,0001
IR_2	13,1862	1	13,1862	6,38	0,0153
Model	51,207	2			

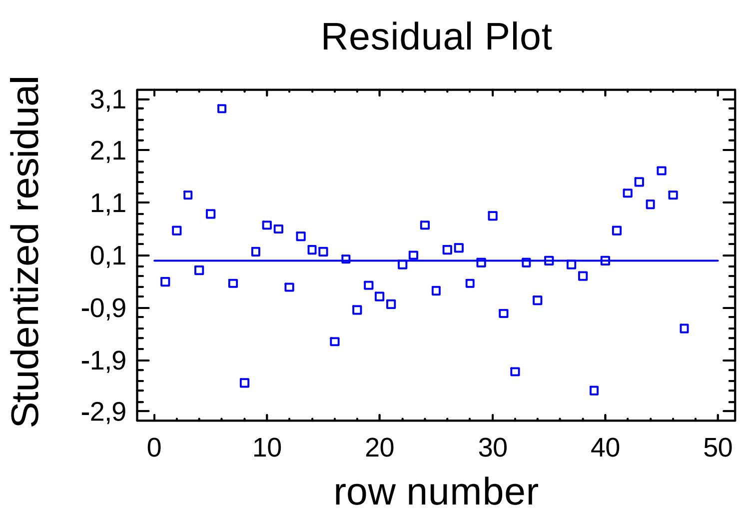
The StatAdvisor

This table shows the statistical significance of each variable as it was added to the model. You can use this table to help determine how much the model could be simplified, especially if you are fitting a polynomial.




```
95,0% confidence intervals for coefficient estimates
--------------------------------------------------------------------------------
                                    Standard
Parameter                Estimate      Error        Lower Limit     Upper Limit
--------------------------------------------------------------------------------
CONSTANT                  48,3906     6,26672         35,7526         61,0287
Al2O3_2                  -3,22561     1,32854        -5,90487       -0,546342
IR_2                    -0,817849    0,323689        -1,47063       -0,165066
--------------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows 95,0% confidence intervals for the coefficients in
the model.  Confidence intervals show how precisely the coefficients
can be estimated given the amount of available data and the noise
which is present.
```




```
Correlation matrix for coefficient estimates
--------------------------------------------------------------------------------
                         CONSTANT         Al2O3_2           IR_2
CONSTANT                   1,0000         -0,9625         0,2534
Al2O3_2                   -0,9625          1,0000        -0,5048
```

IR_2	0,2534	-0,5048	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there is 1 correlation with absolute value greater than 0.5 (not including the constant term).

Regression Results for Est2MT1

Row	Fitted Value	Stnd. Error for Forecast	Lower 95,0% CL for Forecast	Upper 95,0% CL for Forecast	Lower 95,0% CL for Mean	Upper 95,0% CL for Mean
36	24,4493	1,60867	21,2051	27,6935	22,9918	25,9067

The StatAdvisor

This table contains information about Est2MT1 generated using the fitted model. The table includes:
   (1) the predicted value of Est2MT1 using the fitted model
   (2) the standard error for each predicted value
   (3) 95,0% prediction limits for new observations
   (4) 95,0% confidence limits for the mean response
Each item corresponds to the values of the independent variables in a specific row of your data file. To generate forecasts for additional combinations of the variables, add additional rows to the bottom of your data file. In each new row, enter values for the independent variables but leave the cell for the dependent variable empty. When you return to this pane, forecasts will be added to the table for the new rows, but the model will be unaffected.

Unusual Residuals

Row	Y	Predicted Y	Residual	Studentized Residual
6	30,7	26,9593	3,74065	2,89
8	25,6	28,5854	-2,98543	-2,33
32	23,4	26,2874	-2,8874	-2,12
39	22,5	25,8081	-3,30807	-2,48

The StatAdvisor

The table of unusual residuals lists all observations which have Studentized residuals greater than 2.0 in absolute value. Studentized residuals measure how many standard deviations each observed value of Est2MT1 deviates from a model fitted using all of the data except that observation. In this case, there are 4 Studentized residuals greater than 2.0, but none greater than 3.0.

Influential Points

Row	Leverage	Mahalanobis Distance	DFITS

```
     6      0,052369        1,4538      0,680303
     8      0,124426       5,27499     -0,878978
    18      0,213324       10,9538     -0,493367
------------------------------------------------
Average leverage of single data point = 0,0652174
```

The StatAdvisor

The table of influential data points lists all observations which have leverage values greater than 3 times that of an average data point, or which have an unusually large value of DFITS. Leverage is a statistic which measures how influential each observation is in determining the coefficients of the estimated model. DFITS is a statistic which measures how much the estimated coefficients would change if each observation was removed from the data set. In this case, an average data point would have a leverage value equal to 0,0652174. There is one data point with more than 3 times the average leverage, but none with more than 5 times. There are 2 data points with unusually large values of DFITS.

Multiple Regression Analysis

Dependent variable: Est28MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	76,8445	5,53945	13,8722	0,0000
Al2O3_2	-4,44702	1,05161	-4,22876	0,0002

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	27,1147	1	27,1147	17,88	0,0002
Residual	53,0697	35	1,51628		
Total (Corr.)	80,1843	36			

R-squared = 33,8154 percent
R-squared (adjusted for d.f.) = 31,9244 percent
Standard Error of Est. = 1,23137
Mean absolute error = 0,963892
Durbin-Watson statistic = 1,58421 (P=0,0776)
Lag 1 residual autocorrelation = 0,19834

```
Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  36 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 2,22734

     Step 1:
     ---------
     Adding variable Al2O3_2 with F-to-enter = 17,8824
     1 variables in the model.  35 d.f. for error.
     R-squared =  33,82%     Adjusted R-squared =  31,92%     MSE = 1,51628

     Final model selected.
```

The StatAdvisor

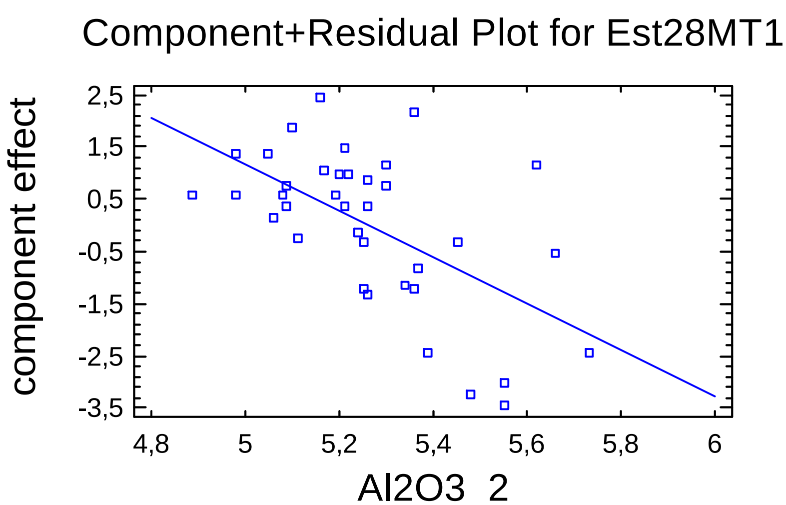
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28MT1 and 5 independent variables. The equation of the fitted model is

Est28MT1 = 76,8445 - 4,44702*Al2O3_2

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 33,8154% of the variability in Est28MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 31,9244%. The standard error of the estimate shows the standard deviation of the residuals to be 1,23137. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,963892 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0002, belonging to Al2O3_2. Since the P-value is less than 0.01, the highest order term is statistically significant at the 99% confidence level. Consequently, you probably don't want to remove any variables from the model.



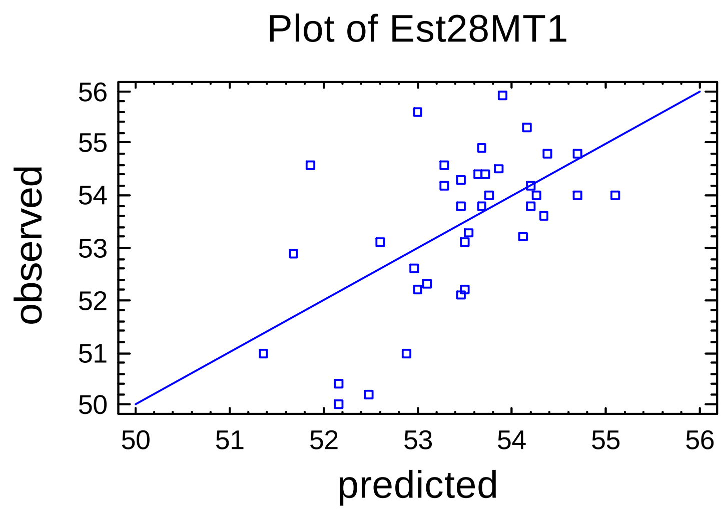
Correlation matrix for coefficient estimates

	CONSTANT	Al2O3_2
CONSTANT	1,0000	-0,9993
Al2O3_2	-0,9993	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).



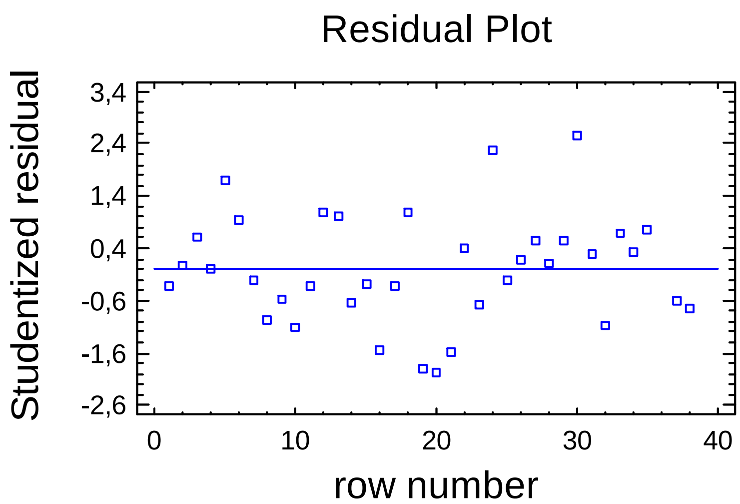
Regression Results for Est28MT1

Row	Fitted Value	Stnd. Error for Forecast	Lower 95,0% CL for Forecast	Upper 95,0% CL for Forecast	Lower 95,0% CL for Mean	Upper 95,0% CL for Mean
36	50,9184	1,38256	48,1116	53,7251	49,6421	52,1946
39	53,1863	1,24929	50,6502	55,7225	52,7584	53,6143
40	53,8534	1,25181	51,3121	56,3947	53,396	54,3108
41	52,0746	1,28871	49,4584	54,6908	51,3029	52,8463
42	52,3859	1,27233	49,8029	54,9689	51,7358	53,036
43	52,8751	1,25491	50,3274	55,4227	52,3839	53,3662
44	53,1419	1,24983	50,6046	55,6792	52,7075	53,5763
45	53,72	1,24972	51,1829	56,2571	53,2869	54,1531
46	53,0974	1,25045	50,5588	55,636	52,6556	53,5392
47	52,7416	1,25863	50,1865	55,2968	52,2127	53,2705

The StatAdvisor

This table contains information about Est28MT1 generated using the fitted model. The table includes:
(1) the predicted value of Est28MT1 using the fitted model
(2) the standard error for each predicted value
(3) 95,0% prediction limits for new observations
(4) 95,0% confidence limits for the mean response

Each item corresponds to the values of the independent variables in a specific row of your data file. To generate forecasts for additional combinations of the variables, add additional rows to the bottom of your data file. In each new row, enter values for the independent variables but leave the cell for the dependent variable empty. When you return to this pane, forecasts will be added to the table for the new rows, but the model will be unaffected.



Simple Regression - Est28MT1 vs. BLAINEMT1

Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)

Dependent variable: Est28MT1
Independent variable: BLAINEMT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	0,0124935	0,0123405	1,01241	0,3183
Slope	29,8138	59,0041	0,505284	0,6165

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	7,47008E-8	1	7,47008E-8	0,26	0,6165
Residual	0,0000102405	35	2,92587E-7		
Total (Corr.)	0,0000103152	36			

Correlation Coefficient = 0,0850987
R-squared = 0,724179 percent
R-squared (adjusted for d.f.) = -2,11227 percent
Standard Error of Est. = 0,000540913
Mean absolute error = 0,000422486
Durbin-Watson statistic = 0,909885 (P=0,0001)
Lag 1 residual autocorrelation = 0,543514

The StatAdvisor

The output shows the results of fitting a double reciprocal model to describe the relationship between Est28MT1 and BLAINEMT1. The equation of the fitted model is

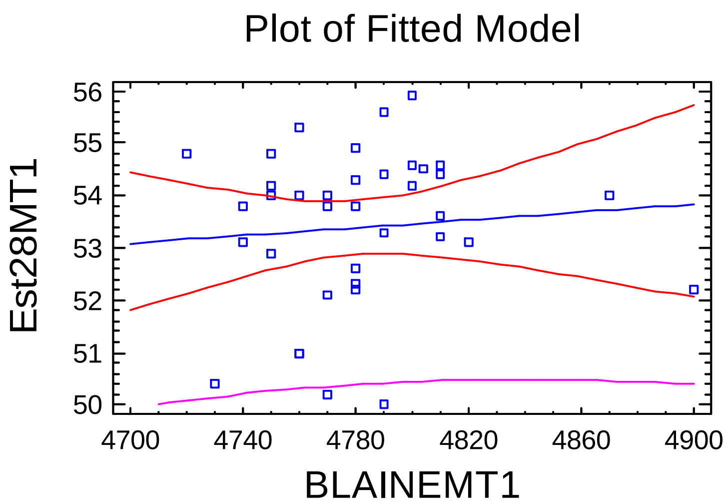
Est28MT1 = 1/(0,0124935 + 29,8138/BLAINEMT1)

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between Est28MT1 and BLAINEMT1 at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains

0,724179% of the variability in Est28MT1 after transforming to a reciprocal scale to linearize the model. The correlation coefficient equals 0,0850987, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,000540913. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,000422486 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



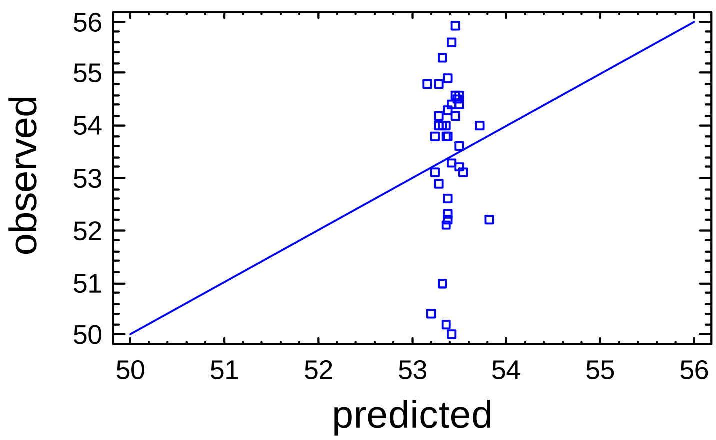
Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	7,47008E-8	1	7,47008E-8	0,26	0,6165
Residual	0,0000102405	35	2,92587E-7		
Lack-of-Fit	0,00000350751	12	2,92293E-7	1,00	0,4800
Pure Error	0,00000673302	23	2,9274E-7		
Total (Corr.)	0,0000103152	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Plot of Est28MT1

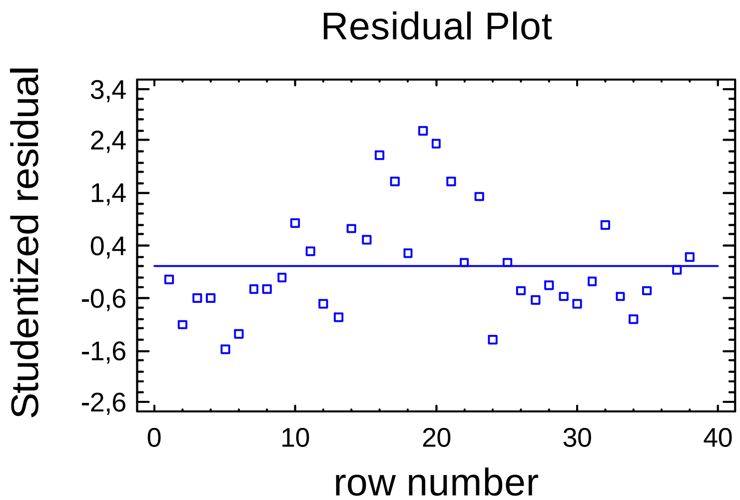


Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	0,0851	0,72%
Reciprocal-Y	-0,0832	0,69%
S-curve	-0,0829	0,69%
Multiplicative	0,0820	0,67%
Exponential	0,0810	0,66%
Reciprocal-X	-0,0808	0,65%
Square root-Y	0,0799	0,64%
Logarithmic-X	0,0798	0,64%
Square root-X	0,0793	0,63%
Linear	0,0788	0,62%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 0,724179%. This is the currently selected model.




```
Simple Regression - Est28MT1 vs. IR_2

Regression Analysis - Linear model: Y = a + b*X
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: IR_2
-----------------------------------------------------------------------------
                                Standard          T
Parameter       Estimate          Error       Statistic         P-Value
-----------------------------------------------------------------------------
Intercept        56,9204        1,78941        31,8096          0,0000
Slope          -0,578772       0,294552       -1,96492          0,0574
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     7,96649      1      7,96649       3,86       0,0574
Residual                  72,2178     35      2,06337
-----------------------------------------------------------------------------
Total (Corr.)             80,1843     36

Correlation Coefficient = -0,315202
R-squared = 9,93522 percent
R-squared (adjusted for d.f.) = 7,36194 percent
Standard Error of Est. = 1,43644
Mean absolute error = 1,06851
Durbin-Watson statistic = 1,07036 (P=0,0008)
Lag 1 residual autocorrelation = 0,458252

The StatAdvisor
---------------
   The output shows the results of fitting a linear model to describe
the relationship between Est28MT1 and IR_2.  The equation of the
fitted model is

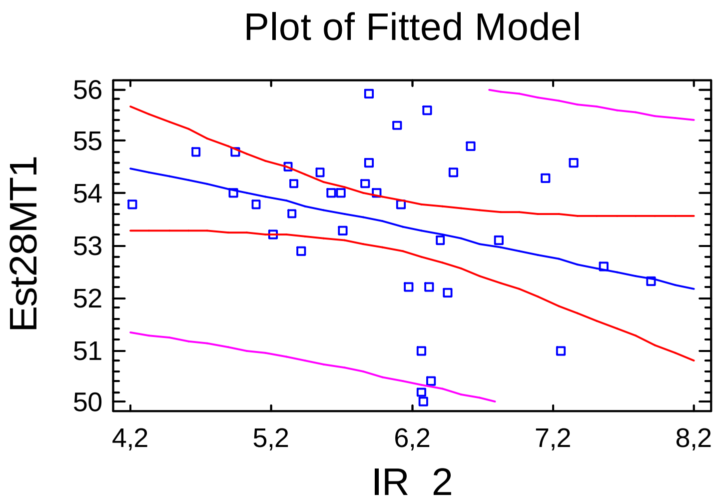
   Est28MT1 = 56,9204 - 0,578772*IR_2

Since the P-value in the ANOVA table is less than 0.10, there is a
statistically significant relationship between Est28MT1 and IR_2 at
the 90% confidence level.

   The R-Squared statistic indicates that the model as fitted explains
9,93522% of the variability in Est28MT1.  The correlation coefficient
equals -0,315202, indicating a relatively weak relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 1,43644.  This value can be used to
construct prediction limits for new observations by selecting the
```

Forecasts option from the text menu.

The mean absolute error (MAE) of 1,06851 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



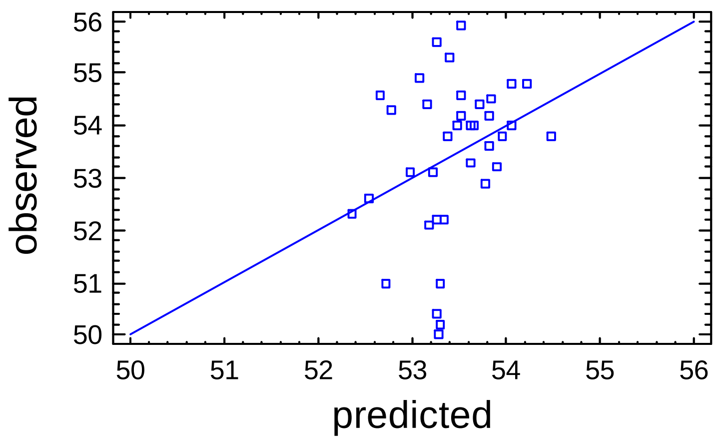
Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	7,96649	1	7,96649	3,86	0,0574
Residual	72,2178	35	2,06337		
Lack-of-Fit	71,0528	33	2,15312	3,70	0,2354
Pure Error	1,165	2	0,5825		
Total (Corr.)	80,1843	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

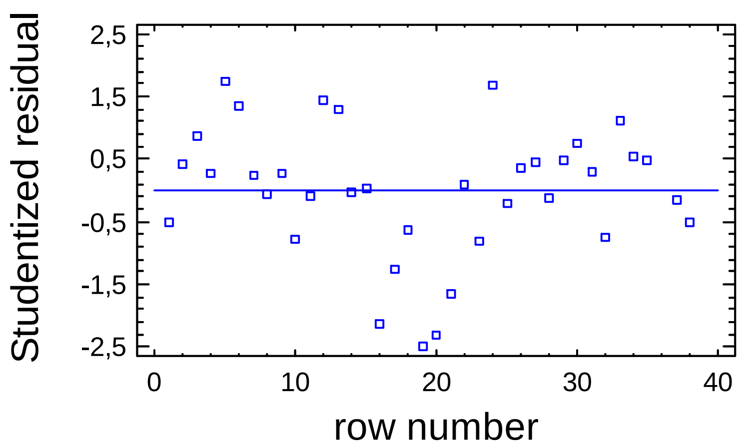
Plot of Est28MT1




```
Simple Regression - Est28MT1 vs. IR_2


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the multiplicative model yields
the highest R-Squared value with 10,0939%.  This is 0,158707% higher
than the currently selected linear model.  To change models, select
the Analysis Options dialog box.
```

Residual Plot




```
Simple Regression - Est28MT1 vs. LOIMT1

Regression Analysis - Linear model: Y = a + b*X
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: LOIMT1
-----------------------------------------------------------------------------
                                Standard          T
Parameter       Estimate         Error        Statistic        P-Value
-----------------------------------------------------------------------------
```

Intercept	57,6598	3,24126	17,7893	0,0000
Slope	-0,838185	0,641264	-1,30708	0,1997

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,73189	1	3,73189	1,71	0,1997
Residual	76,4524	35	2,18436		
Total (Corr.)	80,1843	36			

Correlation Coefficient = -0,215735
R-squared = 4,65414 percent
R-squared (adjusted for d.f.) = 1,92998 percent
Standard Error of Est. = 1,47796
Mean absolute error = 1,13038
Durbin-Watson statistic = 1,0127 (P=0,0004)
Lag 1 residual autocorrelation = 0,492346

The StatAdvisor

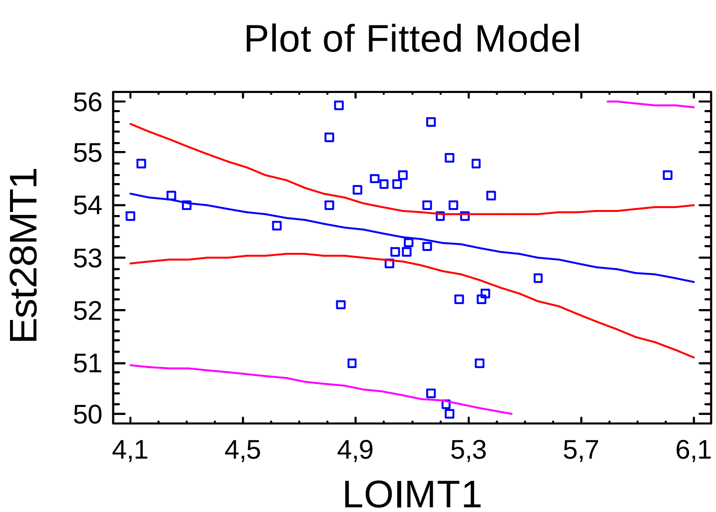
The output shows the results of fitting a linear model to describe the relationship between Est28MT1 and LOIMT1. The equation of the fitted model is

Est28MT1 = 57,6598 - 0,838185*LOIMT1

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between Est28MT1 and LOIMT1 at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 4,65414% of the variability in Est28MT1. The correlation coefficient equals -0,215735, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 1,47796. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 1,13038 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

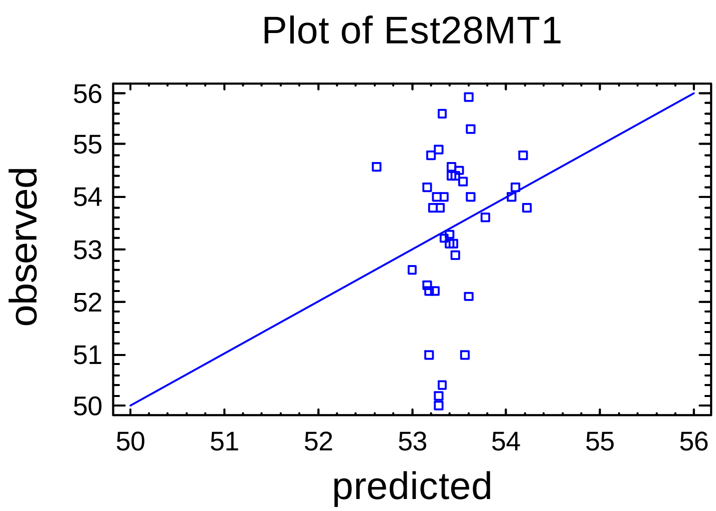


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,73189	1	3,73189	1,71	0,1997
Residual	76,4524	35	2,18436		
Lack-of-Fit	49,7624	31	1,60524	0,24	0,9918
Pure Error	26,69	4	6,6725		
Total (Corr.)	80,1843	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.



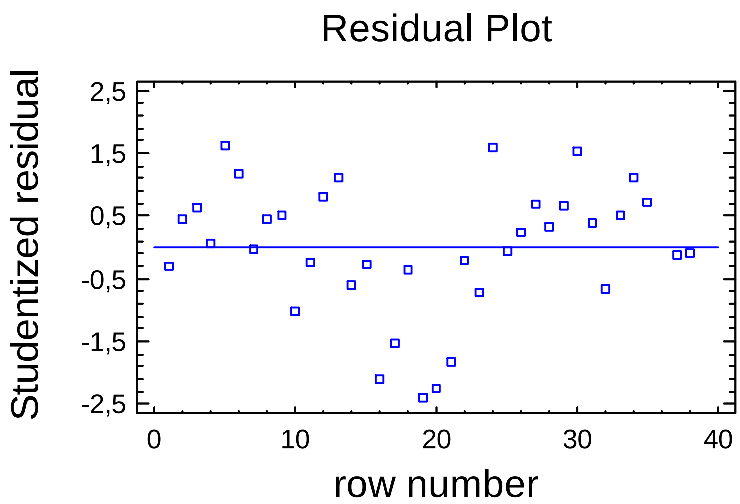
Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	-0,2281	5,20%
S-curve	0,2278	5,19%
Reciprocal-X	0,2273	5,17%
Multiplicative	-0,2229	4,97%
Logarithmic-X	-0,2225	4,95%
Square root-X	-0,2194	4,81%
Reciprocal-Y	0,2163	4,68%
Exponential	-0,2161	4,67%
Square root-Y	-0,2159	4,66%
Linear	-0,2157	4,65%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields

```
the highest R-Squared value with 5,20417%.  This is 0,550024% higher
than the currently selected linear model.  To change models, select
the Analysis Options dialog box.
```




```
Simple Regression - Est28MT1 vs. LOIMT1

Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: LOIMT1
-----------------------------------------------------------------------------
                                Standard          T
Parameter       Estimate         Error        Statistic        P-Value
-----------------------------------------------------------------------------
Intercept       0,0202178     0,00107767       18,7607          0,0000
Slope         -0,00745945     0,00538135      -1,38617          0,1745
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  5,36822E-7      1   5,36822E-7       1,92       0,1745
Residual           0,00000977841      35   2,79383E-7
-----------------------------------------------------------------------------
Total (Corr.)        0,0000103152     36

Correlation Coefficient = -0,228126
R-squared = 5,20417 percent
R-squared (adjusted for d.f.) = 2,49571 percent
Standard Error of Est. = 0,000528567
Mean absolute error = 0,000400428
Durbin-Watson statistic = 1,00546 (P=0,0004)
Lag 1 residual autocorrelation = 0,495405

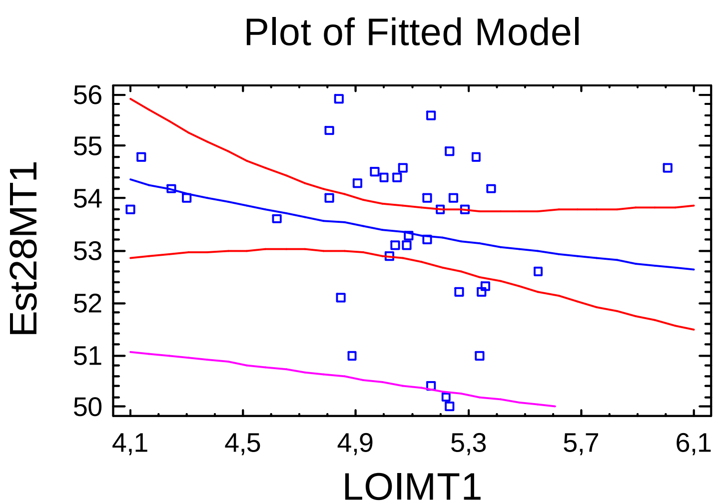
The StatAdvisor
---------------
   The output shows the results of fitting a double reciprocal model
to describe the relationship between Est28MT1 and LOIMT1.  The
equation of the fitted model is

   Est28MT1 = 1/(0,0202178 - 0,00745945/LOIMT1)

Since the P-value in the ANOVA table is greater or equal to 0.10,
there is not a statistically significant relationship between Est28MT1
and LOIMT1 at the 90% or higher confidence level.
```

The R-Squared statistic indicates that the model as fitted explains 5,20417% of the variability in Est28MT1 after transforming to a reciprocal scale to linearize the model. The correlation coefficient equals -0,228126, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,000528567. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,000400428 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

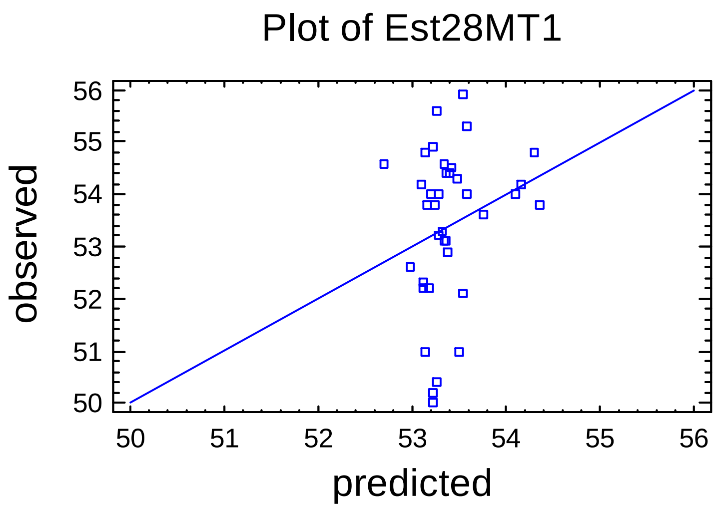


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	5,36822E-7	1	5,36822E-7	1,92	0,1745
Residual	0,00000977841	35	2,79383E-7		
Lack-of-Fit	0,00000632992	31	2,04191E-7	0,24	0,9924
Pure Error	0,00000344849	4	8,62123E-7		
Total (Corr.)	0,0000103152	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

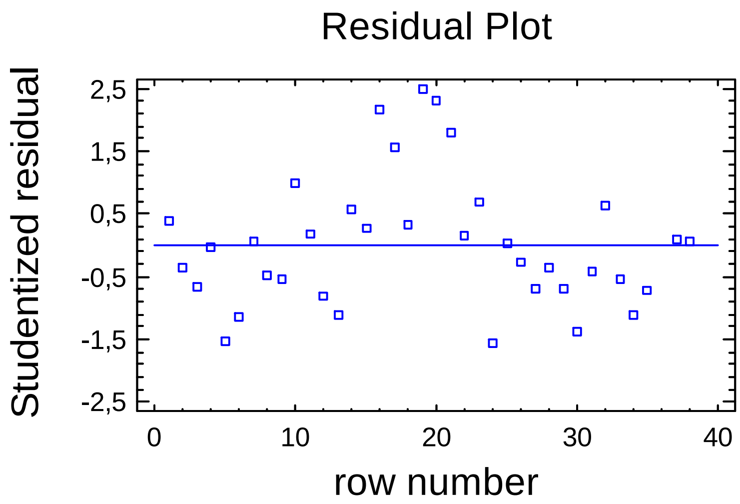


Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	-0,2281	5,20%
S-curve	0,2278	5,19%
Reciprocal-X	0,2273	5,17%
Multiplicative	-0,2229	4,97%
Logarithmic-X	-0,2225	4,95%
Square root-X	-0,2194	4,81%
Reciprocal-Y	0,2163	4,68%
Exponential	-0,2161	4,67%
Square root-Y	-0,2159	4,66%
Linear	-0,2157	4,65%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 5,20417%. This is the currently selected model.




```
Simple Regression - Est28MT1 vs. SiO2MT1

Regression Analysis - Linear model: Y = a + b*X
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: SiO2MT1
-----------------------------------------------------------------------------
                               Standard          T
Parameter       Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
Intercept        68,9271       14,0034        4,92216          0,0000
Slope          -0,696791      0,629746       -1,10646          0,2761
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     2,70997      1      2,70997       1,22       0,2761
Residual                  77,4744     35      2,21355
-----------------------------------------------------------------------------
Total (Corr.)             80,1843     36

Correlation Coefficient = -0,183839
R-squared = 3,37968 percent
R-squared (adjusted for d.f.) = 0,619096 percent
Standard Error of Est. = 1,4878
Mean absolute error = 1,14552
Durbin-Watson statistic = 0,970802 (P=0,0003)
Lag 1 residual autocorrelation = 0,511325

The StatAdvisor
---------------
   The output shows the results of fitting a linear model to describe
the relationship between Est28MT1 and SiO2MT1.  The equation of the
fitted model is

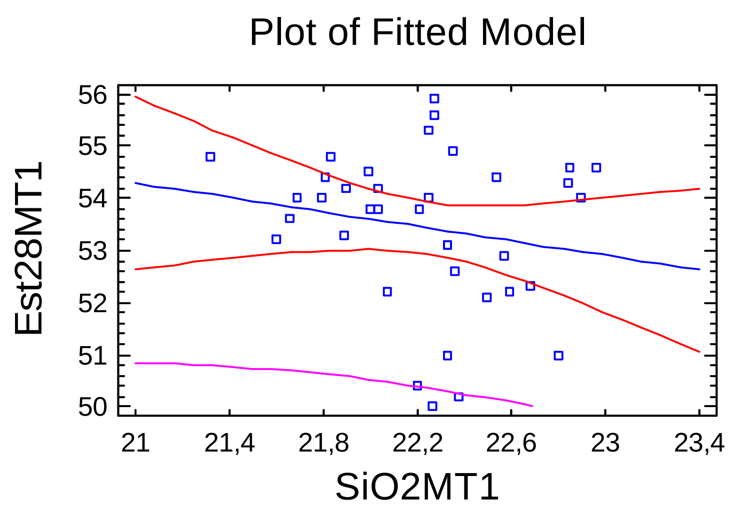
   Est28MT1 = 68,9271 - 0,696791*SiO2MT1

Since the P-value in the ANOVA table is greater or equal to 0.10,
there is not a statistically significant relationship between Est28MT1
and SiO2MT1 at the 90% or higher confidence level.

   The R-Squared statistic indicates that the model as fitted explains
3,37968% of the variability in Est28MT1.  The correlation coefficient
equals -0,183839, indicating a relatively weak relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 1,4878.  This value can be used to
construct prediction limits for new observations by selecting the
```

Forecasts option from the text menu.

The mean absolute error (MAE) of 1,14552 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

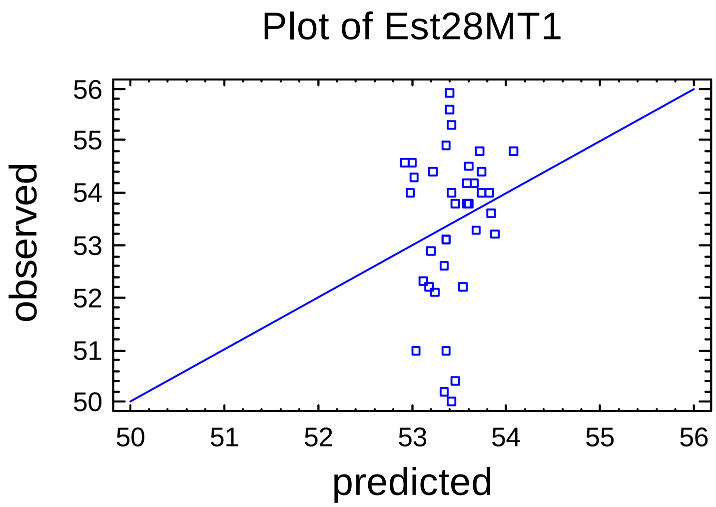


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	2,70997	1	2,70997	1,22	0,2761
Residual	77,4744	35	2,21355		
Lack-of-Fit	73,5644	30	2,45215	3,14	0,1023
Pure Error	3,91	5	0,782		
Total (Corr.)	80,1843	36			

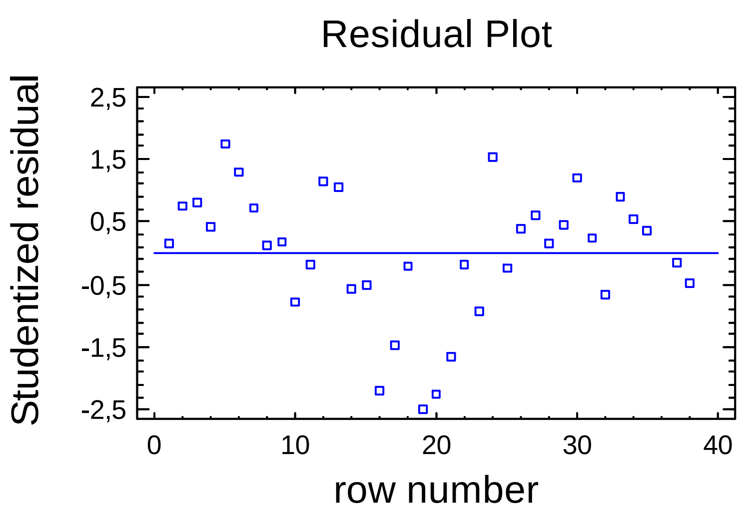
The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.




```
Simple Regression - Est28MT1 vs. SiO2MT1


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the double reciprocal model yields
the highest R-Squared value with 3,61157%.  This is 0,231889% higher
than the currently selected linear model.  To change models, select
the Analysis Options dialog box.
```




```
Simple Regression - Est28MT1 vs. SiO2MT1

Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: SiO2MT1
-----------------------------------------------------------------------------
                                   Standard           T
Parameter        Estimate            Error        Statistic         P-Value
-----------------------------------------------------------------------------
```

```
Intercept       0,024461     0,00500626        4,88607         0,0000
Slope          -0,127405       0,111254       -1,14517         0,2599
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source                Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                    3,72541E-7       1   3,72541E-7       1,31        0,2599
Residual              0,00000994269      35   2,84077E-7
-----------------------------------------------------------------------------
Total (Corr.)          0,0000103152      36

Correlation Coefficient = -0,190041
R-squared = 3,61157 percent
R-squared (adjusted for d.f.) = 0,85761 percent
Standard Error of Est. = 0,000532989
Mean absolute error = 0,000406575
Durbin-Watson statistic = 0,960935 (P=0,0002)
Lag 1 residual autocorrelation = 0,516358

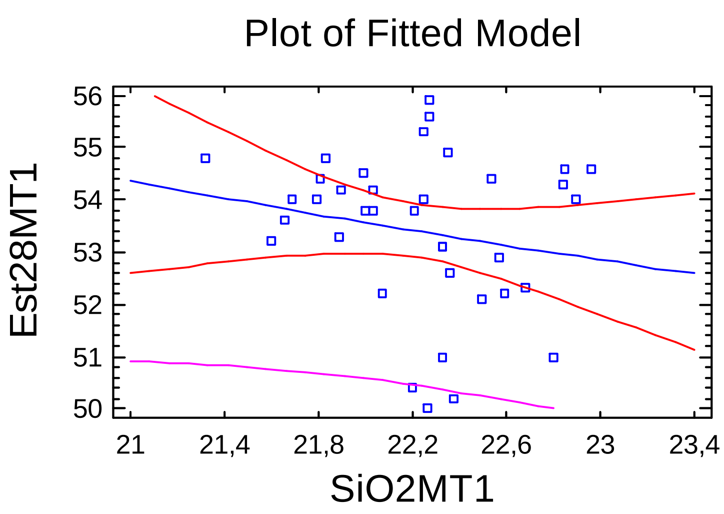
The StatAdvisor
---------------
   The output shows the results of fitting a double reciprocal model
to describe the relationship between Est28MT1 and SiO2MT1.  The
equation of the fitted model is

   Est28MT1 = 1/(0,024461 - 0,127405/SiO2MT1)

Since the P-value in the ANOVA table is greater or equal to 0.10,
there is not a statistically significant relationship between Est28MT1
and SiO2MT1 at the 90% or higher confidence level.

   The R-Squared statistic indicates that the model as fitted explains
3,61157% of the variability in Est28MT1 after transforming to a
reciprocal scale to linearize the model.  The correlation coefficient
equals -0,190041, indicating a relatively weak relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 0,000532989.  This value can be used
to construct prediction limits for new observations by selecting the
Forecasts option from the text menu.

   The mean absolute error (MAE) of 0,000406575 is the average value
of the residuals.  The Durbin-Watson (DW) statistic tests the
residuals to determine if there is any significant correlation based
on the order in which they occur in your data file.  Since the P-value
is less than 0.05, there is an indication of possible serial
correlation.  Plot the residuals versus row order to see if there is
any pattern which can be seen.
```

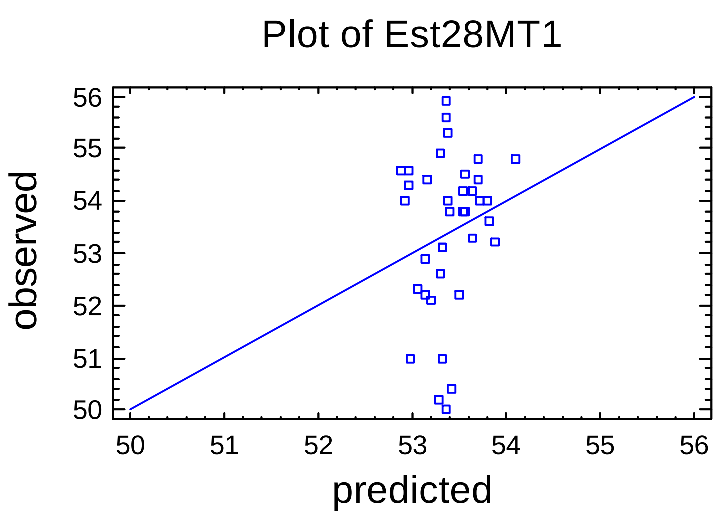


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,72541E-7	1	3,72541E-7	1,31	0,2599
Residual	0,00000994269	35	2,84077E-7		
Lack-of-Fit	0,00000943298	30	3,14433E-7	3,08	0,1056
Pure Error	5,09709E-7	5	1,01942E-7		
Total (Corr.)	0,0000103152	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

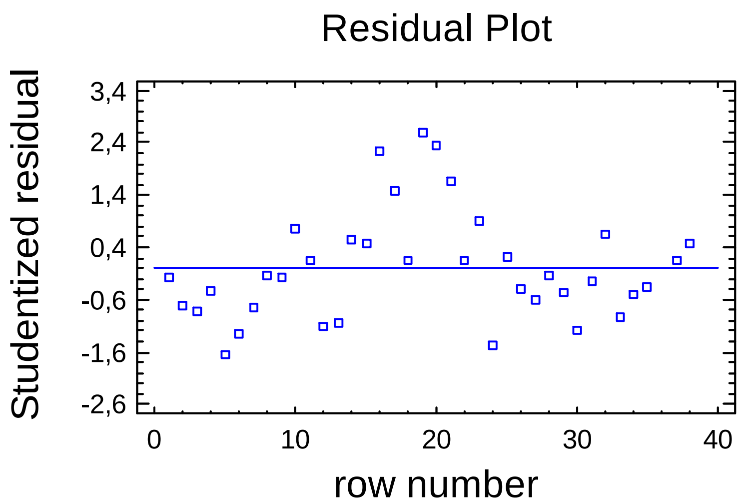


Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	-0,1900	3,61%
S-curve	0,1892	3,58%
Reciprocal-X	0,1883	3,54%
Multiplicative	-0,1870	3,50%
Logarithmic-X	-0,1861	3,46%
Reciprocal-Y	0,1855	3,44%
Square root-X	-0,1850	3,42%
Exponential	-0,1847	3,41%
Square root-Y	-0,1843	3,40%
Linear	-0,1838	3,38%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 3,61157%. This is the currently selected model.



Multiple Regression - Est7MT1

Multiple Regression Analysis

Dependent variable: Est7MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	67,422	7,44241	9,05917	0,0000
Al2O3_2	-4,16081	1,57779	-2,63712	0,0116
IR_2	-0,779985	0,384416	-2,02901	0,0487

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	64,4079	2	32,204	11,05	0,0001
Residual	125,269	43	2,91324		
Total (Corr.)	189,677	45			

R-squared = 33,9566 percent
R-squared (adjusted for d.f.) = 30,8848 percent
Standard Error of Est. = 1,70682
Mean absolute error = 1,27334
Durbin-Watson statistic = 1,73621 (P=0,1401)
Lag 1 residual autocorrelation = 0,101407

Stepwise regression

Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

Step 0:

0 variables in the model. 45 d.f. for error.
R-squared =   0,00%   Adjusted R-squared =   0,00%   MSE = 4,21505

```
Step 1:
---------
Adding variable Al2O3_2 with F-to-enter = 16,8016
1 variables in the model.  44 d.f. for error.
R-squared =  27,63%     Adjusted R-squared =  25,99%     MSE = 3,11961

Step 2:
---------
Adding variable IR_2 with F-to-enter = 4,11689
2 variables in the model.  43 d.f. for error.
R-squared =  33,96%     Adjusted R-squared =  30,88%     MSE = 2,91324

Final model selected.
```

The StatAdvisor

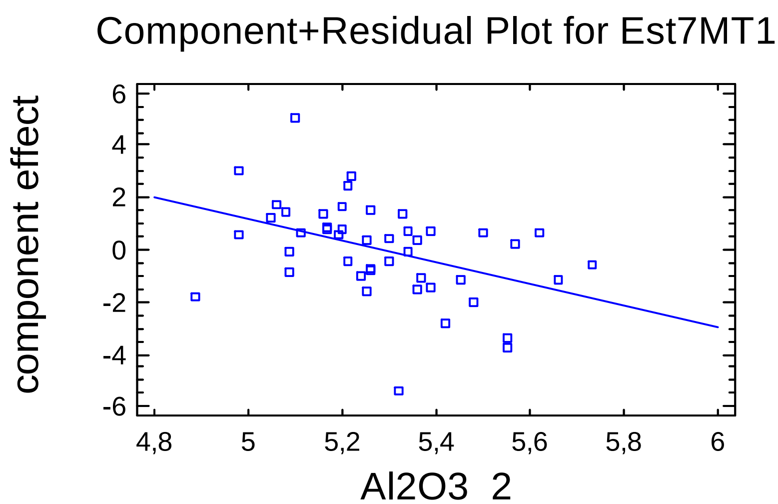
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7MT1 and 5 independent variables. The equation of the fitted model is

Est7MT1 = 67,422 - 4,16081*Al2O3_2 - 0,779985*IR_2

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

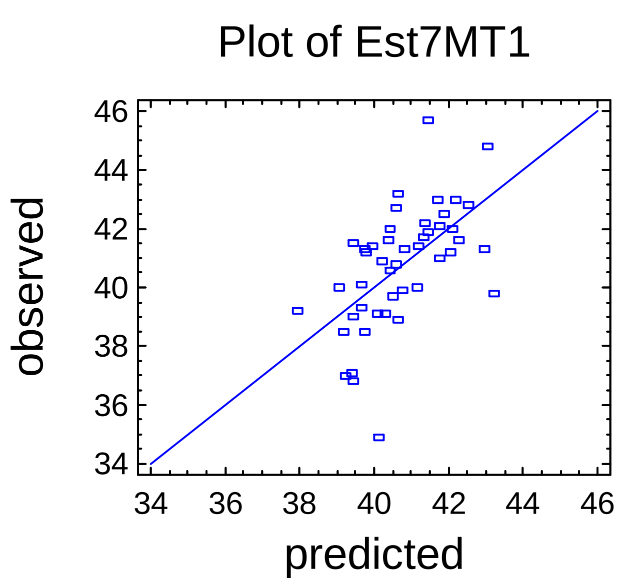
The R-Squared statistic indicates that the model as fitted explains 33,9566% of the variability in Est7MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 30,8848%. The standard error of the estimate shows the standard deviation of the residuals to be 1,70682. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,27334 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

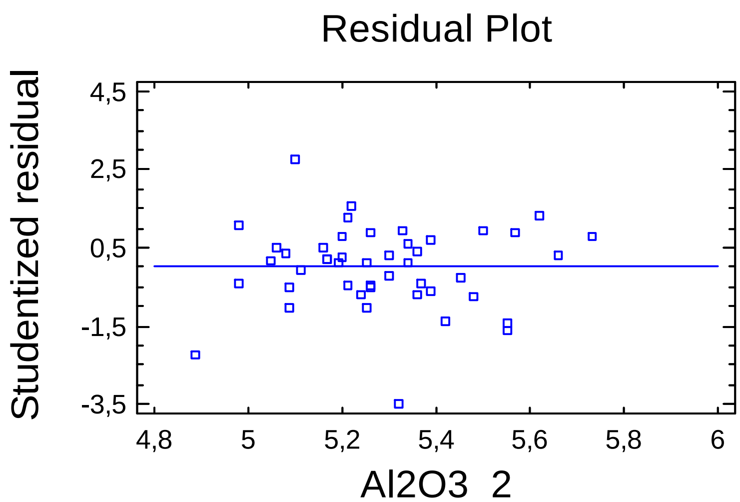
In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0487, belonging to IR_2. Since the P-value is less than 0.05, that term is statistically significant at the 95% confidence level. Consequently, you probably don't want to remove any variables from the model.




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT         Al2O3_2           IR_2
CONSTANT                  1,0000         -0,9625         0,2534
Al2O3_2                  -0,9625          1,0000        -0,5048
IR_2                      0,2534         -0,5048         1,0000
-----------------------------------------------------------------------------
```

```
The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there is 1 correlation with
absolute value greater than 0.5 (not including the constant term).
```





Regression Results for Est7MT1

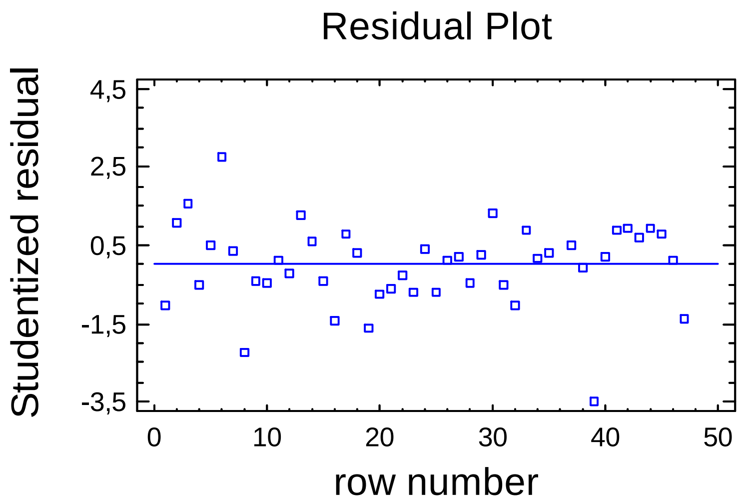
Row	Fitted Value	Stnd. Error for Forecast	Lower 95,0% CL for Forecast	Upper 95,0% CL for Forecast	Lower 95,0% CL for Mean	Upper 95,0% CL for Mean
36	38,2662	1,91047	34,4134	42,119	36,5353	39,9971

The StatAdvisor

This table contains information about Est7MT1 generated using the fitted model. The table includes:

(1) the predicted value of Est7MT1 using the fitted model
(2) the standard error for each predicted value
(3) 95,0% prediction limits for new observations
(4) 95,0% confidence limits for the mean response

Each item corresponds to the values of the independent variables in a specific row of your data file. To generate forecasts for additional combinations of the variables, add additional rows to the bottom of your data file. In each new row, enter values for the independent variables but leave the cell for the dependent variable empty. When you return to this pane, forecasts will be added to the table for the new rows, but the model will be unaffected.




```
Multiple-Variable Analysis

Analysis Summary

Data variables:
     Al2O3_2
     IR_2

There are 47 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

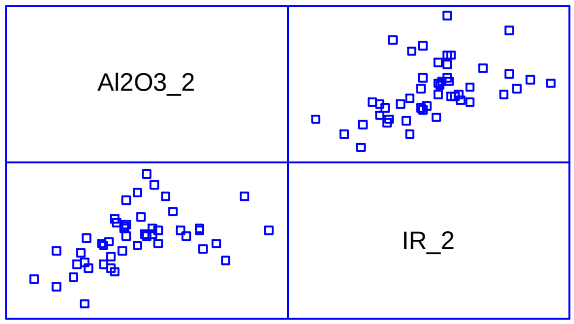
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```



Multiple-Variable Analysis

Summary Statistics

	Al2O3_2	IR_2
Count	47	47
Average	5,29447	6,04468
Variance	0,0405122	0,576382
Standard deviation	0,201276	0,759198
Minimum	4,89	4,22
Maximum	5,83	7,89
Range	0,94	3,67
Stnd. skewness	1,48054	0,440299
Stnd. kurtosis	0,328911	0,373963

The StatAdvisor

This table shows summary statistics for each of the selected data variables. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate many of the statistical procedures normally applied to this data. In this case, the following variables show standardized skewness values outside the expected range:
<none>
The following variables show standardized kurtosis values outside the expected range:
<none>

Correlations

	Al2O3_2	IR_2

```
--------------
Al2O3_2                                0,4813
                                      (   47)
                                       0,0006

IR_2                0,4813
                   (   47)
                    0,0006
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
Al2O3_2 and IR_2

Spearman Rank Correlations

```
                    Al2O3_2            IR_2
--------------------------------------------------------------------------------------
--------------
Al2O3_2                                0,5874
                                      (   47)
                                       0,0001

IR_2                0,5874
                   (   47)
                    0,0001
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
Al2O3_2 and IR_2

Partial Correlations

```
                    Al2O3_2            IR_2
--------------------------------------------------------------------------------------
```

```
--------------
Al2O3_2                                  0,4813
                                        (   47)

IR_2                 0,4813
                    (   47)
--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
```

The StatAdvisor

This table shows partial correlation coefficients between each pair of variables. The partial correlations measure the strength of the linear relationship between the variables having first adjusted for their relationship to other variables in the table. They are helpful in judging how useful one variable would be in improving the prediction of the second variable given that information from all the other variables has already been taken into account. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Ridge Regression - Est7MT1

Ridge Regression

Dependent variable: Est7MT1
Number of complete cases: 46

Model Results for Ridge Parameter = 0,0

Parameter	Estimate	Variance Inflation Factor
CONSTANT	67,422	
Al2O3_2	-4,16081	1,34204
IR_2	-0,779985	1,34204

R-Squared = 33,9566 percent
R-Squared (adjusted for d.f.) = 30,8848 percent
Standard Error of Est. = 1,70682
Mean absolute error = 1,27334
Durbin-Watson statistic = 1,73621 (P=0,2796)
Lag 1 residual autocorrelation = 0,101407

Residual Analysis

	Estimation	Validation
n	46	
MSE	2,91324	
MAE	1,27334	
MAPE	3,17004	
ME	-5,8697E-15	
MPE	-0,169986	

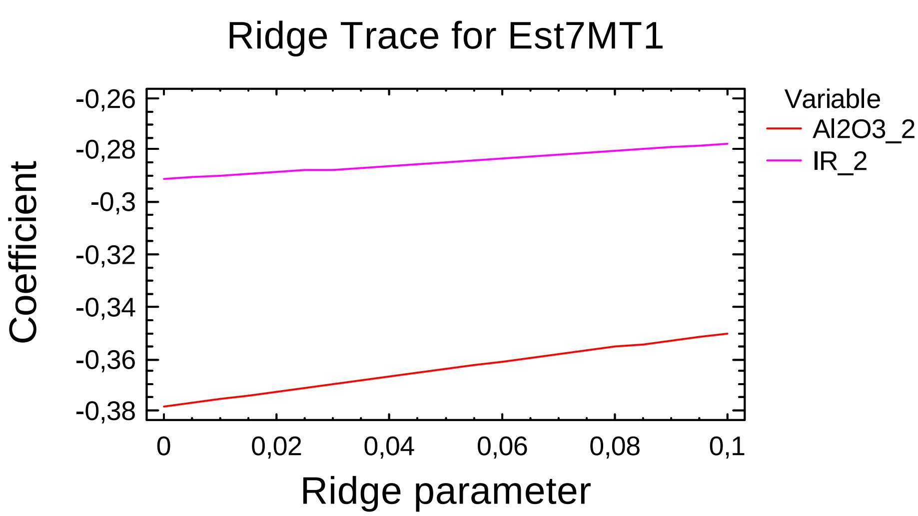
The StatAdvisor

This procedure is designed to provide estimates of regression coefficients when the independent variables are strongly correlated. By allowing for a small amount of bias, the precision of the estimates can often be greatly increased. In this case, the fitted regression model is

Est7MT1 = 67,422 - 4,16081*Al2O3_2 - 0,779985*IR_2

The current value of the ridge parameter is 0,0, which is equivalent to ordinary least squares. To change the ridge parameter, press the alternate mouse button and select Analysis Options. The ridge parameter is usually set between 0.0 and 1.0. In order to determine a good value for the ridge parameter, you should examine the standardized regression coefficients or the variance inflation factors. These values are available on the lists of Tabular and Graphical Options.

The R-Squared statistic indicates that the model as fitted explains 33,9566% of the variability in Est7MT1. The adjusted R-Squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 30,8848%. The standard error of the estimate shows the standard deviation of the residuals to be 1,70682. The mean absolute error (MAE) of 1,27334 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

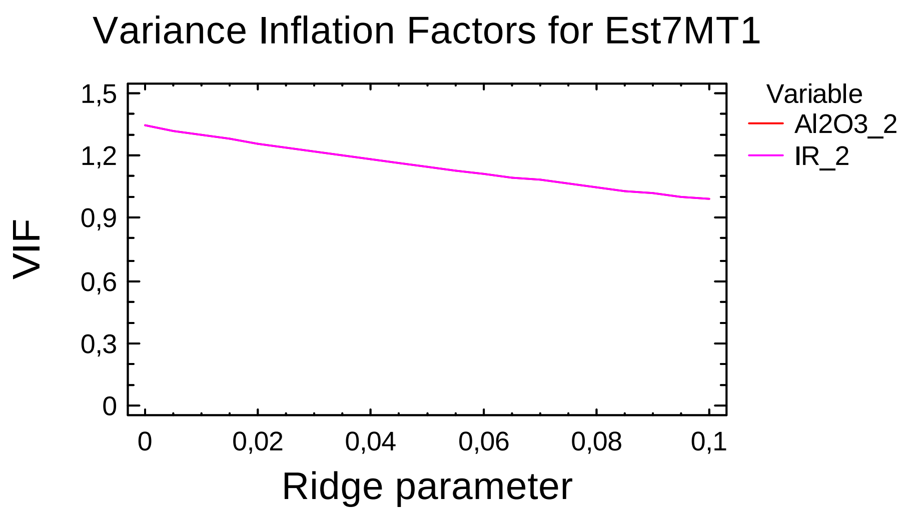


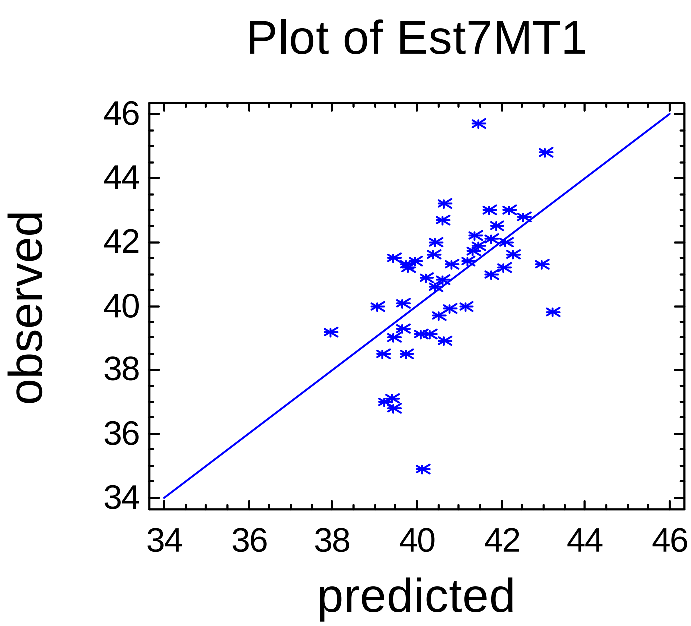
Regression Coefficients

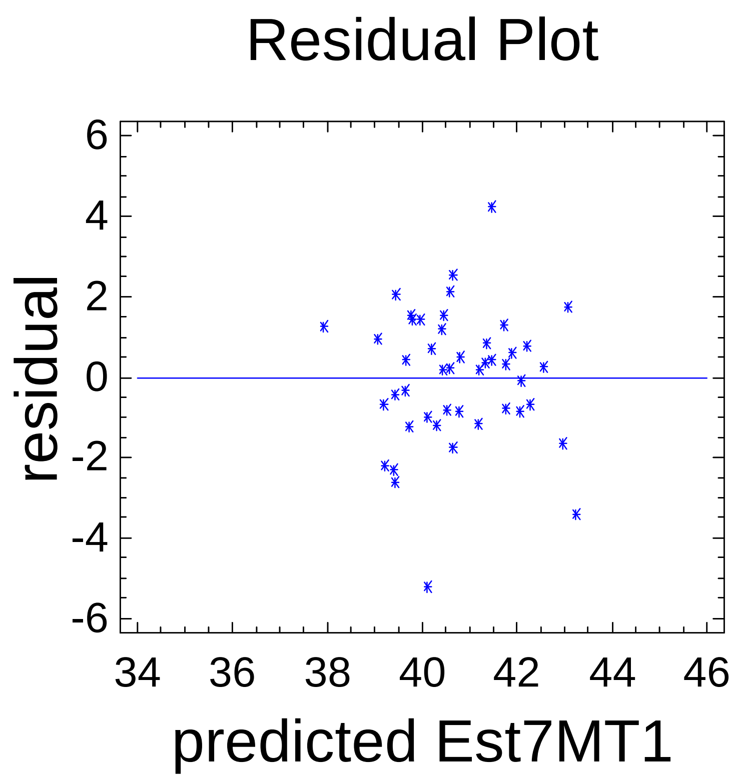
Ridge Parameter	Al2O3_2	IR_2
0,0	-4,16081	-0,779985
0,005	-4,14382	-0,778183
0,01	-4,12701	-0,776378
0,015	-4,11037	-0,77457
0,02	-4,0939	-0,772759
0,025	-4,0776	-0,770946
0,03	-4,06145	-0,769132
0,035	-4,04547	-0,767316
0,04	-4,02964	-0,765499
0,045	-4,01396	-0,763682
0,05	-3,99843	-0,761864
0,055	-3,98305	-0,760046
0,06	-3,96782	-0,758229
0,065	-3,95272	-0,756413
0,07	-3,93777	-0,754597
0,075	-3,92295	-0,752783
0,08	-3,90827	-0,75097
0,085	-3,89372	-0,749159
0,09	-3,87929	-0,74735
0,095	-3,865	-0,745543
0,1	-3,85083	-0,743739

The StatAdvisor

This table shows the estimated regression coefficients for values of the ridge parameter between 0,0 and 0,1. As the ridge parameter is increased from 0.0, the coefficients often change dramatically at first but then become relatively stable. A good value for the ridge parameter is the smallest value after which the estimates change slowly. This is admittedly subjective, but the ridge trace available on the list of Graphical Options may help you make a good choice. To change the range of ridge parameters examined, press the alternate mouse button and select Analysis Options.








```
Multiple-Variable Analysis

Analysis Summary

Data variables:
     Est1MT1
     Est28MT1
     Est7MT1
     Est2MT1

There are 37 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
```

of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

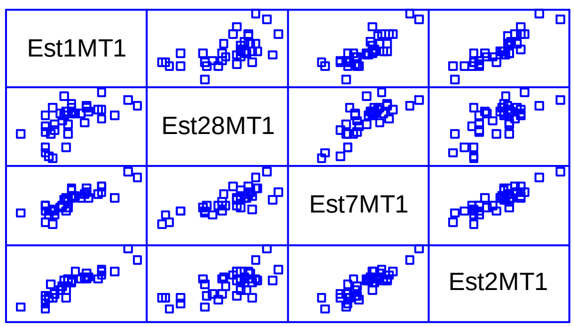
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Summary Statistics

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Count	37	37	37	37
Average	14,7514	53,4351	40,8189	26,3459
Variance	2,61646	2,22734	3,67935	2,63255
Standard deviation	1,61755	1,49243	1,91816	1,62251
Minimum	11,5	50,0	36,8	23,2
Maximum	19,0	55,9	45,7	30,7
Range	7,5	5,9	8,9	7,5
Stnd. skewness	1,79415	-2,00193	0,56397	0,520469
Stnd. kurtosis	0,639206	0,0912519	0,424681	0,28023

The StatAdvisor

This table shows summary statistics for each of the selected data variables. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate many of the statistical procedures normally applied to this data. In this case, the following variables show standardized skewness values outside the expected range:

Est28MT1

The following variables show standardized kurtosis values outside the expected range:

<none>

To make the variables more normal, you might try a transformation such as LOG(Y), SQRT(Y), or 1/Y.

95,0 percent confidence intervals

	Mean	Stnd. error	Lower limit	Upper limit
Est1MT1	14,7514	0,265923	14,212	15,2907
Est28MT1	53,4351	0,245354	52,9375	53,9327
Est7MT1	40,8189	0,315344	40,1794	41,4585
Est2MT1	26,3459	0,26674	25,805	26,8869

	Sigma	Lower limit	Upper limit
Est1MT1	1,61755	1,31541	2,10113
Est28MT1	1,49243	1,21366	1,93861
Est7MT1	1,91816	1,55987	2,49162
Est2MT1	1,62251	1,31945	2,10758

The StatAdvisor

This table shows 95,0% confidence intervals for the means and standard deviations of each of the variables. These intervals bound the sampling error in the estimates of the parameters of the populations from which the data come. They can be used to help judge how precisely the population means and standard deviations have been estimated. The intervals assume that the populations from which the samples come can be represented by normal distributions. While the confidence intervals for the means are quite robust and not very sensitive to violations of this assumption, the confidence intervals for the standard deviations are quite sensitive. You can check the assumption of normality in the One Variable Analysis procedure.

Correlations

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Est1MT1		0,5907 (37) 0,0001	0,8334 (37) 0,0000	0,9024 (37) 0,0000
Est28MT1	0,5907 (37) 0,0001		0,7790 (37) 0,0000	0,6894 (37) 0,0000
Est7MT1	0,8334 (37) 0,0000	0,7790 (37) 0,0000		0,8734 (37) 0,0000
Est2MT1	0,9024 (37) 0,0000	0,6894 (37) 0,0000	0,8734 (37) 0,0000	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est1MT1 and Est28MT1
Est1MT1 and Est7MT1
Est1MT1 and Est2MT1
Est28MT1 and Est7MT1
Est28MT1 and Est2MT1
Est7MT1 and Est2MT1

Spearman Rank Correlations

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Est1MT1		0,6532	0,8412	0,9231
		(37)	(37)	(37)
		0,0001	0,0000	0,0000
Est28MT1	0,6532		0,7717	0,6103
	(37)		(37)	(37)
	0,0001		0,0000	0,0003
Est7MT1	0,8412	0,7717		0,8043
	(37)	(37)		(37)
	0,0000	0,0000		0,0000
Est2MT1	0,9231	0,6103	0,8043	
	(37)	(37)	(37)	
	0,0000	0,0003	0,0000	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in

parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est1MT1 and Est28MT1
Est1MT1 and Est7MT1
Est1MT1 and Est2MT1
Est28MT1 and Est7MT1
Est28MT1 and Est2MT1
Est7MT1 and Est2MT1

Covariances

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Est1MT1	2,61646	1,42592	2,58567	2,36841
	(37)	(37)	(37)	(37)
Est28MT1	1,42592	2,22734	2,23015	1,66945
	(37)	(37)	(37)	(37)
Est7MT1	2,58567	2,23015	3,67935	2,71827
	(37)	(37)	(37)	(37)
Est2MT1	2,36841	1,66945	2,71827	2,63255
	(37)	(37)	(37)	(37)

Covariance
(Sample Size)

The StatAdvisor

This table shows estimated covariances between each pair of variables. The covariances measure how much the variables vary together and are used to compute Pearson product moment correlations. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Partial Correlations

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Est1MT1		-0,2472	0,3089	0,6633
		(37)	(37)	(37)
Est28MT1	-0,2472		0,5384	0,1854
	(37)		(37)	(37)
Est7MT1	0,3089	0,5384		0,3222
	(37)	(37)		(

37)

```
Est2MT1             0,6633              0,1854              0,3222
                   (   37)             (   37)             (   37)
----------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
```

The StatAdvisor

This table shows partial correlation coefficients between each pair of variables. The partial correlations measure the strength of the linear relationship between the variables having first adjusted for their relationship to other variables in the table. They are helpful in judging how useful one variable would be in improving the prediction of the second variable given that information from all the other variables has already been taken into account. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Simple Regression - Est28MT1 vs. Est7MT1

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est28MT1
Independent variable: Est7MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	28,6938	3,36945	8,51587	0,0000
Slope	0,606125	0,0824577	7,35075	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	48,663	1	48,663	54,03	0,0000
Residual	31,5213	35	0,900609		
Total (Corr.)	80,1843	36			

Correlation Coefficient = 0,779031
R-squared = 60,6889 percent
R-squared (adjusted for d.f.) = 59,5658 percent
Standard Error of Est. = 0,949004
Mean absolute error = 0,736398
Durbin-Watson statistic = 1,64211 (P=0,1145)
Lag 1 residual autocorrelation = 0,164512

The StatAdvisor

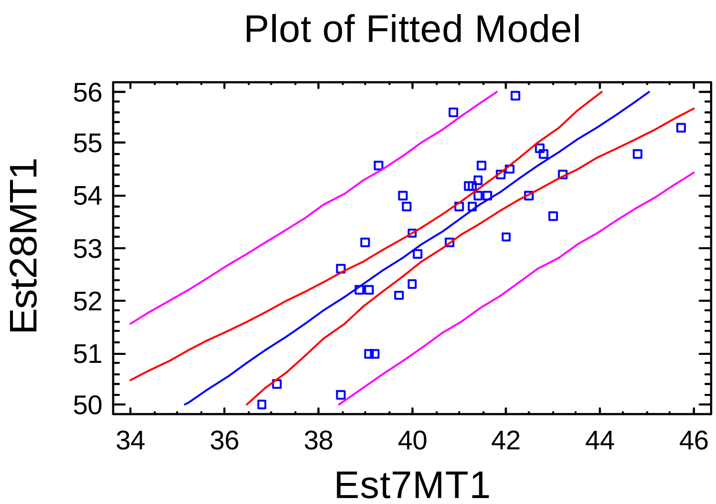
The output shows the results of fitting a linear model to describe the relationship between Est28MT1 and Est7MT1. The equation of the fitted model is

Est28MT1 = 28,6938 + 0,606125*Est7MT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Est28MT1 and Est7MT1 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 60,6889% of the variability in Est28MT1. The correlation coefficient equals 0,779031, indicating a moderately strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,949004. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,736398 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

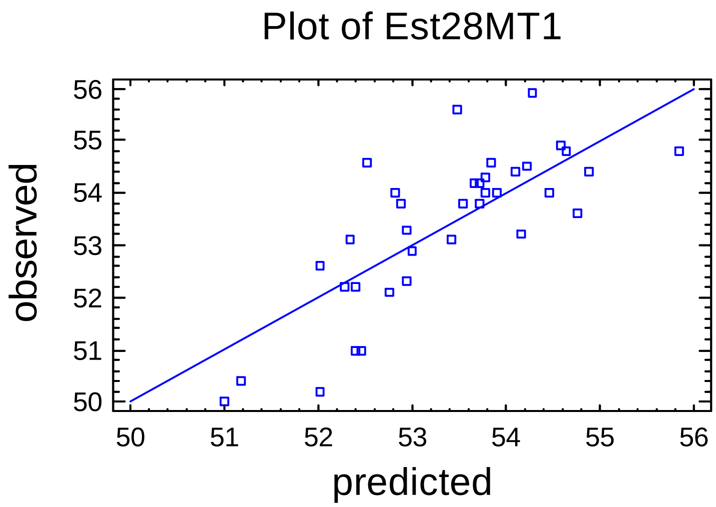


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	48,663	1	48,663	54,03	0,0000
Residual	31,5213	35	0,900609		
Lack-of-Fit	27,2963	30	0,909877	1,08	0,5237
Pure Error	4,225	5	0,845		
Total (Corr.)	80,1843	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

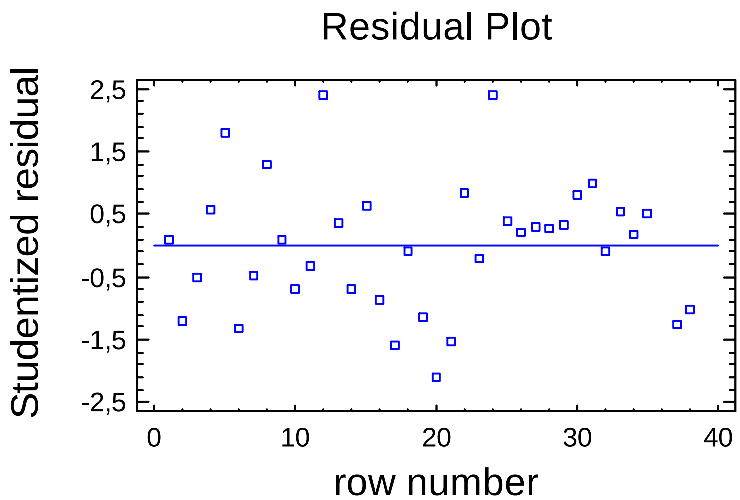


Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	0,7968	63,48%
S-curve	-0,7966	63,46%
Reciprocal-X	-0,7963	63,41%
Multiplicative	0,7882	62,12%
Logarithmic-X	0,7881	62,12%
Square root-X	0,7837	61,42%
Linear	0,7790	60,69%
Square root-Y	0,7789	60,68%
Exponential	0,7788	60,65%
Reciprocal-Y	-0,7784	60,59%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 63,4814%. This is 2,79245% higher than the currently selected linear model. To change models, select the Analysis Options dialog box.




```
Simple Regression - Est7MT1 vs. Est2MT1

Regression Analysis - Linear model: Y = a + b*X
-----------------------------------------------------------------------------
Dependent variable: Est7MT1
Independent variable: Est2MT1
-----------------------------------------------------------------------------
                                Standard          T
Parameter       Estimate         Error        Statistic        P-Value
-----------------------------------------------------------------------------
Intercept        13,5594         2,1717         6,24367         0,0000
Slope            1,02878      0,0820488         12,5387         0,0000
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     148,201      1      148,201     157,22       0,0000
Residual                  41,4764     44     0,942645
-----------------------------------------------------------------------------
Total (Corr.)             189,677     45

Correlation Coefficient = 0,88393
R-squared = 78,1332 percent
R-squared (adjusted for d.f.) = 77,6362 percent
Standard Error of Est. = 0,970899
Mean absolute error = 0,780959
Durbin-Watson statistic = 1,37407 (P=0,0116)
Lag 1 residual autocorrelation = 0,297084

The StatAdvisor
---------------
   The output shows the results of fitting a linear model to describe
the relationship between Est7MT1 and Est2MT1.  The equation of the
fitted model is

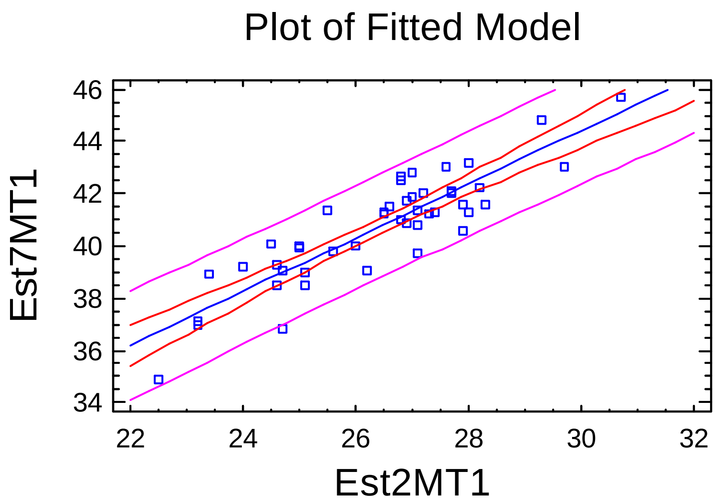
   Est7MT1 = 13,5594 + 1,02878*Est2MT1

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between Est7MT1 and Est2MT1 at
the 99% confidence level.

   The R-Squared statistic indicates that the model as fitted explains
78,1332% of the variability in Est7MT1.  The correlation coefficient
equals 0,88393, indicating a moderately strong relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 0,970899.  This value can be used to
construct prediction limits for new observations by selecting the
```

Forecasts option from the text menu.

The mean absolute error (MAE) of 0,780959 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

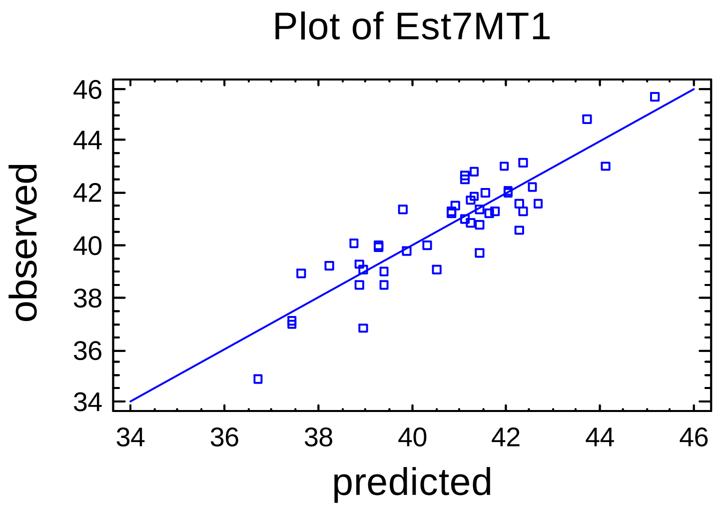


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	148,201	1	148,201	157,22	0,0000
Residual	41,4764	44	0,942645		
Lack-of-Fit	32,1231	29	1,10769	1,78	0,1209
Pure Error	9,35333	15	0,623556		
Total (Corr.)	189,677	45			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

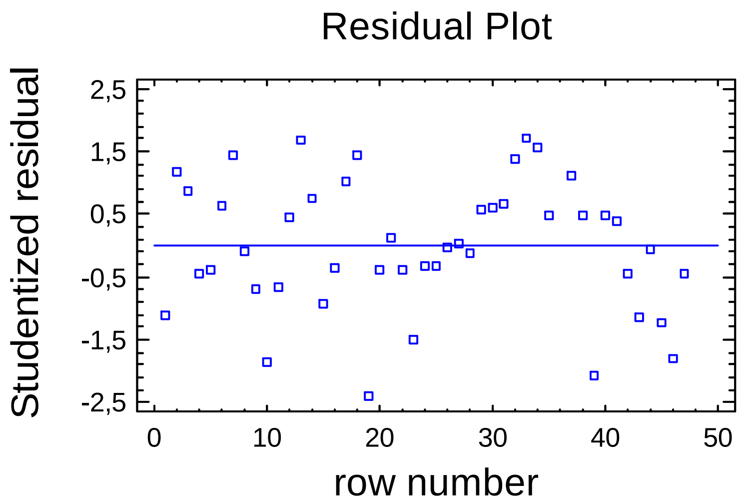


Comparison of Alternative Models

Model	Correlation	R-Squared
S-curve	-0,8863	78,56%
Reciprocal-X	-0,8861	78,51%
Logarithmic-X	0,8857	78,44%
Double reciprocal	0,8851	78,34%
Square root-X	0,8850	78,32%
Multiplicative	0,8846	78,24%
Linear	0,8839	78,13%
Square root-Y	0,8828	77,94%
Exponential	0,8813	77,68%
Reciprocal-Y	-0,8772	76,95%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the S-curve model model yields the highest R-Squared value with 78,5614%. This is 0,428216% higher than the currently selected linear model. To change models, select the Analysis Options dialog box.




```
Analysis Summary

Data variables:
     Al2O3_2
     IR_2
     Est7MT1

There are 46 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

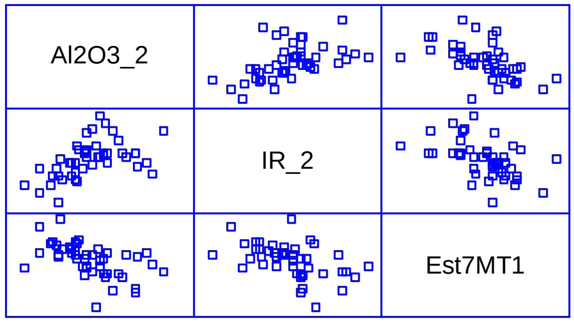
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```



Summary Statistics

	Al2O3_2	IR_2	Est7MT1
Count	46	46	46
Average	5,28283	6,03957	40,7304
Variance	0,0349007	0,587933	4,21505
Standard deviation	0,186817	0,766768	2,05306
Minimum	4,89	4,22	34,9
Maximum	5,73	7,89	45,7
Range	0,84	3,67	10,8
Stnd. skewness	0,900896	0,48871	-1,07601
Stnd. kurtosis	-0,152554	0,299014	1,28179

The StatAdvisor

This table shows summary statistics for each of the selected data variables. It includes measures of central tendency, measures of variability, and measures of shape. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the sample comes from a normal distribution. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate many of the statistical procedures normally applied to this data. In this case, the following variables show standardized skewness values outside the expected range:

<none>

The following variables show standardized kurtosis values outside the expected range:

<none>

Correlations

	Al2O3_2	IR_2	Est7MT1
Al2O3_2		0,5048	-0,5257
		(46)	(46)
		0,0003	0,0002
IR_2	0,5048		-0,4824

	(46)		(46)
	0,0003		0,0007
Est7MT1	-0,5257	-0,4824	
	(46)	(46)	
	0,0002	0,0007	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Al2O3_2 and IR_2
Al2O3_2 and Est7MT1
IR_2 and Est7MT1

Spearman Rank Correlations

	Al2O3_2	IR_2	Est7MT1
Al2O3_2		0,5927	-0,6217
		(46)	(46)
		0,0001	0,0000
IR_2	0,5927		-0,5448
	(46)		(46)
	0,0001		0,0003
Est7MT1	-0,6217	-0,5448	
	(46)	(46)	
	0,0000	0,0003	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Al2O3_2 and IR_2
Al2O3_2 and Est7MT1
IR_2 and Est7MT1

Partial Correlations

	Al2O3_2	IR_2	Est7MT1
Al2O3_2		0,3372	-0,3731
		(46)	(46)
IR_2	0,3372		-0,2956
	(46)		(46)
Est7MT1	-0,3731	-0,2956	
	(46)	(46)	

Correlation
(Sample Size)

The StatAdvisor

This table shows partial correlation coefficients between each pair of variables. The partial correlations measure the strength of the linear relationship between the variables having first adjusted for their relationship to other variables in the table. They are helpful in judging how useful one variable would be in improving the prediction of the second variable given that information from all the other variables has already been taken into account. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Regression Analysis - Multiplicative model: Y = a*X^b

Dependent variable: Est28MT1
Independent variable: IR_2

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	4,09571	0,0595055	68,8291	0,0000
Slope	-0,065843	0,0332155	-1,9823	0,0553

NOTE: intercept = ln(a)

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0029004	1	0,0029004	3,93	0,0553
Residual	0,0258337	35	0,000738107		
Total (Corr.)	0,0287341	36			

Correlation Coefficient = -0,317709
R-squared = 10,0939 percent
R-squared (adjusted for d.f.) = 7,52518 percent
Standard Error of Est. = 0,0271681
Mean absolute error = 0,0202406
Durbin-Watson statistic = 1,05967 (P=0,0007)
Lag 1 residual autocorrelation = 0,462245

The StatAdvisor

The output shows the results of fitting a multiplicative model to describe the relationship between Est28MT1 and IR_2. The equation of the fitted model is

Est28MT1 = 60,0819*IR_2^-0,065843

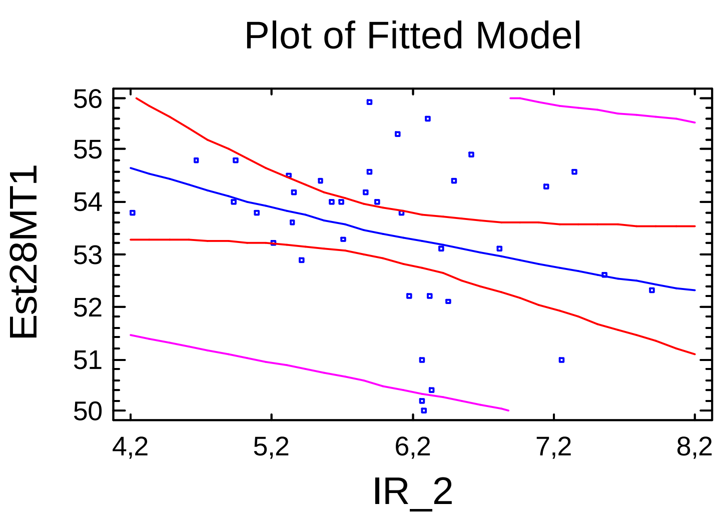
or

```
   ln(Est28MT1) = 4,09571 - 0,065843*ln(IR_2)
```

Since the P-value in the ANOVA table is less than 0.10, there is a statistically significant relationship between Est28MT1 and IR_2 at the 90% confidence level.

The R-Squared statistic indicates that the model as fitted explains 10,0939% of the variability in Est28MT1 after transforming to a logarithmic scale to linearize the model. The correlation coefficient equals -0,317709, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,0271681. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,0202406 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



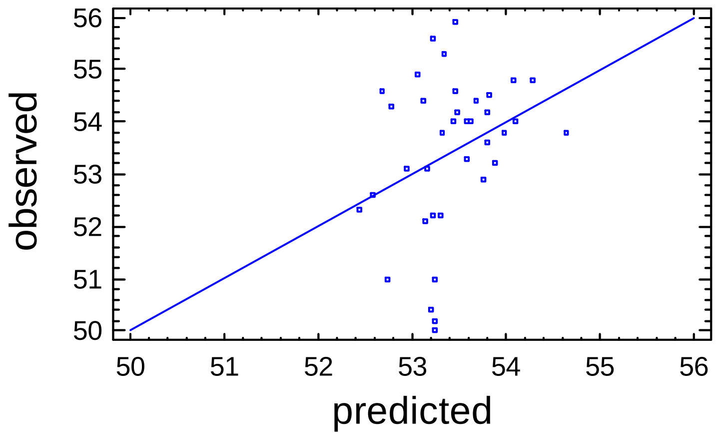
Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0029004	1	0,0029004	3,93	0,0553
Residual	0,0258337	35	0,000738107		
Lack-of-Fit	0,0254319	33	0,000770664	3,84	0,2279
Pure Error	0,00040183	2	0,000200915		
Total (Corr.)	0,0287341	36			

The StatAdvisor

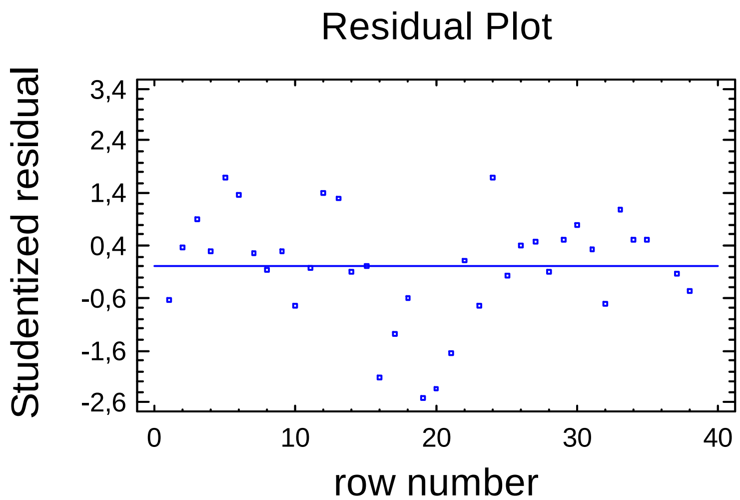
The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Plot of Est28MT1




```
Comparison of Alternative Models
--------------------------------------------------
Model                      Correlation      R-Squared
--------------------------------------------------
Multiplicative                 -0,3177         10,09%
Logarithmic-X                  -0,3166         10,02%
Reciprocal-Y                    0,3165         10,02%
Square root-X                  -0,3164         10,01%
Double reciprocal              -0,3163         10,00%
Exponential                    -0,3160          9,98%
Square root-Y                  -0,3156          9,96%
Linear                         -0,3152          9,94%
S-curve                         0,3151          9,93%
Reciprocal-X                    0,3137          9,84%
Logistic                                 <no fit>
Log probit                               <no fit>
--------------------------------------------------


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the multiplicative model yields
the highest R-Squared value with 10,0939%.  This is the currently
selected model.
```




```
Regression Analysis - Double reciprocal model: Y = 1/(a + b/X)
-----------------------------------------------------------------------------
Dependent variable: Est28MT1
Independent variable: SiO2MT1
-----------------------------------------------------------------------------
                                Standard          T
Parameter        Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
Intercept        0,024461     0,00500626       4,88607         0,0000
Slope           -0,127405       0,111254      -1,14517         0,2599
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  3,72541E-7      1   3,72541E-7       1,31       0,2599
Residual             0,00000994269    35   2,84077E-7
-----------------------------------------------------------------------------
Total (Corr.)         0,0000103152    36

Correlation Coefficient = -0,190041
R-squared = 3,61157 percent
R-squared (adjusted for d.f.) = 0,85761 percent
Standard Error of Est. = 0,000532989
Mean absolute error = 0,000406575
Durbin-Watson statistic = 0,960935 (P=0,0002)
Lag 1 residual autocorrelation = 0,516358

The StatAdvisor
---------------
   The output shows the results of fitting a double reciprocal model
to describe the relationship between Est28MT1 and SiO2MT1.  The
equation of the fitted model is

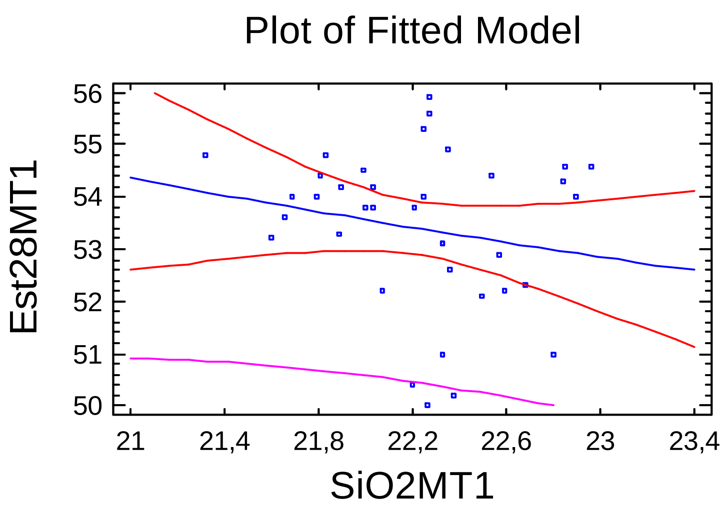
   Est28MT1 = 1/(0,024461 - 0,127405/SiO2MT1)

Since the P-value in the ANOVA table is greater or equal to 0.10,
there is not a statistically significant relationship between Est28MT1
and SiO2MT1 at the 90% or higher confidence level.

   The R-Squared statistic indicates that the model as fitted explains
3,61157% of the variability in Est28MT1 after transforming to a
reciprocal scale to linearize the model.  The correlation coefficient
equals -0,190041, indicating a relatively weak relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 0,000532989.  This value can be used
```

to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,000406575 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

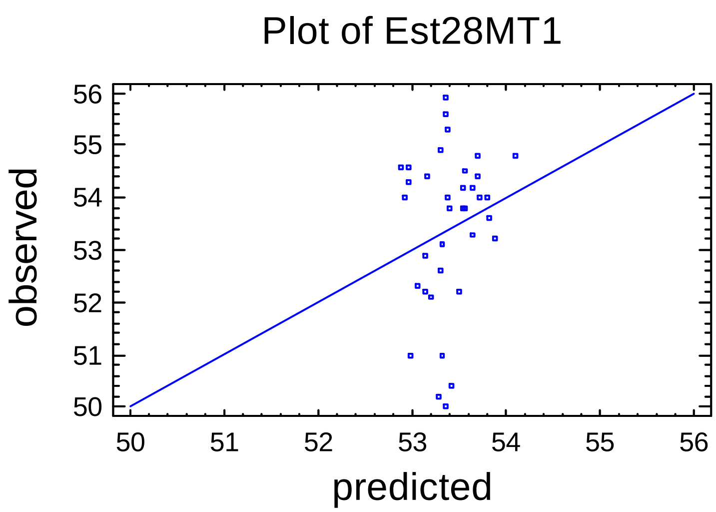


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,72541E-7	1	3,72541E-7	1,31	0,2599
Residual	0,00000994269	35	2,84077E-7		
Lack-of-Fit	0,00000943298	30	3,14433E-7	3,08	0,1056
Pure Error	5,09709E-7	5	1,01942E-7		
Total (Corr.)	0,0000103152	36			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

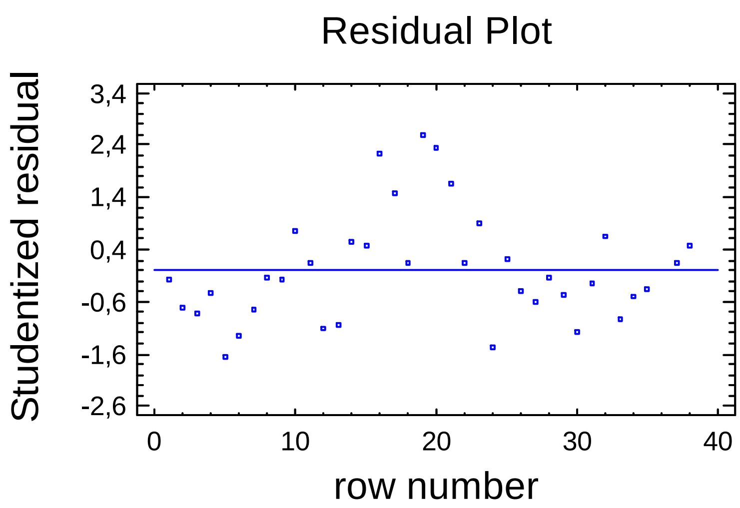


Comparison of Alternative Models

Model	Correlation	R-Squared
Double reciprocal	-0,1900	3,61%
S-curve	0,1892	3,58%
Reciprocal-X	0,1883	3,54%
Multiplicative	-0,1870	3,50%
Logarithmic-X	-0,1861	3,46%
Reciprocal-Y	0,1855	3,44%
Square root-X	-0,1850	3,42%
Exponential	-0,1847	3,41%
Square root-Y	-0,1843	3,40%
Linear	-0,1838	3,38%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the double reciprocal model yields the highest R-Squared value with 3,61157%. This is the currently selected model.



Simple Regression - Est2MT1 vs. Est1MT1

```
Regression Analysis - Linear model: Y = a + b*X
-----------------------------------------------------------------------------
Dependent variable: Est2MT1
Independent variable: Est1MT1
-----------------------------------------------------------------------------
                                Standard          T
Parameter        Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
Intercept         12,0673        1,01159        11,9291         0,0000
Slope            0,973593      0,0682494        14,2652         0,0000
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     115,131      1      115,131     203,50       0,0000
Residual                  24,8936     44     0,565763
-----------------------------------------------------------------------------
Total (Corr.)             140,025     45

Correlation Coefficient = 0,906763
R-squared = 82,222 percent
R-squared (adjusted for d.f.) = 81,818 percent
Standard Error of Est. = 0,752172
Mean absolute error = 0,60131
Durbin-Watson statistic = 1,32218 (P=0,0068)
Lag 1 residual autocorrelation = 0,283894

The StatAdvisor
---------------
   The output shows the results of fitting a linear model to describe
the relationship between Est2MT1 and Est1MT1.  The equation of the
fitted model is

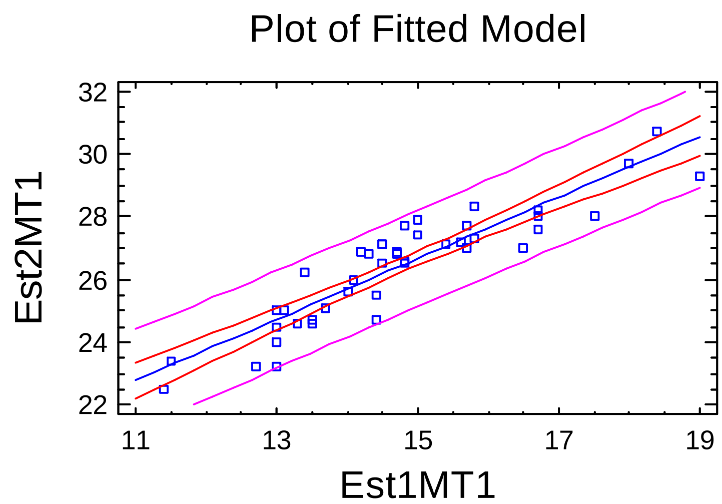
   Est2MT1 = 12,0673 + 0,973593*Est1MT1

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between Est2MT1 and Est1MT1 at
the 99% confidence level.

   The R-Squared statistic indicates that the model as fitted explains
82,222% of the variability in Est2MT1.  The correlation coefficient
equals 0,906763, indicating a relatively strong relationship between
the variables.  The standard error of the estimate shows the standard
```

deviation of the residuals to be 0,752172. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,60131 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

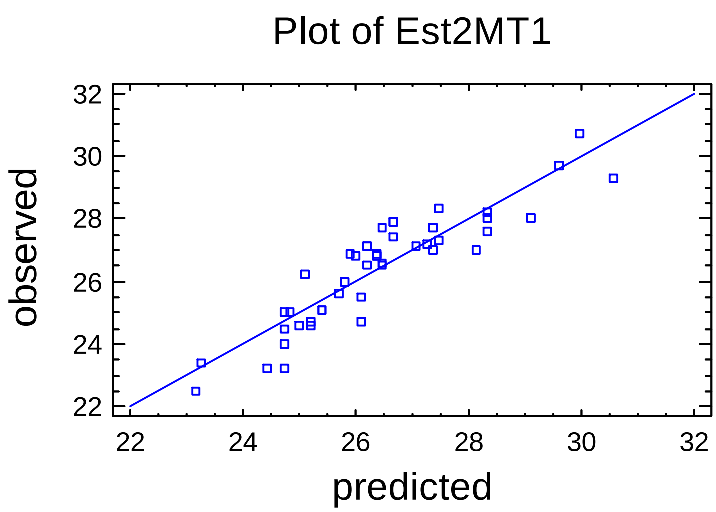


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	115,131	1	115,131	203,50	0,0000
Residual	24,8936	44	0,565763		
Lack-of-Fit	20,5694	26	0,791131	3,29	0,0056
Pure Error	4,32417	18	0,240231		
Total (Corr.)	140,025	45			

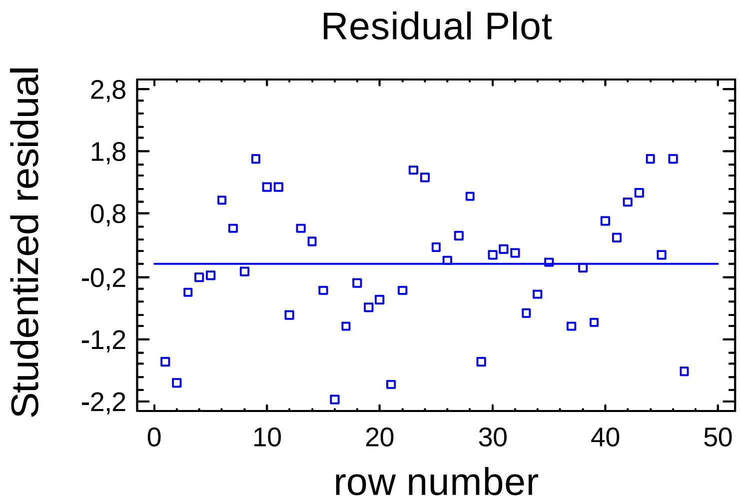
The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is less than 0.01, there is statistically significant lack-of-fit at the 99% confidence level. You might consider selecting a different model form from the Analysis Options dialog box.




```
Comparison of Alternative Models
--------------------------------------------------
Model                    Correlation      R-Squared
--------------------------------------------------
Reciprocal-X                 -0,9186         84,38%
S-curve                      -0,9184         84,34%
Double reciprocal             0,9165         83,99%
Logarithmic-X                 0,9157         83,85%
Multiplicative                0,9125         83,27%
Square root-X                 0,9119         83,16%
Linear                        0,9068         82,22%
Square root-Y                 0,9040         81,72%
Exponential                   0,9008         81,14%
Reciprocal-Y                 -0,8933         79,79%
Logistic                               <no fit>
Log probit                             <no fit>
--------------------------------------------------


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the reciprocal-X model yields the
highest R-Squared value with 84,3821%.  This is 2,16008% higher than
the currently selected linear model.  To change models, select the
Analysis Options dialog box.
```




```
Regression Analysis - Reciprocal-X model: Y = a + b/X
-----------------------------------------------------------------------------
Dependent variable: Est2MT1
Independent variable: Est1MT1
-----------------------------------------------------------------------------
                               Standard          T
Parameter       Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
Intercept         41,209       0,965385        42,6867         0,0000
Slope           -215,444        13,9731       -15,4184         0,0000
-----------------------------------------------------------------------------


                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                    118,156       1      118,156     237,73       0,0000
Residual                 21,8689      44     0,497021
-----------------------------------------------------------------------------
Total (Corr.)            140,025      45

Correlation Coefficient = -0,918597
R-squared = 84,3821 percent
Standard Error of Est. = 0,704997


The StatAdvisor
---------------
   The output shows the results of fitting a reciprocal-X model to
describe the relationship between Est2MT1 and Est1MT1.  The equation
of the fitted model is

   Est2MT1 = 41,209 - 215,444/Est1MT1

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between Est2MT1 and Est1MT1 at
the 99% confidence level.

   The R-Squared statistic indicates that the model as fitted explains
84,3821% of the variability in Est2MT1.  The correlation coefficient
equals -0,918597, indicating a relatively strong relationship between
the variables.  The standard error of the estimate shows the standard
deviation of the residuals to be 0,704997.  This value can be used to
construct prediction limits for new observations by selecting the
Forecasts option from the text menu.


                    Analysis of Variance with Lack-of-Fit
-----------------------------------------------------------------------------
```

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	118,156	1	118,156	237,73	0,0000
Residual	21,8689	44	0,497021		
Lack-of-Fit	17,5448	26	0,674798	2,81	0,0134
Pure Error	4,32417	18	0,240231		
Total (Corr.)	140,025	45			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is less than 0.05, there is statistically significant lack-of-fit at the 95% confidence level. You might consider selecting a different model form from the Analysis Options dialog box.

Παλινδρόμηση- όλες οι μεταβλητές- ποιότητα τσιμέντου CEM II 42,5-μύλος1

Multiple Regression - Est1MT1

Multiple Regression Analysis

Dependent variable: Est1MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	30,4443	30,5925	0,995156	0,3256
Al2O3_2	-1,61101	1,31688	-1,22335	0,2284
BLAINEMT1	0,00385866	0,00543163	0,710405	0,4816
IR_2	-0,496853	0,382514	-1,29891	0,2014
LOIMT1	-1,47793	0,599378	-2,46577	0,0181
SiO2MT1	-0,68055	0,774848	-0,8783	0,3850

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	59,5211	5	11,9042	7,69	0,0000
Residual	61,9399	40	1,5485		
Total (Corr.)	121,461	45			

R-squared = 49,0043 percent
R-squared (adjusted for d.f.) = 42,6298 percent
Standard Error of Est. = 1,24439
Mean absolute error = 0,853128
Durbin-Watson statistic = 1,71618 (P=0,1096)
Lag 1 residual autocorrelation = 0,141136

The StatAdvisor

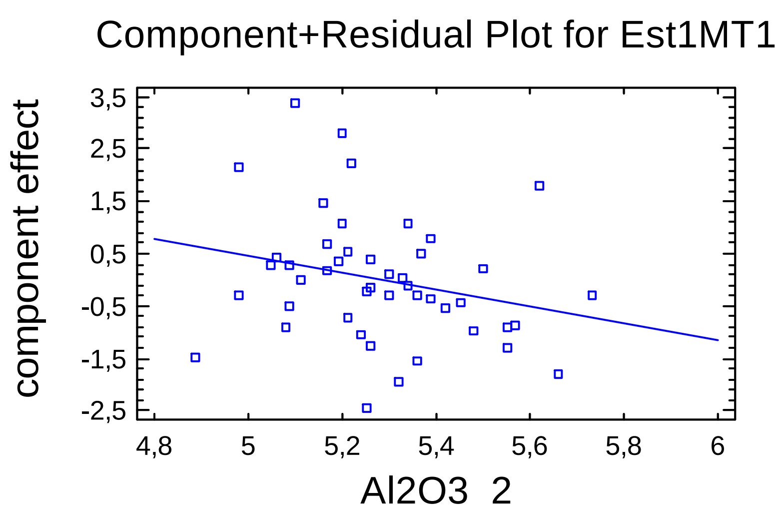
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1MT1 and 5 independent variables. The equation of the fitted model is

Est1MT1 = 30,4443 - 1,61101*Al2O3_2 + 0,00385866*BLAINEMT1 - 0,496853*IR_2 - 1,47793*LOIMT1 - 0,68055*SiO2MT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 49,0043% of the variability in Est1MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 42,6298%. The standard error of the estimate shows the standard deviation of the residuals to be 1,24439. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,853128 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,4816, belonging to BLAINEMT1. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing BLAINEMT1 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	Al2O3_2	BLAINEMT1	IR_2
CONSTANT	1,0000	-0,0828	-0,8698	0,3818
Al2O3_2	-0,0828	1,0000	0,1493	-0,0196
BLAINEMT1	-0,8698	0,1493	1,0000	-0,0563
IR_2	0,3818	-0,0196	-0,0563	1,0000
LOIMT1	-0,0539	-0,3764	-0,1750	-0,4475
SiO2MT1	-0,4734	-0,4128	0,0158	-0,6404

	LOIMT1	SiO2MT1
CONSTANT	-0,0539	-0,4734
Al2O3_2	-0,3764	-0,4128
BLAINEMT1	-0,1750	0,0158
IR_2	-0,4475	-0,6404
LOIMT1	1,0000	0,3947
SiO2MT1	0,3947	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in

the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there is 1 correlation with absolute value greater than 0.5 (not including the constant term).

Multiple Regression - Est2MT1

Multiple Regression Analysis

Dependent variable: Est2MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	1,68222	34,8106	0,0483249	0,9617
Al2O3_2	-2,29699	1,49845	-1,53291	0,1332
BLAINEMT1	0,0108423	0,00618055	1,75426	0,0870
IR_2	-0,662723	0,435255	-1,52261	0,1357
LOIMT1	-0,947734	0,68202	-1,3896	0,1723
SiO2MT1	-0,276071	0,881684	-0,313118	0,7558

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	59,8266	5	11,9653	5,97	0,0003
Residual	80,198	40	2,00495		
Total (Corr.)	140,025	45			

R-squared = 42,7258 percent
R-squared (adjusted for d.f.) = 35,5665 percent
Standard Error of Est. = 1,41596
Mean absolute error = 1,05301
Durbin-Watson statistic = 1,64084 (P=0,0673)
Lag 1 residual autocorrelation = 0,158763

The StatAdvisor

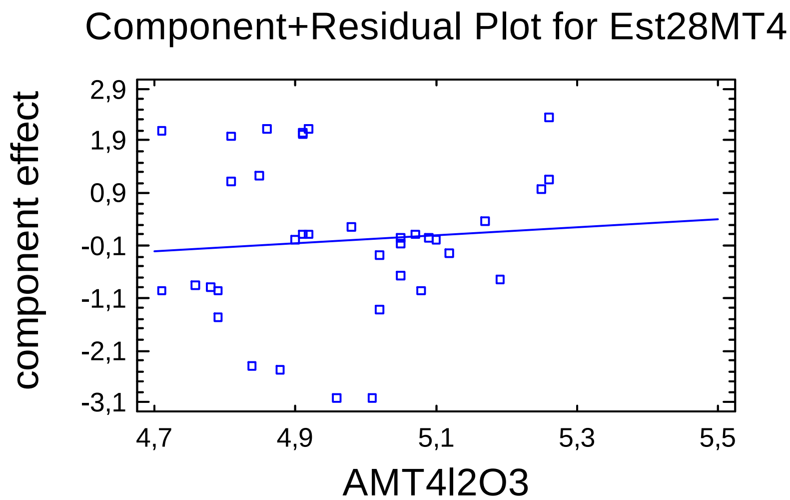
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2MT1 and 5 independent variables. The equation of the fitted model is

Est2MT1 = 1,68222 - 2,29699*Al2O3_2 + 0,0108423*BLAINEMT1 - 0,662723*IR_2 - 0,947734*LOIMT1 - 0,276071*SiO2MT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 42,7258% of the variability in Est2MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 35,5665%. The standard error of the estimate shows the standard deviation of the residuals to be 1,41596. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,05301 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7558, belonging to SiO2MT1. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing SiO2MT1 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	Al2O3_2	BLAINEMT1	IR_2
CONSTANT	1,0000	-0,0828	-0,8698	0,3818
Al2O3_2	-0,0828	1,0000	0,1493	-0,0196
BLAINEMT1	-0,8698	0,1493	1,0000	-0,0563
IR_2	0,3818	-0,0196	-0,0563	1,0000
LOIMT1	-0,0539	-0,3764	-0,1750	-0,4475
SiO2MT1	-0,4734	-0,4128	0,0158	-0,6404

	LOIMT1	SiO2MT1
CONSTANT	-0,0539	-0,4734
Al2O3_2	-0,3764	-0,4128
BLAINEMT1	-0,1750	0,0158
IR_2	-0,4475	-0,6404
LOIMT1	1,0000	0,3947
SiO2MT1	0,3947	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there is 1 correlation with absolute value greater than 0.5 (not including the constant term).

Multiple Regression - Est7MT1

Multiple Regression Analysis

Dependent variable: Est7MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	39,3031	42,2397	0,930478	0,3577
Al2O3_2	-3,89863	1,81824	-2,14418	0,0381
BLAINEMT1	0,00397432	0,00749957	0,52994	0,5991
IR_2	-0,80901	0,528145	-1,5318	0,1334
LOIMT1	-0,927097	0,827573	-1,12026	0,2693
SiO2MT1	0,568193	1,06985	0,531097	0,5983

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value

```
-----------------------------------------------------------------------------
Model                     71,5958      5      14,3192       4,85       0,0015
Residual                  118,082     40      2,95204
-----------------------------------------------------------------------------
Total (Corr.)             189,677     45
```

R-squared = 37,7461 percent
R-squared (adjusted for d.f.) = 29,9644 percent
Standard Error of Est. = 1,71815
Mean absolute error = 1,27185
Durbin-Watson statistic = 1,8567 (P=0,2313)
Lag 1 residual autocorrelation = 0,0290016

The StatAdvisor

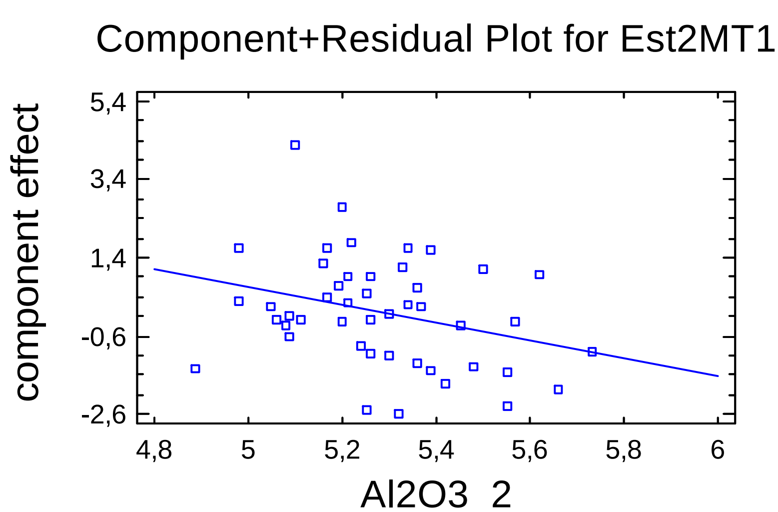
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7MT1 and 5 independent variables. The equation of the fitted model is

Est7MT1 = 39,3031 - 3,89863*Al2O3_2 + 0,00397432*BLAINEMT1 - 0,80901*IR_2 - 0,927097*LOIMT1 + 0,568193*SiO2MT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 37,7461% of the variability in Est7MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 29,9644%. The standard error of the estimate shows the standard deviation of the residuals to be 1,71815. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,27185 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,5991, belonging to BLAINEMT1. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing BLAINEMT1 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	Al2O3_2	BLAINEMT1	IR_2
CONSTANT	1,0000	-0,0828	-0,8698	0,3818
Al2O3_2	-0,0828	1,0000	0,1493	-0,0196
BLAINEMT1	-0,8698	0,1493	1,0000	-0,0563
IR_2	0,3818	-0,0196	-0,0563	1,0000
LOIMT1	-0,0539	-0,3764	-0,1750	-0,4475
SiO2MT1	-0,4734	-0,4128	0,0158	-0,6404

	LOIMT1	SiO2MT1
CONSTANT	-0,0539	-0,4734
Al2O3_2	-0,3764	-0,4128
BLAINEMT1	-0,1750	0,0158
IR_2	-0,4475	-0,6404
LOIMT1	1,0000	0,3947
SiO2MT1	0,3947	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there is 1 correlation with absolute value greater than 0.5 (not including the constant term).

Multiple Regression - Est28MT1

Multiple Regression Analysis

Dependent variable: Est28MT1

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	46,3135	34,3374	1,34877	0,1872
Al2O3_2	-6,21512	1,53238	-4,05587	0,0003
BLAINEMT1	0,000163824	0,00621382	0,0263644	0,9791
IR_2	-0,545235	0,381133	-1,43056	0,1626
LOIMT1	1,02692	0,723732	1,41892	0,1659
SiO2MT1	1,67148	0,801392	2,08572	0,0453

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	34,3516	5	6,87032	4,65	0,0028
Residual	45,8327	31	1,47848		
Total (Corr.)	80,1843	36			

R-squared = 42,8408 percent
R-squared (adjusted for d.f.) = 33,6215 percent
Standard Error of Est. = 1,21593
Mean absolute error = 0,913059
Durbin-Watson statistic = 1,57563 (P=0,0494)
Lag 1 residual autocorrelation = 0,20532

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28MT1 and 5 independent variables. The equation of the fitted model is

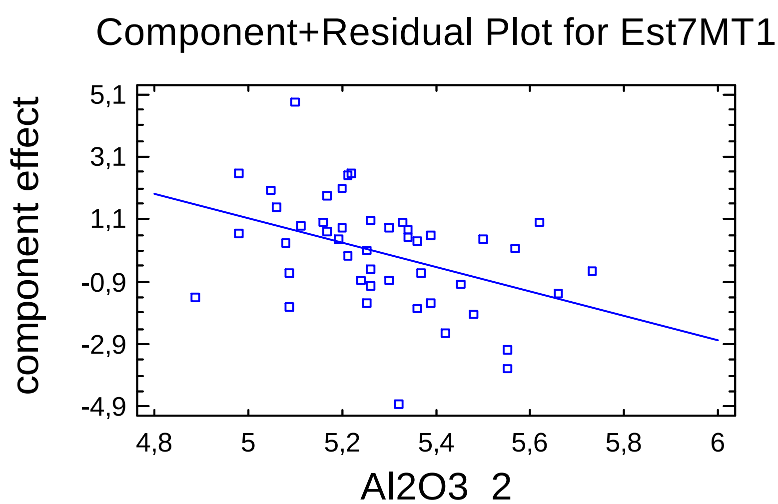
Est28MT1 = 46,3135 - 6,21512*Al2O3_2 + 0,000163824*BLAINEMT1 - 0,545235*IR_2 + 1,02692*LOIMT1 + 1,67148*SiO2MT1

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the

99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 42,8408% of the variability in Est28MT1. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 33,6215%. The standard error of the estimate shows the standard deviation of the residuals to be 1,21593. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,913059 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9791, belonging to BLAINEMT1. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing BLAINEMT1 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	Al2O3_2	BLAINEMT1	IR_2
CONSTANT	1,0000	-0,1495	-0,8962	0,3570
Al2O3_2	-0,1495	1,0000	0,2363	-0,0140
BLAINEMT1	-0,8962	0,2363	1,0000	-0,0815
IR_2	0,3570	-0,0140	-0,0815	1,0000
LOIMT1	0,1086	-0,5103	-0,3008	-0,3765
SiO2MT1	-0,4331	-0,4523	0,0247	-0,5974

	LOIMT1	SiO2MT1
CONSTANT	0,1086	-0,4331
Al2O3_2	-0,5103	-0,4523
BLAINEMT1	-0,3008	0,0247
IR_2	-0,3765	-0,5974
LOIMT1	1,0000	0,3671
SiO2MT1	0,3671	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the

predictor variables. In this case, there are 2 correlations with
absolute values greater than 0.5 (not including the constant term).

Παλινδρόμηση- ποιότητα τσιμέντου CEM II 42,5 –μύλος 4

Multiple Regression - Est1MT4

Multiple Regression Analysis

Dependent variable: Est1MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	38,2197	3,77712	10,1187	0,0000
AMT4l2O3	-3,99913	0,729105	-5,48499	0,0000
LOIMT4	-0,990476	0,209365	-4,73085	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	32,4933	2	16,2466	26,45	0,0000
Residual	24,5732	40	0,614331		
Total (Corr.)	57,0665	42			

R-squared = 56,9393 percent
R-squared (adjusted for d.f.) = 54,7863 percent
Standard Error of Est. = 0,783792
Mean absolute error = 0,635543
Durbin-Watson statistic = 1,60438 (P=0,0687)
Lag 1 residual autocorrelation = 0,186318

```
Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,35873

     Step 1:
     ---------
     Adding variable AMT4l2O3 with F-to-enter = 20,0536
     1 variables in the model.  41 d.f. for error.
     R-squared =  32,85%     Adjusted R-squared =  31,21%     MSE = 0,934695

     Step 2:
     ---------
     Adding variable LOIMT4 with F-to-enter = 22,3809
     2 variables in the model.  40 d.f. for error.
     R-squared =  56,94%     Adjusted R-squared =  54,79%     MSE = 0,614331

     Final model selected.
```

The StatAdvisor

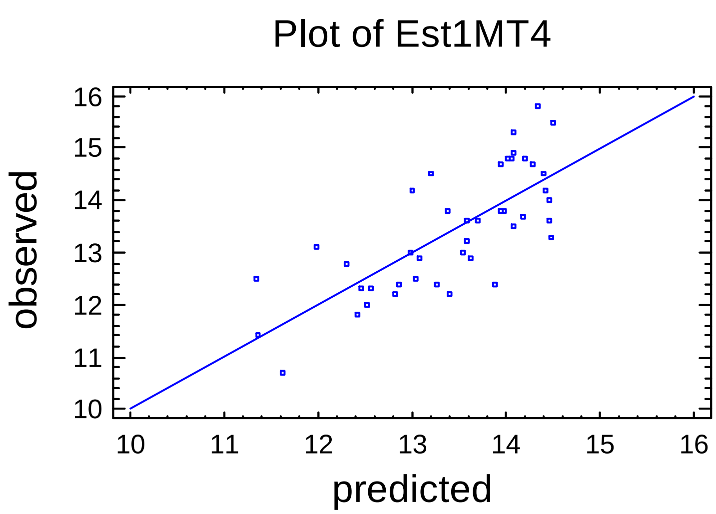
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1MT4 and 5 independent variables. The equation of the fitted model is

Est1MT4 = 38,2197 - 3,99913*AMT4l2O3 - 0,990476*LOIMT4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 56,9393% of the variability in Est1MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 54,7863%. The standard error of the estimate shows the standard deviation of the residuals to be 0,783792. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,635543 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0000, belonging to LOIMT4. Since the P-value is less than 0.01, the highest order term is statistically significant at the 99% confidence level. Consequently, you probably don't want to remove any variables from the model.

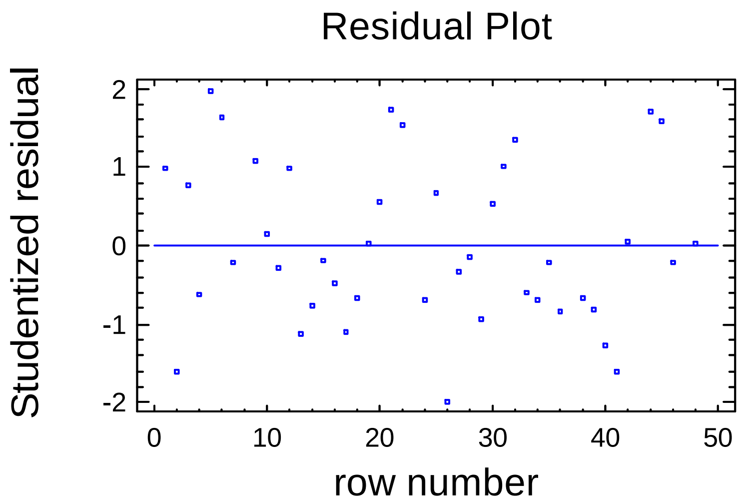


Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	LOIMT4
CONSTANT	1,0000	-0,9627	-0,2609
AMT4l2O3	-0,9627	1,0000	-0,0081
LOIMT4	-0,2609	-0,0081	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).



Multiple-Variable Analysis

```
Analysis Summary

Data variables:
     Est1MT4
     AMT4l2O3
     LOIMT4

There are 45 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

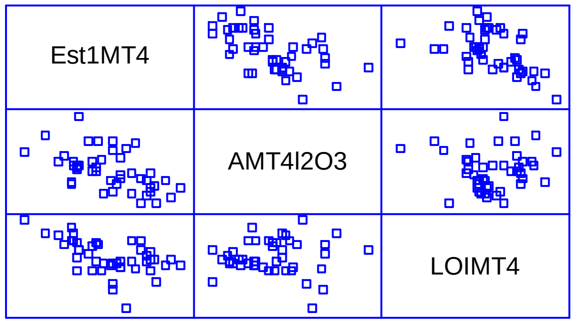
GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
```

PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est1MT4	AMT4l2O3	LOIMT4
Est1MT4		-0,5541 (45) 0,0001	-0,5239 (45) 0,0002
AMT4l2O3	-0,5541 (45) 0,0001		0,0401 (45) 0,7936
LOIMT4	-0,5239 (45) 0,0002	0,0401 (45) 0,7936	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est1MT4 and AMT4l2O3
Est1MT4 and LOIMT4

Ridge Regression - Est1MT4

Ridge Regression

Dependent variable: Est1MT4
Number of complete cases: 28

Model Results for Ridge Parameter = 0,4

Parameter	Estimate	Variance Inflation Factor
CONSTANT	22,9786	
AMT4l2O3	-2,85656	0,519532
BLAINEMT4	0,00241881	0,508705
H2OMT4	-0,280341	0,507343
IRMT4	-0,234335	0,319309
LOIMT4	-0,773155	0,467855
SIO2MT4	0,331417	0,362114

R-Squared = 47,034 percent
R-Squared (adjusted for d.f.) = 31,9009 percent
Standard Error of Est. = 0,976951
Mean absolute error = 0,737753
Durbin-Watson statistic = 0,864381
Lag 1 residual autocorrelation = 0,540066

Residual Analysis

	Estimation	Validation
n	28	
MSE	0,954433	
MAE	0,737753	
MAPE	5,55495	
ME	5,70972E-16	
MPE	-0,526204	

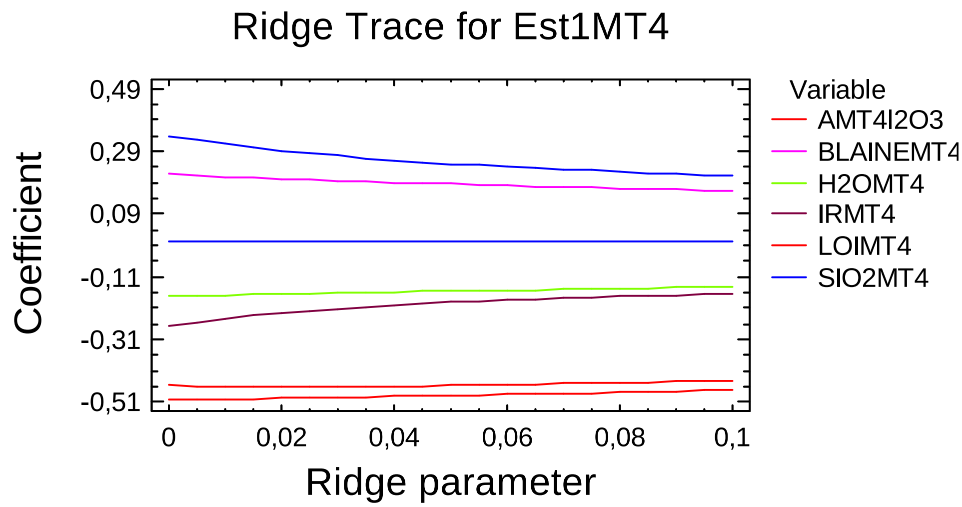
The StatAdvisor

This procedure is designed to provide estimates of regression coefficients when the independent variables are strongly correlated. By allowing for a small amount of bias, the precision of the estimates can often be greatly increased. In this case, the fitted regression model is

Est1MT4 = 22,9786 - 2,85656*AMT4l2O3 + 0,00241881*BLAINEMT4 - 0,280341*H2OMT4 - 0,234335*IRMT4 - 0,773155*LOIMT4 + 0,331417*SIO2MT4

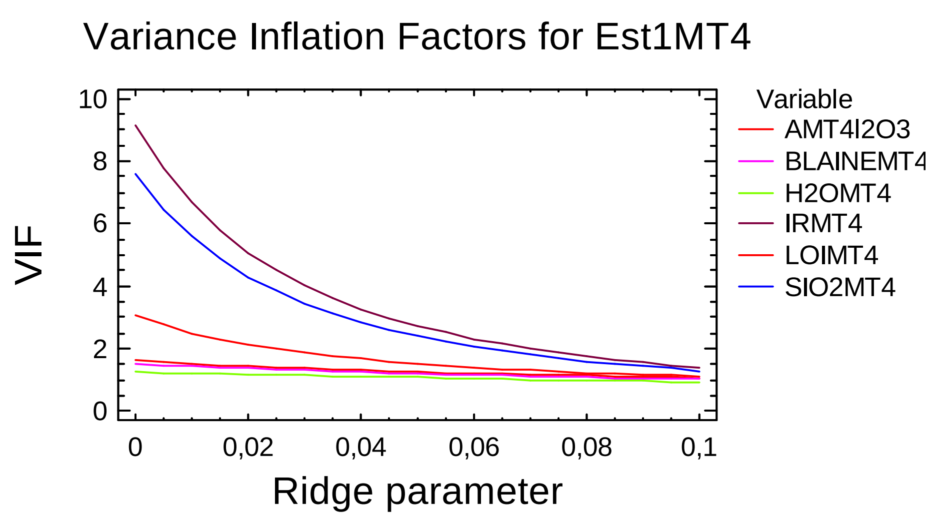
The current value of the ridge parameter is 0,4. To change the ridge parameter, press the alternate mouse button and select Analysis Options. The ridge parameter is usually set between 0.0 and 1.0. In order to determine a good value for the ridge parameter, you should examine the standardized regression coefficients or the variance inflation factors. These values are available on the lists of Tabular and Graphical Options.

The R-Squared statistic indicates that the model as fitted explains 47,034% of the variability in Est1MT4. The adjusted R-Squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 31,9009%. The standard error of the estimate shows the standard deviation of the residuals to be 0,976951. The mean absolute error (MAE) of 0,737753 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file.




```
Regression Results for Est1MT4
----------------------
                 Fitted
Row               Value
----------------------
----------------------
```

```
The StatAdvisor
---------------
   This table contains information about Est1MT4 generated using the
fitted model.  The table includes:
   (1) the predicted value of Est1MT4 using the fitted model
Each item corresponds to the values of the independent variables in a
specific row of your data file.  To generate forecasts for additional
combinations of the variables, add additional rows to the bottom of
your data file.  In each new row, enter values for the independent
variables but leave the cell for the dependent variable empty.  When
you return to this pane, forecasts will be added to the table for the
new rows, but the model will be unaffected.
```



Multiple Regression - Est2MT4

Multiple Regression Analysis

Dependent variable: Est2MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	53,2607	4,58626	11,6131	0,0000
AMT4l2O3	-4,60501	0,884953	-5,20368	0,0000
LOIMT4	-1,12208	0,255951	-4,38395	0,0001

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	42,2353	2	21,1176	23,33	0,0000
Residual	35,2961	39	0,905029		
Total (Corr.)	77,5314	41			

R-squared = 54,4751 percent
R-squared (adjusted for d.f.) = 52,1405 percent
Standard Error of Est. = 0,95133
Mean absolute error = 0,706454
Durbin-Watson statistic = 1,91741 (P=0,3350)
Lag 1 residual autocorrelation = 0,000295617

Stepwise regression

Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

Step 0:

0 variables in the model. 41 d.f. for error.
R-squared = 0,00% Adjusted R-squared = 0,00% MSE = 1,89101

Step 1:

Adding variable AMT4l2O3 with F-to-enter = 18,8587
1 variables in the model. 40 d.f. for error.
R-squared = 32,04% Adjusted R-squared = 30,34% MSE = 1,31725

Step 2:

Adding variable LOIMT4 with F-to-enter = 19,219
2 variables in the model. 39 d.f. for error.
R-squared = 54,48% Adjusted R-squared = 52,14% MSE = 0,905029

Final model selected.

The StatAdvisor

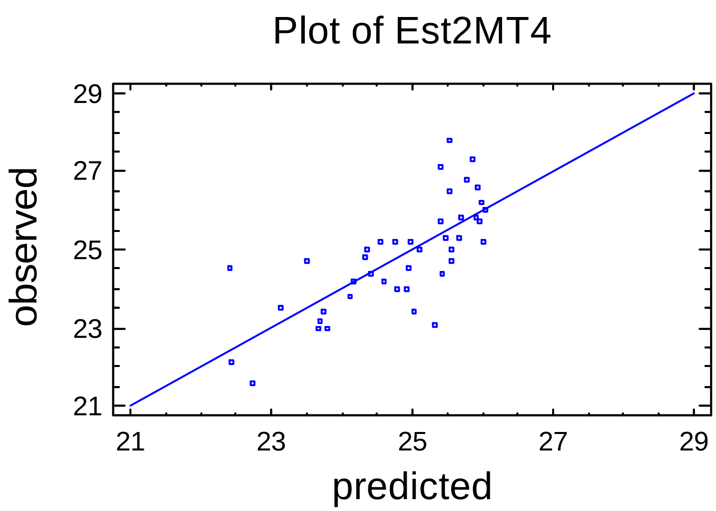
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2MT4 and 5 independent variables. The equation of the fitted model is

Est2MT4 = 53,2607 - 4,60501*AMT4l2O3 - 1,12208*LOIMT4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 54,4751% of the variability in Est2MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 52,1405%. The standard error of the estimate shows the standard deviation of the residuals to be 0,95133. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,706454 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0001, belonging to LOIMT4. Since the P-value is less than 0.01, the highest order term is statistically significant at the 99% confidence level. Consequently, you probably don't want to remove any variables from the model.

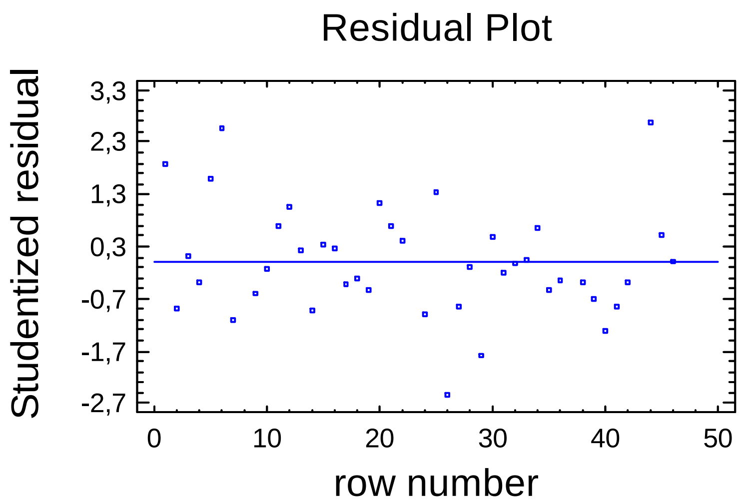


Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	LOIMT4
CONSTANT	1,0000	-0,9623	-0,2622
AMT4l2O3	-0,9623	1,0000	-0,0080
LOIMT4	-0,2622	-0,0080	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).




```
Multiple Regression - Est7MT4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7MT4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter                Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                   40,207      0,348075        115,512          0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square     F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  218,808     42      5,20971
-----------------------------------------------------------------------------
Total (Corr.)             218,808     42

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 2,28248
Mean absolute error = 1,77956
Durbin-Watson statistic = 1,87786 (P=0,3469)
Lag 1 residual autocorrelation = 0,060856


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 5,20971

     Final model selected.

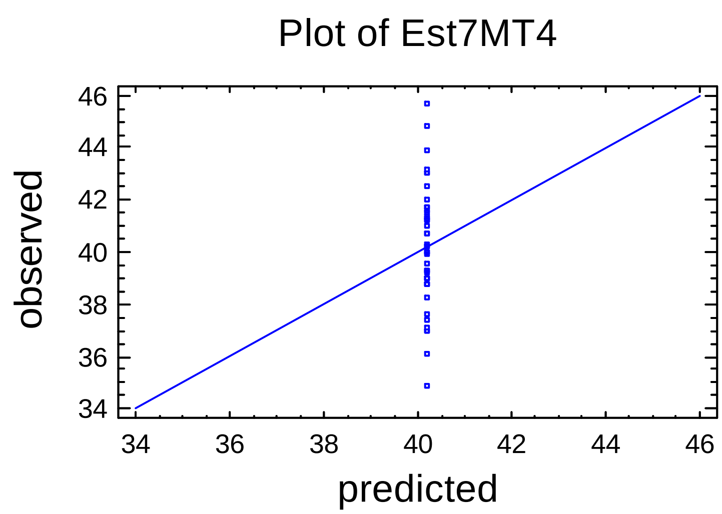


The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est7MT4 and 5
```

independent variables. The equation of the fitted model is

Est7MT4 = 40,207

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est7MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 2,28248. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,77956 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

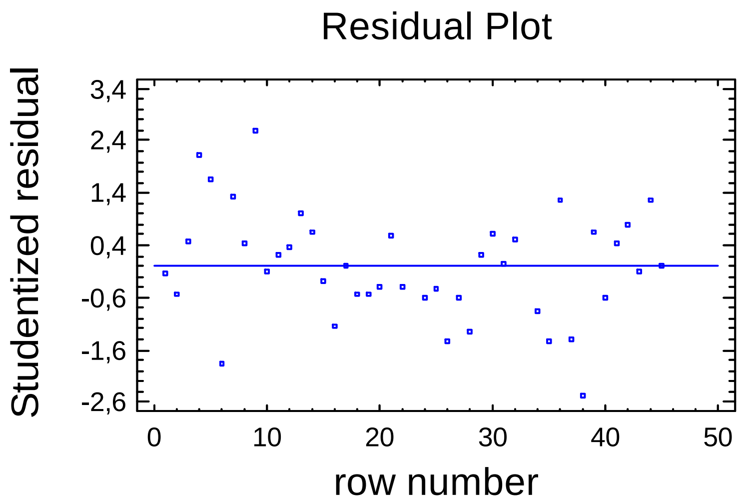


Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).




```
Multiple Regression - Est28MT4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est28MT4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter                Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                  103,315        23,139         4,46497         0,0001
BLAINEMT4              -0,0119256    0,00542922        -2,19656         0,0352
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio       P-Value
-----------------------------------------------------------------------------
Model                     9,71325      1      9,71325       4,82        0,0352
Residual                  66,4342     33      2,01316
-----------------------------------------------------------------------------
Total (Corr.)             76,1474     34

R-squared = 12,7558 percent
R-squared (adjusted for d.f.) = 10,1121 percent
Standard Error of Est. = 1,41886
Mean absolute error = 1,10779
Durbin-Watson statistic = 1,80658 (P=0,2699)
Lag 1 residual autocorrelation = 0,0651023


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  34 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 2,23963

     Step 1:
     ---------
     Adding variable BLAINEMT4 with F-to-enter = 4,82488
     1 variables in the model.  33 d.f. for error.
     R-squared =  12,76%     Adjusted R-squared =  10,11%     MSE = 2,01316

     Final model selected.
```

The StatAdvisor

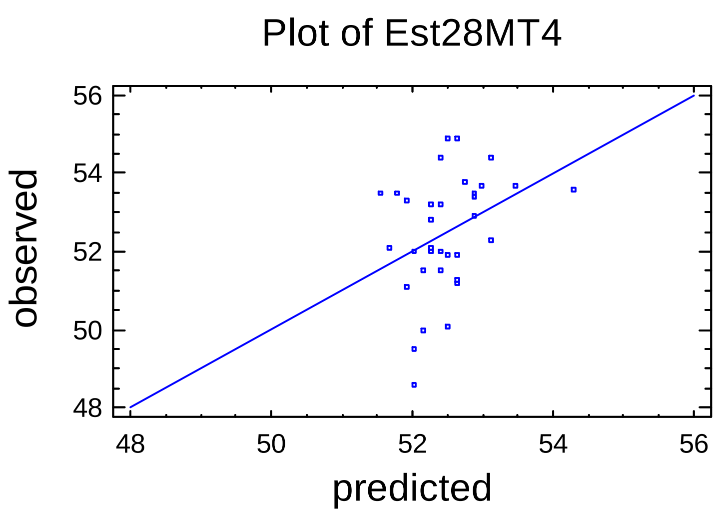
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28MT4 and 5 independent variables. The equation of the fitted model is

Est28MT4 = 103,315 - 0,0119256*BLAINEMT4

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between the variables at the 95% confidence level.

The R-Squared statistic indicates that the model as fitted explains 12,7558% of the variability in Est28MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 10,1121%. The standard error of the estimate shows the standard deviation of the residuals to be 1,41886. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,10779 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0352, belonging to BLAINEMT4. Since the P-value is less than 0.05, that term is statistically significant at the 95% confidence level. Consequently, you probably don't want to remove any variables from the model.



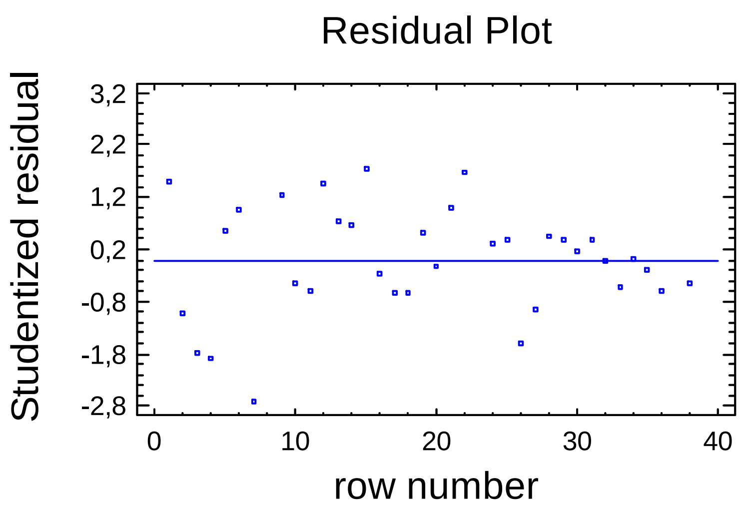
Correlation matrix for coefficient estimates

	CONSTANT	BLAINEMT4
CONSTANT	1,0000	-0,9999
BLAINEMT4	-0,9999	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with

absolute values greater than 0.5 (not including the constant term).



Simple Regression - Est28MT1 vs. H2O_2

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est28MT1
Independent variable: H2O_2

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	46,4444	23,3009	1,99325	0,0608
Slope	0,238345	0,828418	0,287711	0,7767

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,211219	1	0,211219	0,08	0,7767
Residual	48,4812	19	2,55164		
Total (Corr.)	48,6924	20			

Correlation Coefficient = 0,0658622
R-squared = 0,433783 percent
R-squared (adjusted for d.f.) = -4,80654 percent
Standard Error of Est. = 1,59739
Mean absolute error = 1,25737
Durbin-Watson statistic = 0,873126 (P=0,0015)
Lag 1 residual autocorrelation = 0,549083

The StatAdvisor

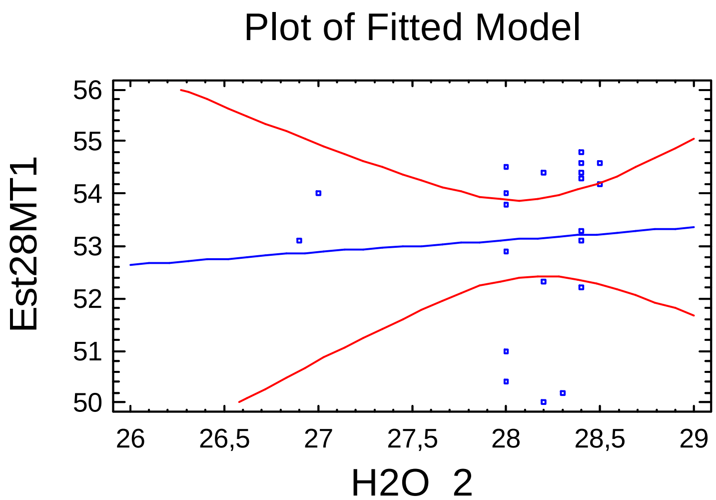
The output shows the results of fitting a linear model to describe the relationship between Est28MT1 and H2O_2. The equation of the fitted model is

Est28MT1 = 46,4444 + 0,238345*H2O_2

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between Est28MT1 and H2O_2 at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 0,433783% of the variability in Est28MT1. The correlation coefficient equals 0,0658622, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 1,59739. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 1,25737 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,211219	1	0,211219	0,08	0,7767
Residual	48,4812	19	2,55164		
Lack-of-Fit	18,8326	5	3,76652	1,78	0,1819
Pure Error	29,6486	14	2,11776		
Total (Corr.)	48,6924	20			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	0,0659	0,43%
Square root-X	0,0643	0,41%
Square root-Y	0,0642	0,41%
Logarithmic-X	0,0628	0,39%
Exponential	0,0626	0,39%
Reciprocal-X	-0,0598	0,36%
Multiplicative	0,0596	0,36%
Reciprocal-Y	-0,0595	0,35%
S-curve	-0,0566	0,32%
Double reciprocal	0,0534	0,29%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 0,433783%. This is the currently selected model.

Simple Regression - Est28MT4 vs. H2OMT4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est28MT4
Independent variable: H2OMT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	65,767	15,5526	4,22868	0,0004
Slope	-0,478717	0,567705	-0,843249	0,4091

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1,2921	1	1,2921	0,71	0,4091
Residual	36,3424	20	1,81712		
Total (Corr.)	37,6345	21			

Correlation Coefficient = -0,185291
R-squared = 3,43328 percent
R-squared (adjusted for d.f.) = -1,39506 percent
Standard Error of Est. = 1,34801
Mean absolute error = 1,1231
Durbin-Watson statistic = 1,29487 (P=0,0335)
Lag 1 residual autocorrelation = 0,30944

The StatAdvisor

The output shows the results of fitting a linear model to describe the relationship between Est28MT4 and H2OMT4. The equation of the fitted model is

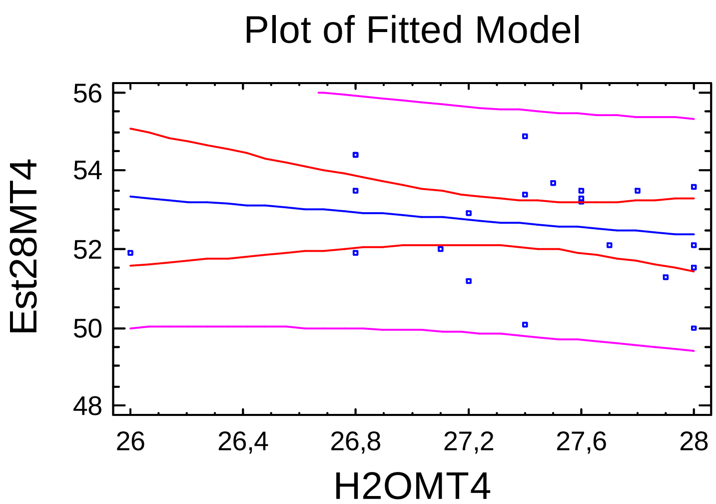
Est28MT4 = 65,767 - 0,478717*H2OMT4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between Est28MT4 and H2OMT4 at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains

3,43328% of the variability in Est28MT4. The correlation coefficient equals -0,185291, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 1,34801. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 1,1231 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1,2921	1	1,2921	0,71	0,4091
Residual	36,3424	20	1,81712		
Lack-of-Fit	11,9608	9	1,32898	0,60	0,7742
Pure Error	24,3817	11	2,21652		
Total (Corr.)	37,6345	21			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Reciprocal-Y	0,1864	3,47%
Exponential	-0,1858	3,45%
Square root-Y	-0,1856	3,44%
Linear	-0,1853	3,43%

Square root-X	-0,1835	3,37%
Multiplicative	-0,1822	3,32%
Logarithmic-X	-0,1816	3,30%
Double reciprocal	-0,1790	3,21%
S-curve	0,1784	3,18%
Reciprocal-X	0,1779	3,16%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the reciprocal-Y model yields the highest R-Squared value with 3,4732%. This is 0,039916% higher than the currently selected linear model. To change models, select the Analysis Options dialog box.

Simple Regression - Est28MT4 vs. H2OMT4

Regression Analysis - Reciprocal-Y model: Y = 1/(a + b*X)

Dependent variable: Est28MT4
Independent variable: H2OMT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	0,0141962	0,00566797	2,50463	0,0210
Slope	0,00017551	0,000206894	0,848312	0,4063

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1,73678E-7	1	1,73678E-7	0,72	0,4063
Residual	0,00000482684	20	2,41342E-7		
Total (Corr.)	0,00000500052	21			

Correlation Coefficient = 0,186365
R-squared = 3,4732 percent
R-squared (adjusted for d.f.) = -1,35314 percent
Standard Error of Est. = 0,000491266
Mean absolute error = 0,000407918
Durbin-Watson statistic = 1,29752 (P=0,0340)
Lag 1 residual autocorrelation = 0,30885

The StatAdvisor

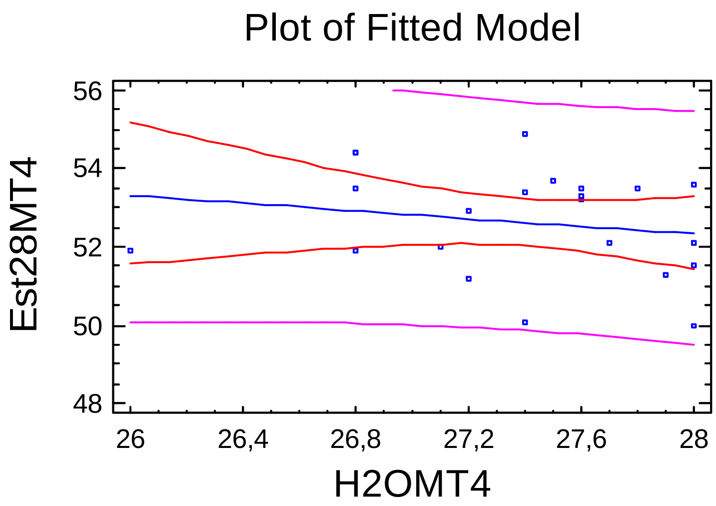
The output shows the results of fitting an reciprocal-Y model to describe the relationship between Est28MT4 and H2OMT4. The equation of the fitted model is

Est28MT4 = 1/(0,0141962 + 0,00017551*H2OMT4)

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between Est28MT4 and H2OMT4 at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 3,4732% of the variability in Est28MT4 after transforming to a reciprocal scale to linearize the model. The correlation coefficient equals 0,186365, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,000491266. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,000407918 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1,73678E-7	1	1,73678E-7	0,72	0,4063
Residual	0,00000482684	20	2,41342E-7		
Lack-of-Fit	0,00000156393	9	1,7377E-7	0,59	0,7845
Pure Error	0,00000326291	11	2,96629E-7		
Total (Corr.)	0,00000500052	21			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Reciprocal-Y	0,1864	3,47%
Exponential	-0,1858	3,45%
Square root-Y	-0,1856	3,44%
Linear	-0,1853	3,43%
Square root-X	-0,1835	3,37%
Multiplicative	-0,1822	3,32%
Logarithmic-X	-0,1816	3,30%
Double reciprocal	-0,1790	3,21%
S-curve	0,1784	3,18%
Reciprocal-X	0,1779	3,16%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the reciprocal-Y model yields the highest R-Squared value with 3,4732%. This is the currently selected model.

Παλινδρόμηση- όλες οι μεταβλητές – ποιότητα τσιμέντου CEM II 42,5 – μύλος 4

Multiple Regression - Est1MT4

Multiple Regression Analysis

Dependent variable: Est1MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	13,7422	16,5972	0,827982	0,4129
AMT4l2O3	-3,86692	0,83369	-4,63832	0,0000
BLAINEMT4	0,00234256	0,00276805	0,846284	0,4027
IRMT4	-0,351936	0,38759	-0,908011	0,3696
LOIMT4	-0,817075	0,32838	-2,4882	0,0173
SIO2MT4	0,679244	0,568142	1,19555	0,2393

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	36,2195	5	7,24391	11,83	0,0000
Residual	23,2623	38	0,612165		
Total (Corr.)	59,4818	43			

R-squared = 60,8918 percent
R-squared (adjusted for d.f.) = 55,746 percent
Standard Error of Est. = 0,78241
Mean absolute error = 0,600331
Durbin-Watson statistic = 1,69973 (P=0,0945)
Lag 1 residual autocorrelation = 0,147714

The StatAdvisor

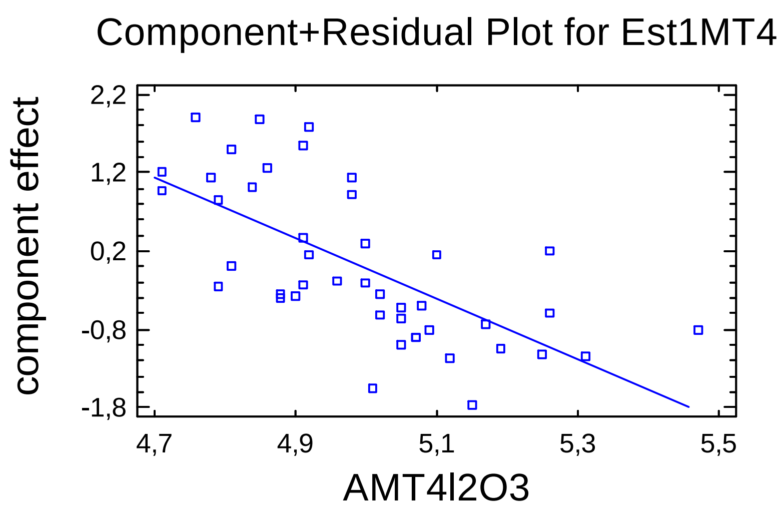
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1MT4 and 5 independent variables. The equation of the fitted model is

Est1MT4 = 13,7422 - 3,86692*AMT4l2O3 + 0,00234256*BLAINEMT4 - 0,351936*IRMT4 - 0,817075*LOIMT4 + 0,679244*SIO2MT4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 60,8918% of the variability in Est1MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 55,746%. The standard error of the estimate shows the standard deviation of the residuals to be 0,78241. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,600331 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,4027, belonging to BLAINEMT4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing BLAINEMT4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	BLAINEMT4	IRMT4
CONSTANT	1,0000	-0,3657	-0,6739	0,5947
AMT4l2O3	-0,3657	1,0000	0,2032	-0,2189
BLAINEMT4	-0,6739	0,2032	1,0000	0,0960
IRMT4	0,5947	-0,2189	0,0960	1,0000
LOIMT4	-0,2834	0,0535	-0,3310	-0,7379
SIO2MT4	-0,6360	-0,0094	-0,0909	-0,8843

	LOIMT4	SIO2MT4
CONSTANT	-0,2834	-0,6360
AMT4l2O3	0,0535	-0,0094
BLAINEMT4	-0,3310	-0,0909
IRMT4	-0,7379	-0,8843
LOIMT4	1,0000	0,6699
SIO2MT4	0,6699	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are 3 correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est2MT4

Multiple Regression Analysis

Dependent variable: Est2MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value

CONSTANT	31,7392	20,6495	1,53704	0,1328
AMT4l2O3	-4,97889	1,00095	-4,97419	0,0000
BLAINEMT4	-0,000753625	0,00330564	-0,227981	0,8209
IRMT4	-0,506593	0,512806	-0,987886	0,3296
LOIMT4	-0,727142	0,405389	-1,79369	0,0810
SIO2MT4	1,24997	0,737032	1,69596	0,0983

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	46,8659	5	9,37319	10,74	0,0000
Residual	32,2801	37	0,872435		
Total (Corr.)	79,146	42			

R-squared = 59,2145 percent
R-squared (adjusted for d.f.) = 53,703 percent
Standard Error of Est. = 0,934042
Mean absolute error = 0,708485
Durbin-Watson statistic = 1,90171 (P=0,2742)
Lag 1 residual autocorrelation = 0,0365136

The StatAdvisor

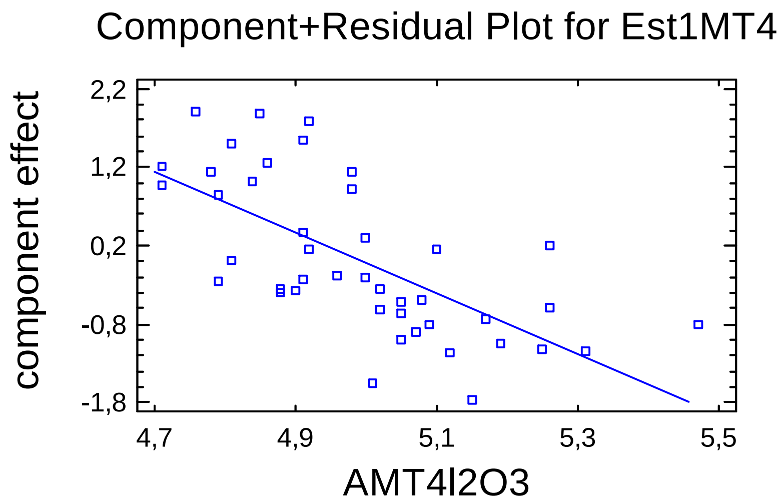
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2MT4 and 5 independent variables. The equation of the fitted model is

Est2MT4 = 31,7392 - 4,97889*AMT4l2O3 - 0,000753625*BLAINEMT4 - 0,506593*IRMT4 - 0,727142*LOIMT4 + 1,24997*SIO2MT4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 59,2145% of the variability in Est2MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 53,703%. The standard error of the estimate shows the standard deviation of the residuals to be 0,934042. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,708485 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,8209, belonging to BLAINEMT4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing BLAINEMT4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	BLAINEMT4	IRMT4
CONSTANT	1,0000	-0,3789	-0,6390	0,6363
AMT4l2O3	-0,3789	1,0000	0,1991	-0,2422
BLAINEMT4	-0,6390	0,1991	1,0000	0,0979
IRMT4	0,6363	-0,2422	0,0979	1,0000
LOIMT4	-0,3347	0,0786	-0,3267	-0,7536
SIO2MT4	-0,6718	0,0330	-0,0939	-0,9030

	LOIMT4	SIO2MT4
CONSTANT	-0,3347	-0,6718
AMT4l2O3	0,0786	0,0330
BLAINEMT4	-0,3267	-0,0939
IRMT4	-0,7536	-0,9030
LOIMT4	1,0000	0,6958
SIO2MT4	0,6958	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are 3 correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est7MT4

Multiple Regression Analysis

Dependent variable: Est7MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	45,0267	46,9732	0,958561	0,3438
AMT4l2O3	-4,54338	2,4213	-1,87642	0,0683
BLAINEMT4	0,00199912	0,00684989	0,291847	0,7720
IRMT4	0,554794	1,2488	0,444261	0,6594
LOIMT4	-0,0609844	0,989334	-0,0616419	0,9512
SIO2MT4	0,302376	1,81697	0,166417	0,8687

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value

```
-----------------------------------------------------------------------------
Model                      21,7955      5       4,3591       0,83       0,5373
Residual                    199,86     38      5,25947
-----------------------------------------------------------------------------
Total (Corr.)              221,655     43
```

R-squared = 9,83305 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 2,29335
Mean absolute error = 1,64761
Durbin-Watson statistic = 2,00882 (P=0,3918)
Lag 1 residual autocorrelation = -0,00541124

The StatAdvisor

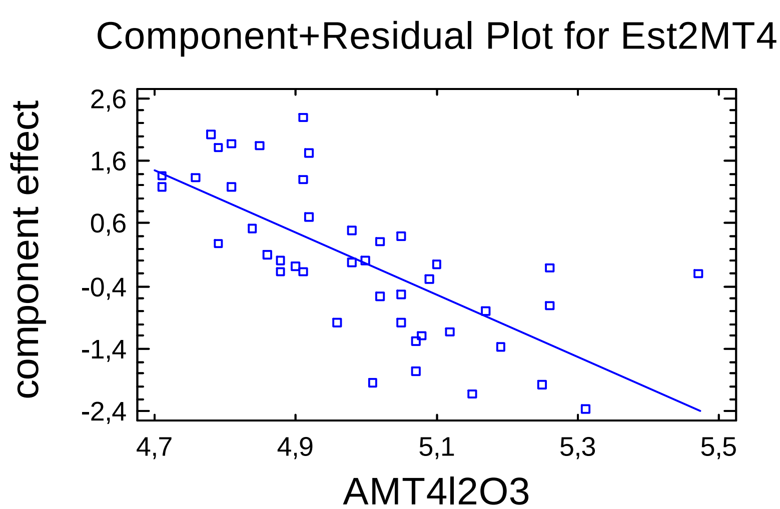
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7MT4 and 5 independent variables. The equation of the fitted model is

Est7MT4 = 45,0267 - 4,54338*AMT4l2O3 + 0,00199912*BLAINEMT4 + 0,554794*IRMT4 - 0,0609844*LOIMT4 + 0,302376*SIO2MT4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 9,83305% of the variability in Est7MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 2,29335. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,64761 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9512, belonging to LOIMT4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing LOIMT4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	BLAINEMT4	IRMT4
CONSTANT	1,0000	-0,3301	-0,5584	0,6906
AMT4l2O3	-0,3301	1,0000	0,1232	-0,2521
BLAINEMT4	-0,5584	0,1232	1,0000	0,1121
IRMT4	0,6906	-0,2521	0,1121	1,0000
LOIMT4	-0,3945	0,0992	-0,3255	-0,7566
SIO2MT4	-0,7396	0,0264	-0,0904	-0,8979

	LOIMT4	SIO2MT4
CONSTANT	-0,3945	-0,7396
AMT4l2O3	0,0992	0,0264
BLAINEMT4	-0,3255	-0,0904
IRMT4	-0,7566	-0,8979
LOIMT4	1,0000	0,6813
SIO2MT4	0,6813	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are 3 correlations with absolute values greater than 0.5 (not including the constant term).

Multiple Regression - Est28MT4

Multiple Regression Analysis

Dependent variable: Est28MT4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	121,658	39,6826	3,06577	0,0046
AMT4l2O3	0,746605	1,98256	0,376587	0,7091
BLAINEMT4	-0,0119392	0,00773467	-1,5436	0,1332
IRMT4	-0,276651	0,93718	-0,295196	0,7699
LOIMT4	-0,281288	0,863747	-0,325661	0,7469
SIO2MT4	-0,873203	1,32894	-0,657067	0,5161

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	24,0012	5	4,80023	1,91	0,1229
Residual	75,571	30	2,51903		
Total (Corr.)	99,5722	35			

R-squared = 24,1043 percent
R-squared (adjusted for d.f.) = 11,455 percent
Standard Error of Est. = 1,58715
Mean absolute error = 1,123
Durbin-Watson statistic = 2,01417 (P=0,3734)
Lag 1 residual autocorrelation = -0,0370767

The StatAdvisor

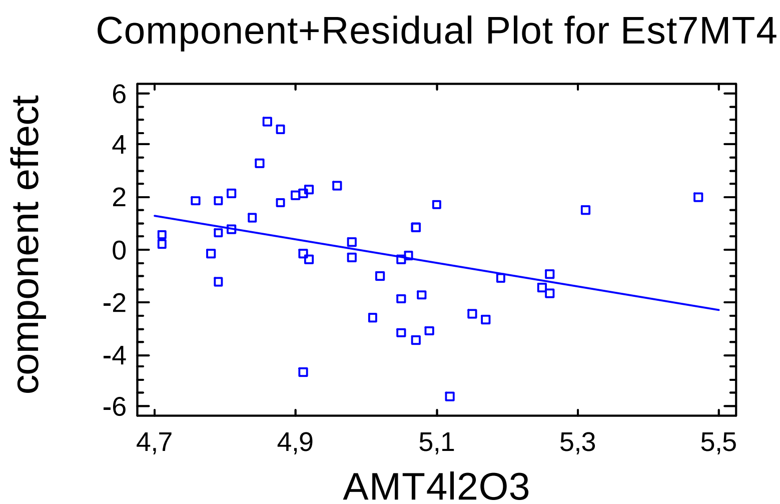
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28MT4 and 5 independent variables. The equation of the fitted model is

Est28MT4 = 121,658 + 0,746605*AMT4l2O3 - 0,0119392*BLAINEMT4 - 0,276651*IRMT4 - 0,281288*LOIMT4 - 0,873203*SIO2MT4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 24,1043% of the variability in Est28MT4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 11,455%. The standard error of the estimate shows the standard deviation of the residuals to be 1,58715. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,123 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7699, belonging to IRMT4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing IRMT4 from the model.



Correlation matrix for coefficient estimates

	CONSTANT	AMT4l2O3	BLAINEMT4	IRMT4
CONSTANT	1,0000	-0,4151	-0,6792	0,4404
AMT4l2O3	-0,4151	1,0000	0,1599	-0,2247
BLAINEMT4	-0,6792	0,1599	1,0000	0,2799
IRMT4	0,4404	-0,2247	0,2799	1,0000
LOIMT4	-0,1076	0,1368	-0,5339	-0,7395
SIO2MT4	-0,5134	0,0653	-0,2335	-0,9076

	LOIMT4	SIO2MT4
CONSTANT	-0,1076	-0,5134
AMT4l2O3	0,1368	0,0653
BLAINEMT4	-0,5339	-0,2335
IRMT4	-0,7395	-0,9076
LOIMT4	1,0000	0,6910
SIO2MT4	0,6910	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are 4 correlations with absolute values greater than 0.5 (not including the constant term).

Συσχέτιση ανεξάρτητων μεταβλητών- ποιότητα τσιμέντου OPC

Multiple-Variable Analysis

```
Analysis Summary

Data variables:
     Al2O3_3
     Blaine_3
     LOI_3
     SiO2_3

There are 66 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

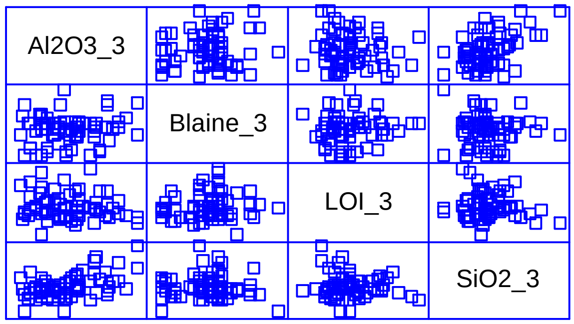
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```



95,0 percent confidence intervals

	Mean	Stnd. error	Lower limit	Upper limit
Al2O3_3	4,77712	0,0133742	4,75041	4,80383
Blaine_3	3667,42	6,91038	3653,62	3681,23
LOI_3	1,14939	0,018502	1,11244	1,18635
SiO2_3	20,6514	0,0268014	20,5978	20,7049

	Sigma	Lower limit	Upper limit
Al2O3_3	0,108653	0,0927622	0,131164
Blaine_3	56,1402	47,9296	67,7718
LOI_3	0,150311	0,128328	0,181454
SiO2_3	0,217736	0,185892	0,262848

The StatAdvisor

This table shows 95,0% confidence intervals for the means and standard deviations of each of the variables. These intervals bound the sampling error in the estimates of the parameters of the populations from which the data come. They can be used to help judge how precisely the population means and standard deviations have been estimated. The intervals assume that the populations from which the samples come can be represented by normal distributions. While the confidence intervals for the means are quite robust and not very sensitive to violations of this assumption, the confidence intervals for the standard deviations are quite sensitive. You can check the assumption of normality in the One Variable Analysis procedure.

Correlations

	Al2O3_3	Blaine_3	LOI_3	SiO2_3
Al2O3_3		0,1327	-0,1197	0,4901
		(66)	(66)	(66)
		0,2882	0,3382	0,0000
Blaine_3	0,1327		0,0904	-0,0344
	(66)		(66)	(66)

	0,2882		0,4703	0,7836
LOI_3	-0,1197	0,0904		-0,0949
	(66)	(66)		(66)
	0,3382	0,4703		0,4483
SiO2_3	0,4901	-0,0344	-0,0949	
	(66)	(66)	(66)	
	0,0000	0,7836	0,4483	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Al2O3_3 and SiO2_3

Spearman Rank Correlations

	Al2O3_3	Blaine_3	LOI_3	SiO2_3
Al2O3_3		0,0638	-0,1083	0,4036
		(66)	(66)	(66)
		0,6071	0,3826	0,0011
Blaine_3	0,0638		0,1043	-0,0768
	(66)		(66)	(66)
	0,6071		0,4004	0,5356
LOI_3	-0,1083	0,1043		0,0055
	(66)	(66)		(66)
	0,3826	0,4004		0,9646
SiO2_3	0,4036	-0,0768	0,0055	
	(66)	(66)	(66)	
	0,0011	0,5356	0,9646	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Al2O3_3 and SiO2_3

Multiple-Variable Analysis

Analysis Summary

Data variables:

CLK_3
Blaine_3
GYP_3

There are 66 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

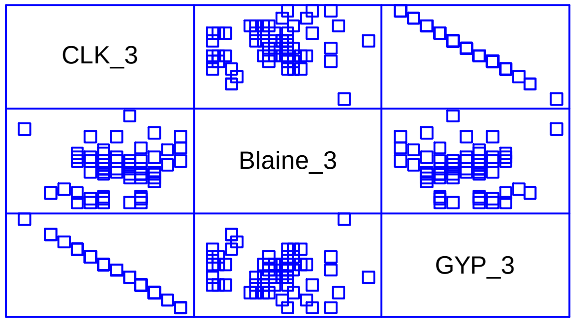
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	CLK_3	Blaine_3	GYP_3
CLK_3		0,1481 (66) 0,2352	-1,0000 (66) 0,0000
Blaine_3	0,1481 (66) 0,2352		-0,1481 (66) 0,2352
GYP_3	-1,0000 (66) 0,0000	-0,1481 (66) 0,2352	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
CLK_3 and GYP_3

Spearman Rank Correlations

	CLK_3	Blaine_3	GYP_3
CLK_3		0,0950 (66) 0,4439	-1,0000 (66) 0,0000
Blaine_3	0,0950		-0,0950

	(66)		(66)
	0,4439		0,4439
GYP_3	-1,0000	-0,0950	
	(66)	(66)	
	0,0000	0,4439	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

CLK_3 and GYP_3

Covariances

	CLK_3	Blaine_3	GYP_3
CLK_3	0,0631166	2,08928	-0,0631166
	(66)	(66)	(66)
Blaine_3	2,08928	3151,72	-2,08928
	(66)	(66)	(66)
GYP_3	-0,0631166	-2,08928	0,0631166
	(66)	(66)	(66)

Covariance
(Sample Size)

The StatAdvisor

This table shows estimated covariances between each pair of variables. The covariances measure how much the variables vary together and are used to compute Pearson product moment correlations. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Multiple-Variable Analysis

Analysis Summary

Data variables:
- Al2O3_4
- Blaine_4
- LOI_4
- sio2_4

There are 44 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

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GOAL: group rows of data with similar characteristics.
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GOAL: reduce the number of columns to a small set of meaningful measures.
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GOAL: determine which combinations of the columns determine most of the variability in your data.
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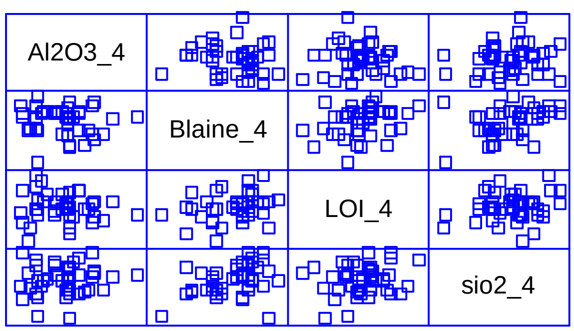
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

```
                    Al2O3_4             Blaine_4            LOI_4               sio2_4
-----------------------------------------------------------------------------------------
--------------
Al2O3_4                                 -0,1213             -0,0690
0,1020
                                        (    44)            (    44)            (
44)
                                         0,4329              0,6562
```

```
0,5101

Blaine_4           -0,1213                              0,3086
0,3933
                   (   44)                             (   44)            (
44)
                    0,4329                              0,4329
0,0083

LOI_4              -0,0690            0,3086
0,1856
                   (   44)           (   44)                              (
44)
                    0,6562            0,0416
0,2277

sio2_4              0,1020            0,3933            0,1856
                   (   44)           (   44)           (   44)
                    0,5101            0,0083            0,2277
--------------------------------------------------------------------------------------
-------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Blaine_4 and LOI_4
   Blaine_4 and sio2_4




Spearman Rank Correlations

                    Al2O3_4           Blaine_4          LOI_4             sio2_4
--------------------------------------------------------------------------------------
-------------
Al2O3_4                              -0,2032           -0,0748
0,0977
                                     (   44)           (   44)            (
44)
                                      0,1826            0,6236
0,5218

Blaine_4           -0,2032                              0,3533
0,3712
                   (   44)                             (   44)            (
44)
                    0,1826                              0,0205
0,0149

LOI_4              -0,0748            0,3533
0,0959
                   (   44)           (   44)                              (
44)
                    0,6236            0,0205
0,5293

sio2_4              0,0977            0,3712            0,0959
                   (   44)           (   44)           (   44)
                    0,5218            0,0149            0,5293
--------------------------------------------------------------------------------------
-------------
```

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
Blaine_4 and LOI_4
Blaine_4 and sio2_4

Covariances

	Al2O3_4	Blaine_4	LOI_4	sio2_4
Al2O3_4	0,00925729	-0,596406	-0,00082315	0,00174271
	(44)	(44)	(44)	(44)
Blaine_4	-0,596406	2612,05	1,95507	3,57082
	(44)	(44)	(44)	(44)
LOI_4	-0,00082315	1,95507	0,0153684	0,0040871
	(44)	(44)	(44)	(44)
sio2_4	0,00174271	3,57082	0,0040871	0,0315526
	(44)	(44)	(44)	(44)

Covariance
(Sample Size)

The StatAdvisor

This table shows estimated covariances between each pair of variables. The covariances measure how much the variables vary together and are used to compute Pearson product moment correlations. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Multiple-Variable Analysis

Analysis Summary

Data variables:
Blaine_4
CLK_4
GYP_4

There are 44 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

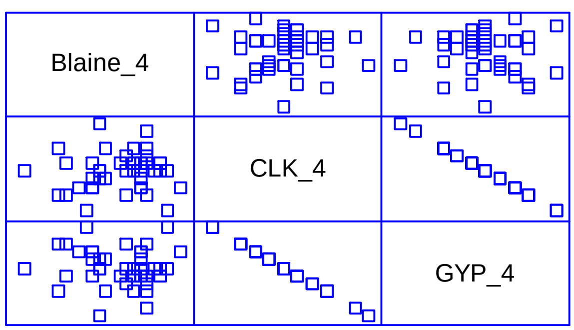
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Blaine_4	CLK_4	GYP_4
Blaine_4		0,0811 (44) 0,6007	-0,0811 (44) 0,6007

CLK_4	0,0811 (44) 0,6007		-1,0000 (44) 0,0000
GYP_4	-0,0811 (44) 0,6007	-1,0000 (44) 0,0000	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

CLK_4 and GYP_4

Spearman Rank Correlations

	Blaine_4	CLK_4	GYP_4
Blaine_4		0,1299 (44) 0,3943	-0,1299 (44) 0,3943
CLK_4	0,1299 (44) 0,3943		-1,0000 (44) 0,0000
GYP_4	-0,1299 (44) 0,3943	-1,0000 (44) 0,0000	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

CLK_4 and GYP_4

Covariances

	Blaine_4	CLK_4	GYP_4
Blaine_4	2612,05 (44)	0,95666 (44)	-0,95666 (44)
CLK_4	0,95666 (44)	0,0532505 (44)	-0,0532505 (44)
GYP_4	-0,95666 (44)	-0,0532505 (44)	0,0532505 (44)

Covariance
(Sample Size)

The StatAdvisor

This table shows estimated covariances between each pair of variables. The covariances measure how much the variables vary together and are used to compute Pearson product moment correlations. Also shown in parentheses is the number of pairs of data values used to compute each coefficient.

Simple Regression - CLK_3 vs. GYP_3

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: CLK_3
Independent variable: GYP_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	100,0	0,0		
Slope	-1,0	0,0		

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	4,10258	1	4,10258		
Residual	0,0	64	0,0		
Total (Corr.)	4,10258	65			

Correlation Coefficient = -1,0
R-squared = 100,0 percent
R-squared (adjusted for d.f.) = 100,0 percent
Standard Error of Est. = 0,0
Mean absolute error = 0,0
Durbin-Watson statistic = 1,03704 (P=0,0000)
Lag 1 residual autocorrelation = 0,444444

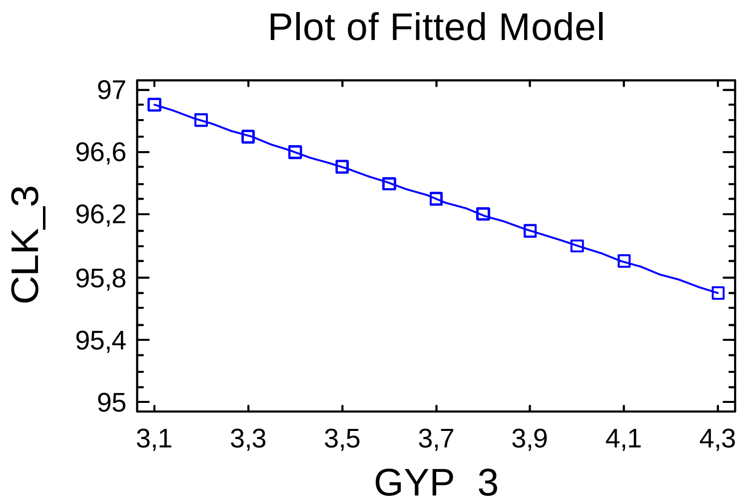
The StatAdvisor

The output shows the results of fitting a linear model to describe the relationship between CLK_3 and GYP_3. The equation of the fitted model is

CLK_3 = 100,0 - 1,0*GYP_3

The R-Squared statistic indicates that the model as fitted explains 100,0% of the variability in CLK_3. The correlation coefficient equals -1,0, indicating a relatively strong relationship between the variables.

The mean absolute error (MAE) of 5,81353E-15 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	-1,0000	100,00%
Square root-Y	-1,0000	100,00%
Exponential	-1,0000	100,00%
Reciprocal-Y	1,0000	100,00%
Square root-X	-0,9997	99,94%
Logarithmic-X	-0,9989	99,78%
Multiplicative	-0,9988	99,76%
Reciprocal-X	0,9957	99,14%
S-curve	0,9955	99,10%
Double reciprocal	-0,9953	99,07%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 100,0%. This is the currently selected model.

Simple Regression - Al2O3_3 vs. SiO2_3

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Al2O3_3
Independent variable: SiO2_3

Parameter	Estimate	Standard Error	T Statistic	P-Value

```
Intercept       -0,273568         1,1229       -0,243626          0,8083
Slope            0,244569      0,0543713         4,49814          0,0000
-----------------------------------------------------------------------------
```

```
                           Analysis of Variance
-----------------------------------------------------------------------------
Source                 Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                        0,184322      1      0,184322      20,23       0,0000
Residual                     0,583031     64    0,00910986
-----------------------------------------------------------------------------
Total (Corr.)                0,767353     65

Correlation Coefficient = 0,490107
R-squared = 24,0205 percent
R-squared (adjusted for d.f.) = 22,8333 percent
Standard Error of Est. = 0,0954456
Mean absolute error = 0,0756953
Durbin-Watson statistic = 0,648371 (P=0,0000)
Lag 1 residual autocorrelation = 0,660983
```

The StatAdvisor

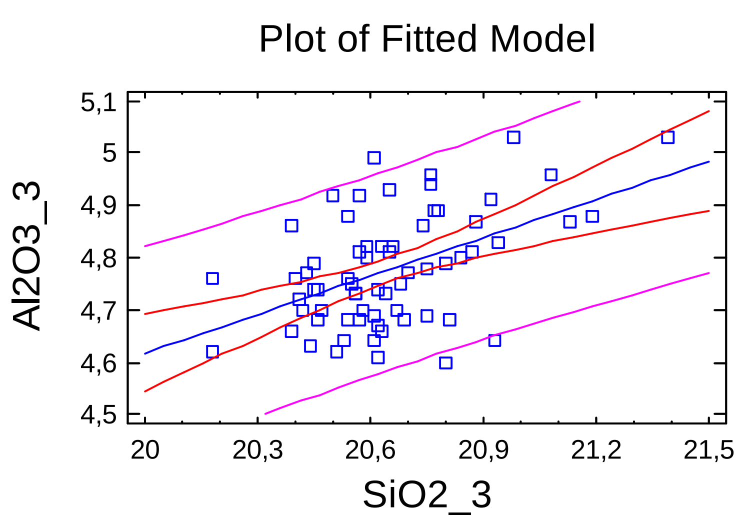
The output shows the results of fitting a linear model to describe the relationship between Al2O3_3 and SiO2_3. The equation of the fitted model is

Al2O3_3 = -0,273568 + 0,244569*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Al2O3_3 and SiO2_3 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 24,0205% of the variability in Al2O3_3. The correlation coefficient equals 0,490107, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,0954456. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,0756953 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,184322	1	0,184322	20,23	0,0000
Residual	0,583031	64	0,00910986		
Lack-of-Fit	0,378415	45	0,00840921	0,78	0,7570
Pure Error	0,204617	19	0,0107693		
Total (Corr.)	0,767353	65			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	0,4901	24,02%
Square root-X	0,4896	23,97%
Logarithmic-X	0,4891	23,92%
Square root-Y	0,4887	23,89%
Reciprocal-X	-0,4881	23,82%
Exponential	0,4873	23,75%
Multiplicative	0,4864	23,66%
S-curve	-0,4854	23,56%
Reciprocal-Y	-0,4845	23,48%
Double reciprocal	0,4826	23,29%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 24,0205%. This is the currently selected model.

Simple Regression - Al2O3_3 vs. SiO2_3

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Al2O3_3
Independent variable: SiO2_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	-0,273568	1,1229	-0,243626	0,8083
Slope	0,244569	0,0543713	4,49814	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,184322	1	0,184322	20,23	0,0000

```
Residual                 0,583031     64   0,00910986
-----------------------------------------------------------------------------
Total (Corr.)            0,767353     65

Correlation Coefficient = 0,490107
R-squared = 24,0205 percent
R-squared (adjusted for d.f.) = 22,8333 percent
Standard Error of Est. = 0,0954456
Mean absolute error = 0,0756953
Durbin-Watson statistic = 0,648371 (P=0,0000)
Lag 1 residual autocorrelation = 0,660983
```

The StatAdvisor

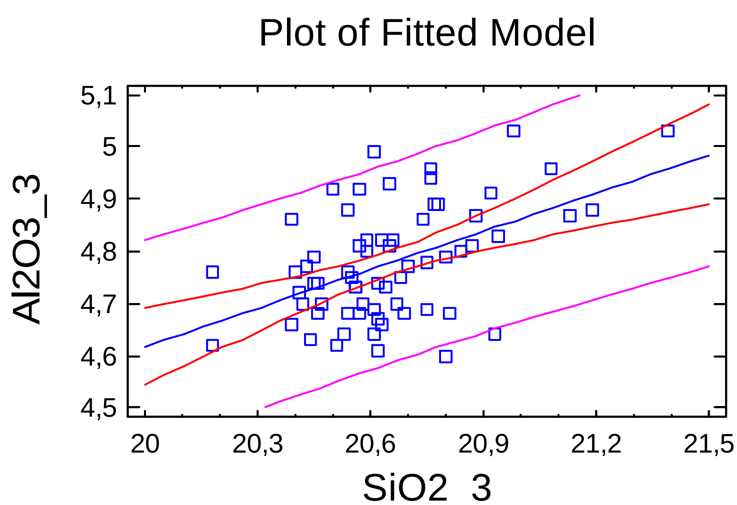
The output shows the results of fitting a linear model to describe the relationship between Al2O3_3 and SiO2_3. The equation of the fitted model is

Al2O3_3 = -0,273568 + 0,244569*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Al2O3_3 and SiO2_3 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 24,0205% of the variability in Al2O3_3. The correlation coefficient equals 0,490107, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,0954456. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,0756953 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



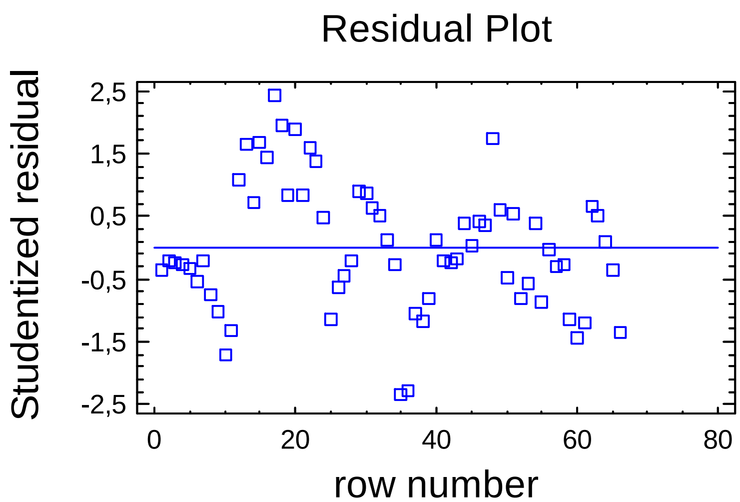
Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,184322	1	0,184322	20,23	0,0000
Residual	0,583031	64	0,00910986		
Lack-of-Fit	0,378415	45	0,00840921	0,78	0,7570
Pure Error	0,204617	19	0,0107693		

```
Total (Corr.)            0,767353     65
```

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.



Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	0,4901	24,02%
Square root-X	0,4896	23,97%
Logarithmic-X	0,4891	23,92%
Square root-Y	0,4887	23,89%
Reciprocal-X	-0,4881	23,82%
Exponential	0,4873	23,75%
Multiplicative	0,4864	23,66%
S-curve	-0,4854	23,56%
Reciprocal-Y	-0,4845	23,48%
Double reciprocal	0,4826	23,29%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 24,0205%. This is the currently selected model.

Simple Regression - Blaine_4 vs. LOI_4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Blaine_4
Independent variable: LOI_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	3538,85	72,9206	48,5302	0,0000
Slope	127,214	60,5095	2,10237	0,0416

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	10694,6	1	10694,6	4,42	0,0416
Residual	101624,0	42	2419,61		
Total (Corr.)	112318,0	43			

Correlation Coefficient = 0,308573
R-squared = 9,52171 percent
R-squared (adjusted for d.f.) = 7,36746 percent
Standard Error of Est. = 49,1895
Mean absolute error = 38,4879
Durbin-Watson statistic = 1,26538 (P=0,0046)
Lag 1 residual autocorrelation = 0,35144

The StatAdvisor

The output shows the results of fitting a linear model to describe the relationship between Blaine_4 and LOI_4. The equation of the fitted model is

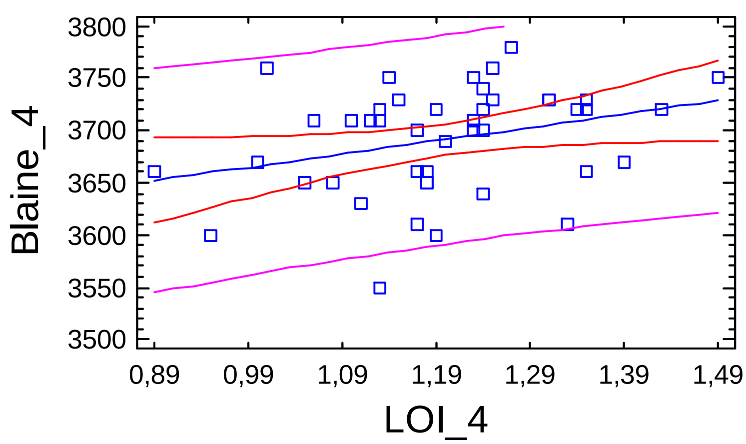
Blaine_4 = 3538,85 + 127,214*LOI_4

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between Blaine_4 and LOI_4 at the 95% confidence level.

The R-Squared statistic indicates that the model as fitted explains 9,52171% of the variability in Blaine_4. The correlation coefficient equals 0,308573, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 49,1895. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 38,4879 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

Plot of Fitted Model



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	10694,6	1	10694,6	4,42	0,0416
Residual	101624,0	42	2419,61		
Lack-of-Fit	61773,6	26	2375,91	0,95	0,5556
Pure Error	39850,0	16	2490,62		
Total (Corr.)	112318,0	43			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	0,3086	9,52%
Square root-X	0,3085	9,52%
Square root-Y	0,3084	9,51%
Exponential	0,3082	9,50%
Logarithmic-X	0,3080	9,49%
Reciprocal-Y	-0,3078	9,47%
Multiplicative	0,3076	9,46%
Reciprocal-X	-0,3056	9,34%
S-curve	-0,3052	9,31%
Double reciprocal	0,3048	9,29%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 9,52171%. This is the currently selected model.

Simple Regression - Blaine_4 vs. sio2_4

Regression Analysis - Reciprocal-Y model: Y = 1/(a + b*X)

Dependent variable: Blaine_4
Independent variable: sio2_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	0,00044524	0,0000622751	7,14956	0,0000
Slope	-0,00000845191	0,00000301989	-2,79875	0,0077

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	9,692E-11	1	9,692E-11	7,83	0,0077
Residual	5,1968E-10	42	1,23733E-11		
Total (Corr.)	6,166E-10	43			

Correlation Coefficient = -0,396465
R-squared = 15,7185 percent
R-squared (adjusted for d.f.) = 13,7118 percent
Standard Error of Est. = 0,00000351757
Mean absolute error = 0,00000267312
Durbin-Watson statistic = 1,54177 (P=0,0543)
Lag 1 residual autocorrelation = 0,221611

The StatAdvisor

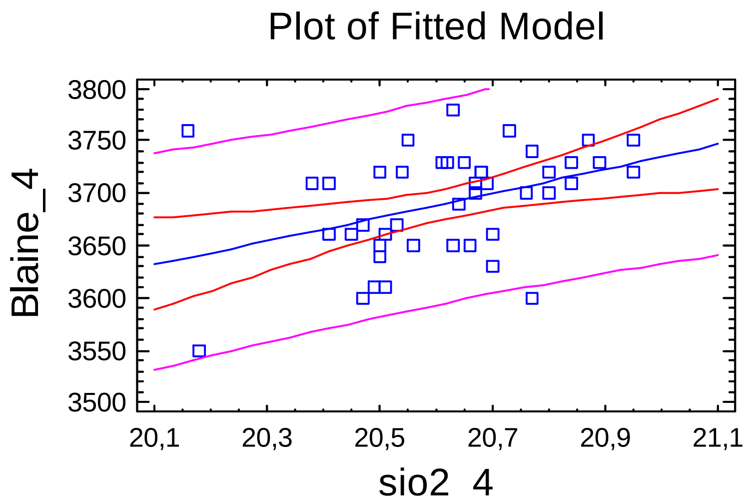
The output shows the results of fitting an reciprocal-Y model to describe the relationship between Blaine_4 and sio2_4. The equation of the fitted model is

Blaine_4 = 1/(0,00044524 - 0,00000845191*sio2_4)

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Blaine_4 and sio2_4 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 15,7185% of the variability in Blaine_4 after transforming to a reciprocal scale to linearize the model. The correlation coefficient equals -0,396465, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,00000351757. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,00000267312 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.



Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	9,692E-11	1	9,692E-11	7,83	0,0077
Residual	5,1968E-10	42	1,23733E-11		
Lack-of-Fit	3,65343E-10	29	1,2598E-11	1,06	0,4748
Pure Error	1,54336E-10	13	1,1872E-11		
Total (Corr.)	6,166E-10	43			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

Comparison of Alternative Models

Model	Correlation	R-Squared
Reciprocal-Y	-0,3965	15,72%
Double reciprocal	0,3952	15,62%
Exponential	0,3949	15,60%
Multiplicative	0,3943	15,55%
Square root-Y	0,3941	15,53%
S-curve	-0,3936	15,50%
Linear	0,3933	15,47%
Square root-X	0,3930	15,45%
Logarithmic-X	0,3927	15,42%
Reciprocal-X	-0,3920	15,37%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the reciprocal-Y model yields the highest R-Squared value with 15,7185%. This is the currently selected model.

Simple Regression - CLK_4 vs. GYP_4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: CLK_4
Independent variable: GYP_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	100,0	0,0		
Slope	-1,0	0,0		

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	2,28977	1	2,28977		
Residual	0,0	42	0,0		
Total (Corr.)	2,28977	43			

Correlation Coefficient = -1,0
R-squared = 100,0 percent
R-squared (adjusted for d.f.) = 100,0 percent
Standard Error of Est. = 0,0
Mean absolute error = 0,0
Durbin-Watson statistic = 1,09524 (P=0,0006)
Lag 1 residual autocorrelation = 0,428571

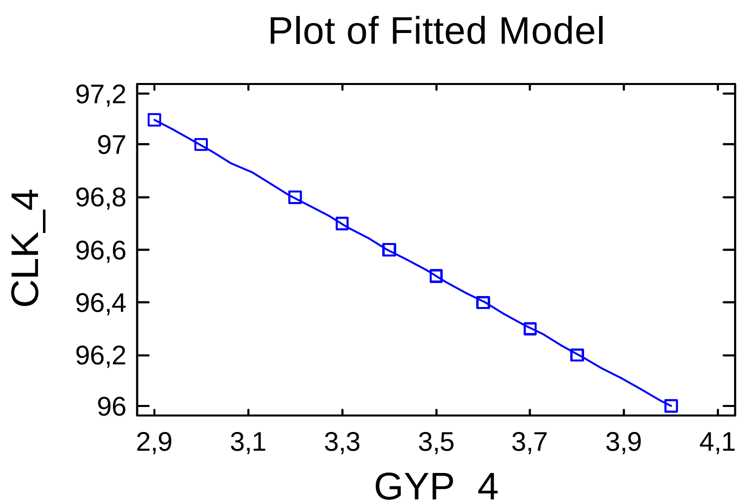
The StatAdvisor

The output shows the results of fitting a linear model to describe the relationship between CLK_4 and GYP_4. The equation of the fitted model is

CLK_4 = 100,0 - 1,0*GYP_4

The R-Squared statistic indicates that the model as fitted explains 100,0% of the variability in CLK_4. The correlation coefficient equals -1,0, indicating a relatively strong relationship between the variables.

The mean absolute error (MAE) of 6,78245E-15 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.



Συσχέτιση ιδιοτήτων- ποιότητα τσιμέντου OPC

Multiple-Variable Analysis

```
Analysis Summary

Data variables:
     Est1_3
     LOI_3
     SiO2_3
     Al2O3_3
     Blaine_3

There are 65 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

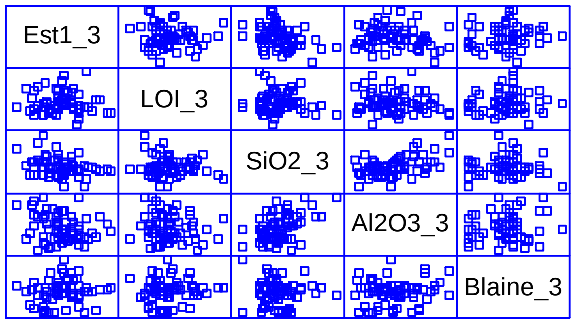
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis
```

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est1_3	LOI_3	SiO2_3	Al2O3_3
Est1_3		-0,0574 (65) 0,6496	-0,3435 (65) 0,0051	-0,1897 (65) 0,1302
LOI_3	-0,0574 (65) 0,6496		-0,0960 (65) 0,4468	-0,1279 (65) 0,3098
SiO2_3	-0,3435 (65) 0,0051	-0,0960 (65) 0,4468		0,4927 (65) 0,0000
Al2O3_3	-0,1897 (65) 0,1302	-0,1279 (65) 0,3098	0,4927 (65) 0,0000	
Blaine_3	0,1464 (65) 0,2447	0,0853 (65) 0,4993	-0,0385 (65) 0,7610	0,1117 (65) 0,3759

```
                    Blaine_3
--------------------------------------------------------------------------------------
--------------
Est1_3              0,1464
                    (   65)
                     0,2447

LOI_3                0,0853
                    (   65)
                     0,4993

SiO2_3              -0,0385
                    (   65)
                     0,7610

Al2O3_3              0,1117
                    (   65)
                     0,3759

Blaine_3


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

   Est1_3 and SiO2_3
   SiO2_3 and Al2O3_3

Multiple-Variable Analysis

Analysis Summary

Data variables:

     Est2_3
     LOI_3
     SiO2_3
     Al2O3_3
     Blaine_3

There are 64 complete cases for use in the calculations.

The StatAdvisor

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```
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more other variables.
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GOAL: develop a method for predicting which of several groups new rows
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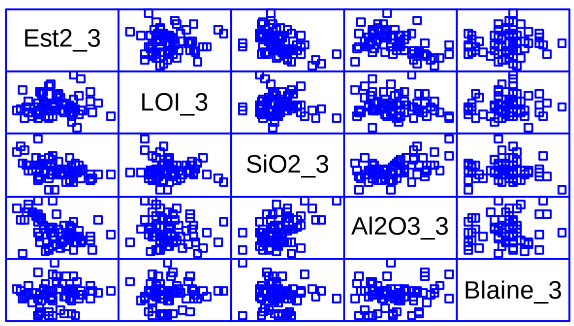
GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```




```
Correlations

                    Est2_3              LOI_3               SiO2_3
Al2O3_3
-------------------------------------------------------------------------------------
--------------
Est2_3                                   0,0242              -0,4472            -
0,4355
                                        (    64)            (    64)            (
64)
                                         0,8495               0,0002
0,0003

LOI_3                0,0242                                  -0,1126            -
0,1430
                    (    64)                                (    64)            (
64)
                     0,8495                                   0,3759
0,2595

SiO2_3              -0,4472             -0,1126
0,4878
                    (    64)            (    64)                                (
64)
                     0,0002              0,3759
```

```
0,0000

Al2O3_3            -0,4355            -0,1430            0,4878
                   (    64)           (    64)           (    64)
                    0,0003             0,2595            0,0000

Blaine_3            0,1108             0,0649            -0,0555
0,0990
                   (    64)           (    64)           (    64)           (
64)
                    0,3836             0,6105            0,6629
0,4362
--------------------------------------------------------------------------------------
--------------

                   Blaine_3
--------------------------------------------------------------------------------------
--------------
Est2_3              0,1108
                   (    64)
                    0,3836

LOI_3               0,0649
                   (    64)
                    0,6105

SiO2_3             -0,0555
                   (    64)
                    0,6629

Al2O3_3             0,0990
                   (    64)
                    0,4362

Blaine_3


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est2_3 and SiO2_3
   Est2_3 and Al2O3_3
   SiO2_3 and Al2O3_3




Multiple-Variable Analysis

Analysis Summary

Data variables:
     Est7_3
     LOI_3
     SiO2_3
     Al2O3_3
     Blaine_3

There are 61 complete cases for use in the calculations.
```

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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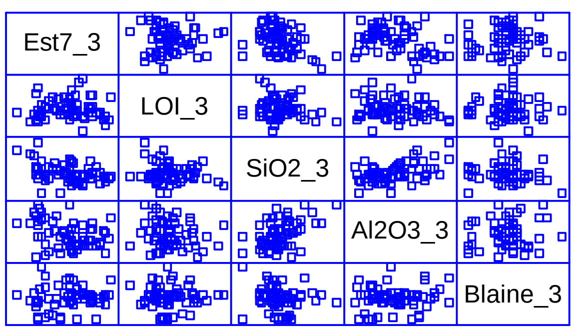
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est7_3	LOI_3	SiO2_3	Al2O3_3
Est7_3		-0,0033	-0,3799	-0,3257
		(61)	(61)	(

```
61)
                                        0,9800              0,0025
0,0104

LOI_3               -0,0033                                 -0,1659             -
0,1521
                    (    61)                                (    61)            (
61)
                     0,9800                                  0,2012
0,2418

SiO2_3              -0,3799             -0,1659
0,4938
                    (    61)            (    61)                                (
61)
                     0,0025              0,2012
0,0001

Al2O3_3             -0,3257             -0,1521              0,4938
                    (    61)            (    61)            (    61)
                     0,0104              0,2418              0,0001

Blaine_3             0,1001             -0,0045             -0,1340
0,0969
                    (    61)            (    61)            (    61)            (
61)
                     0,4426              0,9726              0,3031
0,4574
--------------------------------------------------------------------------------------
--------------

                    Blaine_3
--------------------------------------------------------------------------------------
--------------
Est7_3               0,1001
                    (    61)
                     0,4426

LOI_3               -0,0045
                    (    61)
                     0,9726

SiO2_3              -0,1340
                    (    61)
                     0,3031

Al2O3_3              0,0969
                    (    61)
                     0,4574

Blaine_3


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   Est7_3 and SiO2_3
   Est7_3 and Al2O3_3
   SiO2_3 and Al2O3_3
```

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Est28_3
     LOI_3
     SiO2_3
     Al2O3_3
     Blaine_3

There are 46 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and

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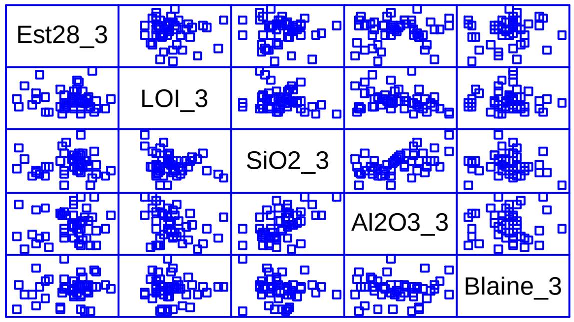
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est28_3	LOI_3	SiO2_3	Al2O3_3
Est28_3		-0,0712 (46) 0,6380	-0,0211 (46) 0,8895	0,1160 (46) 0,4426
LOI_3	-0,0712 (46) 0,6380		-0,2380 (46) 0,1113	-0,2729 (46) 0,0665
SiO2_3	-0,0211 (46) 0,8895	-0,2380 (46) 0,1113		0,5261 (46) 0,0002
Al2O3_3	0,1160 (46) 0,4426	-0,2729 (46) 0,0665	0,5261 (46) 0,0002	
Blaine_3	0,1415 (46) 0,3481	-0,0325 (46) 0,8300	-0,1260 (46) 0,4041	0,0083 (46) 0,9562

	Blaine_3
Est28_3	0,1415 (46) 0,3481
LOI_3	-0,0325 (46) 0,8300

```
SiO2_3              -0,1260
                    (   46)
                     0,4041

Al2O3_3              0,0083
                    (   46)
                     0,9562

Blaine_3


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
   SiO2_3 and Al2O3_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Est1_4
     LOI_4
     SiO2_4
     Al2O3_4
     Blaine_4

There are 43 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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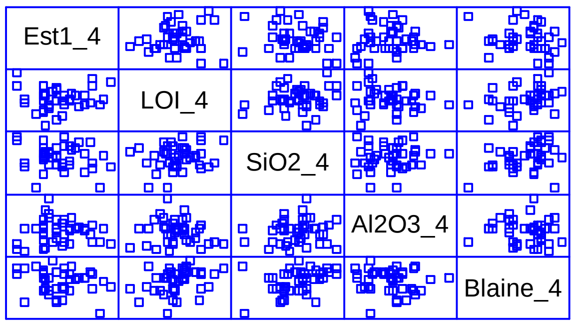
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est1_4	LOI_4	SiO2_4	Al2O3_4
Est1_4		0,0599 (43) 0,7030	-0,2076 (43) 0,1816	0,0084 (43) 0,9572
LOI_4	0,0599 (43) 0,7030		0,1923 (43) 0,2167	-0,0704 (43) 0,6536
SiO2_4	-0,2076 (43) 0,1816	0,1923 (43) 0,2167		0,1053 (43) 0,5017
Al2O3_4	0,0084 (43) 0,9572	-0,0704 (43) 0,6536	0,1053 (43) 0,5017	
Blaine_4	-0,1771 (43) 0,2559	0,3208 (43) 0,0360	0,3838 (43) 0,0111	-0,1188 (43) 0,4480

```
--------------------------------------------------------------------------------------------------

                    Blaine_4
--------------------------------------------------------------------------------------------------
Est1_4              -0,1771
                    (   43)
                     0,2559

LOI_4                0,3208
                    (   43)
                     0,0360

SiO2_4               0,3838
                    (   43)
                     0,0111

Al2O3_4             -0,1188
                    (   43)
                     0,4480

Blaine_4

--------------------------------------------------------------------------------------------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

   LOI_4 and Blaine_4
   SiO2_4 and Blaine_4

Multiple-Variable Analysis

Analysis Summary

Data variables:
- Est2_4
- LOI_4
- SiO2_4
- Al2O3_4
- Blaine_4

There are 43 complete cases for use in the calculations.

The StatAdvisor

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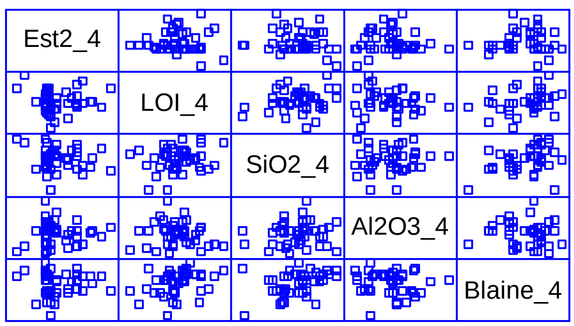
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est2_4	LOI_4	SiO2_4	Al2O3_4
Est2_4		-0,0192	-0,1407	-0,0090
		(43)	(43)	(43)
		0,9026	0,3682	0,9544
LOI_4	-0,0192		0,1923	-0,0704
	(43)		(43)	(43)
	0,9026		0,2167	0,6536
SiO2_4	-0,1407	0,1923		0,1053

```
                    (    43)            (    43)                                 (
43)
                     0,3682              0,2167
0,5017

Al2O3_4             -0,0090             -0,0704              0,1053
                    (    43)            (    43)            (    43)
                     0,9544              0,6536              0,5017

Blaine_4            -0,0094              0,3208              0,3838              -
0,1188
                    (    43)            (    43)            (    43)            (
43)
                     0,9525              0,0360              0,0111
0,4480
-------------------------------------------------------------------------------------
--------------

                    Blaine_4
-------------------------------------------------------------------------------------
--------------
Est2_4              -0,0094
                    (    43)
                     0,9525

LOI_4                0,3208
                    (    43)
                     0,0360

SiO2_4               0,3838
                    (    43)
                     0,0111

Al2O3_4             -0,1188
                    (    43)
                     0,4480

Blaine_4


-------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

   LOI_4 and Blaine_4
   SiO2_4 and Blaine_4

Multiple-Variable Analysis

Analysis Summary

Data variables:

     Est7_4
     LOI_4
     SiO2_4
     Al2O3_4
     Blaine_4

There are 40 complete cases for use in the calculations.

The StatAdvisor

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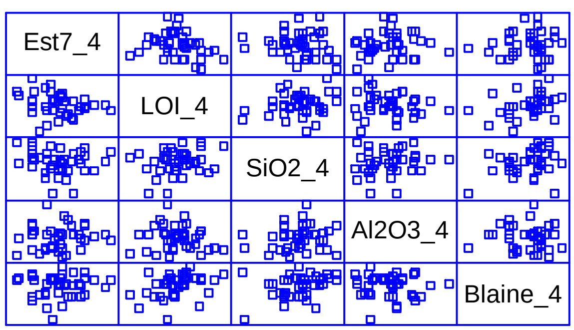
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

```
                    Est7_4              LOI_4               SiO2_4
Al2O3_4
------------------------------------------------------------------------------------
--------------
Est7_4                                  -0,2637             -0,1489
```

```
0,0972
                                        (   40)             (   40)             (
40)
                                         0,1001              0,3591
0,5507

LOI_4               -0,2637                                  0,2273             -
0,0862
                    (   40)                                 (   40)             (
40)
                     0,1001                                  0,1584
0,5969

SiO2_4              -0,1489              0,2273
0,1468
                    (   40)             (   40)                                 (
40)
                     0,3591              0,1584
0,3661

Al2O3_4              0,0972             -0,0862              0,1468
                    (   40)             (   40)             (   40)
                     0,5507              0,5969              0,3661

Blaine_4             0,0399              0,3671              0,3336             -
0,0711
                    (   40)             (   40)             (   40)             (
40)
                     0,8071              0,0198              0,0354
0,6631
--------------------------------------------------------------------------------------
--------------

                    Blaine_4
--------------------------------------------------------------------------------------
--------------
Est7_4               0,0399
                    (   40)
                     0,8071

LOI_4                0,3671
                    (   40)
                     0,0198

SiO2_4               0,3336
                    (   40)
                     0,0354

Al2O3_4             -0,0711
                    (   40)
                     0,6631

Blaine_4


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value


The StatAdvisor
---------------
   This table shows Pearson product moment correlations between each
pair of variables.  These correlation coefficients range between -1
and +1 and measure the strength of the linear relationship between the
variables.  Also shown in parentheses is the number of pairs of data
values used to compute each coefficient.  The third number in each
location of the table is a P-value which tests the statistical
significance of the estimated correlations.  P-values below 0.05
indicate statistically significant non-zero correlations at the 95%
confidence level.  The following pairs of variables have P-values
below 0.05:
   LOI_4 and Blaine_4
   SiO2_4 and Blaine_4
```

Multiple-Variable Analysis

Analysis Summary

Data variables:
Est28_4
LOI_4
SiO2_4
Al2O3_4
Blaine_4

There are 29 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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PROCEDURE: Relate - Multiple regression

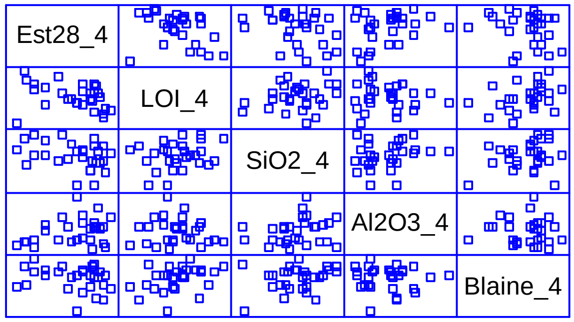
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est28_4	LOI_4	SiO2_4	Al2O3_4
Est28_4		-0,3489	-0,3241	0,3261
		(29)	(29)	(29)
		0,0636	0,0864	0,0843
LOI_4	-0,3489		0,2392	-0,0548
	(29)		(29)	(29)
	0,0636		0,2115	0,7776
SiO2_4	-0,3241	0,2392		0,2112
	(29)	(29)		(29)
	0,0864	0,2115		0,2715
Al2O3_4	0,3261	-0,0548	0,2112	
	(29)	(29)	(29)	
	0,0843	0,7776	0,2715	
Blaine_4	-0,2425	0,3570	0,2633	-0,0496
	(29)	(29)	(29)	(29)
	0,2049	0,0572	0,1675	0,7982

	Blaine_4
Est28_4	-0,2425
	(29)
	0,2049
LOI_4	0,3570
	(29)
	0,0572

```
SiO2_4              0,2633
                   (   29)
                    0,1675

Al2O3_4            -0,0496
                   (   29)
                    0,7982

Blaine_4


--------------------------------------------------------------------------------------
--------------

Correlation
(Sample Size)
P-Value
```

The StatAdvisor

   This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
   <none>

Συσχέτιση ιδιοτήτων και σύνθεσης- ποιότητα τσιμέντου OPC

Multiple-Variable Analysis

Analysis Summary

Data variables:
     CLK_3
     Est1_3
     GYP_3
     Blaine_3

There are 65 complete cases for use in the calculations.

The StatAdvisor

   This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

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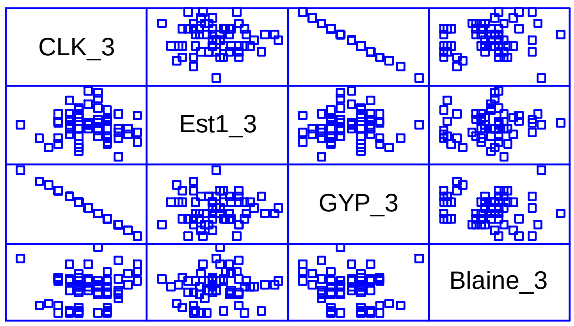
GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	CLK_3	Est1_3	GYP_3	Blaine_3
CLK_3		-0,0126 (65) 0,9208	-1,0000 (65) 0,0000	0,1150 (65) 0,3615
Est1_3	-0,0126 (65) 0,9208		0,0126 (65) 0,9208	0,1464 (65) 0,2447
GYP_3	-1,0000 (65) 0,0000	0,0126 (65) 0,9208		-0,1150 (65) 0,3615
Blaine_3	0,1150 (65) 0,3615	0,1464 (65) 0,2447	-0,1150 (65) 0,3615	

Correlation

(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
CLK_3 and GYP_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
CLK_3
Est2_3
GYP_3
Blaine_3

There are 64 complete cases for use in the calculations.

The StatAdvisor

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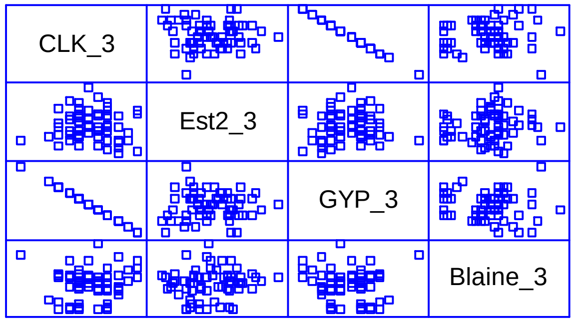

Correlations

	CLK_3	Est2_3	GYP_3	Blaine_3
CLK_3		-0,0429	-1,0000	0,0776
		(64)	(64)	(64)
		0,7365	0,0000	0,5421
Est2_3	-0,0429		0,0429	0,1108
	(64)		(64)	(64)
	0,7365		0,7365	0,3836
GYP_3	-1,0000	0,0429		-0,0776
	(64)	(64)		(64)
	0,0000	0,7365		0,5421
Blaine_3	0,0776	0,1108	-0,0776	
	(64)	(64)	(64)	
	0,5421	0,3836	0,5421	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
CLK_3 and GYP_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
CLK_3
Est7_3
GYP_3
Blaine_3

There are 61 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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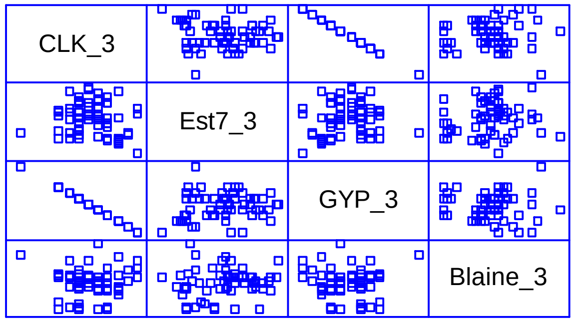

Correlations

	CLK_3	Est7_3	GYP_3	Blaine_3
CLK_3		-0,1203 (61) 0,3557	-1,0000 (61) 0,0000	0,0379 (61) 0,7718
Est7_3	-0,1203 (61) 0,3557		0,1203 (61) 0,3557	0,1001 (61) 0,4426
GYP_3	-1,0000 (61) 0,0000	0,1203 (61) 0,3557		-0,0379 (61) 0,7718
Blaine_3	0,0379 (61) 0,7718	0,1001 (61) 0,4426	-0,0379 (61) 0,7718	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

CLK_3 and GYP_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
     CLK_3
     Est28_3
     GYP_3
     Blaine_3

There are 46 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

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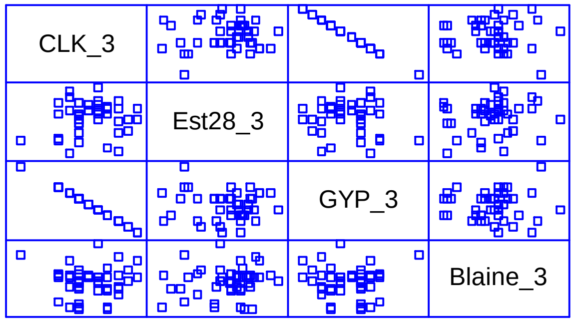

Correlations

	CLK_3	Est28_3	GYP_3	Blaine_3
CLK_3		0,0944	-1,0000	-0,0026
		(46)	(46)	(46)
		0,5328	0,0000	0,9861
Est28_3	0,0944		-0,0944	0,1415
	(46)		(46)	(46)
	0,5328		0,5328	0,3481
GYP_3	-1,0000	-0,0944		0,0026
	(46)	(46)		(46)
	0,0000	0,5328		0,9861
Blaine_3	-0,0026	0,1415	0,0026	
	(46)	(46)	(46)	
	0,9861	0,3481	0,9861	

Correlation
(Sample Size)
P-Value

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CLK_3 and GYP_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Blaine_4
     CLK_4
     Est1_4
     GYP_4

There are 43 complete cases for use in the calculations.

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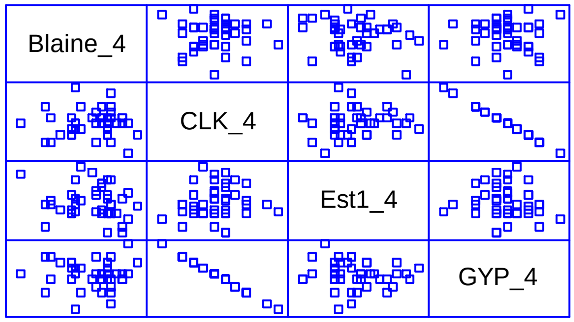

Correlations

	Blaine_4	CLK_4	Est1_4	GYP_4
Blaine_4		0,0317 (43) 0,8401	-0,1771 (43) 0,2559	-0,0317 (43) 0,8401
CLK_4	0,0317 (43) 0,8401		0,0981 (43) 0,5314	-1,0000 (43) 0,0000
Est1_4	-0,1771 (43) 0,2559	0,0981 (43) 0,5314		-0,0981 (43) 0,5314
GYP_4	-0,0317 (43) 0,8401	-1,0000 (43) 0,0000	-0,0981 (43) 0,5314	

Correlation
(Sample Size)
P-Value

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CLK_4 and GYP_4

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Blaine_4
     CLK_4
     Est2_4
     GYP_4

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The StatAdvisor

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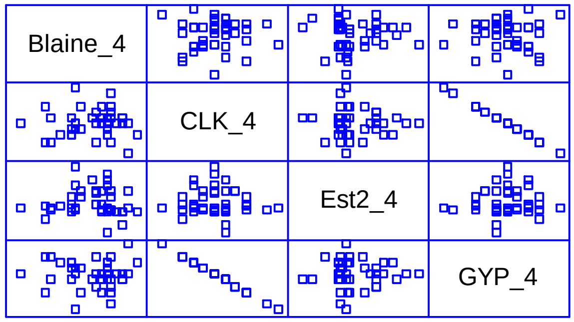

Correlations

	Blaine_4	CLK_4	Est2_4	GYP_4
Blaine_4		0,0317	-0,0094	-0,0317
		(43)	(43)	(43)
		0,8401	0,9525	0,8401
CLK_4	0,0317		-0,0415	-1,0000
	(43)		(43)	(43)
	0,8401		0,7914	0,0000
Est2_4	-0,0094	-0,0415		0,0415
	(43)	(43)		(43)
	0,9525	0,7914		0,7914
GYP_4	-0,0317	-1,0000	0,0415	
	(43)	(43)	(43)	
	0,8401	0,0000	0,7914	

Correlation
(Sample Size)
P-Value

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This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

CLK_4 and GYP_4

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Blaine_4
     CLK_4
     Est7_4
     GYP_4

There are 40 complete cases for use in the calculations.

The StatAdvisor

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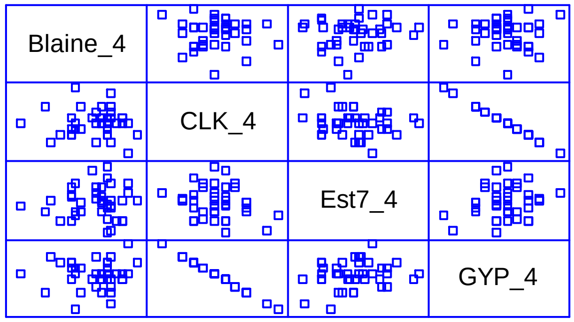

Correlations

	Blaine_4	CLK_4	Est7_4	GYP_4
Blaine_4		-0,0181	0,0399	0,0181
		(40)	(40)	(40)
		0,9115	0,8071	0,9115
CLK_4	-0,0181		-0,2074	-1,0000
	(40)		(40)	(40)
	0,9115		0,1991	0,0000
Est7_4	0,0399	-0,2074		0,2074
	(40)	(40)		(40)
	0,8071	0,1991		0,1991
GYP_4	0,0181	-1,0000	0,2074	
	(40)	(40)	(40)	
	0,9115	0,0000	0,1991	

Correlation
(Sample Size)
P-Value

The StatAdvisor

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CLK_4 and GYP_4

Multiple-Variable Analysis

Analysis Summary

Data variables:
     Blaine_4
     CLK_4
     Est28_4
     GYP_4

There are 29 complete cases for use in the calculations.

The StatAdvisor

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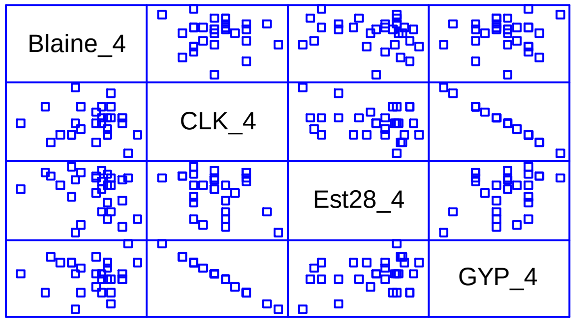

Correlations

	Blaine_4	CLK_4	Est28_4	GYP_4
Blaine_4		-0,0257	-0,2425	0,0257
		(29)	(29)	(29)
		0,8946	0,2049	0,8946
CLK_4	-0,0257		-0,2819	-1,0000
	(29)		(29)	(29)
	0,8946		0,1385	0,0000
Est28_4	-0,2425	-0,2819		0,2819
	(29)	(29)		(29)
	0,2049	0,1385		0,1385
GYP_4	0,0257	-1,0000	0,2819	
	(29)	(29)	(29)	
	0,8946	0,0000	0,1385	

Correlation
(Sample Size)
P-Value

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CLK_4 and GYP_4

Multiple Regression - Est1_3

```
Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est1_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter                Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                  44,1397        15,569         2,8351          0,0062
Al2O3_3                 -0,661762       1,42642      -0,463932          0,6444
Blaine_3                 0,002985    0,00239894         1,2443          0,2182
LOI_3                   -0,797173      0,883779      -0,902004          0,3707
SiO2_3                   -1,59767      0,695462       -2,29728          0,0251
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     11,7228      4      2,93069       2,63       0,0430
Residual                  66,8418     60      1,11403
-----------------------------------------------------------------------------
Total (Corr.)             78,5646     64

R-squared = 14,9212 percent
R-squared (adjusted for d.f.) = 9,24927 percent
Standard Error of Est. = 1,05548
Mean absolute error = 0,797591
Durbin-Watson statistic = 1,07445 (P=0,0000)
Lag 1 residual autocorrelation = 0,4494

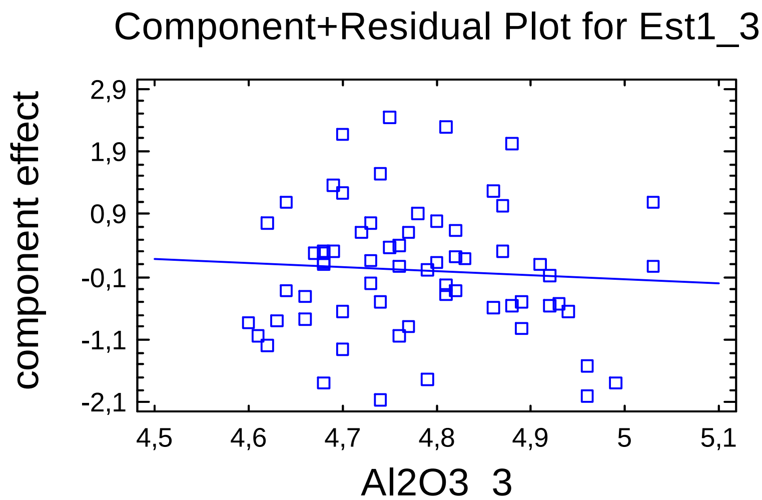

The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est1_3 and 4
independent variables.  The equation of the fitted model is

Est1_3 = 44,1397 - 0,661762*Al2O3_3 + 0,002985*Blaine_3 -
0,797173*LOI_3 - 1,59767*SiO2_3

Since the P-value in the ANOVA table is less than 0.05, there is a
statistically significant relationship between the variables at the
95% confidence level.

     The R-Squared statistic indicates that the model as fitted
explains 14,9212% of the variability in Est1_3.  The adjusted
R-squared statistic, which is more suitable for comparing models with
different numbers of independent variables, is 9,24927%.  The standard
error of the estimate shows the standard deviation of the residuals to
be 1,05548.  This value can be used to construct prediction limits for
new observations by selecting the Reports option from the text menu.
The mean absolute error (MAE) of 0,797591 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.

   In determining whether the model can be simplified, notice that the
highest P-value on the independent variables is 0,6444, belonging to
Al2O3_3.  Since the P-value is greater or equal to 0.10, that term is
not statistically significant at the 90% or higher confidence level.
Consequently, you should consider removing Al2O3_3 from the model.
```



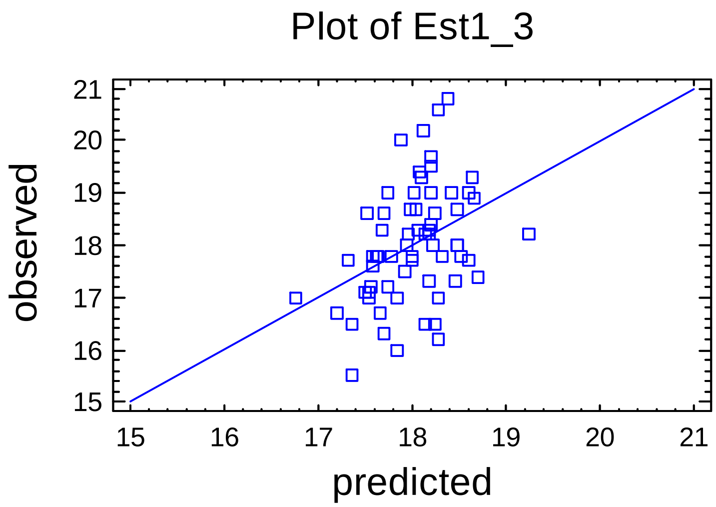
Correlation matrix for coefficient estimates

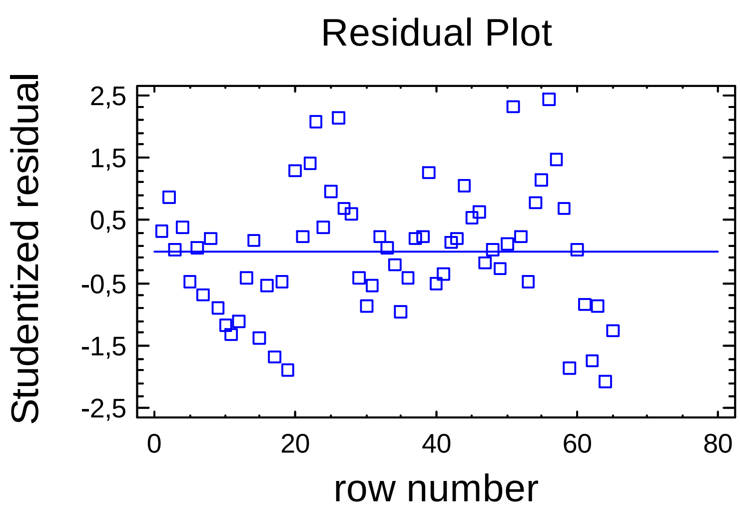
	CONSTANT	Al2O3_3	Blaine_3	LOI_3
CONSTANT	1,0000	0,1012	-0,5859	-0,0825
Al2O3_3	0,1012	1,0000	-0,1591	0,1070
Blaine_3	-0,5859	-0,1591	1,0000	-0,0975
LOI_3	-0,0825	0,1070	-0,0975	1,0000
SiO2_3	-0,7671	-0,4944	0,1048	0,0276

	SiO2_3
CONSTANT	-0,7671
Al2O3_3	-0,4944
Blaine_3	0,1048
LOI_3	0,0276
SiO2_3	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple Regression - Est1_3

Multiple Regression Analysis

Dependent variable: Est1_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	53,8431	12,3425	4,3624	0,0000
SiO2_3	-1,73483	0,59761	-2,90295	0,0051

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	9,2692	1	9,2692	8,43	0,0051
Residual	69,2954	63	1,09993		
Total (Corr.)	78,5646	64			

R-squared = 11,7982 percent
R-squared (adjusted for d.f.) = 10,3982 percent

```
Standard Error of Est. = 1,04877
Mean absolute error = 0,82651
Durbin-Watson statistic = 1,07108 (P=0,0000)
Lag 1 residual autocorrelation = 0,448781


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  64 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,22757

     Step 1:
     ---------
     Adding variable SiO2_3 with F-to-enter = 8,4271
     1 variables in the model.  63 d.f. for error.
     R-squared =  11,80%     Adjusted R-squared =  10,40%     MSE = 1,09993

     Final model selected.



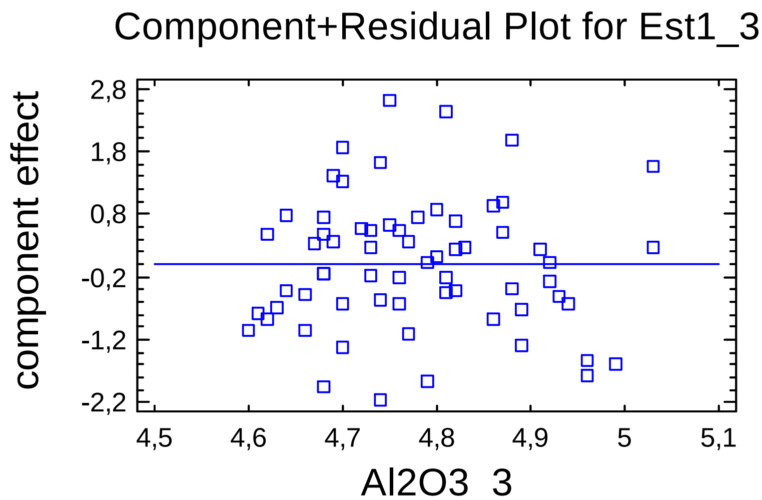

The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est1_3 and 4
independent variables.  The equation of the fitted model is

Est1_3 = 53,8431 - 1,73483*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between the variables at the
99% confidence level.

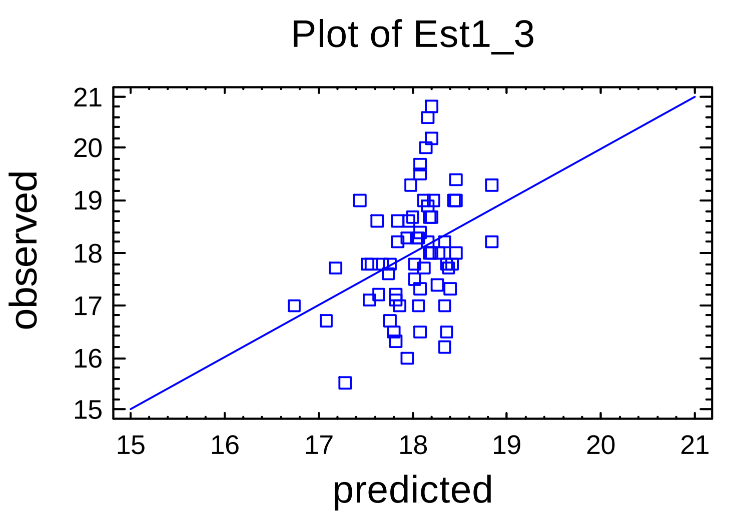
     The R-Squared statistic indicates that the model as fitted
explains 11,7982% of the variability in Est1_3.  The adjusted
R-squared statistic, which is more suitable for comparing models with
different numbers of independent variables, is 10,3982%.  The standard
error of the estimate shows the standard deviation of the residuals to
be 1,04877.  This value can be used to construct prediction limits for
new observations by selecting the Reports option from the text menu.
The mean absolute error (MAE) of 0,82651 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.

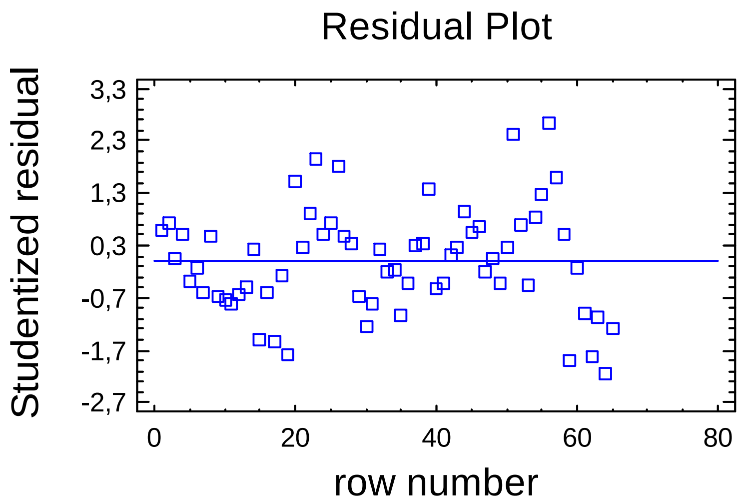
   In determining whether the model can be simplified, notice that the
highest P-value on the independent variables is 0,0051, belonging to
SiO2_3.  Since the P-value is less than 0.01, the highest order term
is statistically significant at the 99% confidence level.
Consequently, you probably don't want to remove any variables from the
model.
```




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT         SiO2_3
CONSTANT                  1,0000        -0,9999
SiO2_3                   -0,9999         1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).
```






```
Multiple Regression - Est2_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 71,0307       16,4934         4,3066         0,0001
Al2O3_3                 -3,62439       1,48515       -2,44042         0,0177
Blaine_3              0,00291448    0,00252093        1,15611         0,2523
LOI_3                  -0,516118      0,929381      -0,555335         0,5808
SiO2_3                   -1,6752      0,726484        -2,3059         0,0246
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     27,7999      4      6,94998       5,76       0,0006
Residual                  71,1395     59      1,20575
-----------------------------------------------------------------------------
Total (Corr.)             98,9394     63

R-squared = 28,0979 percent
R-squared (adjusted for d.f.) = 23,2232 percent
Standard Error of Est. = 1,09807
Mean absolute error = 0,873938
Durbin-Watson statistic = 1,40452 (P=0,0034)
Lag 1 residual autocorrelation = 0,283998


The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2_3 and 4
independent variables.  The equation of the fitted model is

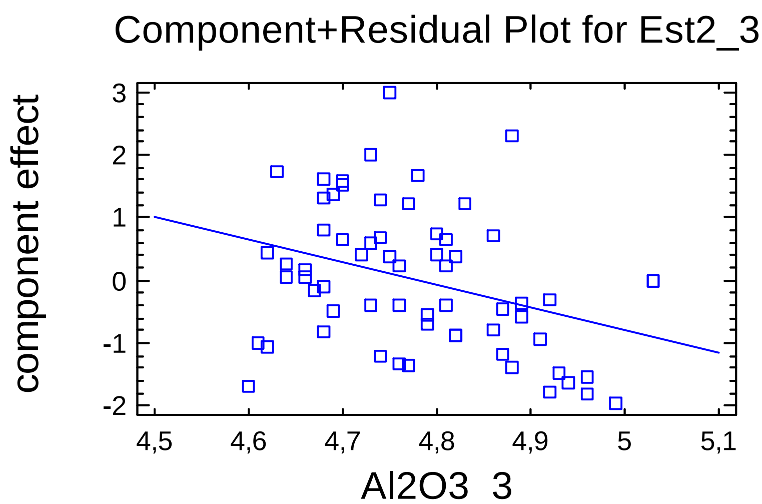
Est2_3 = 71,0307 - 3,62439*Al2O3_3 + 0,00291448*Blaine_3 -
0,516118*LOI_3 - 1,6752*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between the variables at the
99% confidence level.

     The R-Squared statistic indicates that the model as fitted
explains 28,0979% of the variability in Est2_3.  The adjusted
R-squared statistic, which is more suitable for comparing models with
```

different numbers of independent variables, is 23,2232%. The standard error of the estimate shows the standard deviation of the residuals to be 1,09807. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,873938 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,5808, belonging to LOI_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing LOI_3 from the model.



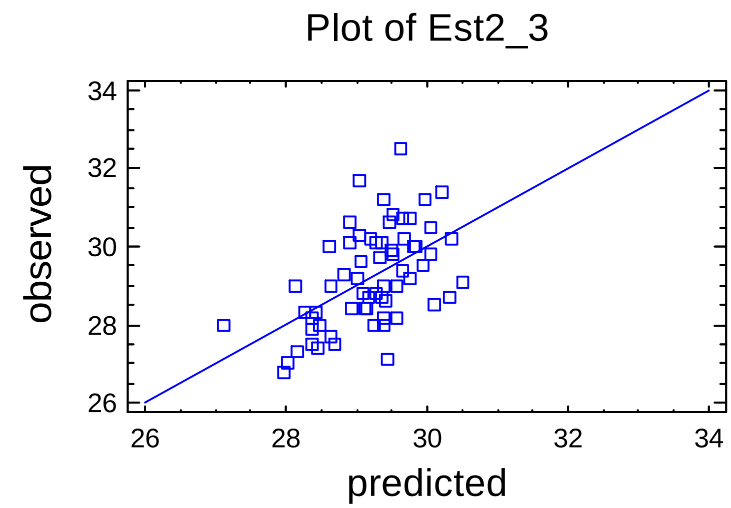
Correlation matrix for coefficient estimates

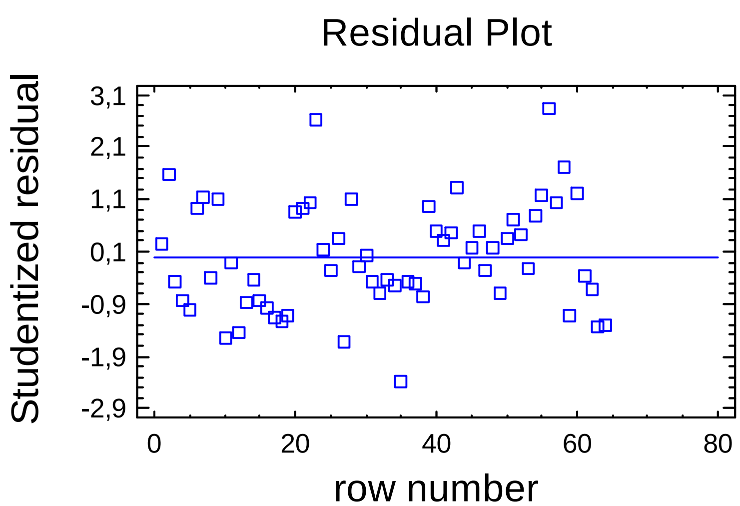
	CONSTANT	Al2O3_3	Blaine_3	LOI_3
CONSTANT	1,0000	0,0918	-0,5963	-0,1076
Al2O3_3	0,0918	1,0000	-0,1517	0,1115
Blaine_3	-0,5963	-0,1517	1,0000	-0,0750
LOI_3	-0,1076	0,1115	-0,0750	1,0000
SiO2_3	-0,7672	-0,4885	0,1161	0,0403

	SiO2_3
CONSTANT	-0,7672
Al2O3_3	-0,4885
Blaine_3	0,1161
LOI_3	0,0403
SiO2_3	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple Regression - Est2_3

Multiple Regression Analysis

Dependent variable: Est2_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	81,2166	12,9514	6,27089	0,0000
Al2O3_3	-3,29373	1,45505	-2,26366	0,0272
SiO2_3	-1,7559	0,718069	-2,44531	0,0174

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	25,922	2	12,961	10,83	0,0001
Residual	73,0174	61	1,19701		
Total (Corr.)	98,9394	63			

R-squared = 26,1999 percent

```
R-squared (adjusted for d.f.) = 23,7802 percent
Standard Error of Est. = 1,09408
Mean absolute error = 0,89903
Durbin-Watson statistic = 1,37022 (P=0,0032)
Lag 1 residual autocorrelation = 0,29792


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  63 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,57047

     Step 1:
     ---------
     Adding variable SiO2_3 with F-to-enter = 15,5005
     1 variables in the model.  62 d.f. for error.
     R-squared =  20,00%     Adjusted R-squared =  18,71%     MSE = 1,27663

     Step 2:
     ---------
     Adding variable Al2O3_3 with F-to-enter = 5,12415
     2 variables in the model.  61 d.f. for error.
     R-squared =  26,20%     Adjusted R-squared =  23,78%     MSE = 1,19701

     Final model selected.



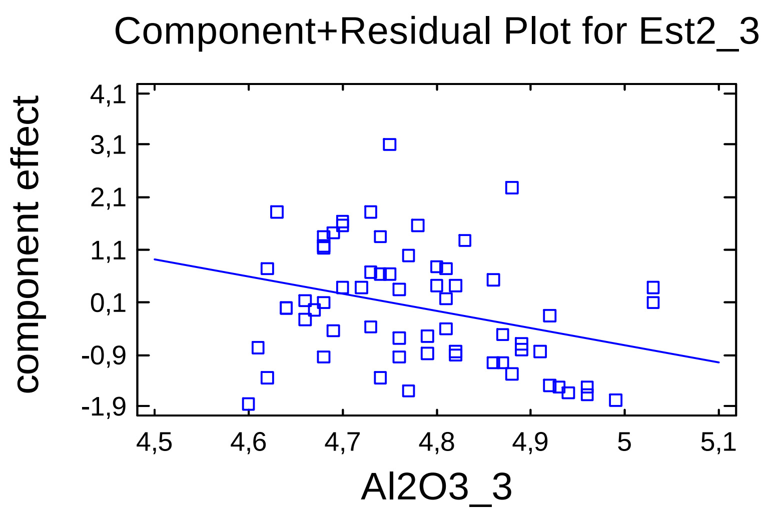

The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2_3 and 4
independent variables.  The equation of the fitted model is

Est2_3 = 81,2166 - 3,29373*Al2O3_3 - 1,7559*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a
statistically significant relationship between the variables at the
99% confidence level.

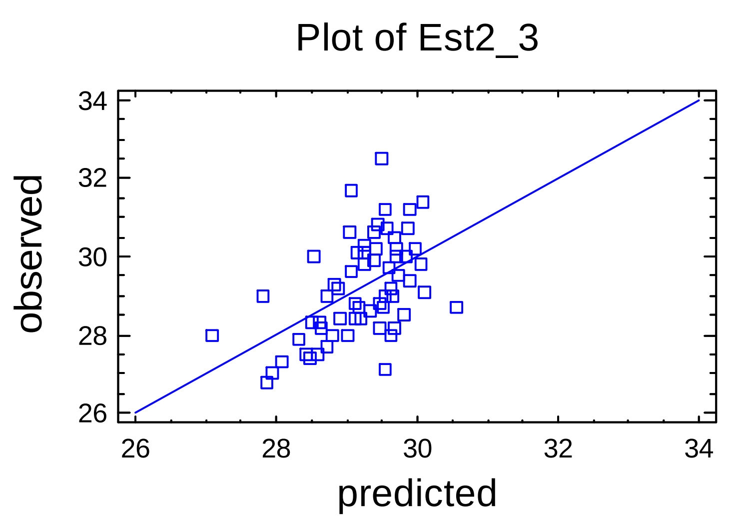
     The R-Squared statistic indicates that the model as fitted
explains 26,1999% of the variability in Est2_3.  The adjusted
R-squared statistic, which is more suitable for comparing models with
different numbers of independent variables, is 23,7802%.  The standard
error of the estimate shows the standard deviation of the residuals to
be 1,09408.  This value can be used to construct prediction limits for
new observations by selecting the Reports option from the text menu.
The mean absolute error (MAE) of 0,89903 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.

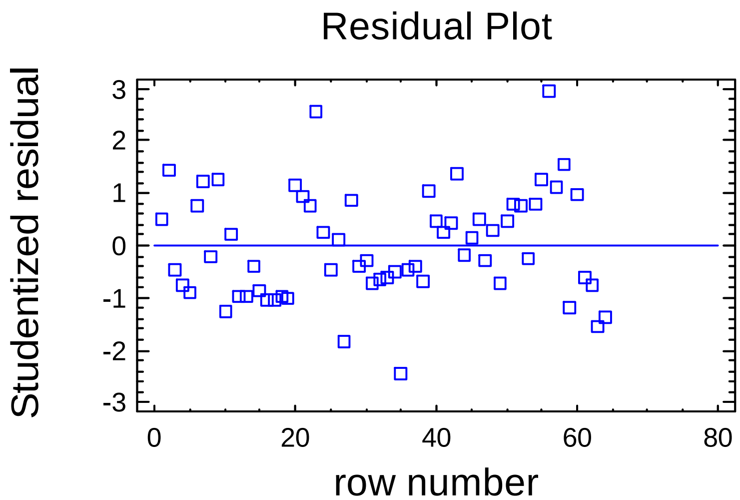
   In determining whether the model can be simplified, notice that the
highest P-value on the independent variables is 0,0272, belonging to
Al2O3_3.  Since the P-value is less than 0.05, that term is
statistically significant at the 95% confidence level.  Consequently,
you probably don't want to remove any variables from the model.
```




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                         CONSTANT        Al2O3_3         SiO2_3
CONSTANT                   1,0000         0,0215        -0,8832
Al2O3_3                    0,0215         1,0000        -0,4878
SiO2_3                    -0,8832        -0,4878         1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).
```






```
Multiple Regression - Est7_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7_3
-----------------------------------------------------------------------------
                                        Standard          T
Parameter               Estimate         Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 90,8807         24,02         3,78354         0,0004
Al2O3_3                 -2,90638       1,98372        -1,46512         0,1485
Blaine_3              0,00237135    0,00357113        0,664033         0,5094
LOI_3                  -0,831902       1,26359       -0,658363         0,5130
SiO2_3                  -1,97108       1,00741        -1,95657         0,0554
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     26,3808      4       6,5952       3,13       0,0217
Residual                  118,169     56      2,11016
-----------------------------------------------------------------------------
Total (Corr.)              144,55     60

R-squared = 18,2503 percent
R-squared (adjusted for d.f.) = 12,411 percent
Standard Error of Est. = 1,45264
Mean absolute error = 1,14818
Durbin-Watson statistic = 1,20374 (P=0,0002)
Lag 1 residual autocorrelation = 0,396884


The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est7_3 and 4
independent variables.  The equation of the fitted model is

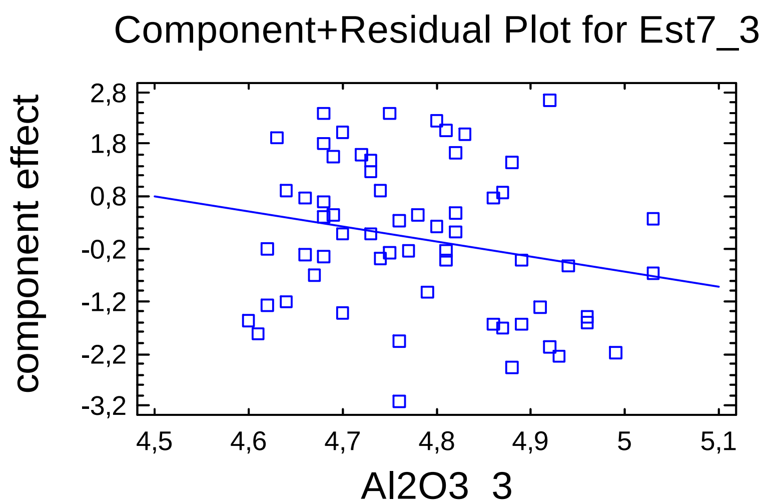
Est7_3 = 90,8807 - 2,90638*Al2O3_3 + 0,00237135*Blaine_3 -
0,831902*LOI_3 - 1,97108*SiO2_3

Since the P-value in the ANOVA table is less than 0.05, there is a
statistically significant relationship between the variables at the
95% confidence level.

     The R-Squared statistic indicates that the model as fitted
explains 18,2503% of the variability in Est7_3.  The adjusted
R-squared statistic, which is more suitable for comparing models with
```

different numbers of independent variables, is 12,411%. The standard error of the estimate shows the standard deviation of the residuals to be 1,45264. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,14818 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,5130, belonging to LOI_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing LOI_3 from the model.



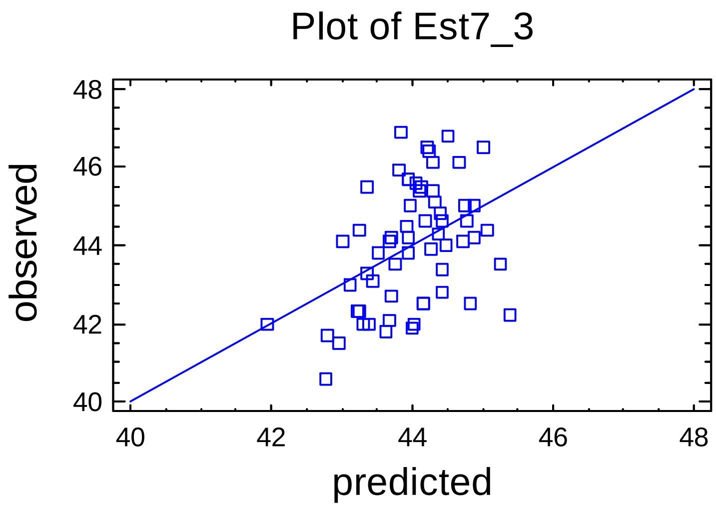
Correlation matrix for coefficient estimates

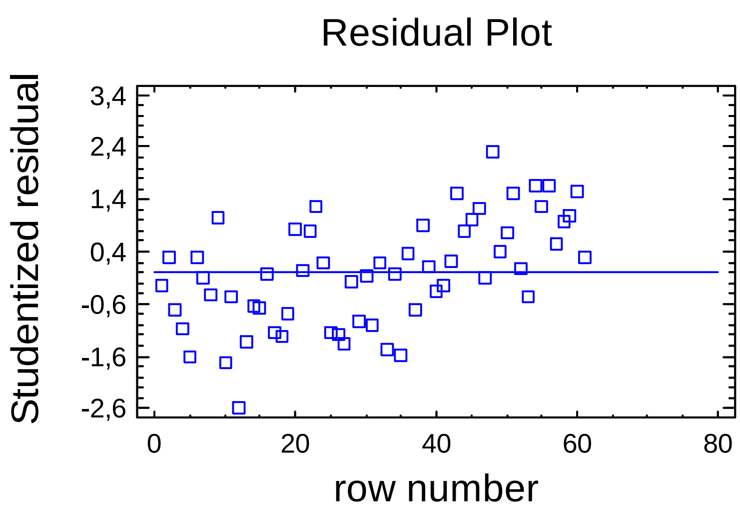
	CONSTANT	Al2O3_3	Blaine_3	LOI_3
CONSTANT	1,0000	0,1372	-0,6550	-0,1902
Al2O3_3	0,1372	1,0000	-0,1877	0,0781
Blaine_3	-0,6550	-0,1877	1,0000	0,0121
LOI_3	-0,1902	0,0781	0,0121	1,0000
SiO2_3	-0,7901	-0,5011	0,2102	0,1058

	SiO2_3
CONSTANT	-0,7901
Al2O3_3	-0,5011
Blaine_3	0,2102
LOI_3	0,1058
SiO2_3	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there is 1 correlation with absolute value greater than 0.5 (not including the constant term).






```
Multiple Regression - Est7_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est7_3
-----------------------------------------------------------------------------
                                          Standard          T
Parameter                 Estimate         Error        Statistic     P-Value
-----------------------------------------------------------------------------
CONSTANT                   99,3417        17,5426        5,66287       0,0000
SiO2_3                    -2,67811       0,848855       -3,15497       0,0025
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                     20,8665      1      20,8665       9,95       0,0025
Residual                  123,683     59      2,09633
-----------------------------------------------------------------------------
Total (Corr.)              144,55     60

R-squared = 14,4355 percent
R-squared (adjusted for d.f.) = 12,9852 percent
```

```
Standard Error of Est. = 1,44787
Mean absolute error = 1,17424
Durbin-Watson statistic = 1,13007 (P=0,0001)
Lag 1 residual autocorrelation = 0,433911


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  60 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 2,40916

     Step 1:
     ---------
     Adding variable SiO2_3 with F-to-enter = 9,95382
     1 variables in the model.  59 d.f. for error.
     R-squared =  14,44%     Adjusted R-squared =  12,99%     MSE = 2,09633

     Final model selected.
```

The StatAdvisor

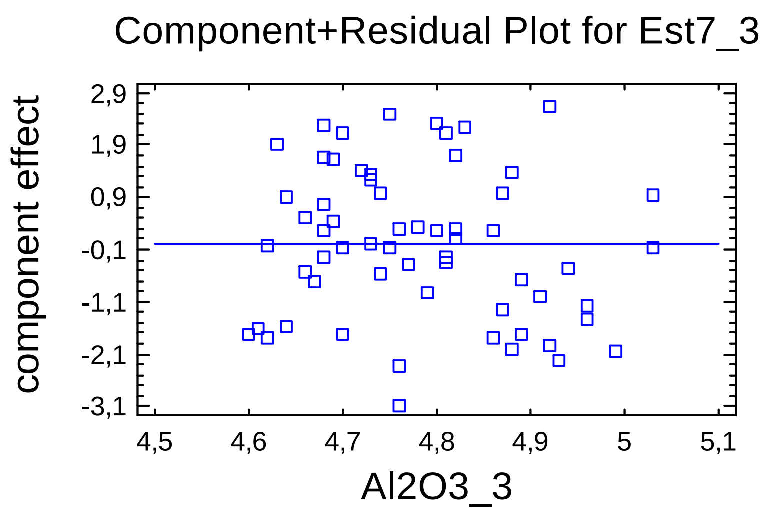
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7_3 and 4 independent variables. The equation of the fitted model is

Est7_3 = 99,3417 - 2,67811*SiO2_3

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99% confidence level.

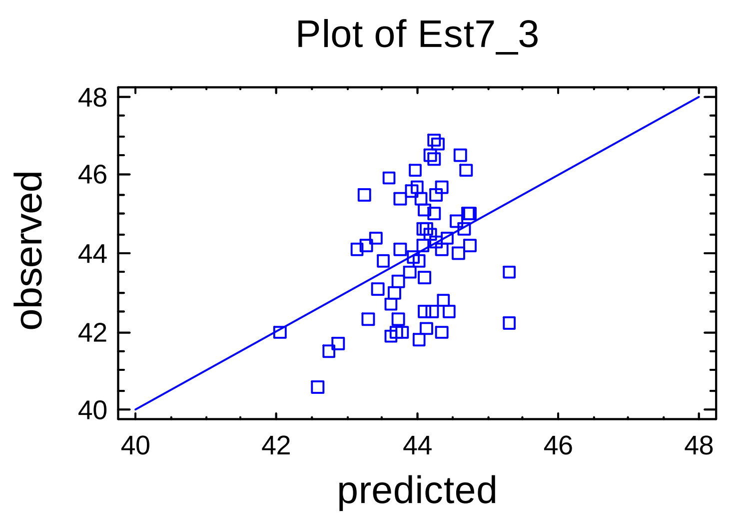
The R-Squared statistic indicates that the model as fitted explains 14,4355% of the variability in Est7_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 12,9852%. The standard error of the estimate shows the standard deviation of the residuals to be 1,44787. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,17424 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

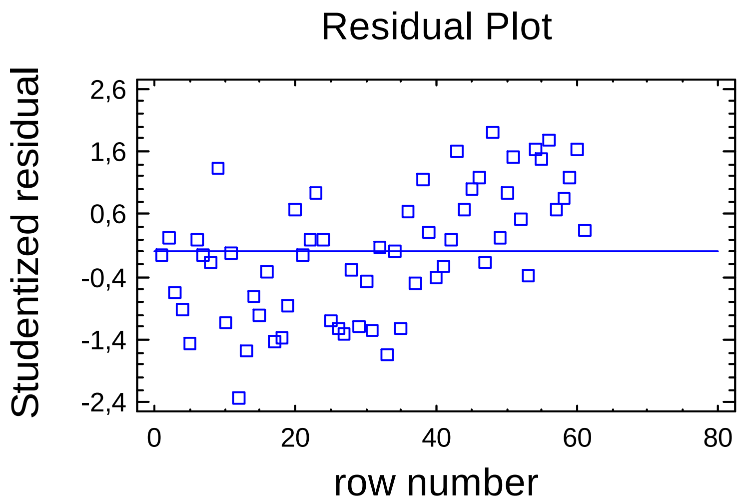
In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,0025, belonging to SiO2_3. Since the P-value is less than 0.01, the highest order term is statistically significant at the 99% confidence level. Consequently, you probably don't want to remove any variables from the model.




```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT          SiO2_3
CONSTANT                  1,0000         -0,9999
SiO2_3                   -0,9999          1,0000
-----------------------------------------------------------------------------


The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).
```






```
Multiple Regression - Est28_3

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est28_3
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error        Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                 62,3109       0,206541        301,688          0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio       P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  88,3046     45      1,96232
-----------------------------------------------------------------------------
Total (Corr.)             88,3046     45

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,40083
Mean absolute error = 1,09981
Durbin-Watson statistic = 1,71622 (P=0,1707)
Lag 1 residual autocorrelation = 0,117729


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  45 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,96232

     Final model selected.

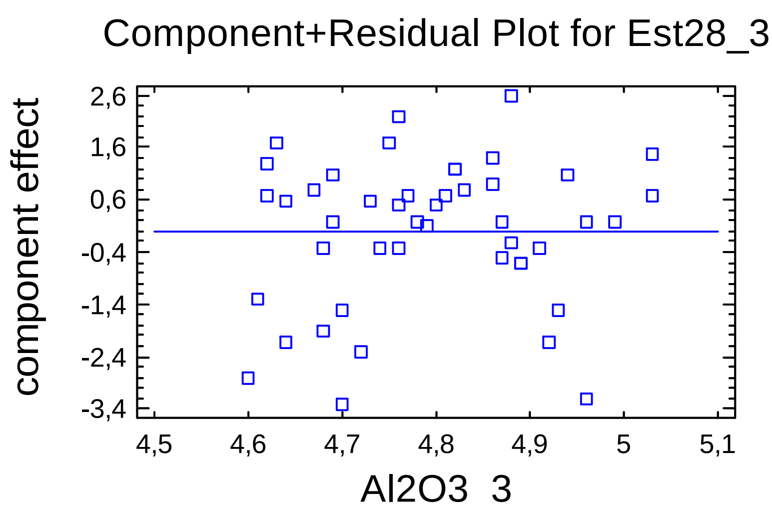


The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est28_3 and 4
```

independent variables. The equation of the fitted model is

Est28_3 = 62,3109

The R-Squared statistic indicates that the model as fitted explains 0,0% of the variability in Est28_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,40083. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,09981 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.



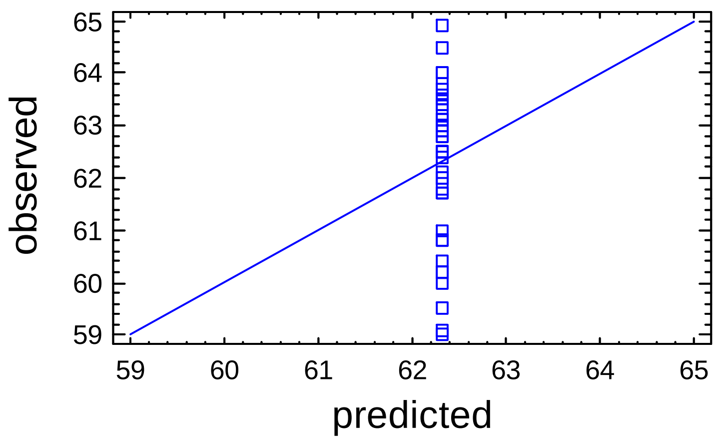
Correlation matrix for coefficient estimates

	CONSTANT
CONSTANT	1,0000

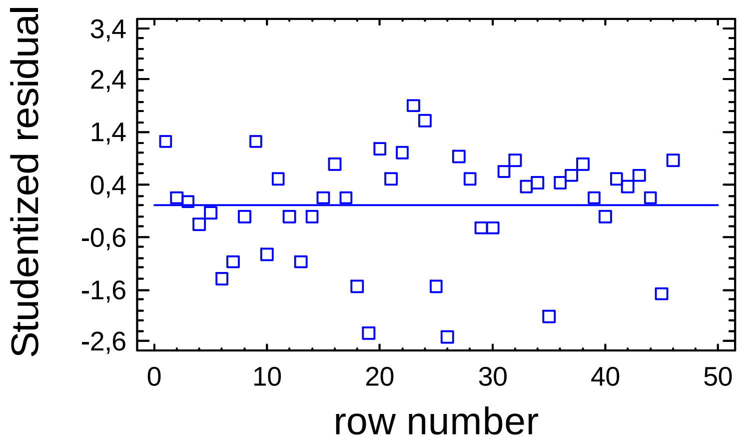
The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Plot of Est28_3



Residual Plot



Multiple Regression - Est28_3

Multiple Regression Analysis

Dependent variable: Est28_3

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	53,9409	25,5446	2,11164	0,0409
Al2O3_3	1,79985	2,15998	0,833274	0,4095
Blaine_3	0,00318596	0,00390407	0,81606	0,4192
LOI_3	-0,46652	1,54036	-0,302864	0,7635
SiO2_3	-0,552152	1,04299	-0,529391	0,5994

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	3,63126	4	0,907815	0,44	0,7792
Residual	84,6733	41	2,0652		
Total (Corr.)	88,3046	45			

```
R-squared = 4,1122 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,43708
Mean absolute error = 1,10963
Durbin-Watson statistic = 1,601 (P=0,0462)
Lag 1 residual autocorrelation = 0,178887
```

The StatAdvisor

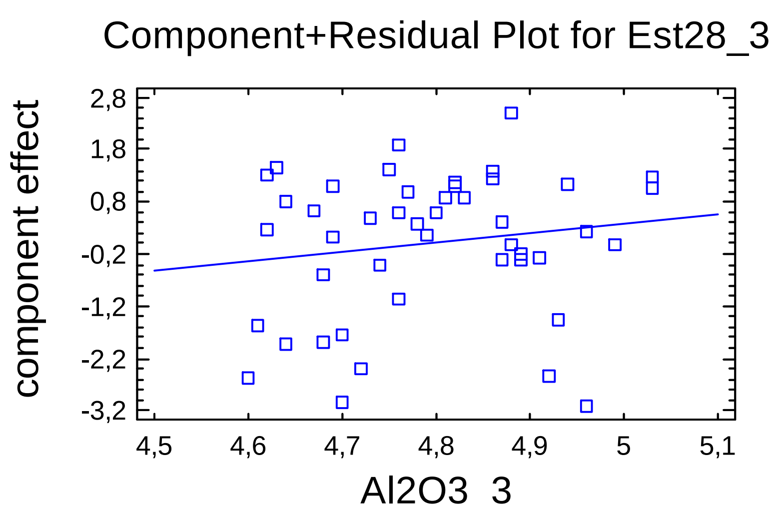
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_3 and 4 independent variables. The equation of the fitted model is

Est28_3 = 53,9409 + 1,79985*Al2O3_3 + 0,00318596*Blaine_3 - 0,46652*LOI_3 - 0,552152*SiO2_3

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 4,1122% of the variability in Est28_3. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 1,43708. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,10963 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7635, belonging to LOI_3. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing LOI_3 from the model.



Correlation matrix for coefficient estimates

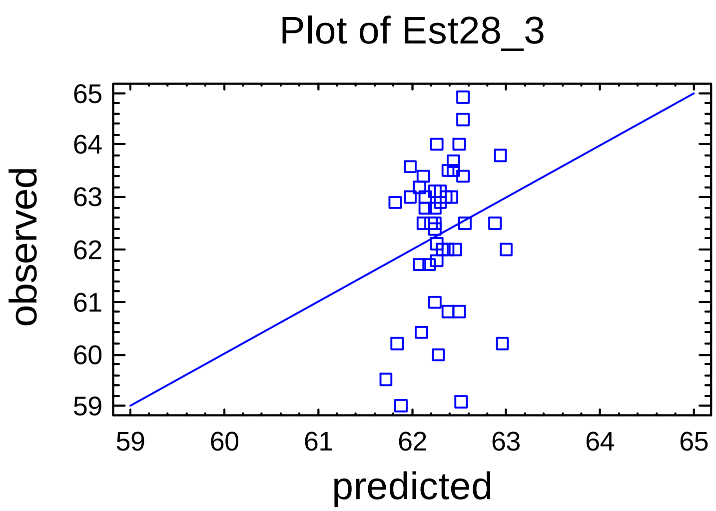
	CONSTANT	Al2O3_3	Blaine_3	LOI_3
CONSTANT	1,0000	0,0471	-0,6671	-0,2722
Al2O3_3	0,0471	1,0000	-0,0783	0,1742

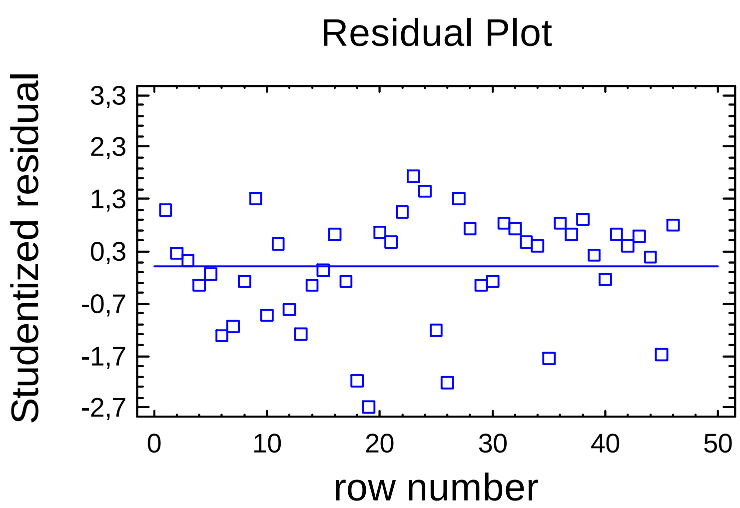
Blaine_3	-0,6671	-0,0783	1,0000	0,0501
LOI_3	-0,2722	0,1742	0,0501	1,0000
SiO2_3	-0,7400	-0,4982	0,1581	0,1217

	SiO2_3
CONSTANT	-0,7400
Al2O3_3	-0,4982
Blaine_3	0,1581
LOI_3	0,1217
SiO2_3	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple-Variable Analysis

```
Analysis Summary

Data variables:
     Al2O3_3
     Blaine_3
     LOI_3
     SO3_3

There are 66 complete cases for use in the calculations.


The StatAdvisor
---------------
   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
build a statistical model for your data.  Depending on your goal, one
of several procedures may be appropriate.  Following is a list of
goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of
more other variables.
PROCEDURE: Relate - Multiple regression

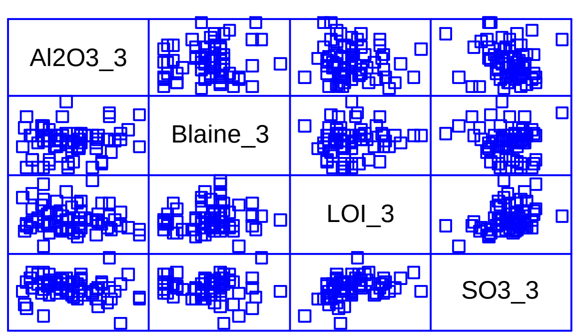
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows
belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful
measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of
the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to
each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations
```



Correlations

	Al2O3_3	Blaine_3	LOI_3	SO3_3
Al2O3_3		0,1327	-0,1197	-0,1717
		(66)	(66)	(66)
		0,2882	0,3382	0,1681
Blaine_3	0,1327		0,0904	-0,0897
	(66)		(66)	(66)
	0,2882		0,4703	0,4736
LOI_3	-0,1197	0,0904		0,3723
	(66)	(66)		(66)
	0,3382	0,4703		0,0021
SO3_3	-0,1717	-0,0897	0,3723	
	(66)	(66)	(66)	
	0,1681	0,4736	0,0021	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

LOI_3 and SO3_3

Spearman Rank Correlations

	Al2O3_3	Blaine_3	LOI_3	SO3_3
Al2O3_3		0,0638	-0,1083	-0,1943
		(66)	(66)	(66)
		0,6071	0,3826	0,1172
Blaine_3	0,0638		0,1043	-0,0066
	(66)		(66)	(66)
	0,6071		0,4004	0,9573
LOI_3	-0,1083	0,1043		0,3963
	(66)	(66)		(

66)
0,3826 0,4004
0,0014

SO3_3	-0,1943	-0,0066	0,3963
	(66)	(66)	(66)
	0,1172	0,9573	0,0014

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:
LOI_3 and SO3_3

Multiple-Variable Analysis

Analysis Summary

Data variables:
Blaine_4
Al2O3_4
LOI_4
sio2_4

There are 44 complete cases for use in the calculations.

The StatAdvisor

This procedure is designed to summarize several columns of quantitative data. It will calculate various statistics, including correlations, covariances, and partial correlations. Also included in the procedure are a number of multivariate graphs, which give interesting views into the data. Use the Tabular Options and Graphical Options buttons on the analysis toolbar to access these different procedures.

After this procedure, you may wish to select another procedure to build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

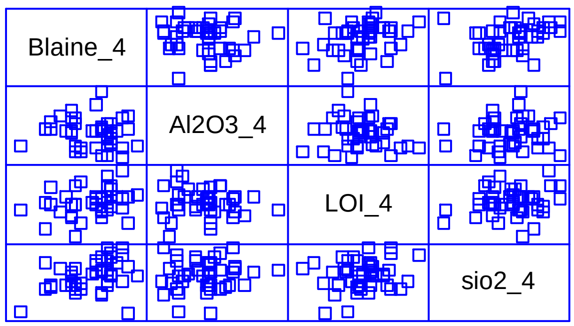
GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.

PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Blaine_4	Al2O3_4	LOI_4	sio2_4
Blaine_4		-0,1213 (44) 0,4329	0,3086 (44) 0,0416	0,3933 (44) 0,0083
Al2O3_4	-0,1213 (44) 0,4329		-0,0690 (44) 0,6562	0,1020 (44) 0,5101
LOI_4	0,3086 (44) 0,0416	-0,0690 (44) 0,6562		0,1856 (44) 0,2277
sio2_4	0,3933 (44) 0,0083	0,1020 (44) 0,5101	0,1856 (44) 0,2277	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Blaine_4 and LOI_4
Blaine_4 and sio2_4

Spearman Rank Correlations

	Blaine_4	Al2O3_4	LOI_4	sio2_4
Blaine_4		-0,2032	0,3533	0,3712
		(44)	(44)	(44)
		0,1826	0,0205	0,0149
Al2O3_4	-0,2032		-0,0748	0,0977
	(44)		(44)	(44)
	0,1826		0,6236	0,5218
LOI_4	0,3533	-0,0748		0,0959
	(44)	(44)		(44)
	0,0205	0,6236		0,5293
sio2_4	0,3712	0,0977	0,0959	
	(44)	(44)	(44)	
	0,0149	0,5218	0,5293	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Blaine_4 and LOI_4
Blaine_4 and sio2_4

Multiple Regression - Est1_4

Multiple Regression Analysis

Dependent variable: Est1_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	41,9881	17,2984	2,42729	0,0201
Al2O3_4	0,171539	1,41834	0,120944	0,9044
Blaine_4	-0,00258124	0,00301118	-0,857219	0,3967
LOI_4	0,997516	1,14297	0,872739	0,3883
sio2_4	-0,86516	0,832512	-1,03922	0,3053

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	2,29028	4	0,572571	0,75	0,5657
Residual	29,1013	38	0,765825		
Total (Corr.)	31,3916	42			

R-squared = 7,29584 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,875114
Mean absolute error = 0,677744
Durbin-Watson statistic = 1,18225 (P=0,0010)
Lag 1 residual autocorrelation = 0,352099

The StatAdvisor

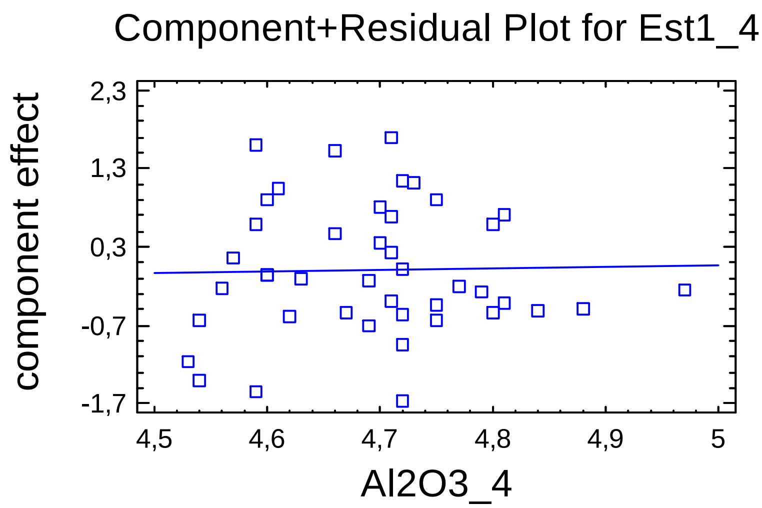
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est1_4 and 4 independent variables. The equation of the fitted model is

Est1_4 = 41,9881 + 0,171539*Al2O3_4 - 0,00258124*Blaine_4 + 0,997516*LOI_4 - 0,86516*sio2_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 7,29584% of the variability in Est1_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 0,875114. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,677744 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9044, belonging to Al2O3_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Al2O3_4 from the model.



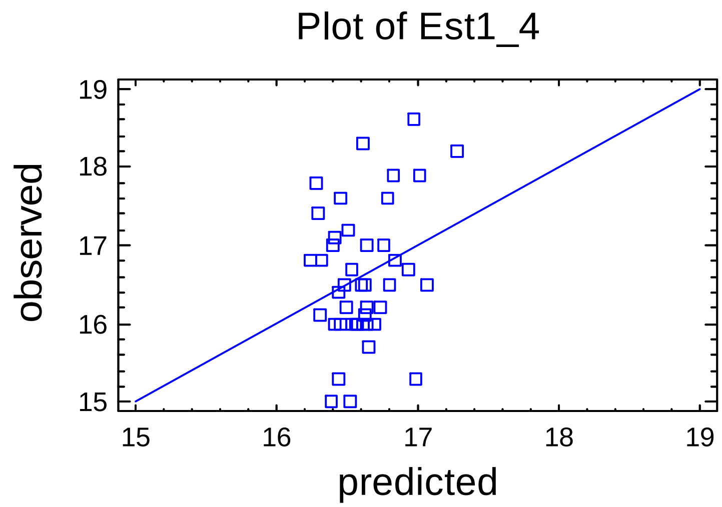
Correlation matrix for coefficient estimates

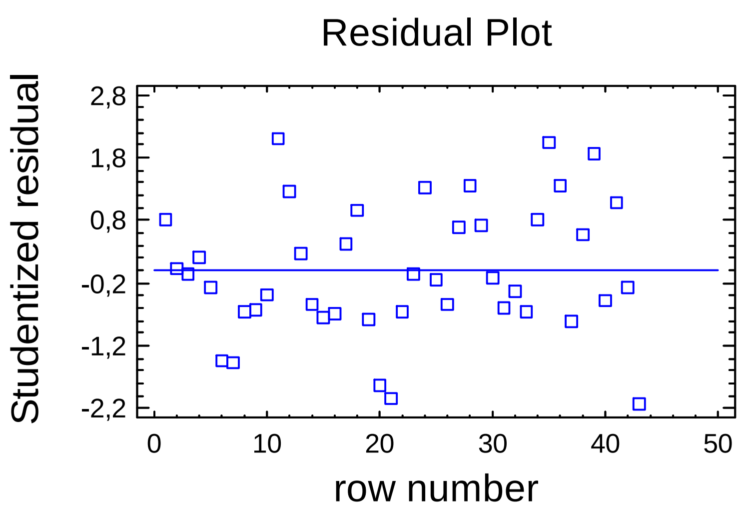
	CONSTANT	Al2O3_4	Blaine_4	LOI_4
CONSTANT	1,0000	-0,3214	-0,3208	0,1557
Al2O3_4	-0,3214	1,0000	0,1545	0,0482
Blaine_4	-0,3208	0,1545	1,0000	-0,2615
LOI_4	0,1557	0,0482	-0,2615	1,0000
sio2_4	-0,6875	-0,1679	-0,3635	-0,0860

	sio2_4
CONSTANT	-0,6875
Al2O3_4	-0,1679
Blaine_4	-0,3635
LOI_4	-0,0860
sio2_4	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).






```
Multiple Regression - Est1_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est1_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter               Estimate         Error       Statistic         P-Value
-----------------------------------------------------------------------------
CONSTANT                  16,614       0,13184         126,016          0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square    F-Ratio       P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                  31,3916     42      0,74742
-----------------------------------------------------------------------------
Total (Corr.)             31,3916     42

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,864534
```

```
Mean absolute error = 0,685343
Durbin-Watson statistic = 1,24651 (P=0,0059)
Lag 1 residual autocorrelation = 0,343775


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 0,74742

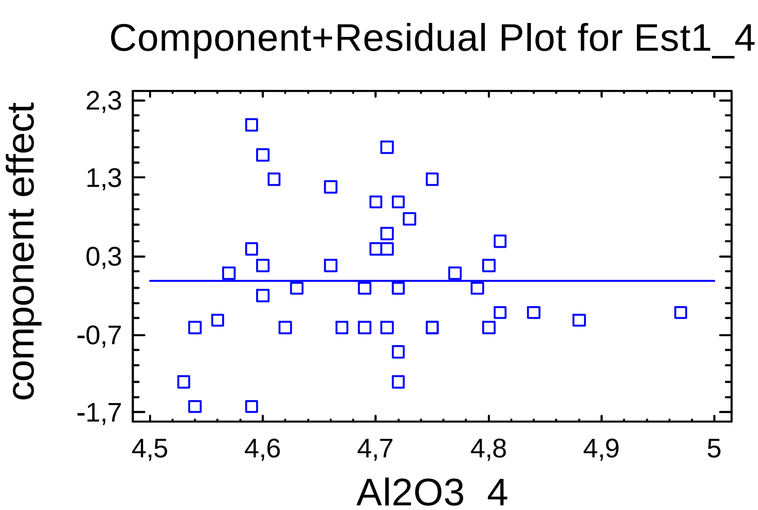
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est1_4 and 4
independent variables.  The equation of the fitted model is

Est1_4 = 16,614

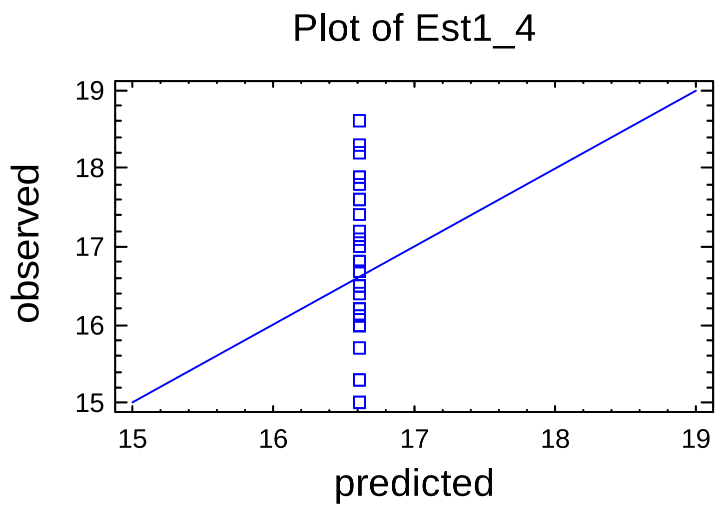
     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est1_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 0,864534.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 0,685343 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.
```

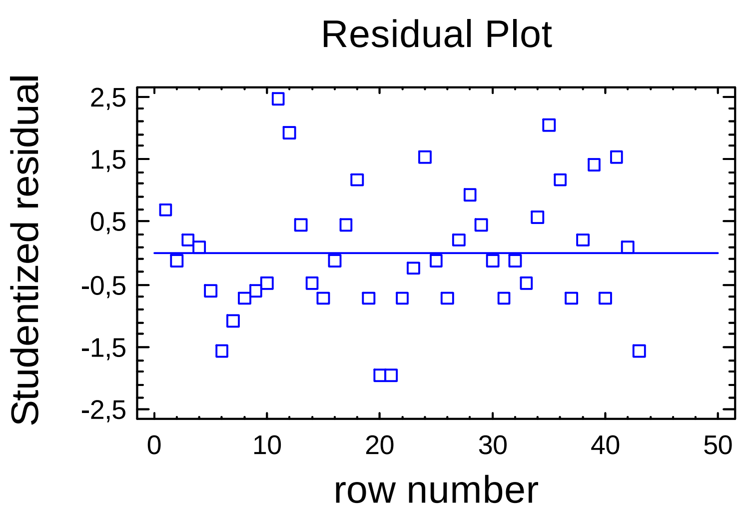



```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
```

```
CONSTANT                  1,0000
-----------------------------------------------------------------------------
```

```
The StatAdvisor
---------------
   This table shows estimated correlations between the coefficients in
the fitted model.  These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables.  In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).
```






```
Multiple Regression - Est2_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2_4
-----------------------------------------------------------------------------
                                            Standard          T
Parameter                Estimate             Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                  40,8838           19,3293         2,11512         0,0410
```

Al2O3_4	0,140413	1,58486	0,0885959	0,9299
Blaine_4	0,00104062	0,00336471	0,309274	0,7588
LOI_4	-0,0375825	1,27716	-0,0294265	0,9767
sio2_4	-0,857598	0,930254	-0,921897	0,3624

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,831148	4	0,207787	0,22	0,9272
Residual	36,3358	38	0,956206		
Total (Corr.)	37,167	42			

R-squared = 2,23625 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,977858
Mean absolute error = 0,754434
Durbin-Watson statistic = 1,46828 (P=0,0204)
Lag 1 residual autocorrelation = 0,238441

The StatAdvisor

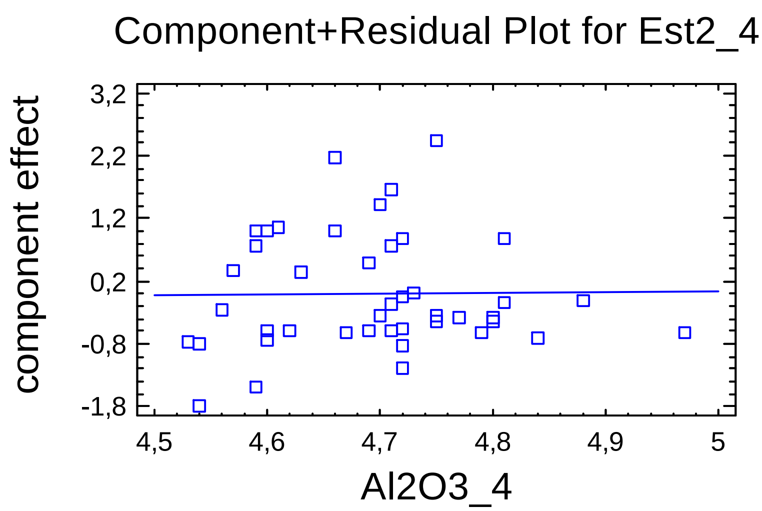
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est2_4 and 4 independent variables. The equation of the fitted model is

Est2_4 = 40,8838 + 0,140413*Al2O3_4 + 0,00104062*Blaine_4 - 0,0375825*LOI_4 - 0,857598*sio2_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 2,23625% of the variability in Est2_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 0,0%. The standard error of the estimate shows the standard deviation of the residuals to be 0,977858. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,754434 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9767, belonging to LOI_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing LOI_4 from the model.



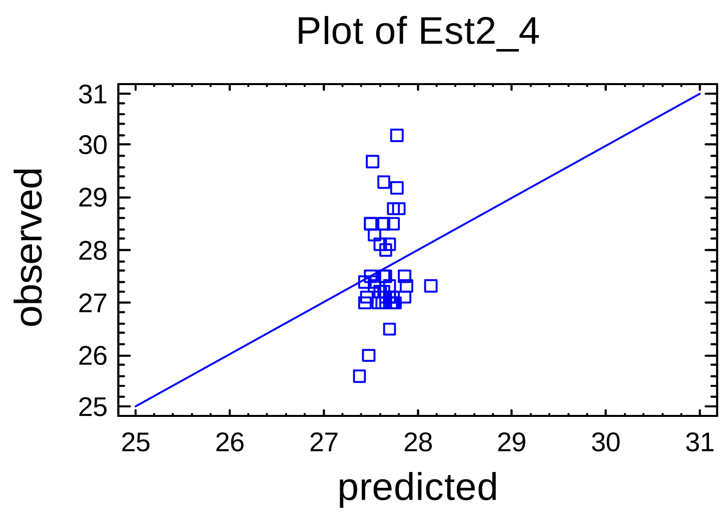
Correlation matrix for coefficient estimates

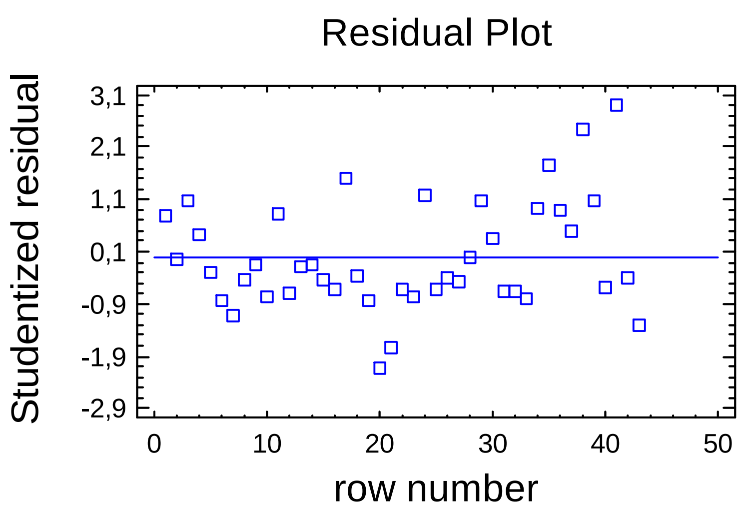
	CONSTANT	Al2O3_4	Blaine_4	LOI_4
CONSTANT	1,0000	-0,3214	-0,3208	0,1557
Al2O3_4	-0,3214	1,0000	0,1545	0,0482
Blaine_4	-0,3208	0,1545	1,0000	-0,2615
LOI_4	0,1557	0,0482	-0,2615	1,0000
sio2_4	-0,6875	-0,1679	-0,3635	-0,0860

	sio2_4
CONSTANT	-0,6875
Al2O3_4	-0,1679
Blaine_4	-0,3635
LOI_4	-0,0860
sio2_4	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).






```
Multiple Regression - Est2_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est2_4
-----------------------------------------------------------------------------
                                           Standard          T
Parameter                Estimate            Error       Statistic        P-Value
-----------------------------------------------------------------------------
CONSTANT                  27,6535         0,143456        192,766         0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source              Sum of Squares     Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                          0,0      0
Residual                    37,167     42     0,884928
-----------------------------------------------------------------------------
Total (Corr.)               37,167     42

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 0,940706
```

```
Mean absolute error = 0,75338
Durbin-Watson statistic = 1,539 (P=0,0661)
Lag 1 residual autocorrelation = 0,206977


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  42 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 0,884928

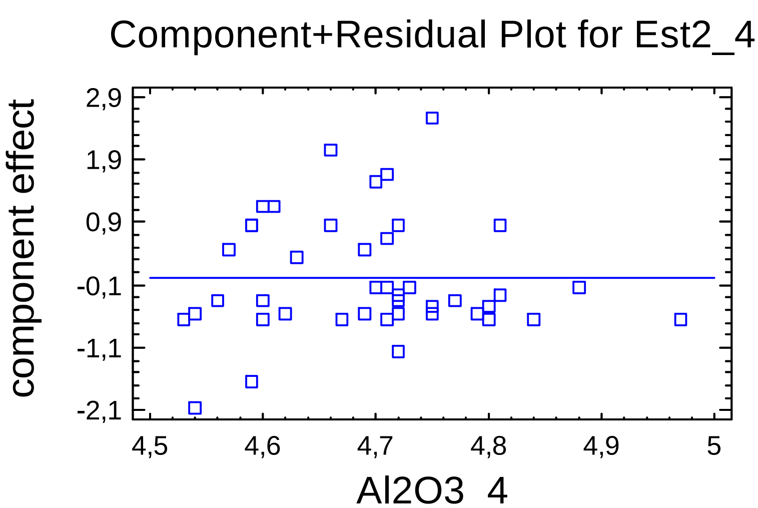
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est2_4 and 4
independent variables.  The equation of the fitted model is

Est2_4 = 27,6535

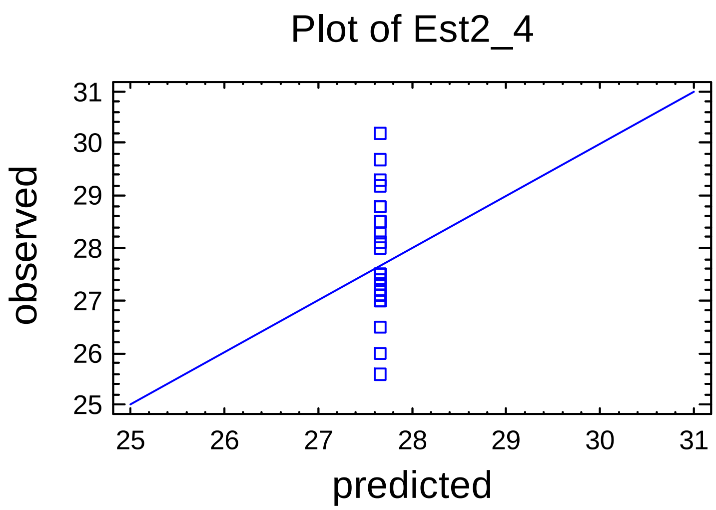
     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est2_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 0,940706.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 0,75338 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is greater
than 0.05, there is no indication of serial autocorrelation in the
residuals.
```

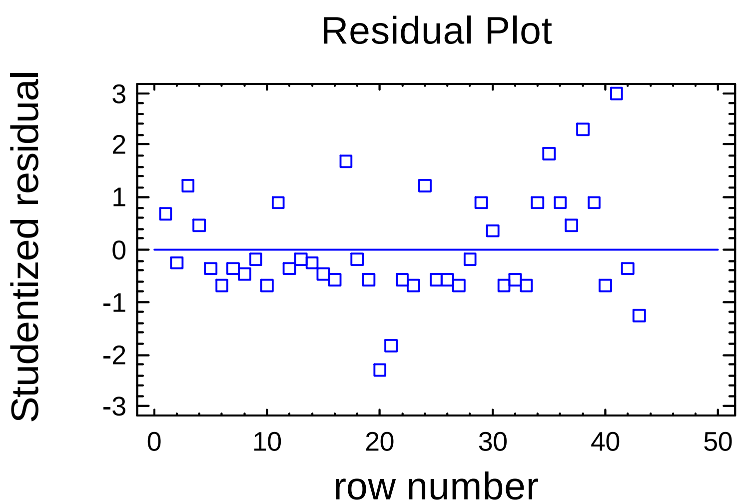



```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
```

The StatAdvisor

   This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple Regression - Est7_4

Multiple Regression Analysis

Dependent variable: Est7_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	43,4854	26,0697	1,66804	0,1042
Al2O3_4	1,42281	2,06208	0,689989	0,4948

Blaine_4	0,00553258	0,00464382	1,19139	0,2415
LOI_4	-2,91636	1,71125	-1,70423	0,0972
sio2_4	-1,19267	1,21386	-0,982545	0,3326

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	7,64638	4	1,91159	1,22	0,3219
Residual	55,0576	35	1,57307		
Total (Corr.)	62,704	39			

R-squared = 12,1944 percent
R-squared (adjusted for d.f.) = 2,15947 percent
Standard Error of Est. = 1,25422
Mean absolute error = 0,907696
Durbin-Watson statistic = 1,21504 (P=0,0020)
Lag 1 residual autocorrelation = 0,363409

The StatAdvisor

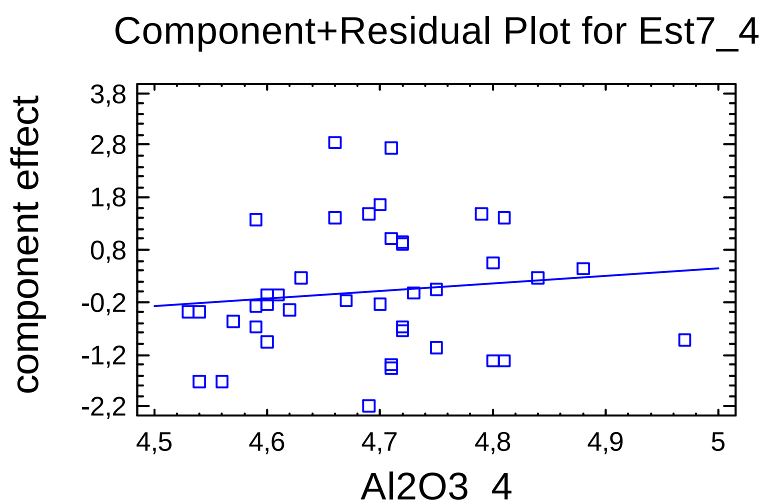
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est7_4 and 4 independent variables. The equation of the fitted model is

Est7_4 = 43,4854 + 1,42281*Al2O3_4 + 0,00553258*Blaine_4 - 2,91636*LOI_4 - 1,19267*sio2_4

Since the P-value in the ANOVA table is greater or equal to 0.10, there is not a statistically significant relationship between the variables at the 90% or higher confidence level.

The R-Squared statistic indicates that the model as fitted explains 12,1944% of the variability in Est7_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 2,15947%. The standard error of the estimate shows the standard deviation of the residuals to be 1,25422. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,907696 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,4948, belonging to Al2O3_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Al2O3_4 from the model.



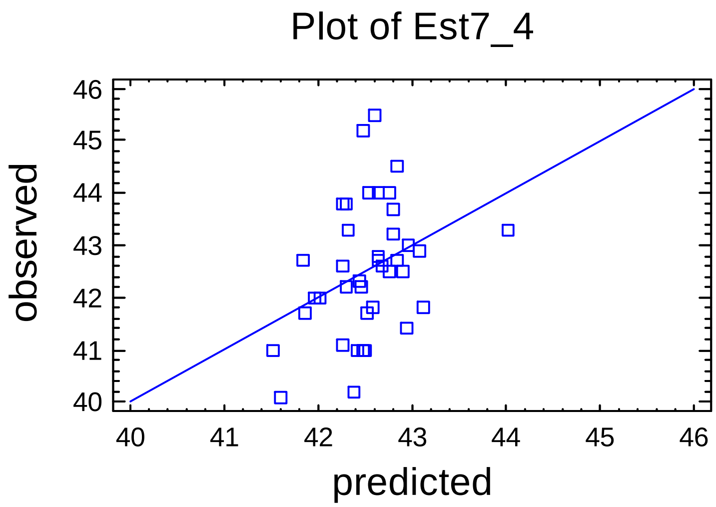
Correlation matrix for coefficient estimates

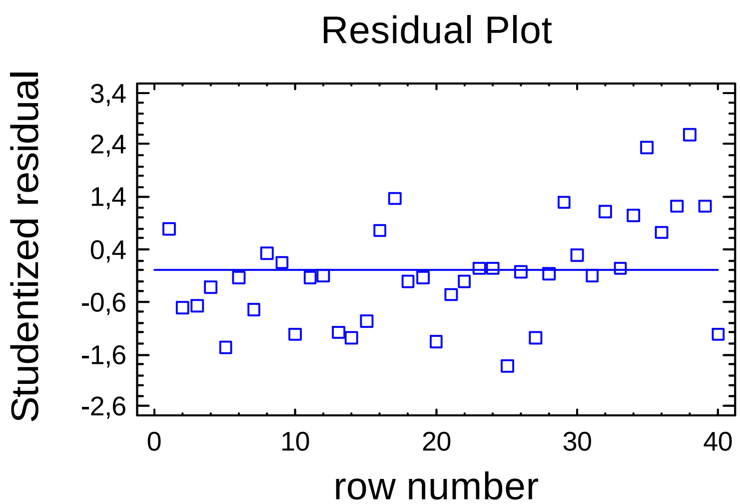
	CONSTANT	Al2O3_4	Blaine_4	LOI_4
CONSTANT	1,0000	-0,2571	-0,3931	0,2189
Al2O3_4	-0,2571	1,0000	0,0949	0,0886
Blaine_4	-0,3931	0,0949	1,0000	-0,3061
LOI_4	0,2189	0,0886	-0,3061	1,0000
sio2_4	-0,6898	-0,1908	-0,2880	-0,1338

	sio2_4
CONSTANT	-0,6898
Al2O3_4	-0,1908
Blaine_4	-0,2880
LOI_4	-0,1338
sio2_4	1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple Regression - Est7_4

Multiple Regression Analysis

Dependent variable: Est7_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	42,52	0,200487	212,084	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,0	0			
Residual	62,704	39	1,60779		
Total (Corr.)	62,704	39			

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 1,26799

```
Mean absolute error = 0,995
Durbin-Watson statistic = 1,04571 (P=0,0008)
Lag 1 residual autocorrelation = 0,453872


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

     Step 0:
     ---------
     0 variables in the model.  39 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 1,60779

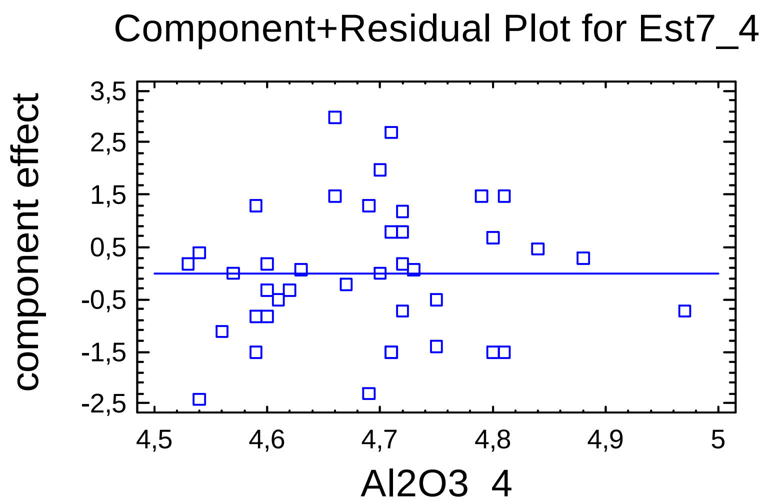
     Final model selected.




The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est7_4 and 4
independent variables.  The equation of the fitted model is

Est7_4 = 42,52

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est7_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 1,26799.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 0,995 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is less than
0.05, there is an indication of possible serial correlation.  Plot the
residuals versus row order to see if there is any pattern which can be
seen.
```

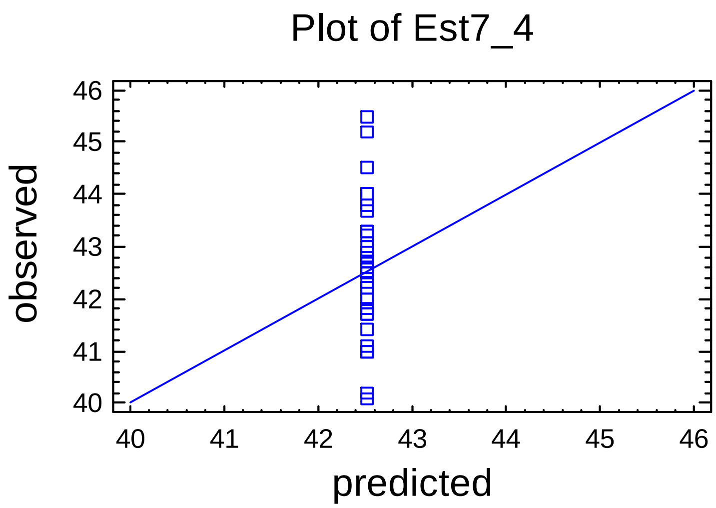


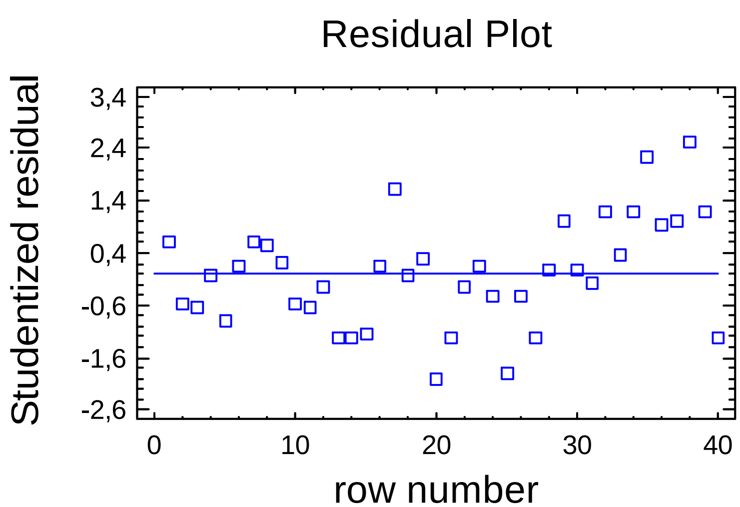

```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
```

CONSTANT   1,0000

The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).





Multiple Regression - Est28_4

Multiple Regression Analysis

Dependent variable: Est28_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	113,664	44,1263	2,57589	0,0166

Al2O3_4	7,75457	3,5148	2,20626	0,0372
Blaine_4	-0,00225153	0,00771833	-0,291713	0,7730
LOI_4	-3,47307	2,77163	-1,25308	0,2222
sio2_4	-3,69425	1,99495	-1,8518	0,0764

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	44,3522	4	11,088	2,90	0,0431
Residual	91,6575	24	3,81906		
Total (Corr.)	136,01	28			

R-squared = 32,6096 percent
R-squared (adjusted for d.f.) = 21,3778 percent
Standard Error of Est. = 1,95424
Mean absolute error = 1,52695
Durbin-Watson statistic = 2,21974 (P=0,1692)
Lag 1 residual autocorrelation = -0,138164

The StatAdvisor

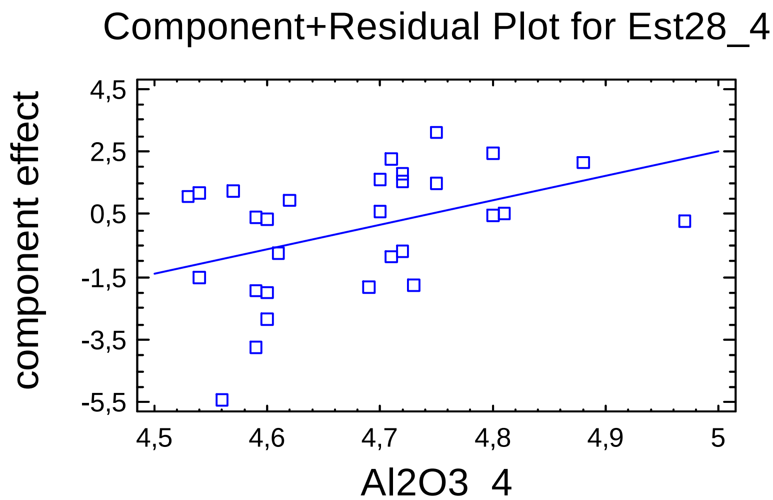
The output shows the results of fitting a multiple linear regression model to describe the relationship between Est28_4 and 4 independent variables. The equation of the fitted model is

Est28_4 = 113,664 + 7,75457*Al2O3_4 - 0,00225153*Blaine_4 - 3,47307*LOI_4 - 3,69425*sio2_4

Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between the variables at the 95% confidence level.

The R-Squared statistic indicates that the model as fitted explains 32,6096% of the variability in Est28_4. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 21,3778%. The standard error of the estimate shows the standard deviation of the residuals to be 1,95424. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 1,52695 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,7730, belonging to Blaine_4. Since the P-value is greater or equal to 0.10, that term is not statistically significant at the 90% or higher confidence level. Consequently, you should consider removing Blaine_4 from the model.



Correlation matrix for coefficient estimates

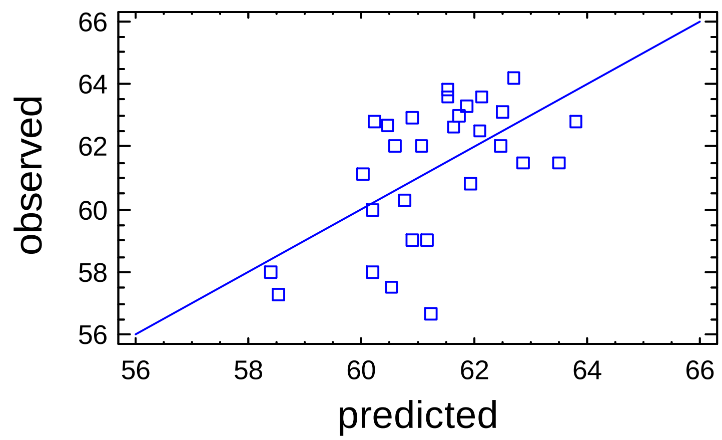
	CONSTANT	Al2O3_4	Blaine_4	LOI_4
CONSTANT	1,0000	-0,2053	-0,4584	0,2555
Al2O3_4	-0,2053	1,0000	0,0813	0,0805
Blaine_4	-0,4584	0,0813	1,0000	-0,3053
LOI_4	0,2555	0,0805	-0,3053	1,0000
sio2_4	-0,6933	-0,2425	-0,2094	-0,1753

	sio2_4
CONSTANT	-0,6933
Al2O3_4	-0,2425
Blaine_4	-0,2094
LOI_4	-0,1753
sio2_4	1,0000

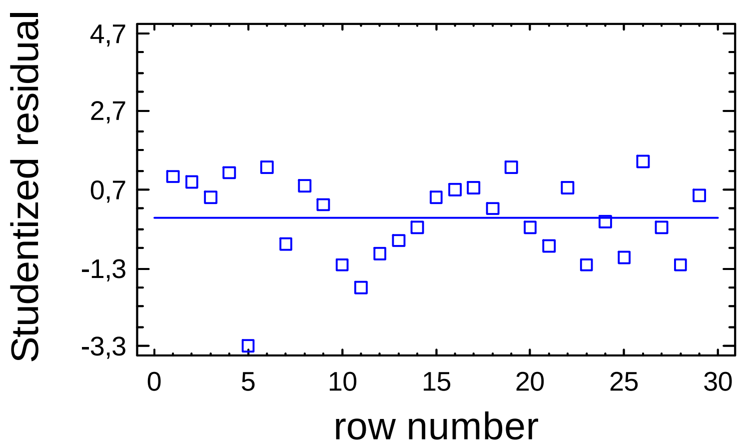
The StatAdvisor

This table shows estimated correlations between the coefficients in the fitted model. These correlations can be used to detect the presence of serious multicollinearity, i.e., correlation amongst the predictor variables. In this case, there are no correlations with absolute values greater than 0.5 (not including the constant term).

Plot of Est28_4



Residual Plot




```
Multiple Regression - Est28_4

Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: Est28_4
-----------------------------------------------------------------------------
                                       Standard          T
Parameter                Estimate         Error     Statistic         P-Value
-----------------------------------------------------------------------------
CONSTANT                  61,2966      0,409267       149,772          0,0000
-----------------------------------------------------------------------------

                           Analysis of Variance
-----------------------------------------------------------------------------
Source             Sum of Squares     Df  Mean Square     F-Ratio     P-Value
-----------------------------------------------------------------------------
Model                         0,0      0
Residual                   136,01     28      4,85749
-----------------------------------------------------------------------------
Total (Corr.)              136,01     28

R-squared = 0,0 percent
R-squared (adjusted for d.f.) = 0,0 percent
Standard Error of Est. = 2,20397
```

```
Mean absolute error = 1,83187
Durbin-Watson statistic = 1,71458 (P=0,2259)
Lag 1 residual autocorrelation = 0,133114


Stepwise regression
-------------------
Method: forward selection
F-to-enter: 4,0
F-to-remove: 4,0

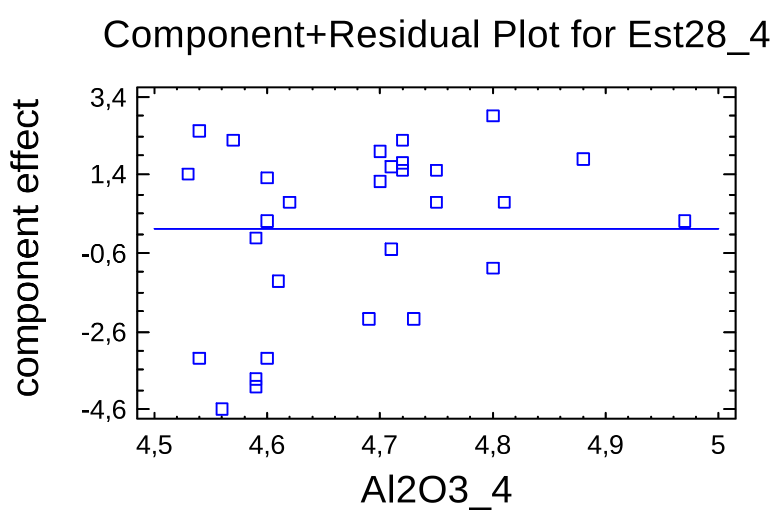
     Step 0:
     ---------
     0 variables in the model.  28 d.f. for error.
     R-squared =   0,00%     Adjusted R-squared =   0,00%     MSE = 4,85749

     Final model selected.
```

```
The StatAdvisor
---------------
   The output shows the results of fitting a multiple linear
regression model to describe the relationship between Est28_4 and 4
independent variables.  The equation of the fitted model is

Est28_4 = 61,2966

     The R-Squared statistic indicates that the model as fitted
explains 0,0% of the variability in Est28_4.  The adjusted R-squared
statistic, which is more suitable for comparing models with different
numbers of independent variables, is 0,0%.  The standard error of the
estimate shows the standard deviation of the residuals to be 2,20397.
This value can be used to construct prediction limits for new
observations by selecting the Reports option from the text menu.  The
mean absolute error (MAE) of 1,83187 is the average value of the
residuals.  The Durbin-Watson (DW) statistic tests the residuals to
determine if there is any significant correlation based on the order
in which they occur in your data file.  Since the P-value is greater
than 0.05, there is no indication of serial autocorrelation in the
residuals.
```

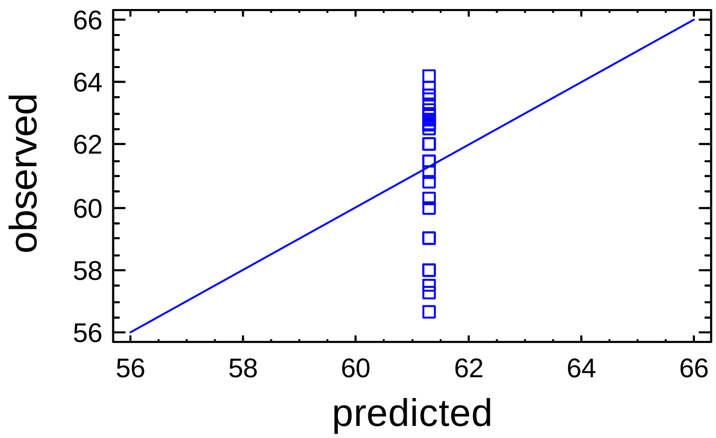



```
Correlation matrix for coefficient estimates
-----------------------------------------------------------------------------
                        CONSTANT
CONSTANT                  1,0000
```

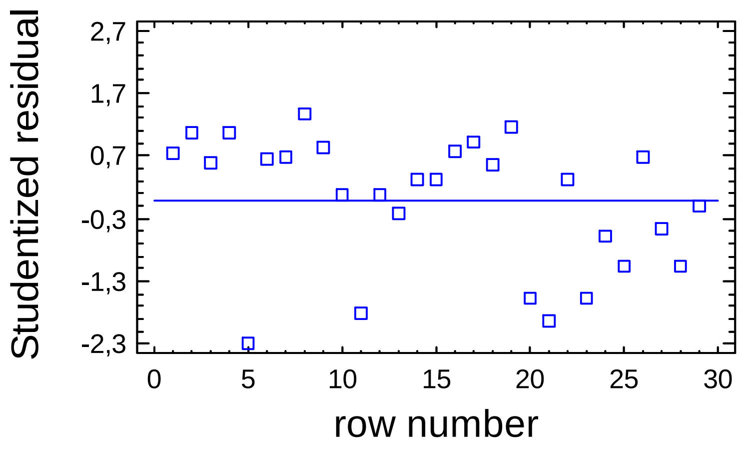
The StatAdvisor

   This table shows estimated correlations between the coefficients in
the fitted model. These correlations can be used to detect the
presence of serious multicollinearity, i.e., correlation amongst the
predictor variables. In this case, there are no correlations with
absolute values greater than 0.5 (not including the constant term).

Plot of Est28_4



Residual Plot



Simple Regression - Est2_4 vs. Est1_4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est2_4
Independent variable: Est1_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	13,4367	1,7486	7,68425	0,0000
Slope	0,857215	0,104725	8,18536	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	30,9339	1	30,9339	67,00	0,0000
Residual	20,3148	44	0,4617		
Total (Corr.)	51,2487	45			

Correlation Coefficient = 0,77692
R-squared = 60,3604 percent
R-squared (adjusted for d.f.) = 59,4595 percent
Standard Error of Est. = 0,679485
Mean absolute error = 0,493968
Durbin-Watson statistic = 1,64103 (P=0,0967)
Lag 1 residual autocorrelation = 0,179071

The StatAdvisor

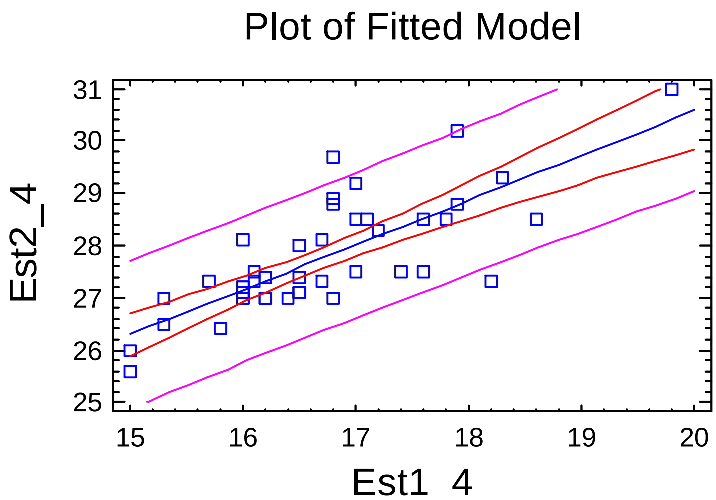
The output shows the results of fitting a linear model to describe the relationship between Est2_4 and Est1_4. The equation of the fitted model is

Est2_4 = 13,4367 + 0,857215*Est1_4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Est2_4 and Est1_4 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 60,3604% of the variability in Est2_4. The correlation coefficient equals 0,77692, indicating a moderately strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,679485. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,493968 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

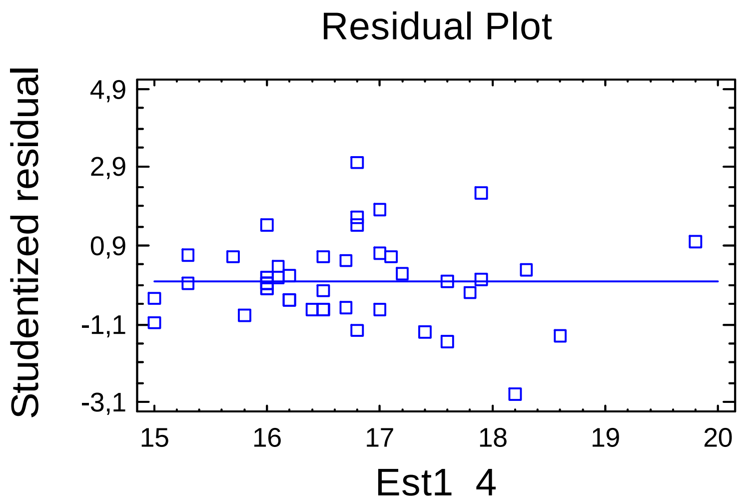


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	30,9339	1	30,9339	67,00	0,0000
Residual	20,3148	44	0,4617		
Lack-of-Fit	11,2961	20	0,564806	1,50	0,1694
Pure Error	9,01867	24	0,375778		
Total (Corr.)	51,2487	45			

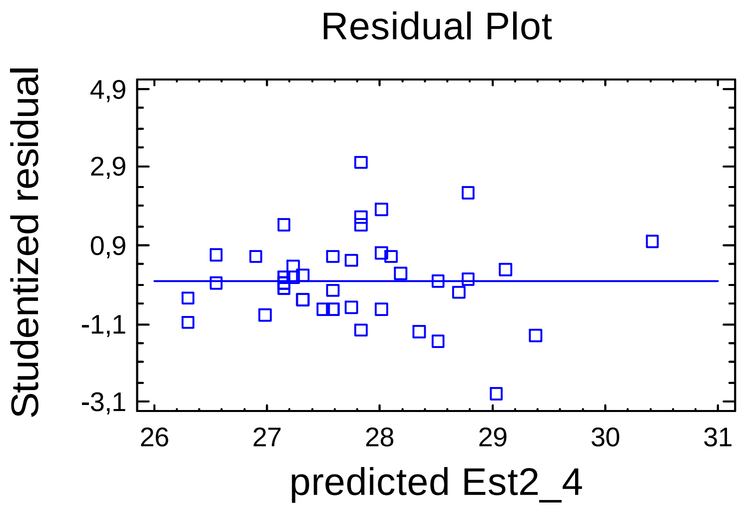
The StatAdvisor

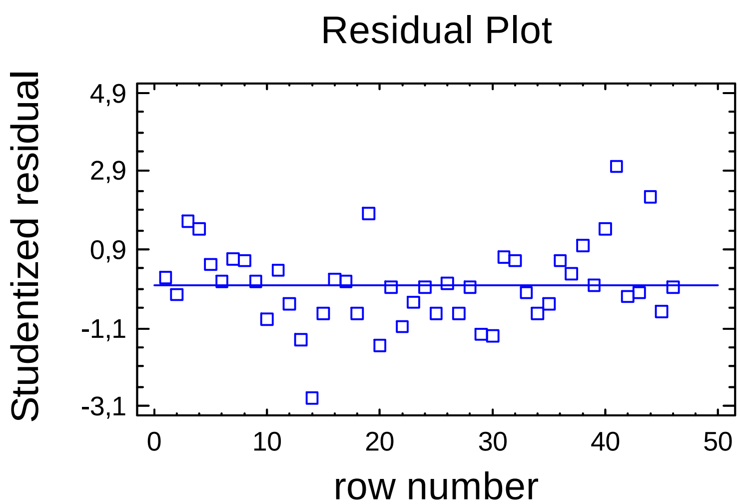
The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.




```
Comparison of Alternative Models
--------------------------------------------------
Model                     Correlation      R-Squared
--------------------------------------------------
Double reciprocal             0,7825         61,23%
S-curve                      -0,7804         60,90%
Multiplicative                0,7795         60,77%
Reciprocal-Y                 -0,7779         60,52%
Logarithmic-X                 0,7779         60,51%
Reciprocal-X                 -0,7778         60,50%
Exponential                   0,7776         60,47%
Square root-X                 0,7775         60,46%
Square root-Y                 0,7773         60,42%
Linear                        0,7769         60,36%
Logistic                           <no fit>
Log probit                         <no fit>
--------------------------------------------------


The StatAdvisor
---------------
   This table shows the results of fitting several curvilinear models
to the data.  Of the models fitted, the double reciprocal model yields
the highest R-Squared value with 61,2303%.  This is 0,86988% higher
than the currently selected linear model.  To change models, select
the Analysis Options dialog box.
```





Simple Regression - Est7_4 vs. Est2_4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est7_4
Independent variable: Est2_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	16,3461	3,96276	4,12492	0,0002
Slope	0,946969	0,14293	6,62541	0,0000

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	38,944	1	38,944	43,90	0,0000
Residual	36,3746	41	0,887186		
Total (Corr.)	75,3186	42			

```
Correlation Coefficient = 0,719067
R-squared = 51,7057 percent
R-squared (adjusted for d.f.) = 50,5278 percent
Standard Error of Est. = 0,941905
Mean absolute error = 0,754773
Durbin-Watson statistic = 1,09584 (P=0,0006)
Lag 1 residual autocorrelation = 0,440261
```

The StatAdvisor

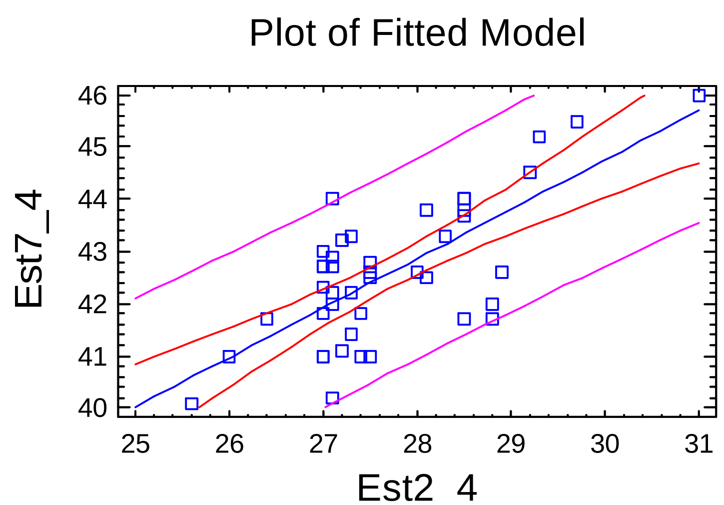
The output shows the results of fitting a linear model to describe the relationship between Est7_4 and Est2_4. The equation of the fitted model is

Est7_4 = 16,3461 + 0,946969*Est2_4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Est7_4 and Est2_4 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 51,7057% of the variability in Est7_4. The correlation coefficient equals 0,719067, indicating a moderately strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0,941905. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 0,754773 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is less than 0.05, there is an indication of possible serial correlation. Plot the residuals versus row order to see if there is any pattern which can be seen.

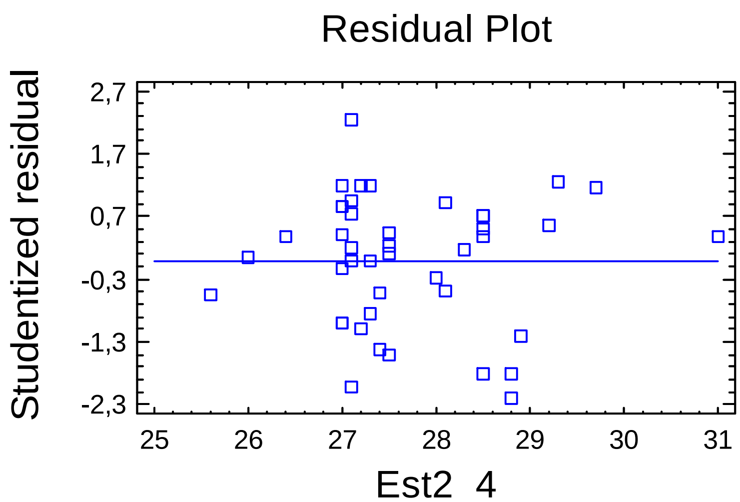


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	38,944	1	38,944	43,90	0,0000
Residual	36,3746	41	0,887186		
Lack-of-Fit	13,2525	17	0,779558	0,81	0,6692
Pure Error	23,1221	24	0,963422		
Total (Corr.)	75,3186	42			

The StatAdvisor

   The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

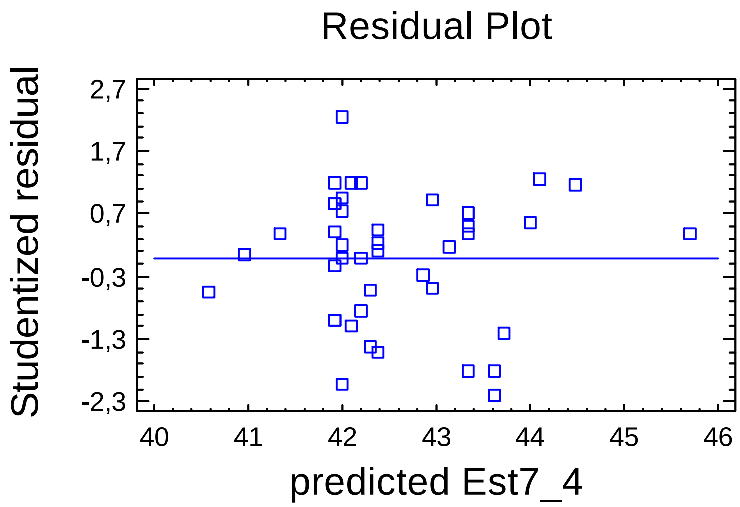


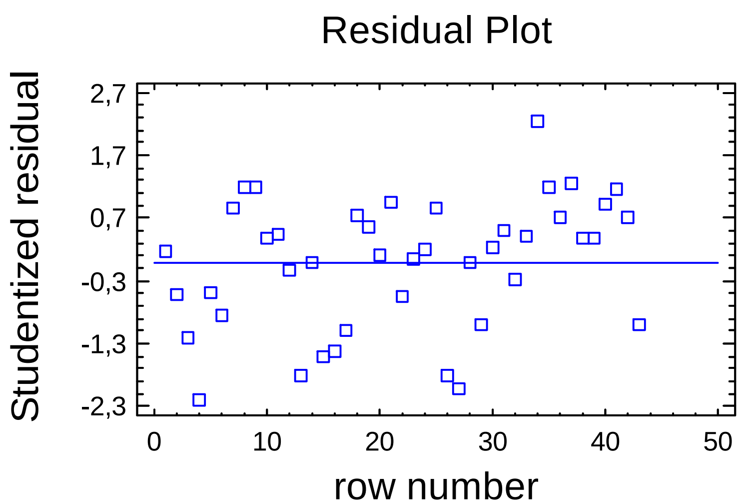
Comparison of Alternative Models

Model	Correlation	R-Squared
Linear	0,7191	51,71%
Square root-X	0,7182	51,58%
Logarithmic-X	0,7172	51,43%
Square root-Y	0,7167	51,37%
Reciprocal-X	-0,7148	51,10%
Exponential	0,7144	51,03%
Multiplicative	0,7129	50,82%
S-curve	-0,7109	50,54%
Reciprocal-Y	-0,7095	50,34%
Double reciprocal	0,7069	49,97%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

   This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the linear model yields the highest R-Squared value with 51,7057%. This is the currently selected model.





Simple Regression - Est28_4 vs. Est7_4

Regression Analysis - Linear model: Y = a + b*X

Dependent variable: Est28_4
Independent variable: Est7_4

Parameter	Estimate	Standard Error	T Statistic	P-Value
Intercept	16,4107	14,8035	1,10857	0,2767
Slope	1,06399	0,351288	3,02882	0,0051

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	34,3967	1	34,3967	9,17	0,0051
Residual	108,734	29	3,74946		
Total (Corr.)	143,131	30			

Correlation Coefficient = 0,49022
R-squared = 24,0316 percent
R-squared (adjusted for d.f.) = 21,412 percent
Standard Error of Est. = 1,93635
Mean absolute error = 1,55603
Durbin-Watson statistic = 2,0285 (P=0,4491)
Lag 1 residual autocorrelation = -0,0318893

The StatAdvisor

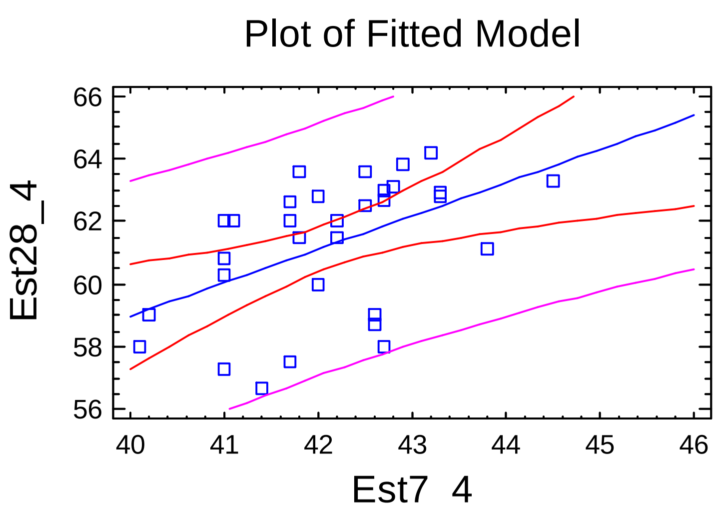
The output shows the results of fitting a linear model to describe the relationship between Est28_4 and Est7_4. The equation of the fitted model is

Est28_4 = 16,4107 + 1,06399*Est7_4

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between Est28_4 and Est7_4 at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 24,0316% of the variability in Est28_4. The correlation coefficient equals 0,49022, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 1,93635. This value can be used to construct prediction limits for new observations by selecting the Forecasts option from the text menu.

The mean absolute error (MAE) of 1,55603 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.

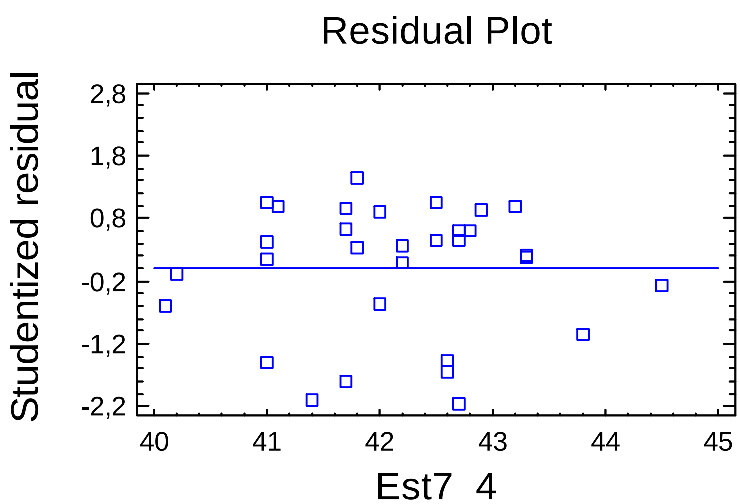


Analysis of Variance with Lack-of-Fit

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	34,3967	1	34,3967	9,17	0,0051
Residual	108,734	29	3,74946		
Lack-of-Fit	58,5826	16	3,66141	0,95	0,5461
Pure Error	50,1517	13	3,85782		
Total (Corr.)	143,131	30			

The StatAdvisor

The lack of fit test is designed to determine whether the selected model is adequate to describe the observed data, or whether a more complicated model should be used. The test is performed by comparing the variability of the current model residuals to the variability between observations at replicate values of the independent variable X. Since the P-value for lack-of-fit in the ANOVA table is greater or equal to 0.10, the model appears to be adequate for the observed data.

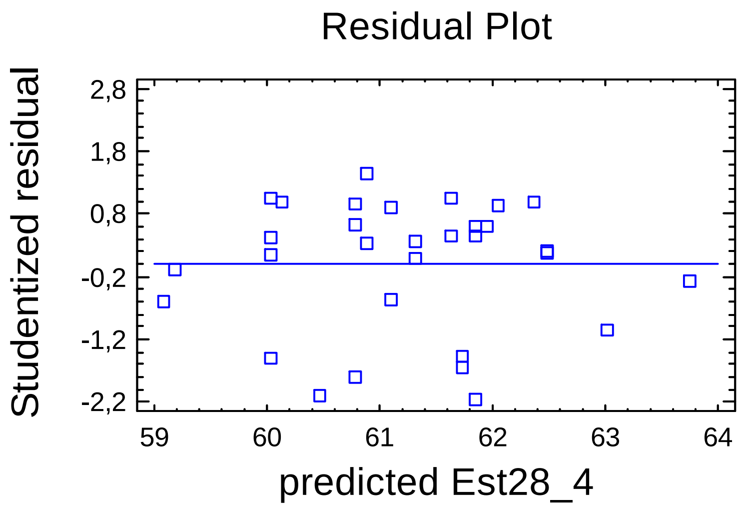


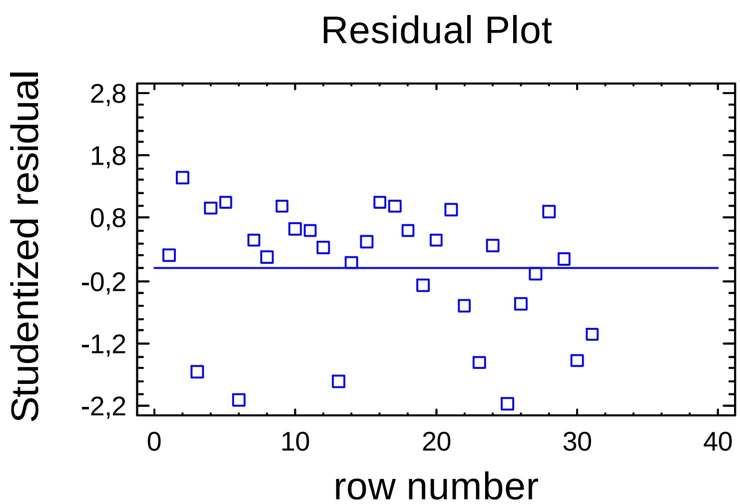
Comparison of Alternative Models

Model	Correlation	R-Squared
Reciprocal-X	-0,4933	24,33%
Logarithmic-X	0,4918	24,19%
Square root-X	0,4910	24,11%
S-curve	-0,4906	24,07%
Linear	0,4902	24,03%
Multiplicative	0,4892	23,93%
Square root-Y	0,4889	23,90%
Double reciprocal	0,4879	23,81%
Exponential	0,4876	23,77%
Reciprocal-Y	-0,4848	23,51%
Logistic	<no fit>	
Log probit	<no fit>	

The StatAdvisor

This table shows the results of fitting several curvilinear models to the data. Of the models fitted, the reciprocal-X model yields the highest R-Squared value with 24,3328%. This is 0,3012% higher than the currently selected linear model. To change models, select the Analysis Options dialog box.






```
Multiple-Variable Analysis

Analysis Summary

Data variables:
     Est2_4
     Est1_4
     Est7_4
     Est28_4

There are 31 complete cases for use in the calculations.


The StatAdvisor
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   This procedure is designed to summarize several columns of
quantitative data.  It will calculate various statistics, including
correlations, covariances, and partial correlations.  Also included in
the procedure are a number of multivariate graphs, which give
interesting views into the data.  Use the Tabular Options and
Graphical Options buttons on the analysis toolbar to access these
different procedures.

   After this procedure, you may wish to select another procedure to
```

build a statistical model for your data. Depending on your goal, one of several procedures may be appropriate. Following is a list of goals with an indication of which procedure would be appropriate:

GOAL: build a model for predicting one variable given values of one of more other variables.
PROCEDURE: Relate - Multiple regression

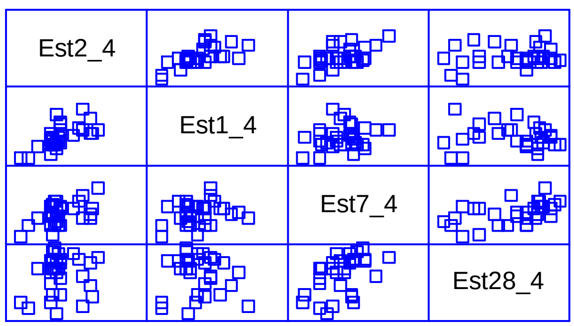
GOAL: group rows of data with similar characteristics.
PROCEDURE: Special - Multivariate Methods - Cluster Analysis

GOAL: develop a method for predicting which of several groups new rows belong to.
PROCEDURE: Special - Multivariate Methods - Discriminant Analysis

GOAL: reduce the number of columns to a small set of meaningful measures.
PROCEDURE: Special - Multivariate Methods - Factor Analysis

GOAL: determine which combinations of the columns determine most of the variability in your data.
PROCEDURE: Special - Multivariate Methods - Principal Components

GOAL: find combinations of the columns which are strongly related to each other.
PROCEDURE: Special - Multivariate Methods - Canonical Correlations



Correlations

	Est2_4	Est1_4	Est7_4	Est28_4
Est2_4		0,6726	0,5155	0,1625
		(31)	(31)	(31)
		0,0000	0,0030	0,3826
Est1_4	0,6726		0,2081	-0,0720
	(31)		(31)	(31)
	0,0000		0,2612	0,7002
Est7_4	0,5155	0,2081		0,4902

	(31)	(31)		(31)
	0,0030	0,2612		0,0051
Est28_4	0,1625	-0,0720	0,4902	
	(31)	(31)	(31)	
	0,3826	0,7002	0,0051	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Pearson product moment correlations between each pair of variables. These correlation coefficients range between -1 and +1 and measure the strength of the linear relationship between the variables. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est2_4 and Est1_4
Est2_4 and Est7_4
Est7_4 and Est28_4

Spearman Rank Correlations

	Est2_4	Est1_4	Est7_4	Est28_4
Est2_4		0,7192	0,3475	0,1471
		(31)	(31)	(31)
		0,0001	0,0570	0,4204
Est1_4	0,7192		0,1303	-0,1312
	(31)		(31)	(31)
	0,0001		0,4754	0,4724
Est7_4	0,3475	0,1303		0,5517
	(31)	(31)		(31)
	0,0570	0,4754		0,0025
Est28_4	0,1471	-0,1312	0,5517	
	(31)	(31)	(31)	
	0,4204	0,4724	0,0025	

Correlation
(Sample Size)
P-Value

The StatAdvisor

This table shows Spearman rank correlations between each pair of variables. These correlation coefficients range between -1 and +1 and

measure the strength of the association between the variables. In contrast to the more common Pearson correlations, the Spearman coefficients are computed from the ranks of the data values rather than from the values themselves. Consequently, they are less sensitive to outliers than the Pearson coefficients. Also shown in parentheses is the number of pairs of data values used to compute each coefficient. The third number in each location of the table is a P-value which tests the statistical significance of the estimated correlations. P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. The following pairs of variables have P-values below 0.05:

Est2_4 and Est1_4
Est7_4 and Est28_4

Ridge regression

Ridge Regression - Est7MT1

Ridge Regression

Dependent variable: Est7MT1
Number of complete cases: 46

Model Results for Ridge Parameter = 3,0

Parameter	Estimate	Variance Inflation Factor
CONSTANT	49,295	
Al2O3_2	-1,29763	0,0573433
IR_2	-0,28304	0,0573433

R-Squared = 11,3069 percent
R-Squared (adjusted for d.f.) = 7,18163 percent
Standard Error of Est. = 1,89208
Mean absolute error = 1,39011
Durbin-Watson statistic = 1,45125 (P=0,1281)
Lag 1 residual autocorrelation = 0,240785

Residual Analysis

	Estimation	Validation
n	46	
MSE	3,57997	
MAE	1,39011	
MAPE	3,46202	
ME	-7,72329E-15	
MPE	-0,227086	

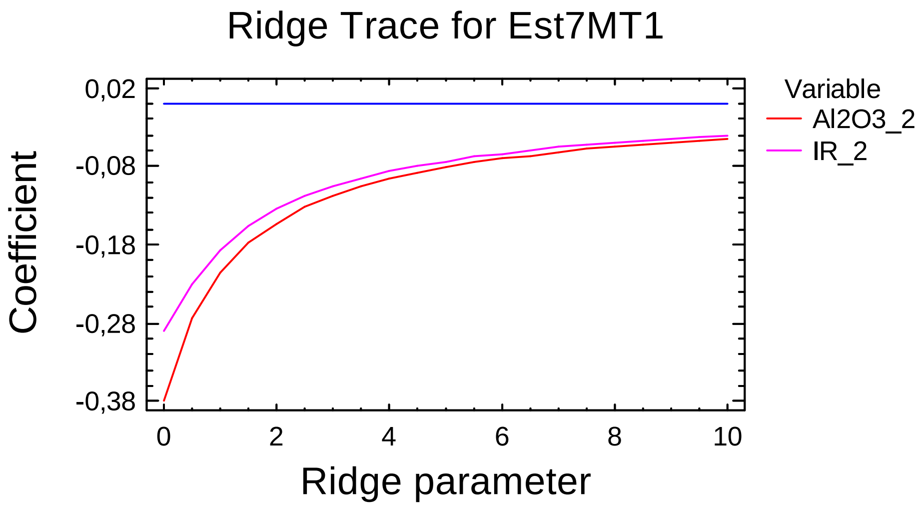
The StatAdvisor

This procedure is designed to provide estimates of regression coefficients when the independent variables are strongly correlated. By allowing for a small amount of bias, the precision of the estimates can often be greatly increased. In this case, the fitted regression model is

Est7MT1 = 49,295 - 1,29763*Al2O3_2 - 0,28304*IR_2

The current value of the ridge parameter is 3,0. To change the ridge parameter, press the alternate mouse button and select Analysis Options. The ridge parameter is usually set between 0.0 and 1.0. In order to determine a good value for the ridge parameter, you should examine the standardized regression coefficients or the variance inflation factors. These values are available on the lists of Tabular and Graphical Options.

The R-Squared statistic indicates that the model as fitted explains 11,3069% of the variability in Est7MT1. The adjusted R-Squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 7,18163%. The standard error of the estimate shows the standard deviation of the residuals to be 1,89208. The mean absolute error (MAE) of 1,39011 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file. Since the P-value is greater than 0.05, there is no indication of serial autocorrelation in the residuals.



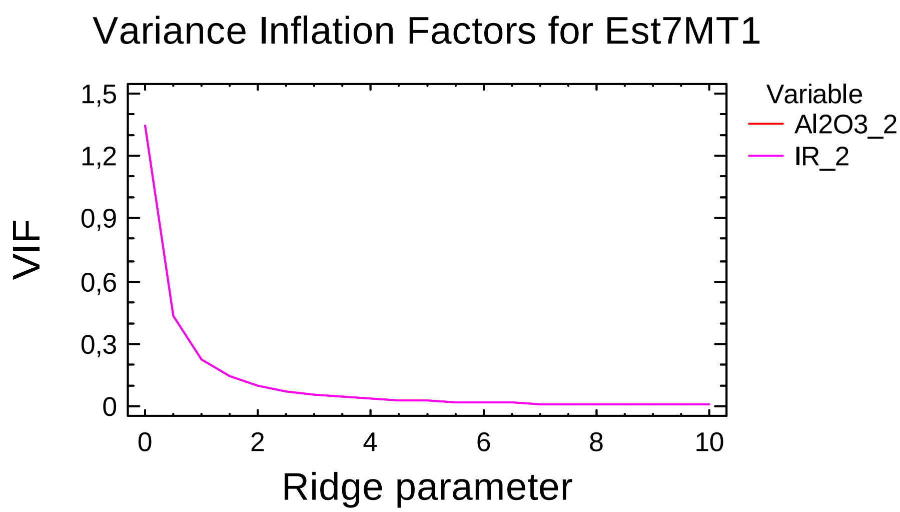
Variance Inflation Factors

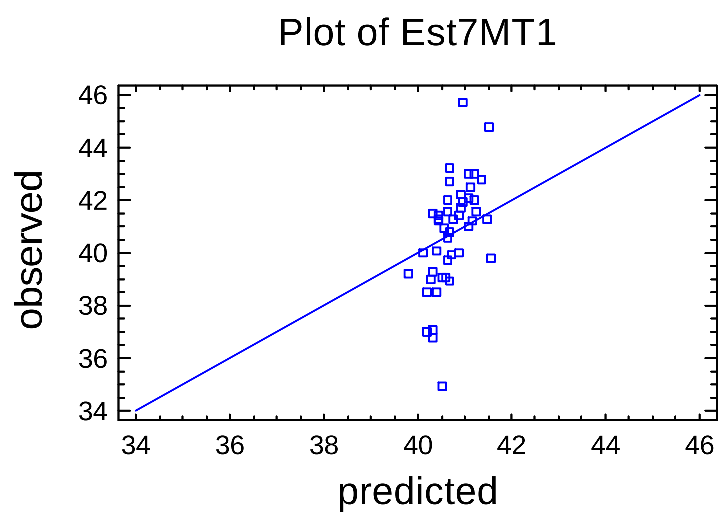
Ridge Parameter	Al2O3_2	IR_2	R-Squared
0,0	1,34204	1,34204	33,96
0,5	0,437192	0,437192	25,44
1,0	0,230671	0,230671	20,35
1,5	0,145528	0,145528	16,96
2,0	0,101019	0,101019	14,54
2,5	0,0745104	0,0745104	12,72
3,0	0,0573433	0,0573433	11,31
3,5	0,0455498	0,0455498	10,18
4,0	0,0370821	0,0370821	9,25
4,5	0,0307892	0,0307892	8,48
5,0	0,0259811	0,0259811	7,83
5,5	0,0222226	0,0222226	7,27
6,0	0,0192277	0,0192277	6,79
6,5	0,016802	0,016802	6,36
7,0	0,0148094	0,0148094	5,99
7,5	0,0131523	0,0131523	5,65
8,0	0,0117592	0,0117592	5,36
8,5	0,0105767	0,0105767	5,09
9,0	0,00956444	0,00956444	4,85
9,5	0,00869107	0,00869107	4,63
10,0	0,00793228	0,00793228	4,43

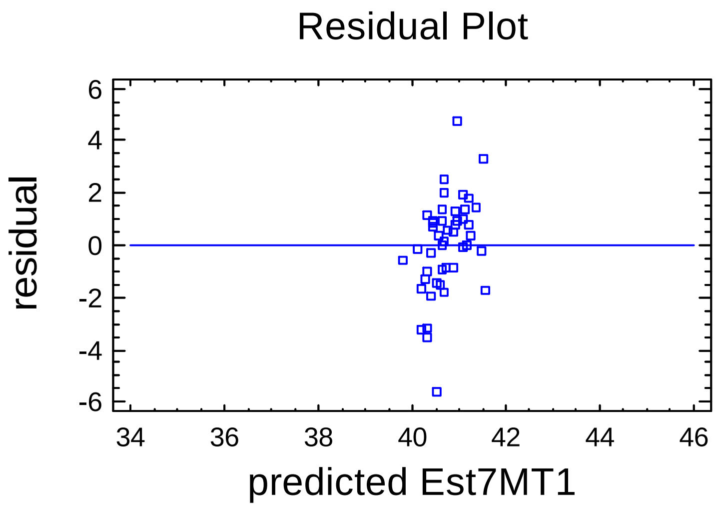
The StatAdvisor

This table shows the variance inflation factors for each of the coefficients in the regression model. The variance inflation factors measure how much the variance of the estimated coefficients is inflated relative to the case when all of the independent variables are uncorrelated. As the ridge parameter is increased from 0.0, the VIFs often decrease dramatically at first but then become relatively stable. A good value for the ridge parameter is the smallest value after which the VIF's change slowly. This is admittedly subjective, but the plot of the VIFs available on the list of Graphical Options may help you make a good choice. To change the range of ridge parameters examined, press the alternate mouse button and select

Analysis Options.







ΠΑΡΑΡΤΗΜΑ Γ

Σύγκριση δύο πληθυσμών-ποιότητα τσιμέντου CEM II 42,5

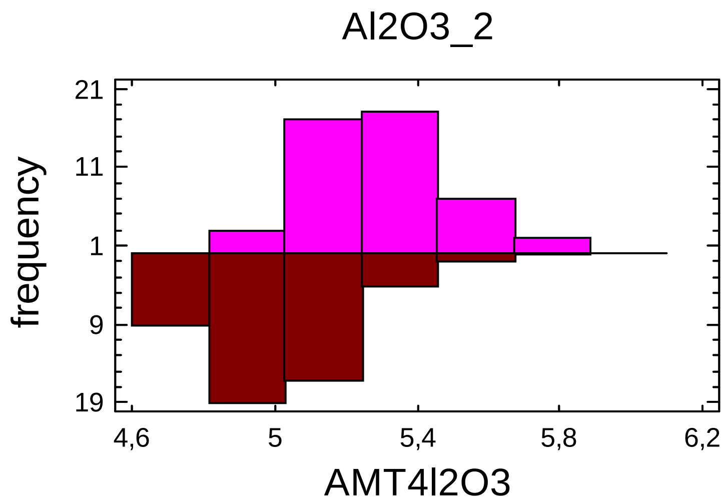
Two-Sample Comparison - Al2O3_2 & AMT4l2O3

```
Analysis Summary

Sample 1: Al2O3_2
Sample 2: AMT4l2O3

Sample 1: 47 values ranging from 4,89 to 5,83
Sample 2: 49 values ranging from 4,71 to 5,47


The StatAdvisor
---------------
   This procedure is designed to compare two samples of data.  It will
calculate various statistics and graphs for each sample, and it will
run several tests to determine whether there are statistically
significant differences between the two samples.
```

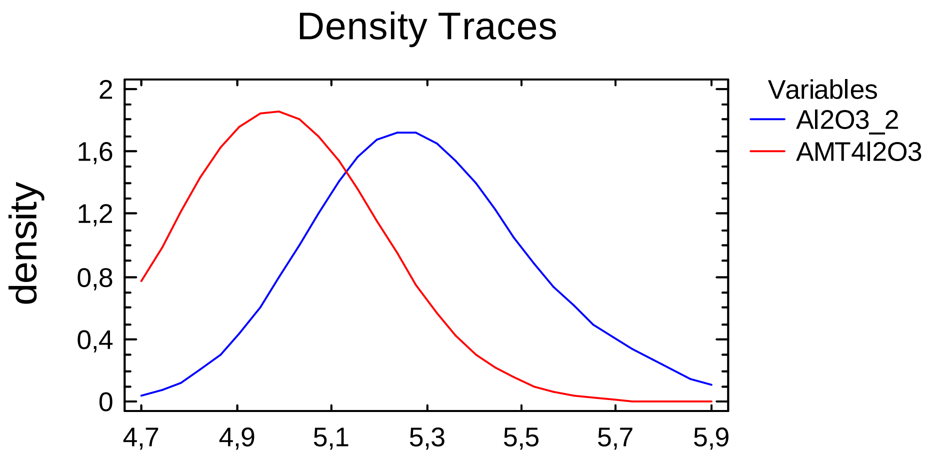


Summary Statistics

	Al2O3_2	AMT4l2O3
Count	47	49
Average	5,29447	4,99735
Variance	0,0405122	0,0281949
Standard deviation	0,201276	0,167913
Minimum	4,89	4,71
Maximum	5,83	5,47
Range	0,94	0,76
Stnd. skewness	1,48054	1,27492
Stnd. kurtosis	0,328911	0,0629493

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of Al2O3_2: 5,29447 +/- 0,0590971
[5,23537,5,35357]
95,0% confidence interval for mean of AMT4l2O3: 4,99735 +/- 0,0482304
[4,94912,5,04558]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,297121 +/- 0,074993   [0,222128,0,372114]

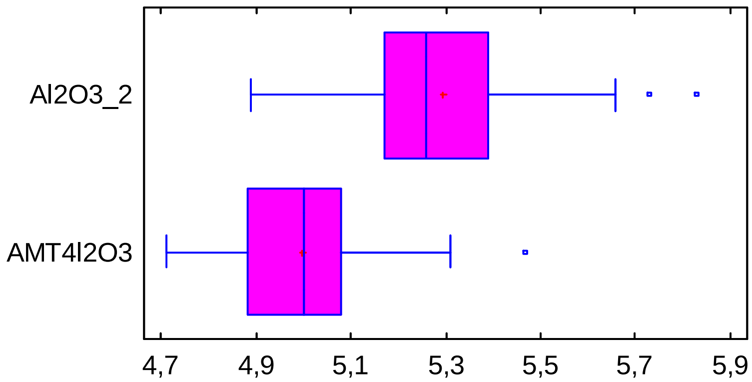
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 7,86663   P-value = 6,07492E-12



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,222128 to 0,372114.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    Al2O3_2             AMT4l2O3
------------------------------------------------------------
Standard deviation  0,201276            0,167913
Variance            0,0405122           0,0281949
Df                  46                  48

     Ratio of Variances = 1,43686

95,0% Confidence Intervals
     Standard deviation of Al2O3_2: [0,167256;0,2528]
     Standard deviation of AMT4l2O3: [0,140027;0,209774]
     Ratio of Variances: [0,806827;2,56812]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,43686   P-value = 0,216497
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,806827 to 2,56812. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - BLAINEMT1 & BLAINEMT4

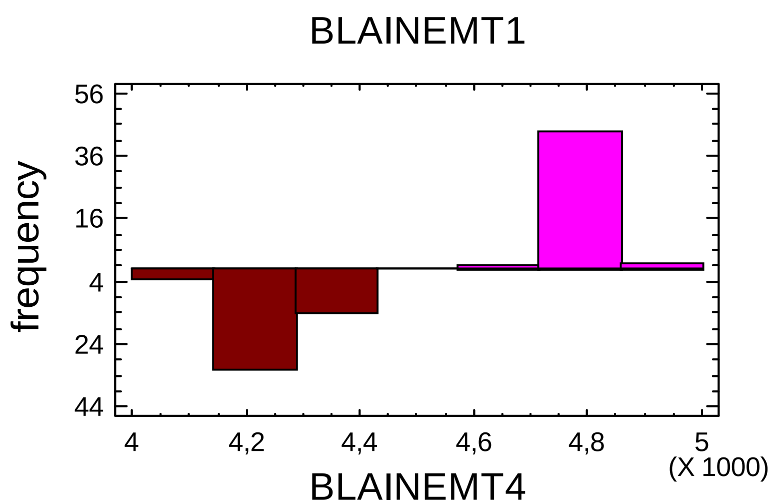
Analysis Summary

Sample 1: BLAINEMT1
Sample 2: BLAINEMT4

Sample 1: 47 values ranging from 4700,0 to 4900,0
Sample 2: 49 values ranging from 4110,0 to 4350,0

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

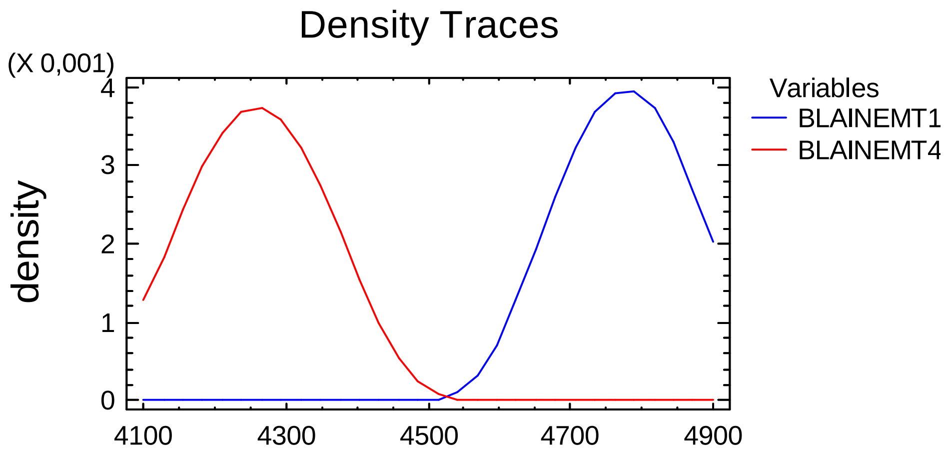


Summary Statistics

	BLAINEMT1	BLAINEMT4
Count	47	49
Average	4778,81	4255,1
Variance	1245,85	2875,51
Standard deviation	35,2967	53,6238
Minimum	4700,0	4110,0
Maximum	4900,0	4350,0
Range	200,0	240,0
Stnd. skewness	2,55893	-2,64714
Stnd. kurtosis	3,70393	1,35442

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both samples have standardized skewness values outside the normal range. BLAINEMT1 has a standardized kurtosis value outside the normal range.




```
Comparison of Means
-------------------

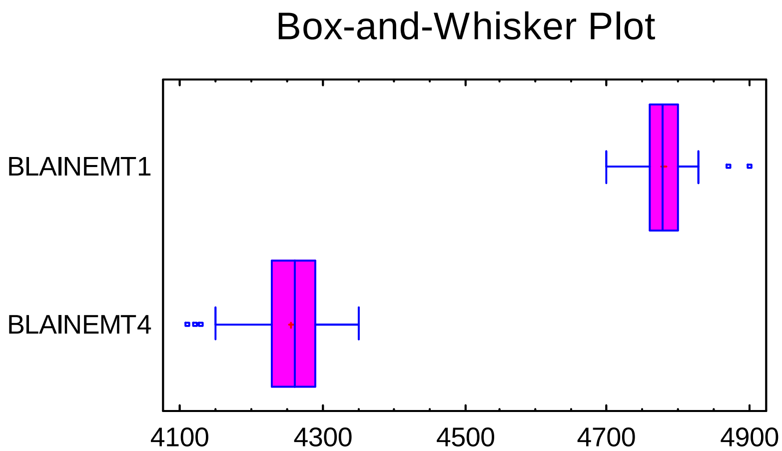
95,0% confidence interval for mean of BLAINEMT1: 4778,81 +/- 10,3635
[4768,45,4789,17]
95,0% confidence interval for mean of BLAINEMT4: 4255,1 +/- 15,4026   [4239,7,4270,5]
95,0% confidence interval for the difference between the means
   assuming equal variances: 523,706 +/- 18,4795   [505,227,542,186]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 56,2697   P-value = 0,0



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 505,227 to 542,186.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption is questionable since the
results of an F-test to compare the standard deviations suggests that
there may be a significant difference between them.  You can see the
results of that test by selecting Comparison of Standard Deviations
from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------
                    BLAINEMT1           BLAINEMT4
------------------------------------------------------------
Standard deviation  35,2967             53,6238
Variance            1245,85             2875,51
Df                  46                  48

     Ratio of Variances = 0,433264

95,0% Confidence Intervals
     Standard deviation of BLAINEMT1: [29,3306;44,3321]
     Standard deviation of BLAINEMT4: [44,718;66,9921]
     Ratio of Variances: [0,243286;0,774375]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,433264   P-value = 0,00508828
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,243286 to 0,774375. Since the interval does not contain the value 1.0, there is a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - IR_2 & IRMT4

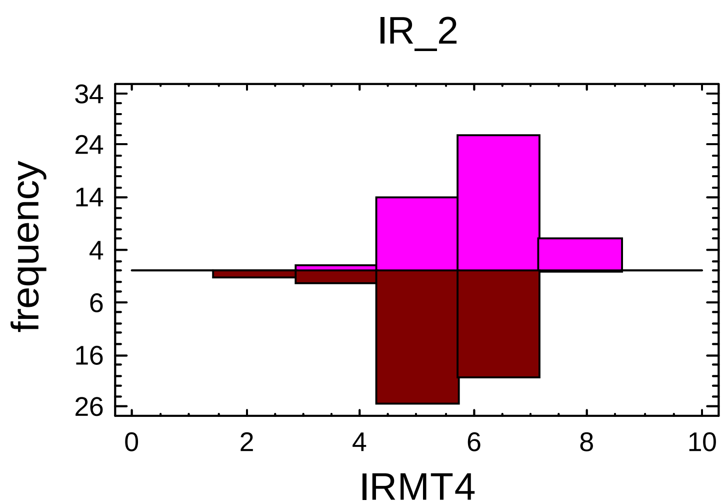
Analysis Summary

Sample 1: IR_2
Sample 2: IRMT4

Sample 1: 47 values ranging from 4,22 to 7,89
Sample 2: 48 values ranging from 2,16 to 6,85

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

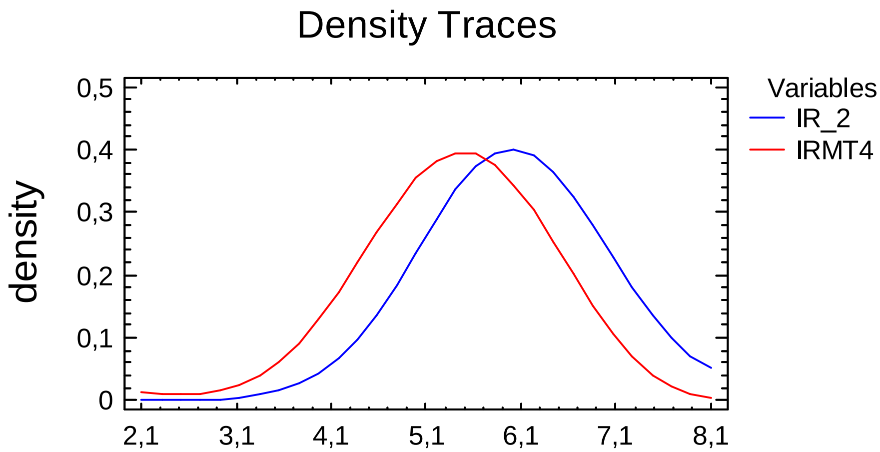


Summary Statistics

	IR_2	IRMT4
Count	47	48
Average	6,04468	5,38812
Variance	0,576382	0,684092
Standard deviation	0,759198	0,827099
Minimum	4,22	2,16
Maximum	7,89	6,85
Range	3,67	4,69
Stnd. skewness	0,440299	-3,42009
Stnd. kurtosis	0,373963	4,97428

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, IRMT4 has a standardized skewness value outside the normal range. IRMT4 has a standardized kurtosis value outside the normal range.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of IR_2: 6,04468 +/- 0,222909   [5,82177,6,26759]
95,0% confidence interval for mean of IRMT4: 5,38812 +/- 0,240165   [5,14796,5,62829]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,656556 +/- 0,323654   [0,332902,0,980209]

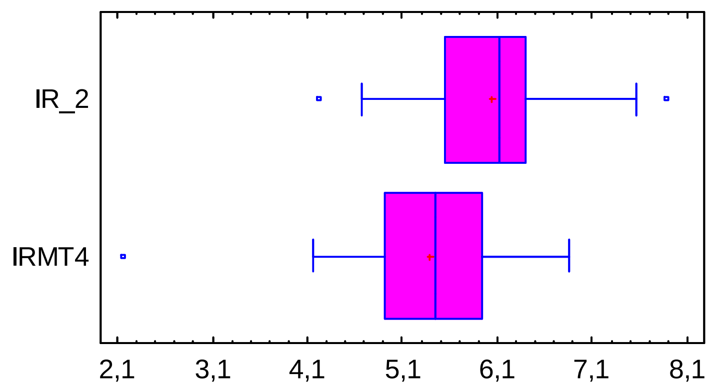
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 4,02836   P-value = 0,000114826



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,332902 to 0,980209.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    IR_2                IRMT4
------------------------------------------------------------
Standard deviation  0,759198            0,827099
Variance            0,576382            0,684092
Df                  46                  47

     Ratio of Variances = 0,84255

95,0% Confidence Intervals
     Standard deviation of IR_2: [0,630875;0,953542]
     Standard deviation of IRMT4: [0,688534;1,03601]
     Ratio of Variances: [0,471239;1,50921]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,84255   P-value = 0,562333



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,471239 to 1,50921.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.


Two-Sample Comparison - LOIMT1 & LOIMT4
```

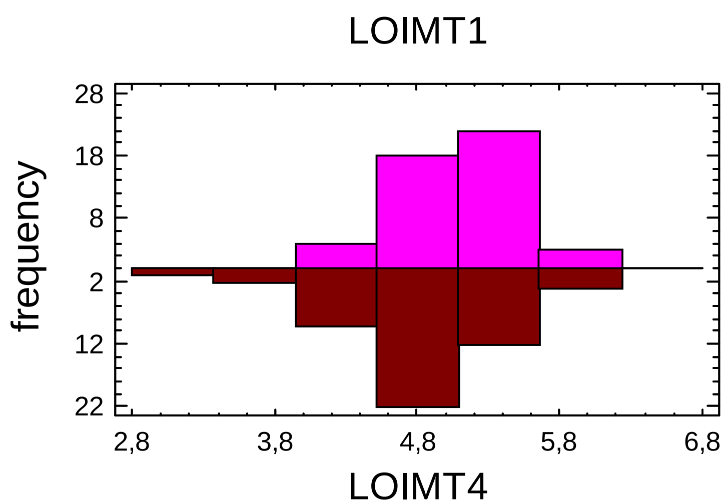
Analysis Summary

Sample 1: LOIMT1
Sample 2: LOIMT4

Sample 1: 47 values ranging from 4,1 to 6,01
Sample 2: 49 values ranging from 3,04 to 6,07

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

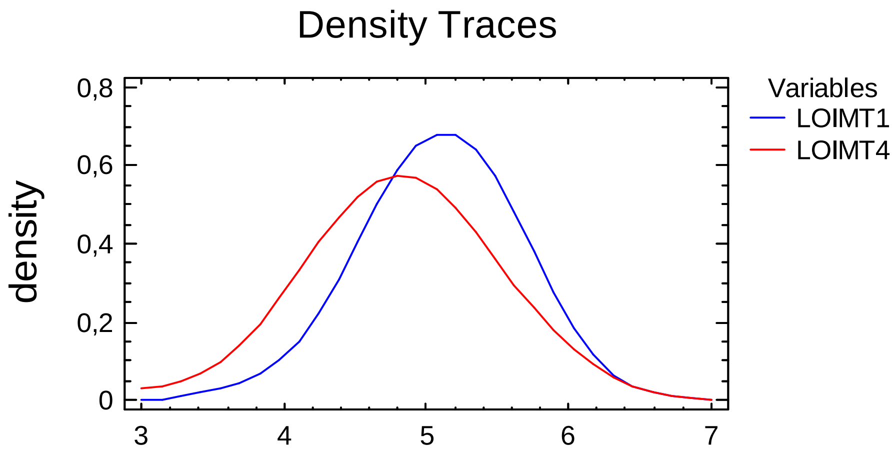


Summary Statistics

	LOIMT1	LOIMT4
Count	47	49
Average	5,09128	4,81163
Variance	0,151268	0,324147
Standard deviation	0,388932	0,569339
Minimum	4,1	3,04
Maximum	6,01	6,07
Range	1,91	3,03
Stnd. skewness	-1,4963	-1,14022
Stnd. kurtosis	1,60564	1,49041

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of LOIMT1: 5,09128 +/- 0,114195   [4,97708,5,20547]
95,0% confidence interval for mean of LOIMT4: 4,81163 +/- 0,163534   [4,6481,4,97517]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,279644 +/- 0,198408   [0,0812357,0,478052]

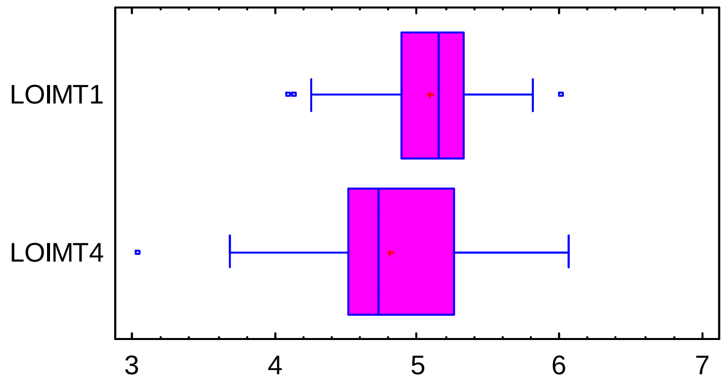
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 2,79848   P-value = 0,00622961



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,0812357 to 0,478052.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption is questionable since the
results of an F-test to compare the standard deviations suggests that
there may be a significant difference between them.  You can see the
results of that test by selecting Comparison of Standard Deviations
from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    LOIMT1              LOIMT4
------------------------------------------------------------
Standard deviation  0,388932            0,569339
Variance            0,151268            0,324147
Df                  46                  48

     Ratio of Variances = 0,466664

95,0% Confidence Intervals
     Standard deviation of LOIMT1: [0,323193;0,488493]
     Standard deviation of LOIMT4: [0,474784;0,711275]
     Ratio of Variances: [0,262041;0,834072]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,466664   P-value = 0,0104968
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,262041 to 0,834072. Since the interval does not contain the value 1.0, there is a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - SiO2MT1 & SIO2MT4

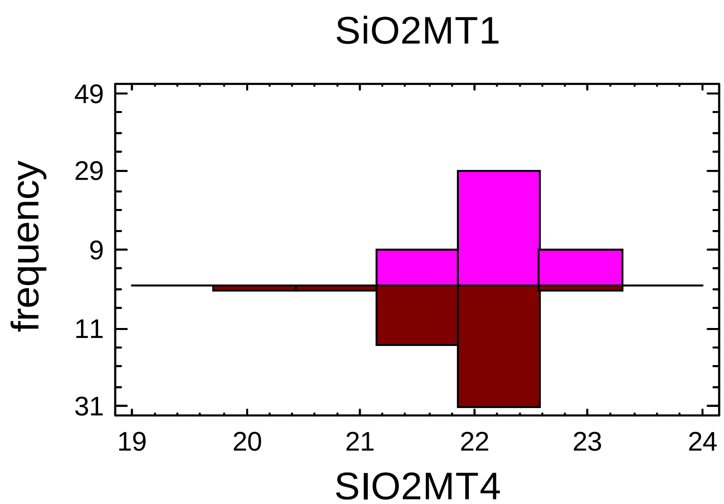
Analysis Summary

Sample 1: SiO2MT1
Sample 2: SIO2MT4

Sample 1: 47 values ranging from 21,32 to 23,24
Sample 2: 49 values ranging from 20,04 to 22,61

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

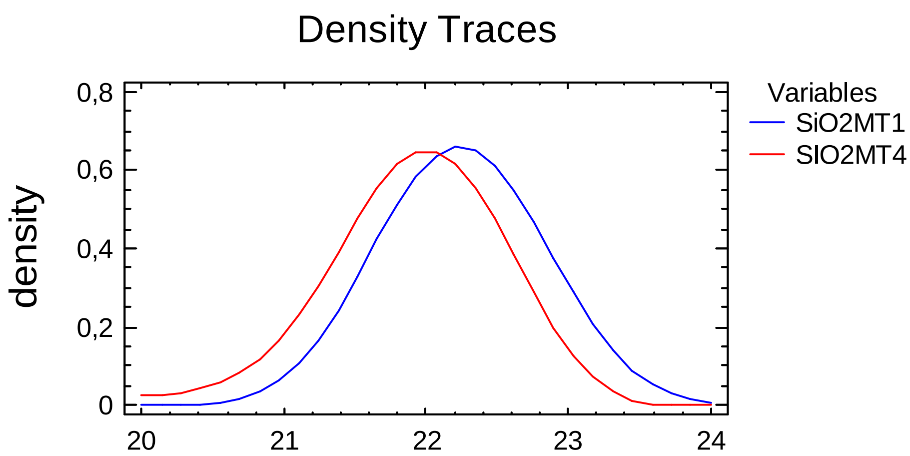


Summary Statistics

	SiO2MT1	SIO2MT4
Count	47	49
Average	22,2479	21,9122
Variance	0,160952	0,235714
Standard deviation	0,401188	0,485503
Minimum	21,32	20,04
Maximum	23,24	22,61
Range	1,92	2,57
Stnd. skewness	0,338989	-4,29694
Stnd. kurtosis	-0,0933634	5,34637

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, SIO2MT4 has a standardized skewness value outside the normal range. SIO2MT4 has a standardized kurtosis value outside the normal range.




```
Comparison of Means
-------------------

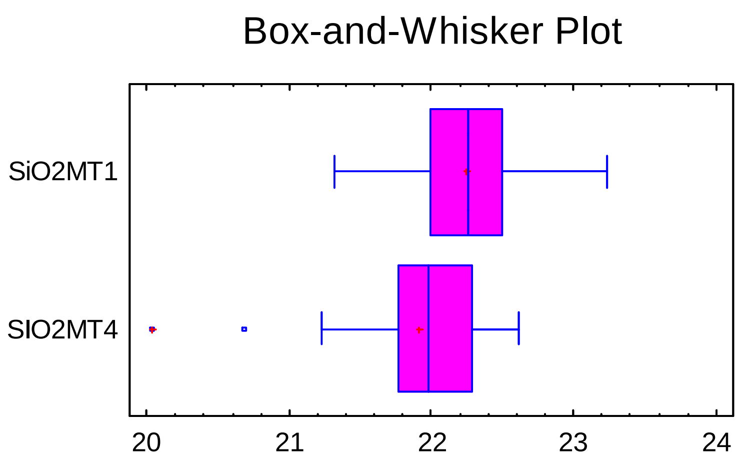
95,0% confidence interval for mean of SiO2MT1: 22,2479 +/- 0,117793
[22,1301,22,3657]
95,0% confidence interval for mean of SIO2MT4: 21,9122 +/- 0,139453
[21,7728,22,0517]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,335627 +/- 0,180897   [0,154731,0,516524]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 3,68386   P-value = 0,000383725



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,154731 to 0,516524.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------

                    SiO2MT1             SIO2MT4
------------------------------------------------------------
Standard deviation  0,401188            0,485503
Variance            0,160952            0,235714
Df                  46                  48

     Ratio of Variances = 0,682828

95,0% Confidence Intervals
     Standard deviation of SiO2MT1: [0,333377;0,503887]
     Standard deviation of SIO2MT4: [0,404872;0,606539]
     Ratio of Variances: [0,383421;1,22042]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,682828   P-value = 0,196071
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,383421 to 1,22042. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - Est1MT1 & Est1MT4

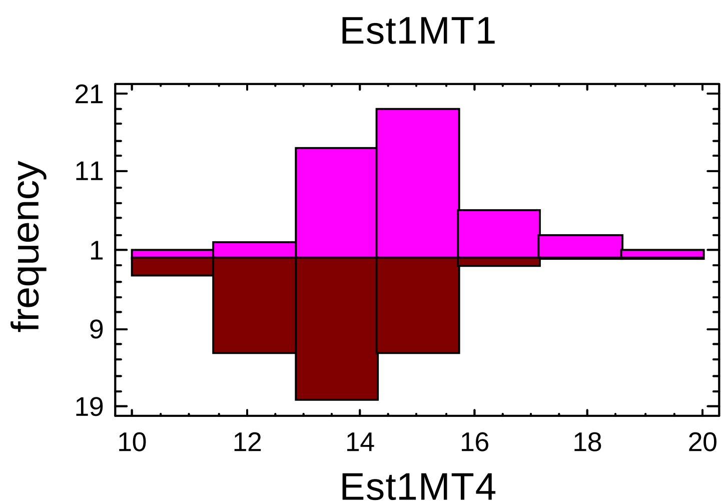
Analysis Summary

Sample 1: Est1MT1
Sample 2: Est1MT4

Sample 1: 46 values ranging from 11,4 to 19,0
Sample 2: 45 values ranging from 10,7 to 15,8

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

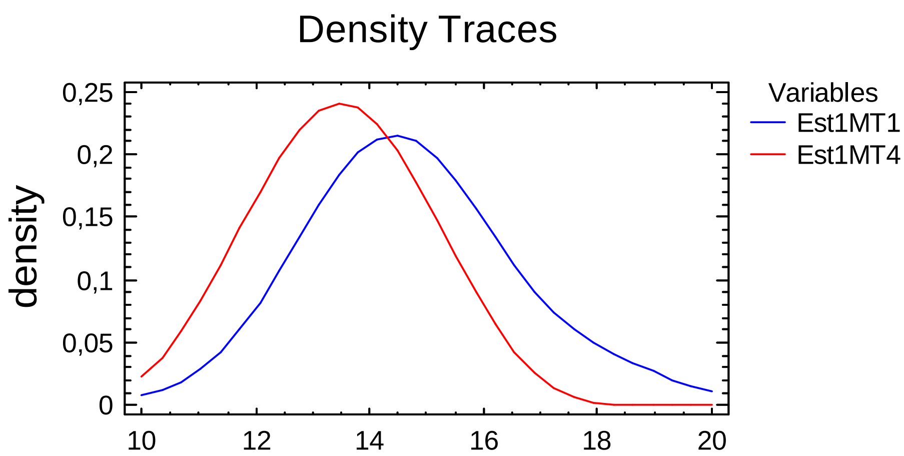


Summary Statistics

	Est1MT1	Est1MT4
Count	46	45
Average	14,7326	13,4822
Variance	2,69914	1,3674
Standard deviation	1,6429	1,16936
Minimum	11,4	10,7
Maximum	19,0	15,8
Range	7,6	5,1
Stnd. skewness	1,45266	-0,231335
Stnd. kurtosis	0,634088	-0,782801

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of Est1MT1: 14,7326 +/- 0,487883
[14,2447,15,2205]
95,0% confidence interval for mean of Est1MT4: 13,4822 +/- 0,351315
[13,1309,13,8335]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,25039 +/- 0,595148   [0,655239,1,84553]

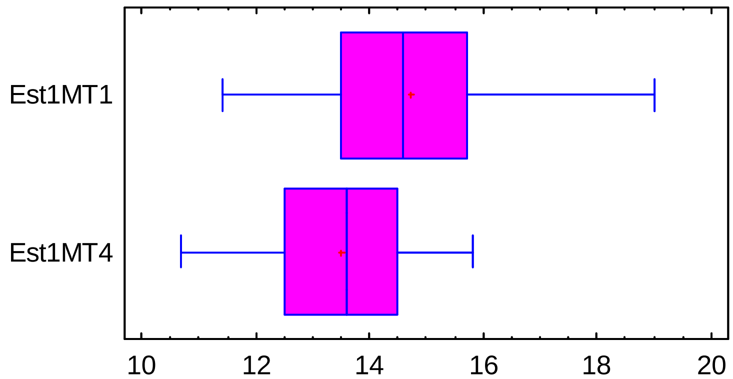
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 4,17459   P-value = 0,0000695561



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,655239 to 1,84553.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption is questionable since the
results of an F-test to compare the standard deviations suggests that
there may be a significant difference between them.  You can see the
results of that test by selecting Comparison of Standard Deviations
from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    Est1MT1             Est1MT4
------------------------------------------------------------
Standard deviation  1,6429              1,16936
Variance            2,69914             1,3674
Df                  45                  44

     Ratio of Variances = 1,97391

95,0% Confidence Intervals
     Standard deviation of Est1MT1: [1,36269;2,06928]
     Standard deviation of Est1MT4: [0,96806;1,47714]
     Ratio of Variances: [1,08736;3,57608]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,97391   P-value = 0,0257244
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 1,08736 to 3,57608. Since the interval does not contain the value 1.0, there is a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - Est2MT1 & Est2MT4

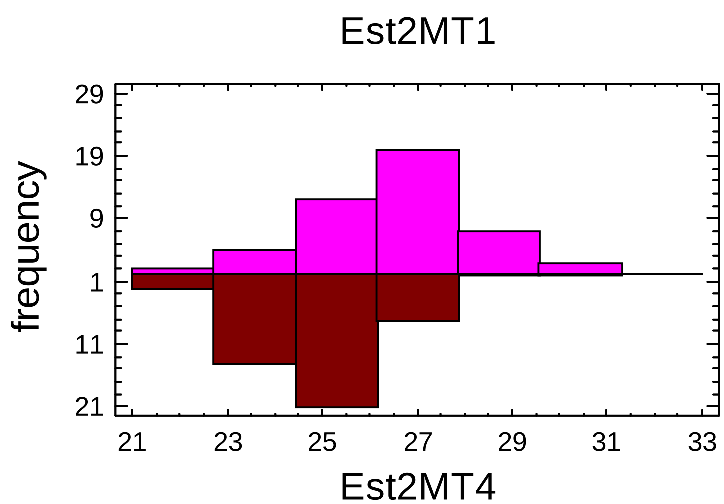
Analysis Summary

Sample 1: Est2MT1
Sample 2: Est2MT4

Sample 1: 46 values ranging from 22,5 to 30,7
Sample 2: 44 values ranging from 21,6 to 27,8

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

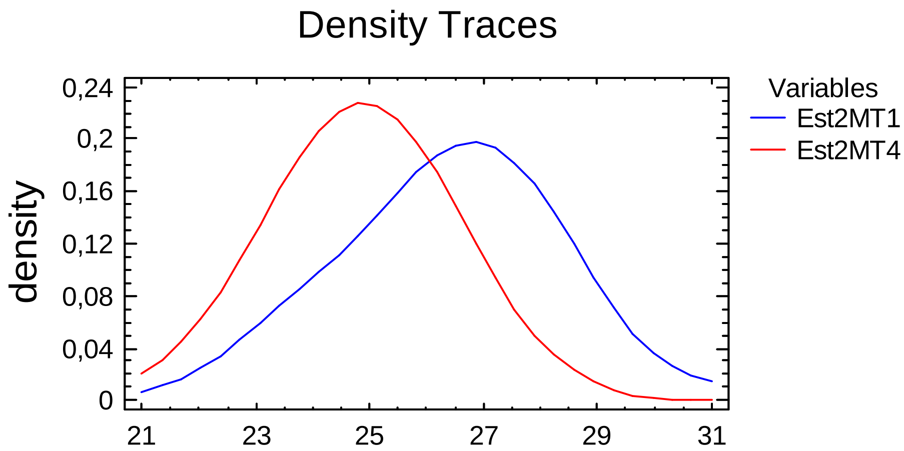


Summary Statistics

	Est2MT1	Est2MT4
Count	46	44
Average	26,4109	24,85
Variance	3,11166	1,84209
Standard deviation	1,76399	1,35724
Minimum	22,5	21,6
Maximum	30,7	27,8
Range	8,2	6,2
Stnd. skewness	-0,375575	-0,293311
Stnd. kurtosis	-0,0491938	-0,0633007

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

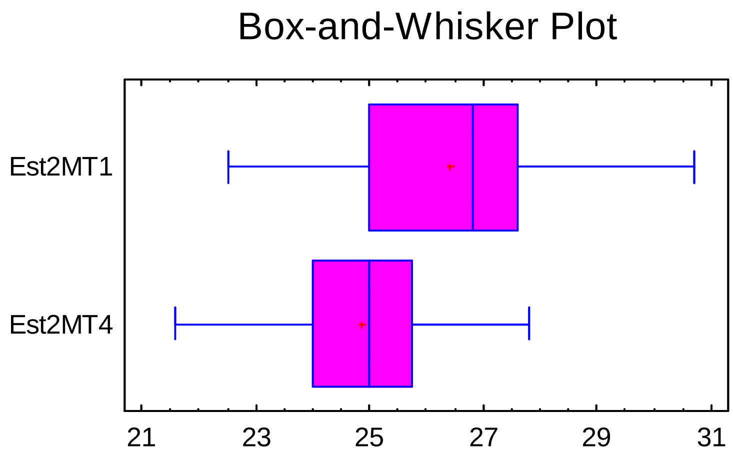
95,0% confidence interval for mean of Est2MT1: 26,4109 +/- 0,523841   [25,887,26,9347]
95,0% confidence interval for mean of Est2MT4: 24,85 +/- 0,412639   [24,4374,25,2626]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,56087 +/- 0,661441   [0,899428,2,22231]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 4,68962   P-value = 0,0000099474



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,899428 to 2,22231.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```



Comparison of Standard Deviations

	Est2MT1	Est2MT4
Standard deviation	1,76399	1,35724
Variance	3,11166	1,84209
Df	45	43

Ratio of Variances = 1,6892

95,0% Confidence Intervals
Standard deviation of Est2MT1: [1,46312;2,22178]
Standard deviation of Est2MT4: [1,12138;1,71965]
Ratio of Variances: [0,926222;3,06802]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 1,6892 P-value = 0,0866891

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,926222 to 3,06802. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Two-Sample Comparison - Est7MT1 & Est7MT4

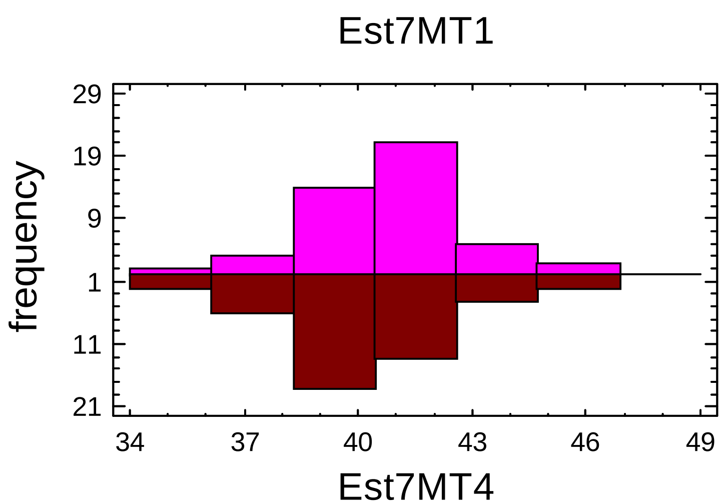
Analysis Summary

Sample 1: Est7MT1
Sample 2: Est7MT4

Sample 1: 46 values ranging from 34,9 to 45,7
Sample 2: 45 values ranging from 34,9 to 45,7

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

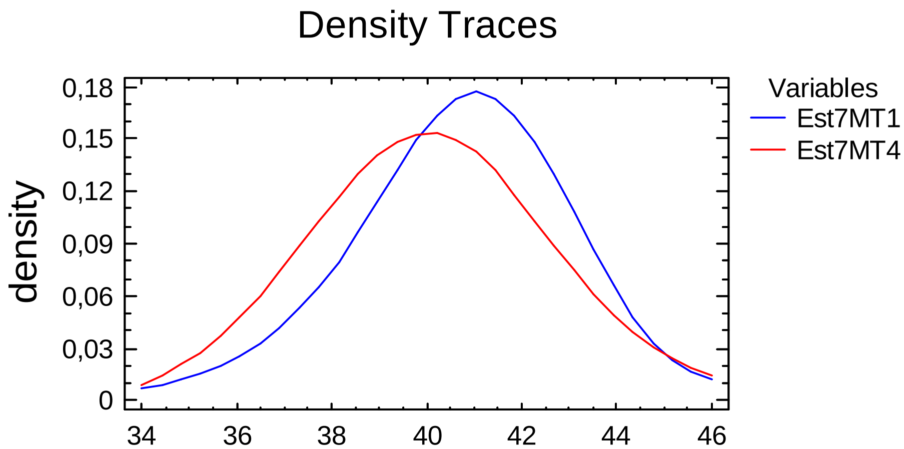


Summary Statistics

	Est7MT1	Est7MT4
Count	46	45
Average	40,7304	40,1
Variance	4,21505	5,24682
Standard deviation	2,05306	2,29059
Minimum	34,9	34,9
Maximum	45,7	45,7
Range	10,8	10,8
Stnd. skewness	-1,07601	0,432137
Stnd. kurtosis	1,28179	0,0644646

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of Est7MT1: 40,7304 +/- 0,609685
[40,1208,41,3401]
95,0% confidence interval for mean of Est7MT4: 40,1 +/- 0,688172   [39,4118,40,7882]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,630435 +/- 0,905601   [-0,275166,1,53604]

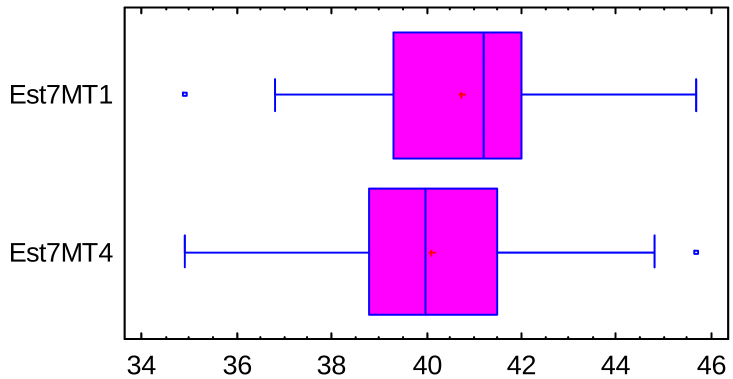
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 1,38324   P-value = 0,170052



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from -0,275166 to 1,53604.  Since the interval contains the
value 0.0, there is not a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is not less than 0,05, we cannot
reject the null hypothesis.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    Est7MT1             Est7MT4
------------------------------------------------------------
Standard deviation  2,05306             2,29059
Variance            4,21505             5,24682
Df                  45                  44

     Ratio of Variances = 0,803354

95,0% Confidence Intervals
     Standard deviation of Est7MT1: [1,70288;2,58588]
     Standard deviation of Est7MT4: [1,89628;2,89348]
     Ratio of Variances: [0,442542;1,45541]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,803354   P-value = 0,467295



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,442542 to 1,45541.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.
```

Two-Sample Comparison - Est28MT1 & Est28MT4

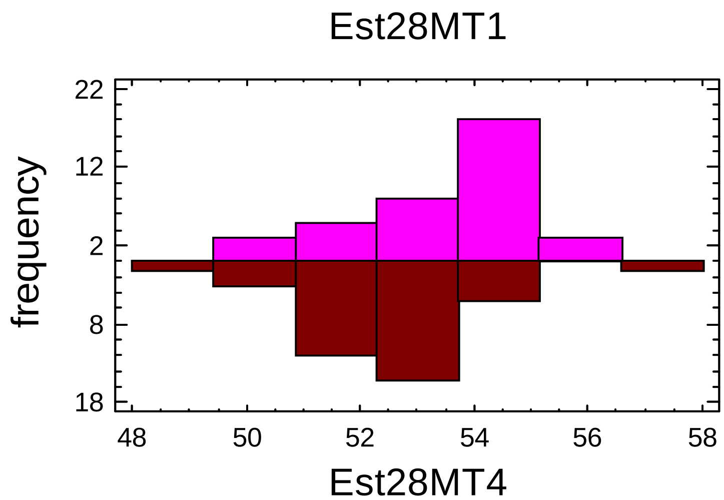
Analysis Summary

Sample 1: Est28MT1
Sample 2: Est28MT4

Sample 1: 37 values ranging from 50,0 to 55,9
Sample 2: 37 values ranging from 48,6 to 57,4

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

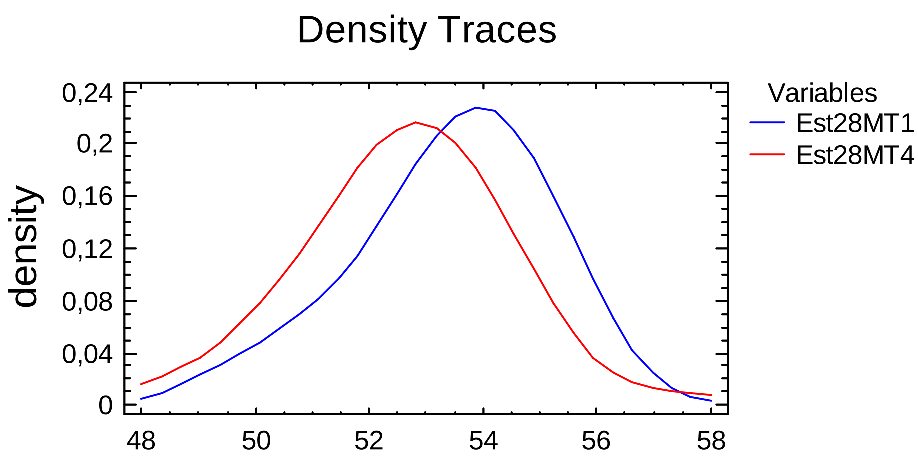


Summary Statistics

	Est28MT1	Est28MT4
Count	37	37
Average	53,4351	52,6514
Variance	2,22734	2,78646
Standard deviation	1,49243	1,66927
Minimum	50,0	48,6
Maximum	55,9	57,4
Range	5,9	8,8
Stnd. skewness	-2,00193	0,0265021
Stnd. kurtosis	0,0912519	1,53087

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, Est28MT1 has a standardized skewness value outside the normal range. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

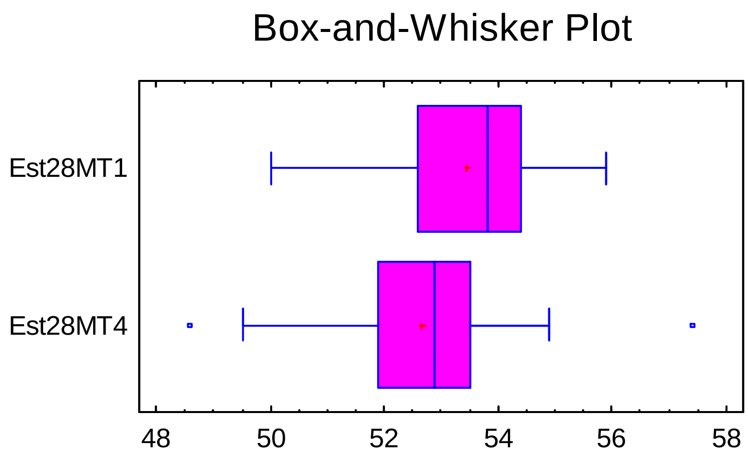
95,0% confidence interval for mean of Est28MT1: 53,4351 +/- 0,497601
[52,9375,53,9327]
95,0% confidence interval for mean of Est28MT4: 52,6514 +/- 0,556563
[52,0948,53,2079]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,783784 +/- 0,733824   [0,0499601,1,51761]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 2,12919   P-value = 0,0366594



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,0499601 to 1,51761.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------

                    Est28MT1            Est28MT4
------------------------------------------------------------
Standard deviation  1,49243             1,66927
Variance            2,22734             2,78646
Df                  36                  36

     Ratio of Variances = 0,799346

95,0% Confidence Intervals
     Standard deviation of Est28MT1: [1,21366;1,93861]
     Standard deviation of Est28MT4: [1,35747;2,16831]
     Ratio of Variances: [0,411585;1,55242]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 0,799346   P-value = 0,505063



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,411585 to 1,55242.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.
```

Σύγκριση δύο πληθυσμών- ποιότητα τσιμέντου OPC

Two-Sample Comparison - Al2O3_3 & Al2O3_4

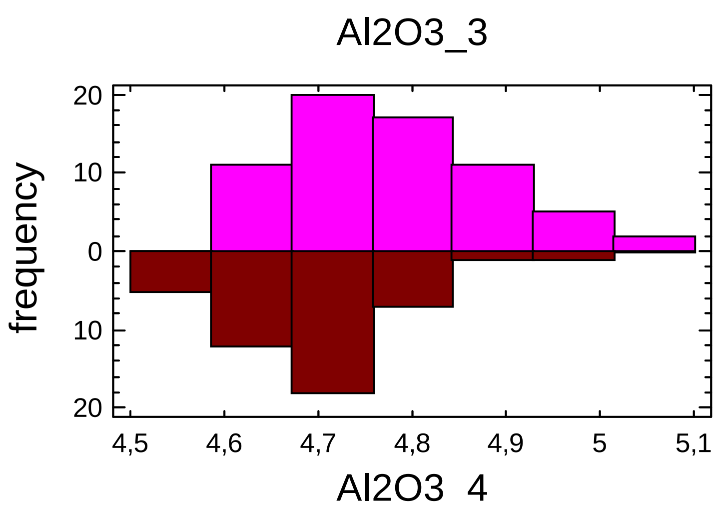
Analysis Summary

Sample 1: Al2O3_3
Sample 2: Al2O3_4

Sample 1: 66 values ranging from 4,6 to 5,03
Sample 2: 44 values ranging from 4,53 to 4,97

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



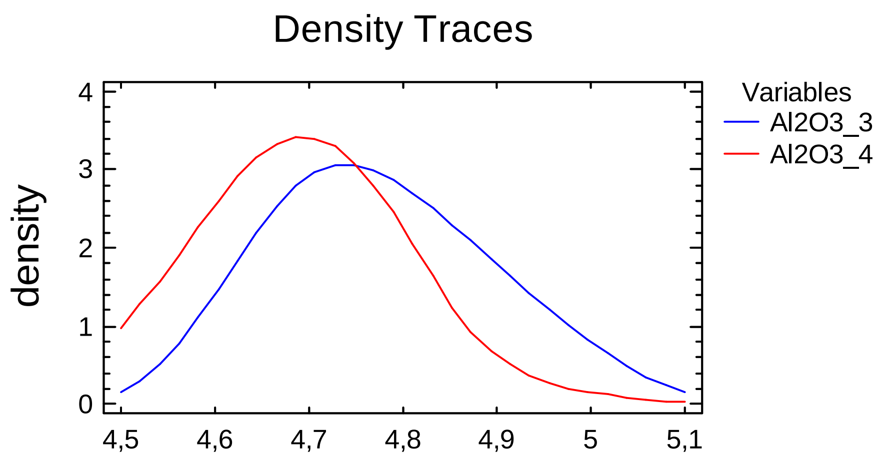
Summary Statistics

	Al2O3_3	Al2O3_4
Count	66	44
Average	4,77712	4,69409
Variance	0,0118054	0,00925729
Standard deviation	0,108653	0,0962148
Minimum	4,6	4,53
Maximum	5,03	4,97
Range	0,43	0,44
Stnd. skewness	1,51044	1,09077
Stnd. kurtosis	-0,910087	0,415599

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to

determine whether the samples come from normal distributions. Values
of these statistics outside the range of -2 to +2 indicate significant
departures from normality, which would tend to invalidate the tests
which compare the standard deviations. In this case, both
standardized skewness values are within the range expected. Both
standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of Al2O3_3: 4,77712 +/- 0,0267102
[4,75041,4,80383]
95,0% confidence interval for mean of Al2O3_4: 4,69409 +/- 0,029252
[4,66484,4,72334]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,0830303 +/- 0,0400746   [0,0429557,0,123105]

t test to compare means

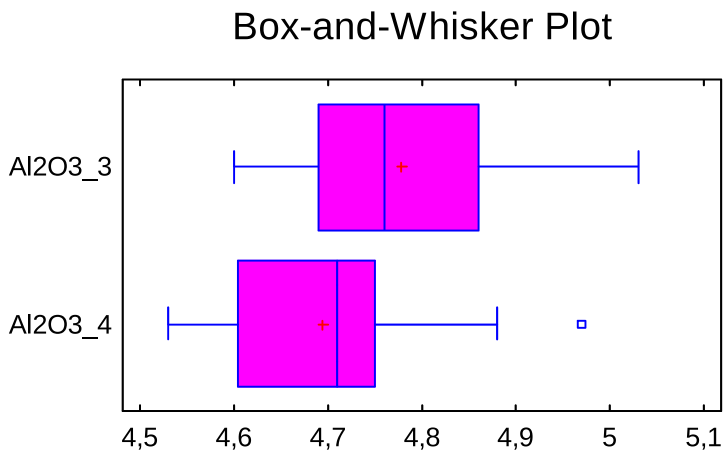
   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 4,10686   P-value = 0,000078229
```

The StatAdvisor

This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from 0,0429557 to 0,123105. Since the interval does not contain the value 0.0, there is a statistically significant difference between the means of the two samples at the 95,0% confidence level.

A t-test may also be used to test a specific hypothesis about the difference between the means of the populations from which the two samples come. In this case, the test has been constructed to determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.




```
Comparison of Standard Deviations
---------------------------------

                    Al2O3_3             Al2O3_4
------------------------------------------------------------
Standard deviation  0,108653            0,0962148
Variance            0,0118054           0,00925729
Df                  65                  43

     Ratio of Variances = 1,27526

95,0% Confidence Intervals
     Standard deviation of Al2O3_3: [0,0927622;0,131164]
     Standard deviation of Al2O3_4: [0,0794949;0,121907]
     Ratio of Variances: [0,723569;2,17846]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,27526   P-value = 0,398947



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,723569 to 2,17846.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.


Kolmogorov-Smirnov Test
-----------------------
```

Estimated overall statistic DN = 0,378788
Two-sided large sample K-S statistic = 1,94625
Approximate P value = 0,00102546

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,378788, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Blaine_3 & Blaine_4

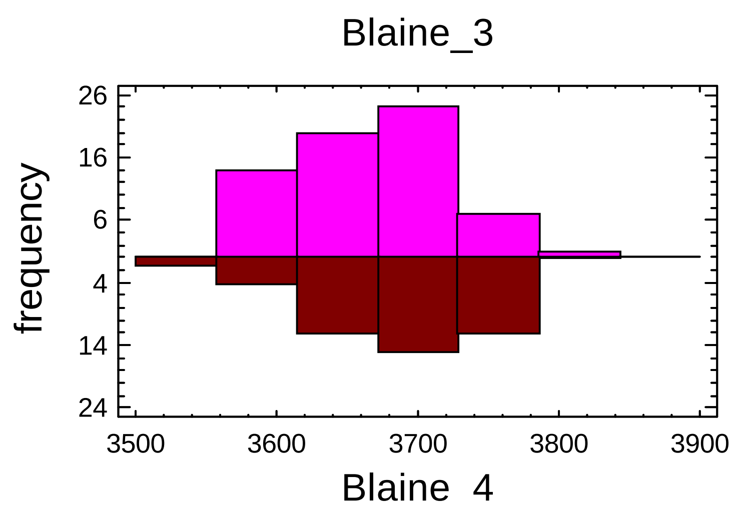
Analysis Summary

Sample 1: Blaine_3
Sample 2: Blaine_4

Sample 1: 66 values ranging from 3570,0 to 3820,0
Sample 2: 44 values ranging from 3550,0 to 3780,0

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



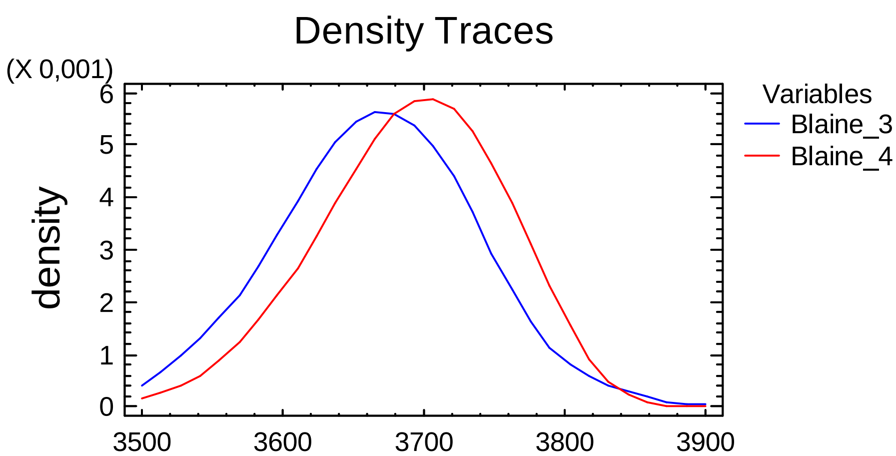
Summary Statistics

	Blaine_3	Blaine_4
Count	66	44
Average	3667,42	3691,36
Variance	3151,72	2612,05
Standard deviation	56,1402	51,1082
Minimum	3570,0	3550,0
Maximum	3820,0	3780,0

```
Range                250,0               230,0
Stnd. skewness       0,248365            -1,82542
Stnd. kurtosis       0,0494155           0,0241074
------------------------------------------------------------
```

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.



Comparison of Means

```
95,0% confidence interval for mean of Blaine_3: 3667,42 +/- 13,801    [3653,62,3681,23]
95,0% confidence interval for mean of Blaine_4: 3691,36 +/- 15,5384    [3675,83,3706,9]
95,0% confidence interval for the difference between the means
   assuming equal variances: -23,9394 +/- 20,9065   [-44,8459,-3,03287]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = -2,26973   P-value = 0,0252098
```

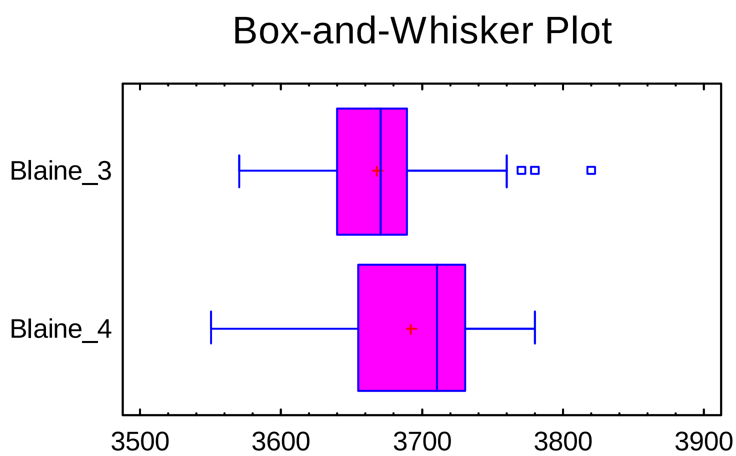
The StatAdvisor

This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from -44,8459 to -3,03287. Since the interval does not contain the value 0.0, there is a statistically significant difference between the means of the two samples at the 95,0% confidence level.

A t-test may also be used to test a specific hypothesis about the difference between the means of the populations from which the two samples come. In this case, the test has been constructed to

determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	Blaine_3	Blaine_4
Standard deviation	56,1402	51,1082
Variance	3151,72	2612,05
Df	65	43

Ratio of Variances = 1,20661

95,0% Confidence Intervals
Standard deviation of Blaine_3: [47,9296;67,7718]
Standard deviation of Blaine_4: [42,2268;64,7554]
Ratio of Variances: [0,684619;2,0612]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 1,20661   P-value = 0,516477

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,684619 to 2,0612. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the

computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,409091
Two-sided large sample K-S statistic = 2,10195
Approximate P value = 0,000290701

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,409091, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - CLK_3 & CLK_4

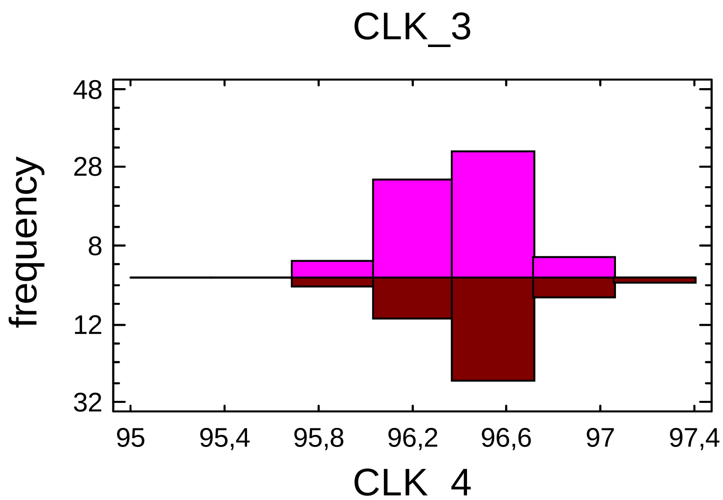
Analysis Summary

Sample 1: CLK_3
Sample 2: CLK_4

Sample 1: 66 values ranging from 95,7 to 96,9
Sample 2: 44 values ranging from 96,0 to 97,1

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

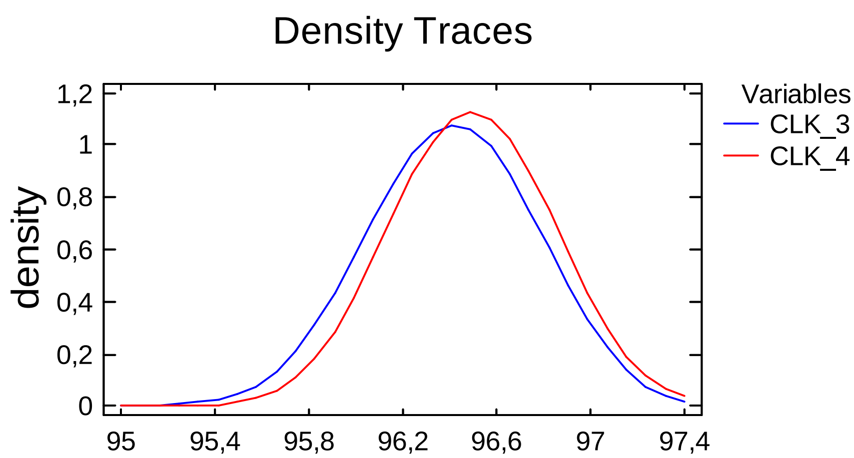


Summary Statistics

	CLK_3	CLK_4
Count	66	44
Average	96,4106	96,4977
Variance	0,0631166	0,0532505
Standard deviation	0,25123	0,230761
Minimum	95,7	96,0
Maximum	96,9	97,1
Range	1,2	1,1
Stnd. skewness	-0,788508	0,432815
Stnd. kurtosis	0,0912864	0,704415

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

95,0% confidence interval for mean of CLK_3: 96,4106 +/- 0,0617602   [96,3488,96,4724]
95,0% confidence interval for mean of CLK_4: 96,4977 +/- 0,0701578   [96,4276,96,5679]
95,0% confidence interval for the difference between the means
   assuming equal variances: -0,0871212 +/- 0,0938553   [-0,180977,0,00673411]

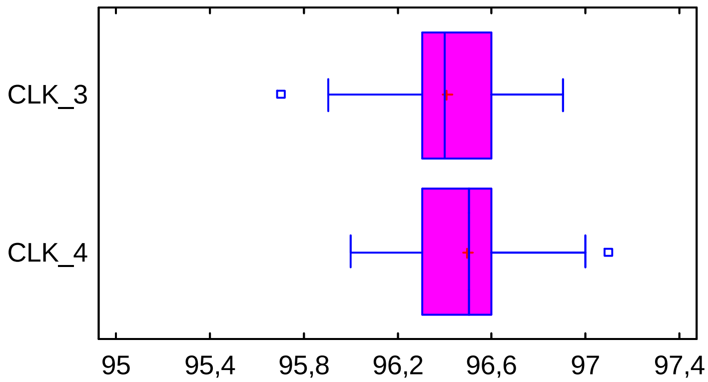
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = -1,83996   P-value = 0,0685208



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from -0,180977 to 0,00673411.  Since the interval contains the
value 0.0, there is not a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is not less than 0,05, we cannot
reject the null hypothesis.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```

Box-and-Whisker Plot




```
Comparison of Standard Deviations
---------------------------------

                    CLK_3               CLK_4
------------------------------------------------------------
Standard deviation  0,25123             0,230761
Variance            0,0631166           0,0532505
Df                  65                  43

     Ratio of Variances = 1,18528

95,0% Confidence Intervals
     Standard deviation of CLK_3: [0,214487;0,303282]
     Standard deviation of CLK_4: [0,19066;0,29238]
     Ratio of Variances: [0,672515;2,02475]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,18528   P-value = 0,558009



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,672515 to 2,02475.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.


Kolmogorov-Smirnov Test
-----------------------
```

Estimated overall statistic DN = 0,318182
Two-sided large sample K-S statistic = 1,63485
Approximate P value = 0,00953957

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,318182, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - GYP_3 & GYP_4

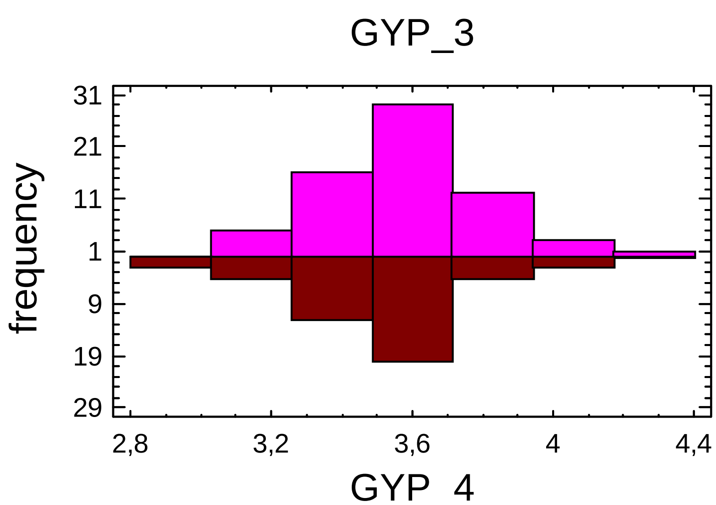
Analysis Summary

Sample 1: GYP_3
Sample 2: GYP_4

Sample 1: 66 values ranging from 3,1 to 4,3
Sample 2: 44 values ranging from 2,9 to 4,0

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



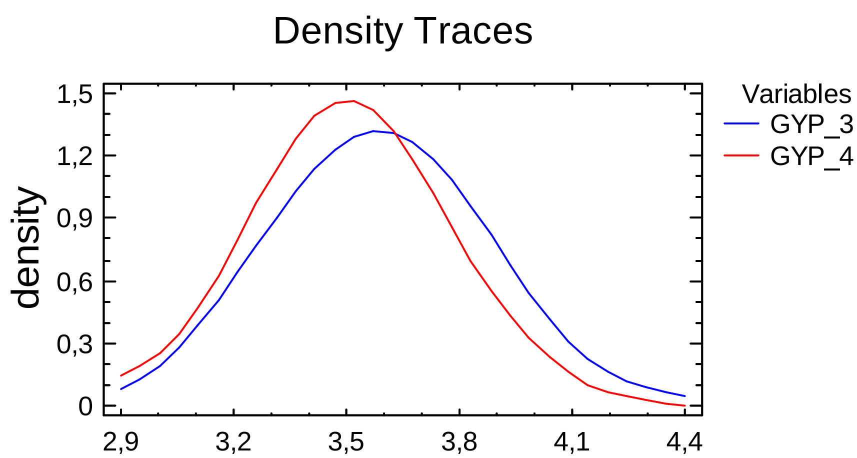
Summary Statistics

	GYP_3	GYP_4
Count	66	44
Average	3,58939	3,50227
Variance	0,0631166	0,0532505
Standard deviation	0,25123	0,230761
Minimum	3,1	2,9
Maximum	4,3	4,0

```
Range                1,2                  1,1
Stnd. skewness       0,788508             -0,432815
Stnd. kurtosis       0,0912864            0,704415
------------------------------------------------------------
```

The StatAdvisor

   This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.



Comparison of Means

```
95,0% confidence interval for mean of GYP_3: 3,58939 +/- 0,0617602   [3,52763,3,65115]
95,0% confidence interval for mean of GYP_4: 3,50227 +/- 0,0701578   [3,43211,3,57243]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,0871212 +/- 0,0938553   [-0,00673411,0,180977]

t test to compare means

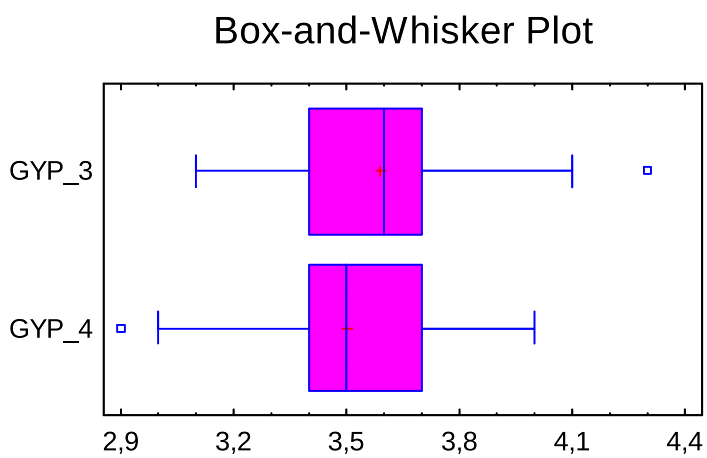
   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 1,83996   P-value = 0,0685208
```

The StatAdvisor

   This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from -0,00673411 to 0,180977. Since the interval contains the value 0.0, there is not a statistically significant difference between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the difference between the means of the populations from which the two samples come. In this case, the test has been constructed to

determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	GYP_3	GYP_4
Standard deviation	0,25123	0,230761
Variance	0,0631166	0,0532505
Df	65	43

Ratio of Variances = 1,18528

95,0% Confidence Intervals
Standard deviation of GYP_3: [0,214487;0,303282]
Standard deviation of GYP_4: [0,19066;0,29238]
Ratio of Variances: [0,672515;2,02475]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 1,18528   P-value = 0,558009

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,672515 to 2,02475. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the

computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,318182
Two-sided large sample K-S statistic = 1,63485
Approximate P value = 0,00953957

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,318182, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - LOI_3 & LOI_4

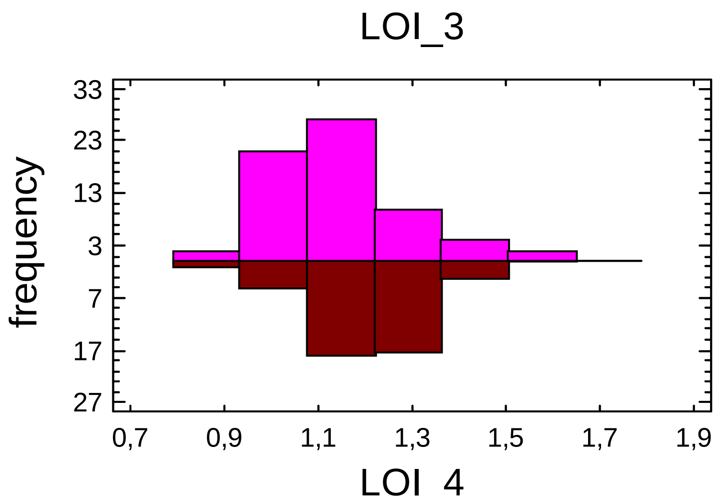
Analysis Summary

Sample 1: LOI_3
Sample 2: LOI_4

Sample 1: 66 values ranging from 0,83 to 1,6
Sample 2: 44 values ranging from 0,89 to 1,49

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



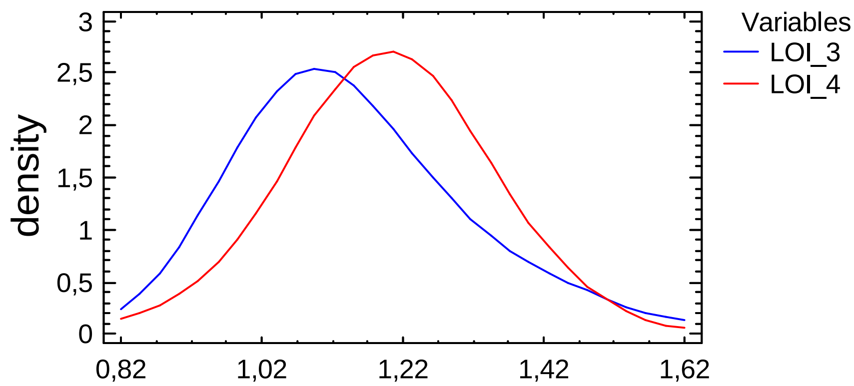
Summary Statistics

	LOI_3	LOI_4
Count	66	44
Average	1,14939	1,19886
Variance	0,0225935	0,0153684
Standard deviation	0,150311	0,12397
Minimum	0,83	0,89
Maximum	1,6	1,49
Range	0,77	0,6
Stnd. skewness	2,7588	-0,260205
Stnd. kurtosis	1,23789	0,407193

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, LOI_3 has a standardized skewness value outside the normal range. Both standardized kurtosis values are within the range expected.

Density Traces




```
Comparison of Means
-------------------

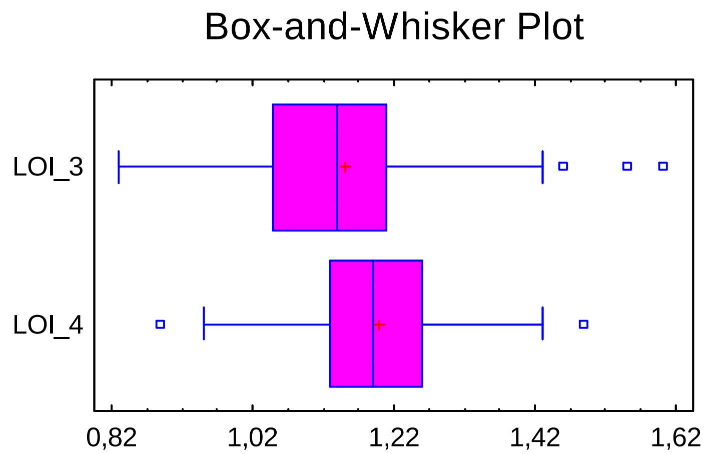
95,0% confidence interval for mean of LOI_3: 1,14939 +/- 0,0369512   [1,11244,1,18635]
95,0% confidence interval for mean of LOI_4: 1,19886 +/- 0,0376903   [1,16117,1,23655]
95,0% confidence interval for the difference between the means
   assuming equal variances: -0,0494697 +/- 0,05417   [-0,10364,0,00470035]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = -1,81018   P-value = 0,0730481



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from -0,10364 to 0,00470035.  Since the interval contains the
value 0.0, there is not a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is not less than 0,05, we cannot
reject the null hypothesis.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```



Comparison of Standard Deviations

	LOI_3	LOI_4
Standard deviation	0,150311	0,12397
Variance	0,0225935	0,0153684
Df	65	43

Ratio of Variances = 1,47012

95,0% Confidence Intervals
Standard deviation of LOI_3: [0,128328;0,181454]
Standard deviation of LOI_4: [0,102426;0,157073]
Ratio of Variances: [0,834133;2,51134]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 1,47012   P-value = 0,180544

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,834133 to 2,51134. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,325758
Two-sided large sample K-S statistic = 1,67377
Approximate P value = 0,00737335

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,325758, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - SiO2_3 & sio2_4

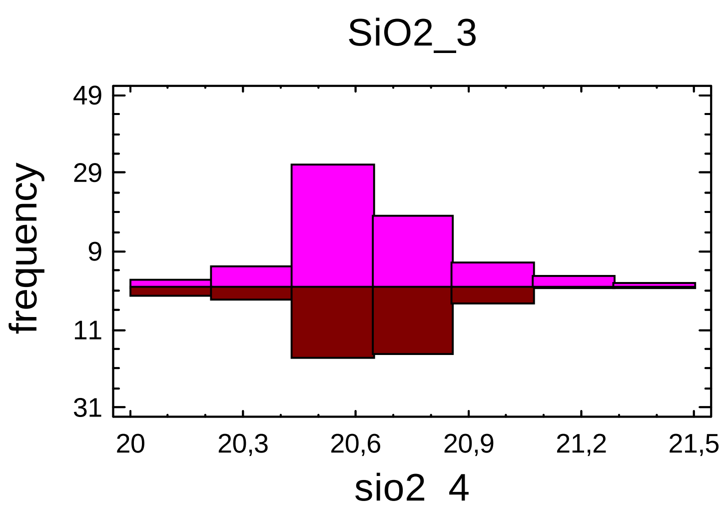
Analysis Summary

Sample 1: SiO2_3
Sample 2: sio2_4

Sample 1: 66 values ranging from 20,18 to 21,39
Sample 2: 44 values ranging from 20,16 to 20,95

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



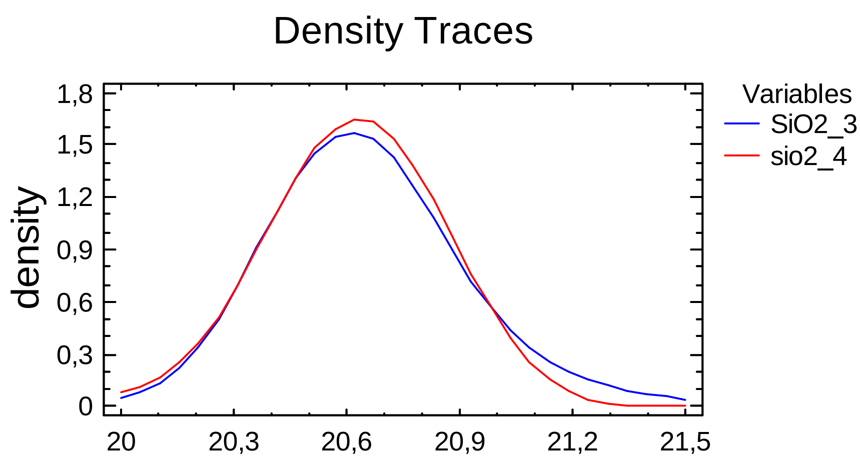
Summary Statistics

	SiO2_3	sio2_4
Count	66	44
Average	20,6514	20,6209
Variance	0,0474089	0,0315526
Standard deviation	0,217736	0,177631
Minimum	20,18	20,16
Maximum	21,39	20,95

```
Range               1,21               0,79
Stnd. skewness      2,72936            -1,04715
Stnd. kurtosis      2,73719            0,525681
------------------------------------------------------------
```

The StatAdvisor

   This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, SiO2_3 has a standardized skewness value outside the normal range. SiO2_3 has a standardized kurtosis value outside the normal range.



Comparison of Means

95,0% confidence interval for mean of SiO2_3: 20,6514 +/- 0,0535262 [20,5978,20,7049]
95,0% confidence interval for mean of sio2_4: 20,6209 +/- 0,0540048 [20,5669,20,6749]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,0304545 +/- 0,0782058   [-0,0477513,0,10866]

t test to compare means

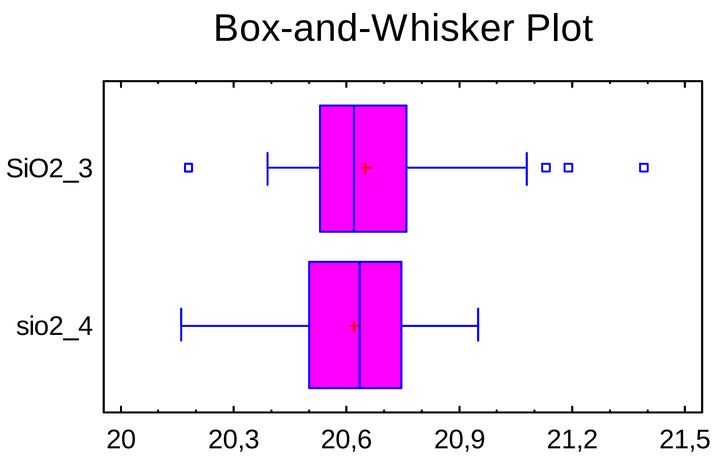
   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 0,77189   P-value = 0,441865

The StatAdvisor

   This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from -0,0477513 to 0,10866. Since the interval contains the value 0.0, there is not a statistically significant difference between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the

difference between the means of the populations from which the two samples come. In this case, the test has been constructed to determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	SiO2_3	sio2_4
Standard deviation	0,217736	0,177631
Variance	0,0474089	0,0315526
Df	65	43

Ratio of Variances = 1,50253

95,0% Confidence Intervals
  Standard deviation of SiO2_3: [0,185892;0,262848]
  Standard deviation of sio2_4: [0,146762;0,225063]
  Ratio of Variances: [0,852524;2,56671]

F-test to Compare Standard Deviations

  Null hypothesis: sigma1 = sigma2
  Alt. hypothesis: sigma1 NE sigma2
  F = 1,50253   P-value = 0,157236

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,852524 to 2,56671. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,106061
Two-sided large sample K-S statistic = 0,544949
Approximate P value = 0,927799

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,106061, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is greater than or equal to 0,05, there is not a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Est1_3 & Est1_4

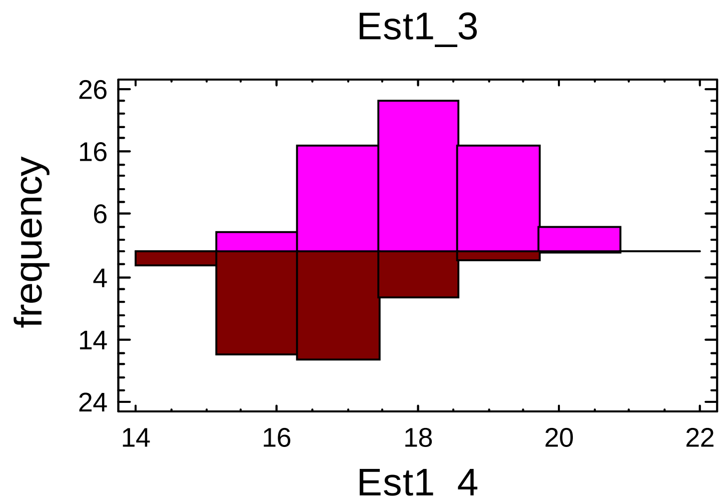
Analysis Summary

Sample 1: Est1_3
Sample 2: Est1_4

Sample 1: 65 values ranging from 15,5 to 20,8
Sample 2: 43 values ranging from 15,0 to 18,6

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

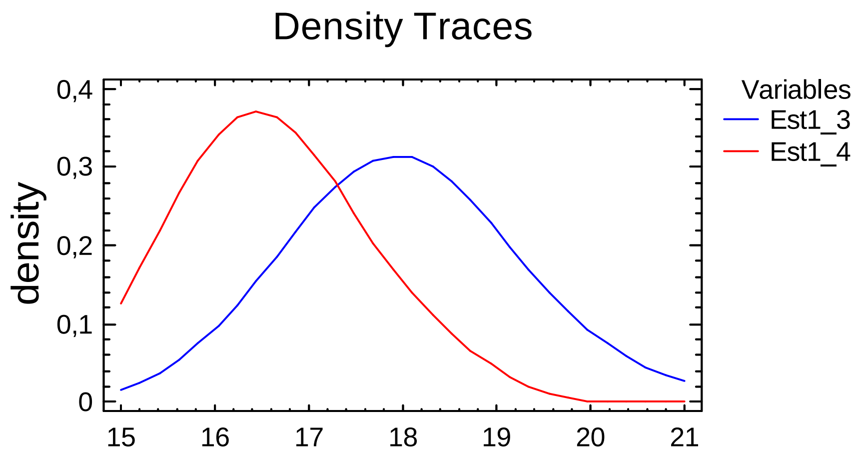


Summary Statistics

	Est1_3	Est1_4
Count	65	43
Average	18,0154	16,614
Variance	1,22757	0,74742
Standard deviation	1,10796	0,864534
Minimum	15,5	15,0
Maximum	20,8	18,6
Range	5,3	3,6
Stnd. skewness	0,81769	0,971413
Stnd. kurtosis	0,0076236	-0,269562

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.




```
Comparison of Means
-------------------

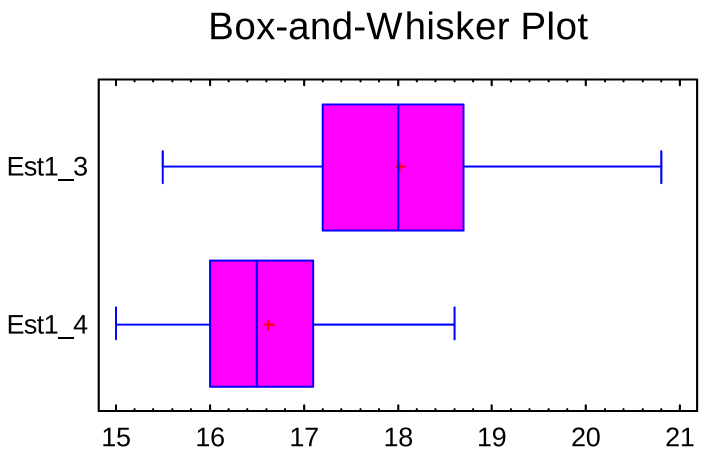
95,0% confidence interval for mean of Est1_3: 18,0154 +/- 0,274539   [17,7408,18,2899]
95,0% confidence interval for mean of Est1_4: 16,614 +/- 0,266065   [16,3479,16,88]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,40143 +/- 0,396929   [1,0045,1,79836]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 6,99993   P-value = 2,42002E-10



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 1,0045 to 1,79836.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------

                    Est1_3              Est1_4
------------------------------------------------------------
Standard deviation  1,10796             0,864534
Variance            1,22757             0,74742
Df                  64                  42

     Ratio of Variances = 1,64241

95,0% Confidence Intervals
     Standard deviation of Est1_3: [0,944848;1,33966]
     Standard deviation of Est1_4: [0,712844;1,09883]
     Ratio of Variances: [0,925946;2,82013]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,64241   P-value = 0,0888994



The StatAdvisor
---------------
   This option runs an F-test to compare the variances of the two
samples.  It also constructs confidence intervals or bounds for each
standard deviation and for the ratio of the variances.  Of particular
interest is the confidence interval for the ratio of the variances,
which extends from 0,925946 to 2,82013.  Since the interval contains
the value 1.0, there is not a statistically significant difference
between the standard deviations of the two samples at the 95,0%
confidence level.
   An F-test may also be used to test a specific hypothesis about the
standard deviations of the populations from which the two samples
come.  In this case, the test has been constructed to determine
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.


Kolmogorov-Smirnov Test
-----------------------
```

```
Estimated overall statistic DN = 0,605725
Two-sided large sample K-S statistic = 3,08144
Approximate P value = 1,13116E-8
```

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,605725, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Est2_3 & Est2_4

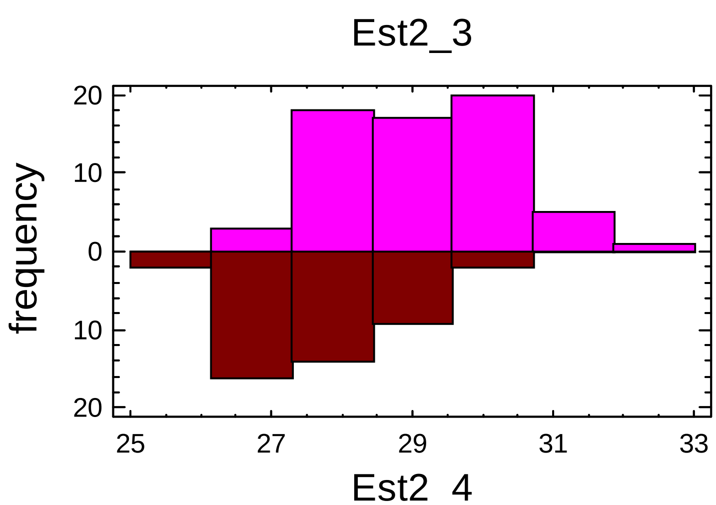
Analysis Summary

Sample 1: Est2_3
Sample 2: Est2_4

Sample 1: 64 values ranging from 26,8 to 32,5
Sample 2: 43 values ranging from 25,6 to 30,2

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



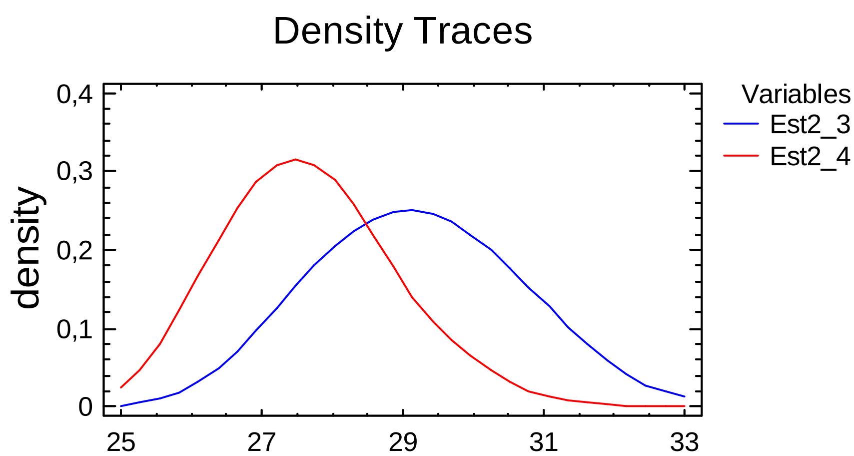
Summary Statistics

	Est2_3	Est2_4
Count	64	43
Average	29,2031	27,6535
Variance	1,57047	0,884928
Standard deviation	1,25318	0,940706
Minimum	26,8	25,6
Maximum	32,5	30,2

```
Range               5,7                 4,6
Stnd. skewness      0,789736            1,74165
Stnd. kurtosis      -0,669312           0,750425
------------------------------------------------------------
```

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.



Comparison of Means

```
95,0% confidence interval for mean of Est2_3: 29,2031 +/- 0,313036   [28,8901,29,5162]
95,0% confidence interval for mean of Est2_4: 27,6535 +/- 0,289507   [27,364,27,943]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,54964 +/- 0,445139   [1,1045,1,99478]

t test to compare means

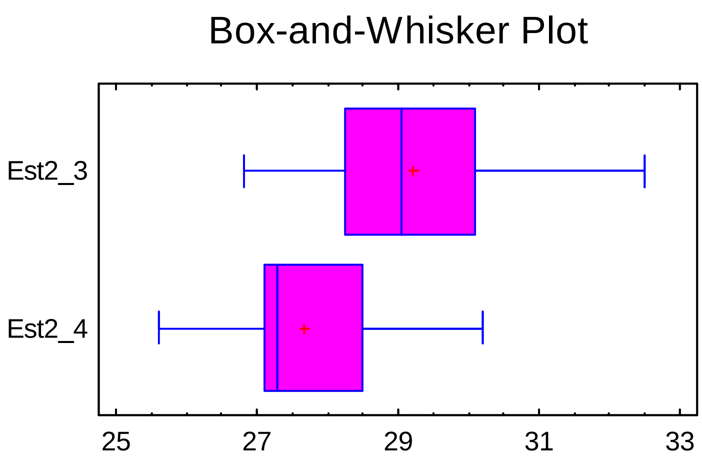
   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 6,90268   P-value = 2,93128E-7
```

The StatAdvisor

This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from 1,1045 to 1,99478. Since the interval does not contain the value 0.0, there is a statistically significant difference between the means of the two samples at the 95,0% confidence level.
A t-test may also be used to test a specific hypothesis about the difference between the means of the populations from which the two samples come. In this case, the test has been constructed to

determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	Est2_3	Est2_4
Standard deviation	1,25318	0,940706
Variance	1,57047	0,884928
Df	63	42

Ratio of Variances = 1,77468

95,0% Confidence Intervals
Standard deviation of Est2_3: [1,06746;1,51775]
Standard deviation of Est2_4: [0,77565;1,19565]
Ratio of Variances: [0,999231;3,05415]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 1,77468   P-value = 0,0503011

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,999231 to 3,05415. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the

computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,573038
Two-sided large sample K-S statistic = 2,90613
Approximate P value = 9,23132E-8

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,573038, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Est7_3 & Est7_4

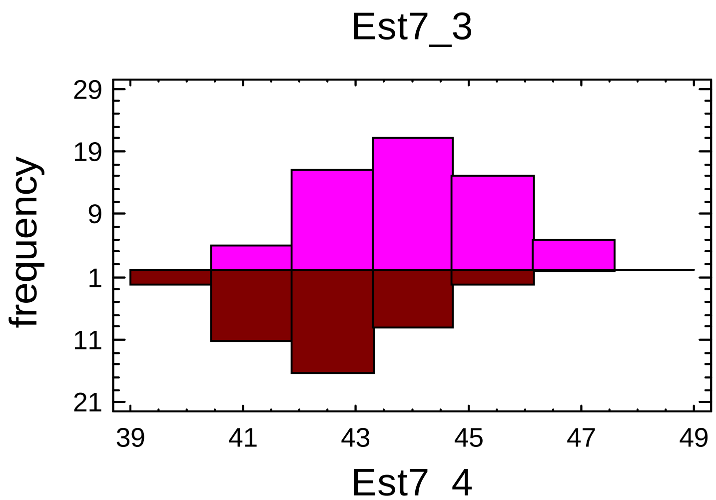
Analysis Summary

Sample 1: Est7_3
Sample 2: Est7_4

Sample 1: 61 values ranging from 40,6 to 46,9
Sample 2: 40 values ranging from 40,1 to 45,5

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.



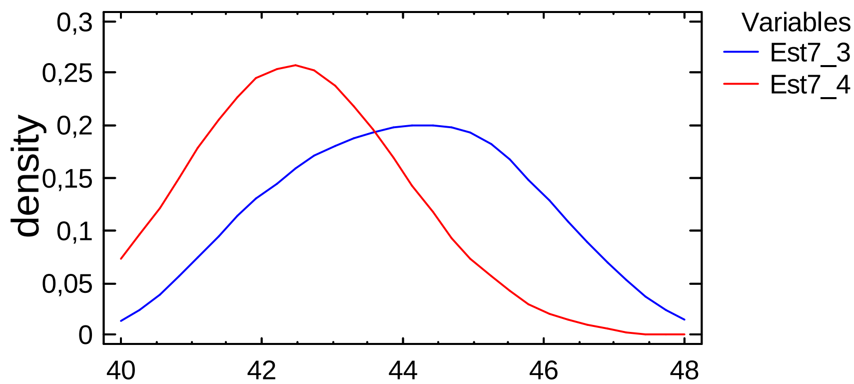
Summary Statistics

	Est7_3	Est7_4
Count	61	40
Average	43,9984	42,52
Variance	2,40916	1,60779
Standard deviation	1,55215	1,26799
Minimum	40,6	40,1
Maximum	46,9	45,5
Range	6,3	5,4
Stnd. skewness	-0,127274	0,677298
Stnd. kurtosis	-1,42973	-0,220099

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.

Density Traces




```
Comparison of Means
-------------------

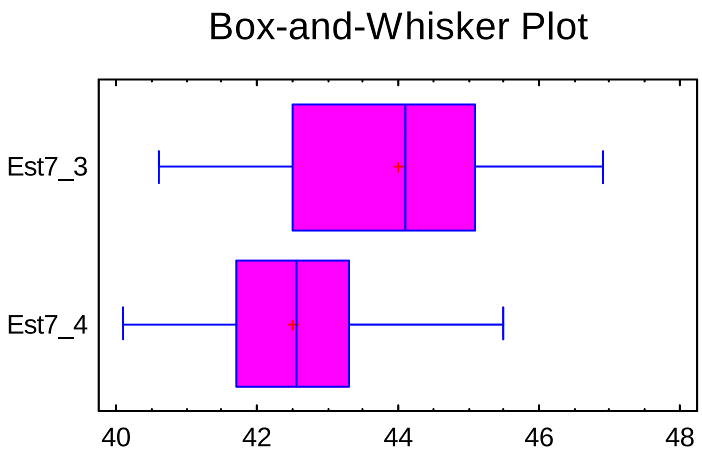
95,0% confidence interval for mean of Est7_3: 43,9984 +/- 0,397524   [43,6008,44,3959]
95,0% confidence interval for mean of Est7_4: 42,52 +/- 0,405523   [42,1145,42,9255]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,47836 +/- 0,584103   [0,894258,2,06246]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 5,02205   P-value = 0,00000243534



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,894258 to 2,06246.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------

                    Est7_3              Est7_4
------------------------------------------------------------
Standard deviation  1,55215             1,26799
Variance            2,40916             1,60779
Df                  60                  39

     Ratio of Variances = 1,49843

95,0% Confidence Intervals
     Standard deviation of Est7_3: [1,31732;1,88964]
     Standard deviation of Est7_4: [1,03869;1,62814]
     Ratio of Variances: [0,826371;2,62182]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,49843   P-value = 0,18062
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,826371 to 2,62182. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

```
Estimated overall statistic DN = 0,482377
Two-sided large sample K-S statistic = 2,37094
Approximate P value = 0,0000262045
```

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,482377, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is less than 0,05, there is a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Est28_3 & Est28_4

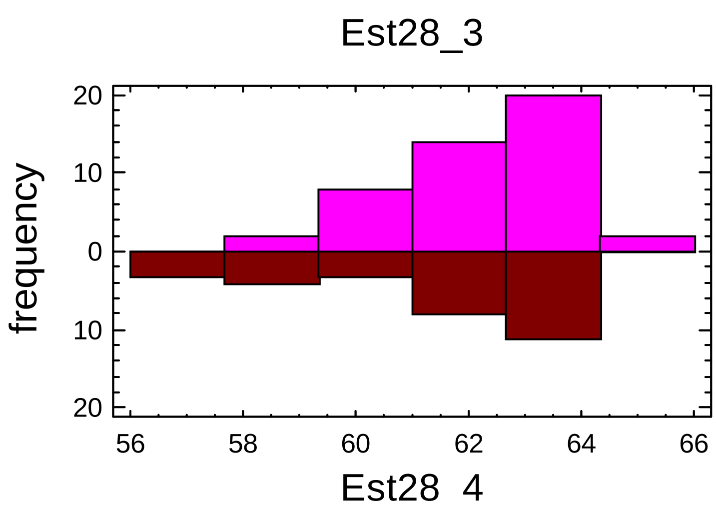
Analysis Summary

Sample 1: Est28_3
Sample 2: Est28_4

Sample 1: 46 values ranging from 59,0 to 64,9
Sample 2: 29 values ranging from 56,7 to 64,2

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

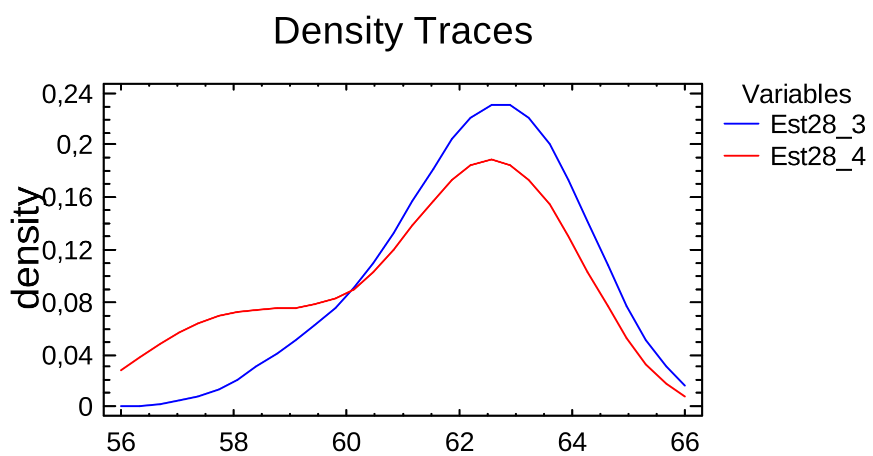


Summary Statistics

	Est28_3	Est28_4
Count	46	29
Average	62,3109	61,2966
Variance	1,96232	4,85749
Standard deviation	1,40083	2,20397
Minimum	59,0	56,7
Maximum	64,9	64,2

```
Range               5,9                 7,5
Stnd. skewness      -1,97443            -1,67541
Stnd. kurtosis      0,0215103           -0,727697
------------------------------------------------------------
```

```
The StatAdvisor
---------------
   This table shows summary statistics for the two samples of data.
Other tabular options within this analysis can be used to test whether
differences between the statistics from the two samples are
statistically significant.  Of particular interest here are the
standardized skewness and standardized kurtosis, which can be used to
determine whether the samples come from normal distributions.  Values
of these statistics outside the range of -2 to +2 indicate significant
departures from normality, which would tend to invalidate the tests
which compare the standard deviations.  In this case, both
standardized skewness values are within the range expected.  Both
standardized kurtosis values are within the range expected.
```




```
Comparison of Means
-------------------

95,0% confidence interval for mean of Est28_3: 62,3109 +/- 0,415996
[61,8949,62,7269]
95,0% confidence interval for mean of Est28_4: 61,2966 +/- 0,838347
[60,4582,62,1349]
95,0% confidence interval for the difference between the means
   assuming equal variances: 1,01432 +/- 0,828375   [0,185942,1,84269]

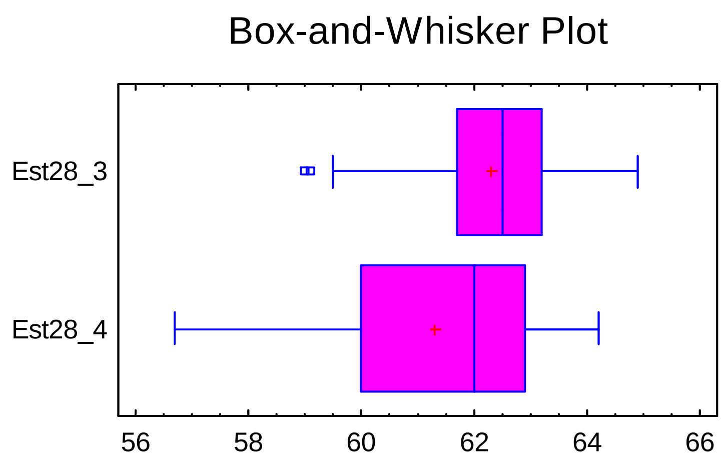
t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 2,44036   P-value = 0,0171002
```

```
The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,185942 to 1,84269.  Since the interval does not contain
the value 0.0, there is a statistically significant difference between
the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
```

difference between the means of the populations from which the two samples come. In this case, the test has been constructed to determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption is questionable since the results of an F-test to compare the standard deviations suggests that there may be a significant difference between them. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	Est28_3	Est28_4
Standard deviation	1,40083	2,20397
Variance	1,96232	4,85749
Df	45	28

Ratio of Variances = 0,403979

95,0% Confidence Intervals
Standard deviation of Est28_3: [1,1619;1,76438]
Standard deviation of Est28_4: [1,74903;2,98076]
Ratio of Variances: [0,199454;0,775189]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 0,403979   P-value = 0,00652292

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,199454 to 0,775189. Since the interval does not contain the value 1.0, there is a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

Estimated overall statistic DN = 0,269115
Two-sided large sample K-S statistic = 1,13497
Approximate P value = 0,152138

The StatAdvisor

This option runs a Kolmogorov-Smirnov test to compare the distributions of the two samples. This test is performed by computing the maximum distance between the cumulative distributions of the two samples. In this case, the maximum distance is 0,269115, which you can see visually by selecting Quantile Plot from the list of Graphical Options. Of particular interest is the approximate P-value for the test. Since the P-value is greater than or equal to 0,05, there is not a statistically significant difference between the two distributions at the 95,0% confidence level.

Two-Sample Comparison - Est2 to Est7_3 & Est2 to Est7_4

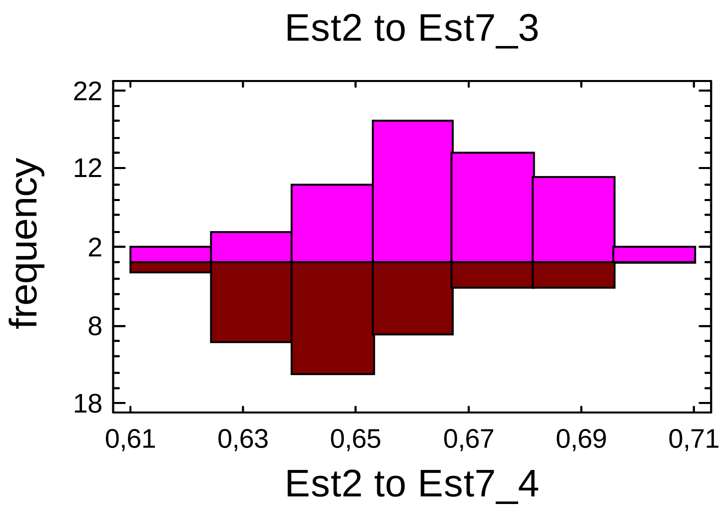
Analysis Summary

Sample 1: Est2 to Est7_3
Sample 2: Est2 to Est7_4

Sample 1: 61 values ranging from 0,618421 to 0,699552
Sample 2: 40 values ranging from 0,615909 to 0,690647

The StatAdvisor

This procedure is designed to compare two samples of data. It will calculate various statistics and graphs for each sample, and it will run several tests to determine whether there are statistically significant differences between the two samples.

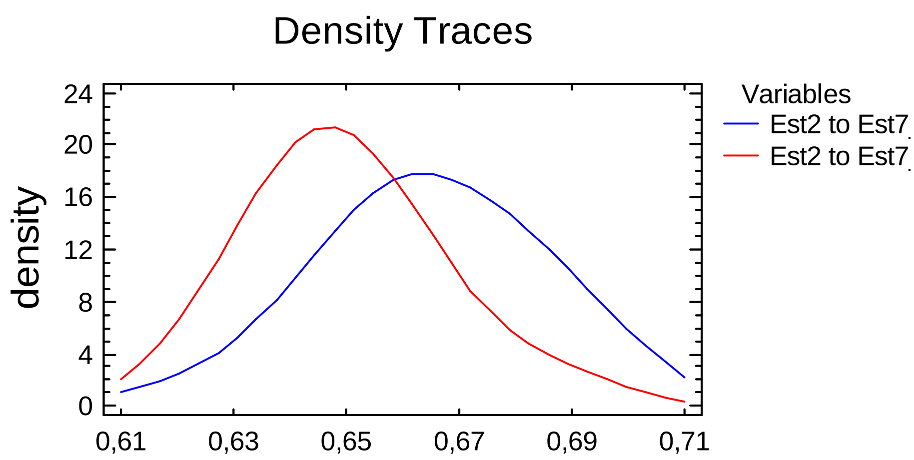


Summary Statistics

	Est2 to Est7_3	Est2 to Est7_4
Count	61	40
Average	0,664807	0,649925
Variance	0,000360725	0,000268776
Standard deviation	0,0189928	0,0163944
Minimum	0,618421	0,615909
Maximum	0,699552	0,690647
Range	0,0811305	0,0747384
Stnd. skewness	-0,663281	1,44722
Stnd. kurtosis	-0,547589	0,467464

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.

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Comparison of Means
-------------------

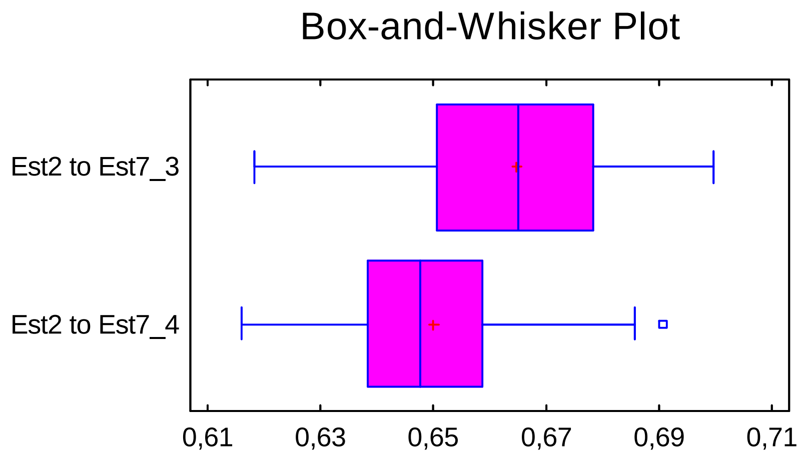
95,0% confidence interval for mean of Est2 to Est7_3: 0,664807 +/- 0,00486428
[0,659942,0,669671]
95,0% confidence interval for mean of Est2 to Est7_4: 0,649925 +/- 0,00524319
[0,644682,0,655168]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,0148819 +/- 0,00727218   [0,00760969,0,0221541]

t test to compare means

   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 4,06053   P-value = 0,0000981703



The StatAdvisor
---------------
   This option runs a t-test to compare the means of the two samples.
It also constructs confidence intervals or bounds for each mean and
for the difference between the means.  Of particular interest is the
confidence interval for the difference between the means, which
extends from 0,00760969 to 0,0221541.  Since the interval does not
contain the value 0.0, there is a statistically significant difference
between the means of the two samples at the 95,0% confidence level.
   A t-test may also be used to test a specific hypothesis about the
difference between the means of the populations from which the two
samples come.  In this case, the test has been constructed to
determine whether the difference between the two means equals 0,0
versus the alternative hypothesis that the difference does not equal
0,0.  Since the computed P-value is less than 0,05, we can reject the
null hypothesis in favor of the alternative.
   NOTE: these results assume that the variances of the two samples
are equal.  In this case, that assumption appears to be reasonable
based on the results of an F-test to compare the standard deviations.
You can see the results of that test by selecting Comparison of
Standard Deviations from the Tabular Options menu.
```




```
Comparison of Standard Deviations
---------------------------------

                    Est2 to Est7_3      Est2 to Est7_4
------------------------------------------------------------
Standard deviation  0,0189928           0,0163944
Variance            0,000360725         0,000268776
Df                  60                  39

     Ratio of Variances = 1,3421

95,0% Confidence Intervals
     Standard deviation of Est2 to Est7_3: [0,0161193;0,0231225]
     Standard deviation of Est2 to Est7_4: [0,0134296;0,021051]
     Ratio of Variances: [0,740159;2,3483]

F-test to Compare Standard Deviations

   Null hypothesis: sigma1 = sigma2
   Alt. hypothesis: sigma1 NE sigma2
   F = 1,3421   P-value = 0,330206
```

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,740159 to 2,3483. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine whether the ratio of the standard deviations equals 1,0 versus the alternative hypothesis that the ratio does not equal 1,0. Since the computed P-value is not less than 0,05, we cannot reject the null hypothesis.

IMPORTANT NOTE: the F-tests and confidence intervals shown here depend on the samples having come from normal distributions. To test this assumption, select Summary Statistics from the list of Tabular Options and check the standardized skewness and standardized kurtosis values.

Kolmogorov-Smirnov Test

```
Estimated overall statistic DN = 0,429918
Two-sided large sample K-S statistic = 2,1131
Approximate P value = 0,000264616


The StatAdvisor
---------------
   This option runs a Kolmogorov-Smirnov test to compare the
distributions of the two samples.  This test is performed by computing
the maximum distance between the cumulative distributions of the two
samples.  In this case, the maximum distance is 0,429918, which you
can see visually by selecting Quantile Plot from the list of Graphical
Options.  Of particular interest is the approximate P-value for the
test.  Since the P-value is less than 0,05, there is a statistically
significant difference between the two distributions at the 95,0%
confidence level.



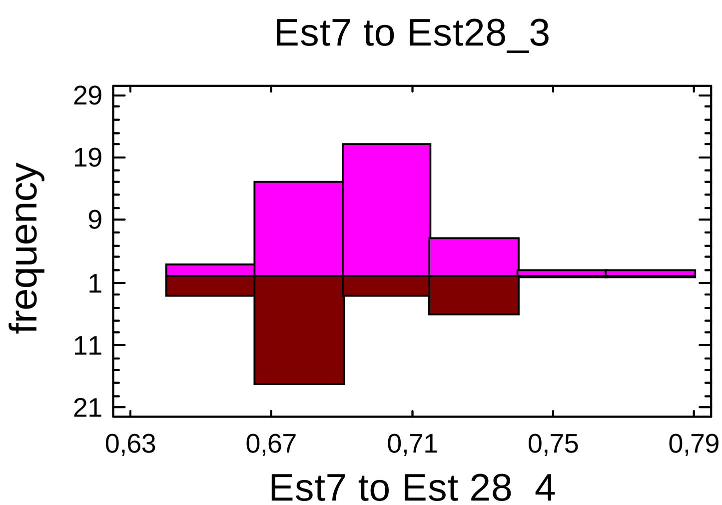
Two-Sample Comparison - Est7 to Est28_3 & Est7 to Est 28_4

Analysis Summary

Sample 1: Est7 to Est28_3
Sample 2: Est7 to Est 28_4

Sample 1: 46 values ranging from 0,653784 to 0,768333
Sample 2: 29 values ranging from 0,657233 to 0,736207


The StatAdvisor
---------------
   This procedure is designed to compare two samples of data.  It will
calculate various statistics and graphs for each sample, and it will
run several tests to determine whether there are statistically
significant differences between the two samples.
```



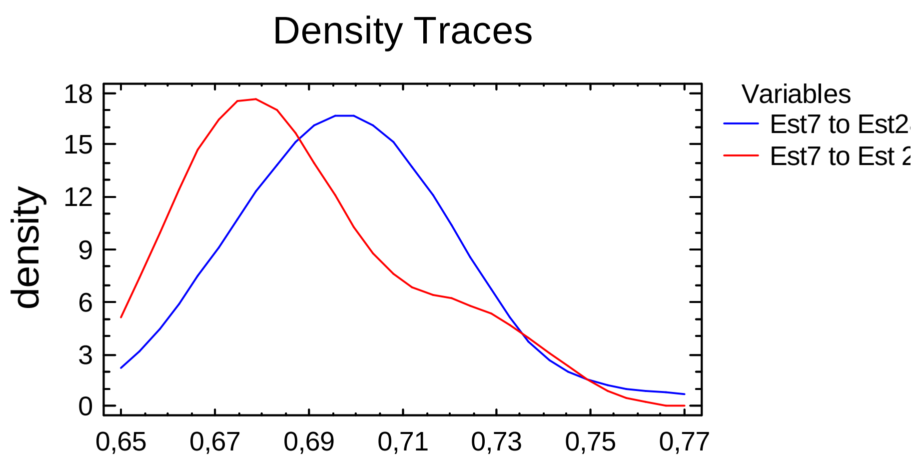

```
Summary Statistics

                    Est7 to Est28_3     Est7 to Est 28_4
------------------------------------------------------------
Count               46                  29
Average             0,698467            0,687841
Variance            0,000463208         0,000476791
Standard deviation  0,0215223           0,0218355
Minimum             0,653784            0,657233
Maximum             0,768333            0,736207
```

```
Range                0,114549            0,0789742
Stnd. skewness       1,75819             1,86865
Stnd. kurtosis       1,97156             -0,299397
------------------------------------------------------------
```

The StatAdvisor

This table shows summary statistics for the two samples of data. Other tabular options within this analysis can be used to test whether differences between the statistics from the two samples are statistically significant. Of particular interest here are the standardized skewness and standardized kurtosis, which can be used to determine whether the samples come from normal distributions. Values of these statistics outside the range of -2 to +2 indicate significant departures from normality, which would tend to invalidate the tests which compare the standard deviations. In this case, both standardized skewness values are within the range expected. Both standardized kurtosis values are within the range expected.



Comparison of Means

95,0% confidence interval for mean of Est7 to Est28_3: 0,698467 +/- 0,00639134 [0,692075,0,704858]
95,0% confidence interval for mean of Est7 to Est 28_4: 0,687841 +/- 0,00830581 [0,679535,0,696147]
95,0% confidence interval for the difference between the means
   assuming equal variances: 0,0106255 +/- 0,0102277   [0,000397815,0,0208532]

t test to compare means

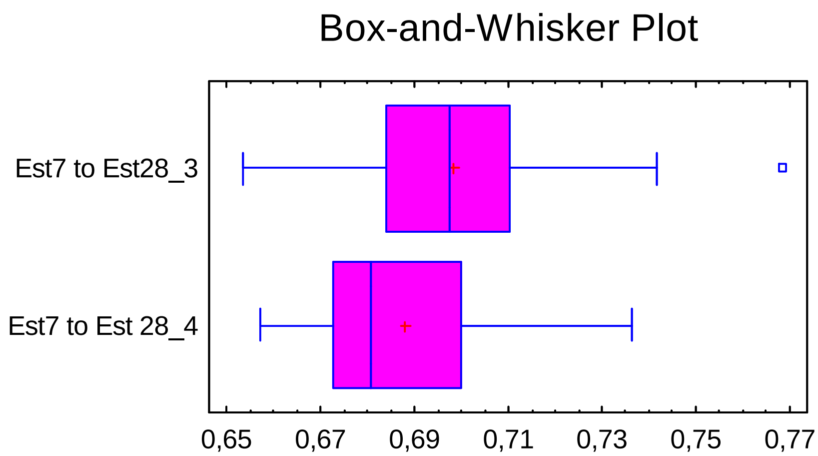
   Null hypothesis: mean1 = mean2
   Alt. hypothesis: mean1 NE mean2
      assuming equal variances: t = 2,07052   P-value = 0,0419409

The StatAdvisor

This option runs a t-test to compare the means of the two samples. It also constructs confidence intervals or bounds for each mean and for the difference between the means. Of particular interest is the confidence interval for the difference between the means, which extends from 0,000397815 to 0,0208532. Since the interval does not contain the value 0.0, there is a statistically significant difference between the means of the two samples at the 95,0% confidence level.
A t-test may also be used to test a specific hypothesis about the

difference between the means of the populations from which the two samples come. In this case, the test has been constructed to determine whether the difference between the two means equals 0,0 versus the alternative hypothesis that the difference does not equal 0,0. Since the computed P-value is less than 0,05, we can reject the null hypothesis in favor of the alternative.

NOTE: these results assume that the variances of the two samples are equal. In this case, that assumption appears to be reasonable based on the results of an F-test to compare the standard deviations. You can see the results of that test by selecting Comparison of Standard Deviations from the Tabular Options menu.



Comparison of Standard Deviations

	Est7 to Est28_3	Est7 to Est 28_4
Standard deviation	0,0215223	0,0218355
Variance	0,000463208	0,000476791
Df	45	28

Ratio of Variances = 0,971512

95,0% Confidence Intervals

Standard deviation of Est7 to Est28_3: [0,0178514;0,0271078]
Standard deviation of Est7 to Est 28_4: [0,0173282;0,0295315]
Ratio of Variances: [0,479658;1,86422]

F-test to Compare Standard Deviations

Null hypothesis: sigma1 = sigma2
Alt. hypothesis: sigma1 NE sigma2
F = 0,971512   P-value = 0,911666

The StatAdvisor

This option runs an F-test to compare the variances of the two samples. It also constructs confidence intervals or bounds for each standard deviation and for the ratio of the variances. Of particular interest is the confidence interval for the ratio of the variances, which extends from 0,479658 to 1,86422. Since the interval contains the value 1.0, there is not a statistically significant difference between the standard deviations of the two samples at the 95,0% confidence level.

An F-test may also be used to test a specific hypothesis about the standard deviations of the populations from which the two samples come. In this case, the test has been constructed to determine

```
whether the ratio of the standard deviations equals 1,0 versus the
alternative hypothesis that the ratio does not equal 1,0.  Since the
computed P-value is not less than 0,05, we cannot reject the null
hypothesis.
   IMPORTANT NOTE:  the F-tests and confidence intervals shown here
depend on the samples having come from normal distributions.  To test
this assumption, select Summary Statistics from the list of Tabular
Options and check the standardized skewness and standardized kurtosis
values.


Kolmogorov-Smirnov Test
-----------------------

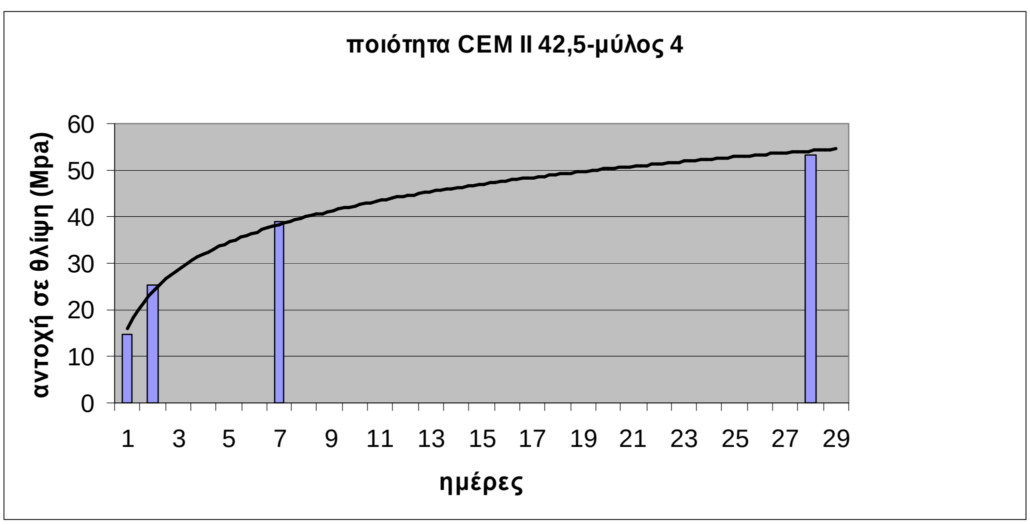
Estimated overall statistic DN = 0,390555
Two-sided large sample K-S statistic = 1,64713
Approximate P value = 0,00880039


The StatAdvisor
---------------
   This option runs a Kolmogorov-Smirnov test to compare the
distributions of the two samples.  This test is performed by computing
the maximum distance between the cumulative distributions of the two
samples.  In this case, the maximum distance is 0,390555, which you
can see visually by selecting Quantile Plot from the list of Graphical
Options.  Of particular interest is the approximate P-value for the
test.  Since the P-value is less than 0,05, there is a statistically
significant difference between the two distributions at the 95,0%
confidence level.
```

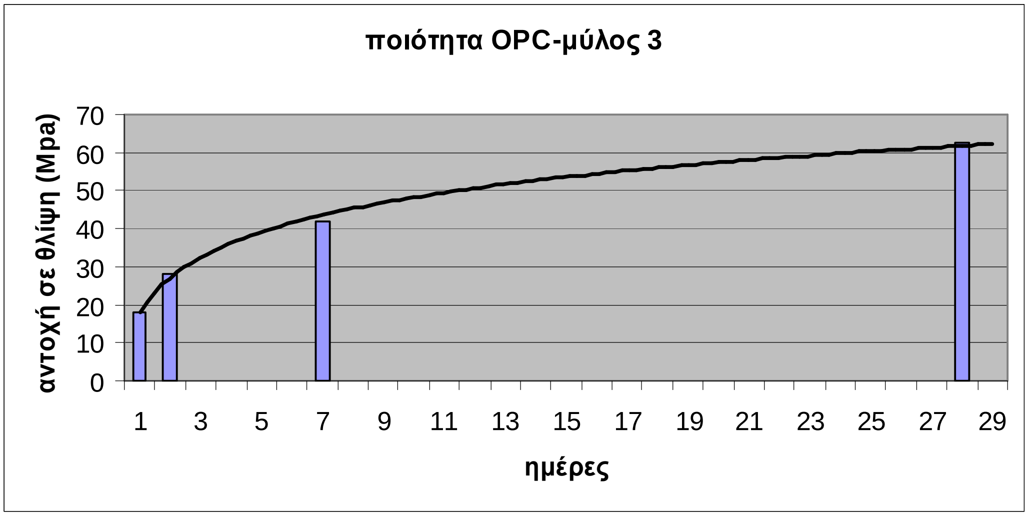
ΠΑΡΑΡΤΗΜΑ Δ

Διαγράμματα αντοχής θλίψης συναρτήσει του χρόνου

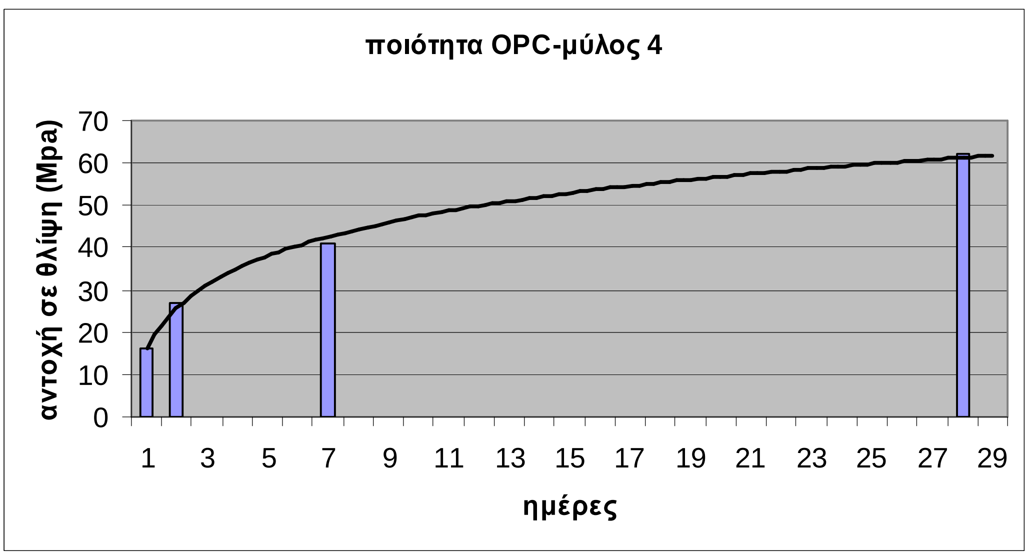
Ποιότητα τσιμέντου CEM II 42,5- μύλος 4



Ποιότητα τσιμέντου OPC- μύλος 3



Ποιότητα τσιμέντου OPC-μύλος 4



ΠΑΡΑΡΤΗΜΑ Ε

ΠΙΝΑΚΕΣ

ΠΙΝΑΚΑΣ Α

	διαγράμματα για μέση τιμή			διαγράμματα για τυπική απόκλιση				
	συντελεστές για όρια ελέγχου			συντελεστές για κεντρική γραμμή		συντελεστές για όρια ελέγχο		
παρατηρήσεις στο δείγμα, n	A	A2	A3	C4	1/C4	B3	B4	B5
2	2,121	1,88	2,659	0,7979	1,25329	0	3,267	0
3	1,732	1,023	1,954	0,8862	1,128413	0	2,568	0
4	1,5	0,729	1,628	0,9213	1,085423	0	2,266	0
5	1,342	0,577	1,427	0,94	1,06383	0	2,089	0
6	1,225	0,483	1,287	0,9515	1,050972	0,03	1,97	29
7	1,134	0,419	1,182	0,9594	1,042318	0,118	1,882	0,113
8	1,061	0,373	1,099	0,965	1,036269	0,185	1,815	0,179
9	1	0,337	1,032	0,9693	1,031672	0,239	1,761	0,232
10	0,949	0,308	0,975	0,9727	1,028066	0,284	1,716	0,276
11	0,905	0,285	0,927	0,9754	1,02522	0,321	1,679	0,313
12	0,866	0,266	0,886	0,9776	1,022913	0,354	1,646	0,346
13	0,832	0,249	0,85	0,9794	1,021033	0,382	1,618	0,374
14	0,802	0,235	0,817	0,981	1,019368	0,406	1,594	0,399
15	0,775	0,223	0,789	0,9823	1,018019	0,428	1,572	0,421
16	0,75	0,212	0,763	0,9835	1,016777	0,448	1,552	0,44
17	0,728	0,203	0,739	0,9845	1,015744	0,446	1,534	0,458
18	0,707	0,194	0,718	0,9854	1,014816	0,482	1,518	0,475
19	0,688	0,187	0,698	0,9862	1,013993	0,497	1,503	0,49
20	0,671	0,18	0,68	0,9869	1,013274	0,51	1,49	0,504
21	0,655	0,173	0,663	0,9876	1,012556	0,523	1,477	0,516
22	0,64	0,167	0,647	0,9882	1,011941	0,534	1,466	0,528
23	0,626	0,162	0,633	0,9887	1,011429	0,545	1,455	0,539
24	0,612	0,157	0,619	0,9892	1,010918	0,555	1,445	0,549
25	0,6	0,153	0,606	0,9896	1,010509	0,565	1,435	0,559

* ο παραπάνω πίνακας αποτελεί μέρος του πίνακα 27 στο Εγχειρίδιο παρουσίασης δεδομένων και ανάλυσης
STP15D,pp134-135

Πίνακας Β: E_2 συντελεστής για διαγράμματα ελέγχου

Αριθμός παρατηρήσεων σε κάθε υποομάδα	E_2
2	2.660
3	1.772
4	1.457
5	1.290
6	1.184
7	1.109
8	1.054
9	1.010
10	0.975
11	0.946
12	0.921
13	0.899

14	0.881
15	0.864

ΠΙΝΑΚΑΣ Γ

$Z = \frac{(x-\mu)}{\sigma}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3238	.3192	.3156	.3121
0.5	.3085	.3050	.3015	2981	.2946	.2912	.2877	.2843	.2810	.2776
0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
1.4	0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
2.0	.0228	.0222	.0216	.0211	.0206	.0201	.0197	.0192	.0187	.0183
2.1	.0179	.0174	.0170	.0165	.0161	.0157	.0153	.0150	.0146	.0142
2.2	.0139	.0135	.0132	.0128	.0125	.0122	.0119	.0116	.0113	.0110
2.3	.0107	.0104	.0101	.0099	.0096	.0093	.0091	.0088	.0086	.0084
2.4	.0082	.0079	.0077	.0075	.0073	.0071	.0069	.0067	.0065	.0063
2.5	.0062	.0060	.0058	.0057	.0055	.0053	.0052	.0050	.0049	.0048
2.6	.0046	.0045	.0044	.0042	.0041	.0040	.0039	.0037	.0036	.0035
2.7	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0028	.0027	.0026
2.8	.0025	.0024	.0024	.0023	.0022	.0021	.0021	.0020	.0019	.0019
2.9	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014	.0013
3.0	.0013									
3.1	.0009									
3.2	.0006									
3.3	.0004									
3.4	.0003									
3.5	.00025									
3.6	.00015									
3.7	.00010									
3.8	.00007									
3.9	.00005									
4.0	.00003									

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ

ΕΥΡΩΠΑΪΚΟ ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ ΣΤΗ ΔΙΟΙΚΗΣΗ ΕΠΙΧΕΙΡΗΣΕΩΝ – ΟΛΙΚΗ ΠΟΙΟΤΗΤΑ (MBA-TQM)

ΣΤΑΤΙΣΤΙΚΗ ΑΝΑΛΥΣΗ ΠΟΙΟΤΗΤΑΣ ΔΙΕΡΓΑΣΙΩΝ

ΜΕΛΕΤΗ ΠΕΡΙΠΤΩΣΗΣ ΒΙΟΜΗΧΑΝΙΑΣ ΠΑΡΑΓΩΓΗΣ ΤΣΙΜΕΝΤΟΥ

ΧΡΙΣΤΙΝΑ – ΝΙΚΟΛΕΤΤΑ του ΑΝΤΩΝΙΟΥ ΣΠΗΛΙΩΤΟΠΟΥΛΟΥ

2004

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΩΣ
ΤΜΗΜΑ ΟΡΓΑΝΩΣΗΣ ΚΑΙ ΔΙΟΙΚΗΣΗΣ ΕΠΙΧΕΙΡΗΣΕΩΝ

ΕΥΡΩΠΑΪΚΟ ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ ΣΤΗ ΔΙΟΙΚΗΣΗ ΕΠΙΧΕΙΡΗΣΕΩΝ – ΟΛΙΚΗ ΠΟΙΟΤΗΤΑ (MBA-TQM)

ΣΤΑΤΙΣΤΙΚΗ ΑΝΑΛΥΣΗ ΠΟΙΟΤΗΤΑΣ ΔΙΕΡΓΑΣΙΩΝ

ΜΕΛΕΤΗ ΠΕΡΙΠΤΩΣΗΣ ΒΙΟΜΗΧΑΝΙΑΣ ΠΑΡΑΓΩΓΗΣ ΤΣΙΜΕΝΤΟΥ

ΧΡΙΣΤΙΝΑ – ΝΙΚΟΛΕΤΤΑ του ΑΝΤΩΝΙΟΥ ΣΠΗΛΙΩΤΟΠΟΥΛΟΥ

ΧΗΜΙΚΟΣ ΜΗΧΑΝΙΚΟΣ Ε.Μ.Π.

ΠΕΙΡΑΙΑΣ 2004

ΣΤΑΤΙΣΤΙΚΗ ΑΝΑΛΥΣΗ ΠΟΙΟΤΗΤΑΣ ΔΙΕΡΓΑΣΙΩΝ ΜΕΛΕΤΗ ΠΕΡΙΠΤΩΣΗΣ ΒΙΟΜΗΧΑΝΙΑΣ ΠΑΡΑΓΩΓΗΣ ΤΣΙΜΕΝΤΟΥ

Σημαντικοί όροι **:** στατιστική ανάλυση ποιότητας διεργασιών, στατιστικός έλεγχος ποιότητας, χάρτες ελέγχου, ανάλυση ικανότητας διεργασιών, παλινδρόμηση, συσχέτιση, σύγκριση πληθυσμών

Περίληψη

Αντικείμενο μελέτης της παρούσας εργασίας αποτελεί η Στατιστική Ανάλυση Ποιότητας Διεργασιών. Ύστερα από αναφορά στις σημαντικότερες μεθόδους εφαρμογής Στατιστικού Ελέγχου Ποιότητας πραγματοποιείται επισταμένη έρευνα για τον βέλτιστο τρόπο εφαρμογής αυτών σε τμήματα παραγωγής και πιο συγκεκριμένα σε βιομηχανική μονάδα παραγωγής τσιμέντου.

Στόχο της εργασίας αποτελεί όχι μόνο η εφαρμογή των συνήθων εργαλείων του Στατιστικού Ελέγχου Διεργασιών. Η παρακολούθηση του τρόπου παραγωγής του τελικού προϊόντος ανέδειξε την ανάγκη πρόβλεψης της τελικής ποιότητάς του. Πραγματοποιείται προσπάθεια ανάπτυξης συγκεκριμένου μοντέλου, με τη χρήση μεθόδων της στατιστικής, το οποίο έχει ως σκοπό τον προσδιορισμό των τελικών ιδιοτήτων του προϊόντος γνωρίζοντας τη σύνθεσή του και τις ιδιότητες των συστατικών του.

Η μεθοδολογία που ακολουθήθηκε περιλαμβάνει την έρευνα θεωριών στατιστικού ελέγχου διεργασιών καθώς και ανάλυση της προς μελέτη εταιρίας. Πραγματοποιείται Επισταμένη σπουδή στη διαδικασία παραγωγής τσιμέντου και εφαρμόζονται βασικές μέθοδοι του Στατιστικού Ελέγχου Ποιότητας. Ακολουθεί έλεγχος της ικανότητας παραγωγής για τη συμφωνία των ιδιοτήτων του προϊόντος με τις προδιαγραφές που έχουν τεθεί. Εν συνεχεία εφαρμόζονται μέθοδοι παλινδρόμησης με σκοπό τη συσχέτιση βασικών για την παραγωγή παραμέτρων και την εξακρίβωση του ποσοστού που αυτές επηρεάζουν την τελική, ως προς τις μηχανικές ιδιότητες, ποιότητα τσιμέντου. Παράλληλα, πραγματοποιείται σύγκριση σε προϊόντα που προέρχονται από διαφορετικούς μύλους παραγωγής με σκοπό την εξακρίβωση του ποσοστού που τα τεχνικά χαρακτηριστικά και οι εξωτερικές συνθήκες της μονάδας παραγωγής επηρεάζουν το τελικό προϊόν.

Η έρευνα ανέδειξε τη μεγάλη συσχέτιση που υφίσταται μεταξύ τόσο της σύνθεσης όσο και της διαδικασίας παραγωγής με τις τελικές ιδιότητες του προϊόντος. Το γεγονός αυτό ενισχύει την άποψη ότι ο έλεγχος και οι τρόποι βελτίωσης της λειτουργίας μιας επιχείρησης είναι δυνατό να πραγματοποιηθούν άρτια, με τη χρήση μεθόδων της στατιστικής.

Περιεχόμενα

<u>ΕΥΧΑΡΙΣΤΙΕΣ</u>

Η παρούσα εργασία με τίτλο «Στατιστική Ανάλυση Ποιότητας Διεργασιών: Μελέτη περίπτωσης βιομηχανίας παραγωγής τσιμέντου» πραγματοποιήθηκε στα πλαίσια του ευρωπαϊκού μεταπτυχιακού προγράμματος «Διοίκηση Επιχειρήσεων-Διοίκηση Ολικής Ποιότητας» του τμήματος Οργάνωση και Διοίκηση Επιχειρήσεων του Πανεπιστημίου Πειραιώς.

Με την ολοκλήρωση αυτής της εργασίας νιώθω την ανάγκη να εκφράσω τις θερμές ευχαριστίες στα πρόσωπα που συντέλεσαν στην πραγματοποίησή της.

Πρωτίστως, οφείλω να ευχαριστήσω τον επιβλέποντα της εργασίας αυτής και Επίκουρο καθηγητή κ. Μ.Σφακιανάκη, για την ανάθεση του θέματος, την εμπιστοσύνη που έδειξε στο πρόσωπό μου και την πολύτιμη βοήθεια που προσέφερε στη διεξαγωγή της παρούσας μελέτης αλλά και σε οποιαδήποτε επιστημονική πληροφορία χρειάστηκα.

Θα ήταν παράληψη να μην ευχαριστήσω τον πρόεδρο του μεταπτυχιακού προγράμματος, καθηγητή κ. Σ.Καρβούνη, για τις γνώσεις που μου παρείχε ως καθηγητής μου στο μεταπτυχιακό πρόγραμμα αλλά και για τις πολύτιμες συμβουλές του.

Επίσης, θα ήθελα να εκφράσω θερμές ευχαριστίες στον κ.Ν.Λίτινα, Υπεύθυνο Διαχείρισης Ποιότητας Βιομηχανίας παραγωγής τσιμέντου, για το χρόνο που διέθεσε στη συζήτηση των όποιων αποτελεσμάτων, για την ανεκτίμητη γνώση που μου μετέδωσε προς θέματα εφαρμογής του στατιστικού ελέγχου σε μια μεγάλη βιομηχανική μονάδα και για την αμέριστη διάθεσή του προς κάθε βοήθεια.

Παράλληλα, θα ήθελα να ευχαριστήσω τον κ. Α.Κατσιάμπουλα, Προϊστάμενο Ποιοτικού Ελέγχου Βιομηχανίας Παραγωγής τσιμέντου, για τη διαρκή ενημέρωση σε τεχνικά θέματα , διαδικασίες και τρόπους λειτουργίας μιας μεγάλης βιομηχανικής μονάδας, για τη συνεχή πρόσβαση σε απαραίτητα για τη συγγραφή της εργασίας στοιχεία και για την αμείωτη διάθεση παροχής οποιασδήποτε μορφής επιστημονικής βοήθειας.

Τέλος, θα ήθελα να ευχαριστήσω όλο το διδακτικό προσωπικό του μεταπτυχιακού προγράμματος, για τις γνώσεις, τον τρόπο σκέψης και δράσης που μου μετέδωσαν, για το συνεχές ενδιαφέρον που δείχνουν και για τη συμπαράστασή τους προς οποιαδήποτε προσπάθεια των φοιτητών τους.

Κατάσταση πινάκων

Κατάσταση διαγραμμάτων

Κατάσταση σχημάτων

ΕΙΣΑΓΩΓΗ

Το αντικείμενο της παρούσας εργασίας είναι ο Στατιστικός Έλεγχος Διεργασιών στη Βιομηχανία παραγωγής τσιμέντου. Σκοπό της εργασίας αποτελεί όχι μόνο η ενδεικτική εφαρμογή των εργαλείων του στατιστικού ελέγχου διεργασιών αλλά κυρίως η χρήση μεθόδων και θεωριών της στατιστικής με σκοπό τη συσχέτιση βασικών για την παραγωγή παραμέτρων και κυρίως με σκοπό την εξακρίβωση του βαθμού που αυτές επηρεάζουν την τελική, ως προς τις μηχανικές αντοχές, ποιότητα του τσιμέντου. Πραγματοποιείται προσπάθεια οριοθέτησης συγκεκριμένης τεχνικής με την οποία είναι δυνατή η πρόβλεψη της τελικής ποιότητας του προϊόντος γνωρίζοντας τη σύνθεση και τις ιδιότητές του. Η πρόβλεψη αυτή αποτελεί σημαντικό στοιχείο τόσο για το τμήμα της παραγωγής όσο και για το τμήμα στρατηγικού σχεδιασμού και προώθησης του προϊόντος. Η εκ των προτέρων γνώση της ποιότητας καθιστά πιο ελεγχόμενη την παραγωγή, ενώ η γρήγορη ενημέρωση για πιθανές αποκλίσεις από τις προδιαγραφές δίνει τη δυνατότητα εύρεσης νέων αγοραστών για διοχέτευση των προϊόντων που αποκλίνουν από τις συνήθεις ποιότητες.

Η μελέτη αυτή στηρίχθηκε σε πραγματικά δεδομένα τα οποία ελήφθησαν από το τμήμα ποιοτικού ελέγχου σημαντικής για την εγχώριο αγορά τσιμεντοβιομηχανίας. Το γεγονός αυτό καθιστά ιδιαίτερα σημαντικά τα αποτελέσματα που εξήχθησαν από τη μελέτη δεδομένου ότι ελήφθησαν υπόψη και παράγοντες που θα ήταν αδύνατο να συμπεριληφθούν σε μία εργαστηριακή μελέτη. Ο όγκος της παραγωγής, οι διαφορετικές γραμμές παραγωγής του ιδίου προϊόντος, τα τεχνικά χαρακτηριστικά, ακόμα και η στρατηγική που ακολουθεί μία μεγάλη βιομηχανική μονάδα αποτελούν μερικούς από αυτούς τους παράγοντες οι οποίοι είναι ιδιαιτέρως δύσκολο να εξομοιωθούν σε ένα περιβάλλον εργαστηρίου αλλά είναι ιδιαίτερα σημαντικοί για τα εξαγόμενα συμπεράσματα.

Η μελέτη αυτή στοχεύει να επιβεβαιώσει ότι οι μέθοδοι της στατιστικής αποτελούν απαραίτητο στοιχείο για την οργάνωση και βελτίωση μιας επιχείρησης. Η παρούσα εργασία επικεντρώνεται στο τμήμα της παραγωγικής διαδικασίας.

Κεφάλαιο 1.
ΑΝΑΣΚΟΠΗΣΗ ΣΧΕΤΙΚΗΣ ΒΙΒΛΙΟΓΡΑΦΙΑΣ

Οι περισσότερες αποφάσεις στον έλεγχο ποιότητας βασίζονται στην στατιστική, η οποία προσδιορίζεται στενά σαν τη συλλογή, την ανάλυση και την ερμηνεία των δεδομένων ή, πιο ευρέως, σαν την επιστήμη λήψης αποφάσεων κάτω από συνθήκες αβεβαιότητας. [1]

Επιπρόσθετα των βασικών στατιστικών μεθόδων, βασικά στοιχεία όπως ο στατιστικός έλεγχος διεργασιών, η αποδοχή δειγματοληψίας, ο σχεδιασμός ανάλυσης των πειραμάτων και η ανάλυση δεδομένων αξιοπιστίας αποτελούν βασικές μεθόδους οι οποίες βασίζονται στην στατιστική και έχουν καθοριστικό ρόλο στον έλεγχο της ποιότητας των διεργασιών.

Η έννοια της μεταβολής στα βιομηχανικά προϊόντα που παρήγαγε η Western Electric Company και μελέτες των αποτελεσμάτων δειγματοληψίας οδήγησαν τον Walter A. Shewhart να αναπτύξει τους χάρτες ελέγχου (1924). Από τότε και μέχρι σήμερα έχουν γίνει πολλές βελτιώσεις . Σήμερα οι χάρτες ελέγχου χρησιμοποιούνται ευρέως σε κάθε βιομηχανία και αποτελούν το βασικό εργαλείο για το στατιστικό έλεγχο διεργασιών(spc). [2]Στη Μεγάλη Βρετανία αναπτύχθηκε για πρώτη φορά από την εταιρία Ford το 1981 με εφαρμογές στο δικό της εργοστάσιο οι οποίες περιορίζονταν κυρίως στη χρήση χαρτών ελέγχου που στηρίζονταν στην ανεκτικότητα και όχι στην εφαρμογή. [3]

Ο στατιστικός έλεγχος διεργασιών είναι από τις πιο φημισμένες επεμβάσεις ενός οργανισμού στο όνομα της βελτίωσης της ποιότητας (Chen,1991;General Accounting Office[4],1991;Lascelles & Dale,1998[5]; Modarress & Ansari,1989[6]). Αποτελεί μια μεθοδολογία παρακολούθησης μιας διεργασίας με στόχο τον εντοπισμό των ειδικών αιτιών στις οποίες οφείλονται οι όποιες μεταβολές και με σκοπό την παροχή σήματος για την αναγκαία διορθωτική ενέργεια όπου απαιτείται[2]. Εφαρμόζεται σε διάφορες βιομηχανίες όπως είναι η βιομηχανία αυτοκινήτων (Lanscelles Dale, 1988[7]), βιομηχανία ηλεκτρονικών (Kumar & Gupta,1993[8]), σε οργανισμούς υγείας (Welsh, 1997)[9], ακόμα και σε αλυσίδες εστιατορίων(Apte & Reynolds,1995)[10].Ο κατάλογος εφαρμογής του στατιστικού ελέγχου διεργασιών μπορεί να αυξηθεί στη χημική βιομηχανία, στη μεταλλευτική βιομηχανία[11]

Σε πολλές περιπτώσεις μάλιστα η ευρέως διαδεδομένη εφαρμογή του SPC συνοδεύεται από άφθονα ανέκδοτα στοιχεία τα οποία αποδίδουν ποιότητα, παραγωγικότητα και οφέλη στο κόστος της παραγωγής.[12].

Μία διαδικασία η όποία είναι εντός στατιστικού ελέγχου σημαίνει ότι η μεταβολή στη διεργασία μειώνεται, γεγονός που προσφέρει σημαντικά οφέλη. Τα οφέλη αυτά υπογραμμίζει ο LeslieW.Flott (2002)[13]

1. χαμηλή μεταβλητότητα μπορεί να αποτελέσει αποτέλεσμα στη βελτίωση της εκτέλεσης ενός έργου, κάτι που είναι ευδιάκριτο από τον πελάτη.
2. χαμηλή μεταβλητότητα σε ορισμένα στοιχεία μπορούν να βοηθήσουν στην αποζημίωση για μεγαλύτερη μεταβλητότητα σε άλλα συστατικά.
3. χαμηλή μεταβλητότητα σε ορισμένους παράγοντες όπως το βάρος προϊόντος δίνουν δυνατότητες να μειωθεί το κόστος με το να επιτρέπονται καλύτεροι έλεγχοι.

4. χαμηλή μεταβλητότητα μπορεί να μειώσει την ανάγκη για επιθεώρηση.
5. χαμηλή μεταβλητότητα μπορεί να δημιουργήσει ανταγωνιστικό πλεονέκτημα στην αγορά.13]

Ότι ο στατιστικός έλεγχος διεργασιών βελτιώνει την ποιότητα δεν είναι κάτι που πρέπει να παραξενέψει κάποιον, αφού ο καθαρός στόχος υλοποίησης αυτής της μεσολάβησης είναι η βελτίωση της ποιότητας. Μελέτες (Chaudry, Higbie, 1989)[14] έχουν δείξει ότι η υλοποίηση στατιστικών ελέγχων επιφέρει την αποτελεσματικότητα της παραγωγής, την σταθερότητα του προϊόντος και την καλή επικοινωνία με τους πελάτες. Η χρήση στατιστικών ελέγχων διεργασιών μειώνει σε σημαντικό βαθμό το ποσοστό των ελαττωματικών(Kumar and Gupta, Motorola 1993)[15] και βελτιώνει τις σχέσεις του οργανισμού με τους πελάτες (Welsh,1997). [16]

Η θετική επίδραση του στατιστικού ελέγχου διαδικασιών μπορεί να διαχωριστεί μεταξύ Ποιότητας Διαδικασιών και Ποιότητας Προϊόντος, ένας διαχωρισμός που αποτελεί απόρροια μελετών(Misterek,Anderson, and Dooley, 1990)[17]. Η επίδραση που έχει ο στατιστικός έλεγχος διαδικασιών στην ποιότητα παρουσιάζεται και στον παρακάτω πίνακα.

Πίνακας 2. 1 στατιστικός έλεγχος διαδικασιών και ποιότητα

Μελέτη	Ποιότητα διαδικασιών	Επίδραση σε ποιότητα προϊόντος	Άλλες επιδράσεις
Benneyan και Chute (1993)[[18]	↑ παραγωγικότητα ↓έξοδα		
Kumar & Gupta (1993)[19]	↓ έξοδα ↑ ακρίβεια	↓ ποσοστό ελαττωματικών ↑ ποιότητα προϊόντος	
Dondero(1991)[20}	↑ σταθερότητα διεργασίας	↓ποσοστό ελαττωματικών	
Rucinski(1991)[21]	↑ ικανότητα διεργασίας		
Cantello et al. (1190)[22]	↑ σταθερότητα διεργασίας ↑ ικανότητα διεργασίας		
Sower(1990,1993)[23]		↑ σταθερά προϊόντων ↓παράπονα πελατών	↑ θετική στάση προς τον οργανισμό =έλεγχος στην εργασία =στάση προς τη διοίκηση
Oakland And Followell(1990)[24]	↓ μεταβλητότητα διεργασίας ↑ ομοιομορφία διεργασίας	↑ικανοποίηση πελατών ↑ομοιομορφία προϊόντος ↑αναλογία ελαττωματικών ↓κόστος αποτυχίας ↓ποσοστού αχρηστευμένων τεμαχίων	↑ μερίδιο αγοράς
Chaudhry and Higbie(1989)[25]	↑ αποδοτικότητα διεργασίας		↑ σχέσεις με πελάτες ↑ ικανοποίηση από την εργασία
Manson and Dale(1989)[26]	↓μεταβλητότητα διαδικασιών = παραγωγικότητα		
Followell and Oakland(1985)[27]	↑ομοιομορφία διαδικασιών	=ποιότητα προϊόντος ↓ αναλογία ελαττωματικών ↑ποιότητα προϊόντος ↓εξωτερικής αποτυχίας κόστος	
Harmon(1984)[28]		↓ ποσοστό αχρηστευμένων τεμαχίων	

Ο στατιστικός έλεγχος διεργασιών λοιπόν αποτελεί ένα ιδιαιτέρως σημαντικό εργαλείο για τον έλεγχο της ποιότητας . Φυσικά, για να αποτελέσει χρήσιμο στοιχείο για την παραγωγική διαδικασία θα πρέπει να χρησιμοποιείται ευρέως και σε πολλά σημεία στην παραγωγική διαδικασία. Είναι κοστοβόρο και δεν επιφέρει κανένα αποτέλεσμα αν χρησιμοποιείται μόνο στον έλεγχο των τελικών προϊόντων.[29]

Η χρήση του SPC είναι συνήθως προβληματική όταν το γράμμα "P" παριστάνει την λέξη product(προϊόν) και όχι process(διαδικασία). Σε πολλές περιπτώσεις ο στατιστικός έλεγχος διεργασιών έχει εφαρμοστεί απλά και μόνο σαν πρακτική εξάσκηση για λύση στατιστικών εργαλείων όπως είναι τα διαγράμματα pareto, οι χάρτες ελέγχου, τα διαγράμματα αιτίας-αποτελέσματος (cause and effect diagrams). (Depew,1987[30];Kefeer,1986[31}) ή σαν τη χρήση των διαγραμμάτων ελέγχου για την πρώτη γραμμή παραγωγής.[32]

Γενικά, έχει αναφερθεί ότι λίγη γνώση έχει καταγραφεί για την αναγνώριση, την περιγραφή και τον προσδιορισμό απαιτούμενων τακτικών και ενεργειών ώστε να καταστεί ο στατιστικός έλεγχος διαδικασιών ένα αποτελεσματικό και απαραίτητο στοιχείο για τη διοίκηση ποιότητας κάθε οργανισμού. (Rungtusanatham et al., 1997:114). [33]

Προς ενίσχυση της παραπάνω άποψης έχουν διεξαχθεί συμπερασματικές και επαγωγικές έρευνες αναφορικά με το τι μία εταιρία εννοεί όταν υποστηρίζει ότι έχουν εφαρμόσει και εξακολουθούν να χρησιμοποιούν το στατιστικό έλεγχο παραγωγής. Τα αποτελέσματα αυτής της έρευνας έχουν αναδείξει τέσσερις απόψεις στις προσπάθειες ενός οργανισμού να πραγματοποιήσει και να εφαρμόσει στατιστικό έλεγχο διεργασιών:

1. Η ιστορική άποψη ανατρέχει στη θεωρία του "Shewhart" (1939)[34] που έχει δύο έννοιες για την εφαρμογή του SPC, την λειτουργία του στατιστικού ελέγχου και την κατάσταση του στατιστικού ελέγχου.
2. Η τρέχον προσδιοριστική άποψη που ουσιαστικά είναι η εφαρμογή συστηματικών και ποικίλων στατιστικών και νοητικών εργαλείων επίλυσης διαφόρων προβλημάτων.
3. Η "προληπτική ενέργεια- ενέργεια εντοπισμού" που παρέχει ενόραση στο σκοπό πραγματοποίησης κι εφαρμογής στατιστικού ελέγχου διεργασιών.
4. Τέλος, η προοπτική ανάπτυξης η οποία αντιλαμβάνεται την πραγματοποίηση και την πρακτική του στατιστικού ελέγχου διεργασιών ως ένα πολύπλευρα μεταβαλλόμενο φαινόμενο που εμπλέκει καθήκοντα, τεχνολογία, δομή και πρόσωπα του οργανισμού.

Από τη σύνθεση των παραπάνω μπορεί να εισηγηθεί μία νέα ερμηνεία για την έννοια του στατιστικού ελέγχου διεργασιών, η οποία θα την ορίσει ως ένα σύνολο στατιστικών αλλά και άλλων τεχνικών με σκοπό την επίλυση προβλημάτων.

Έρευνα που έγινε για την πραγματοποίηση και εφαρμογή του στατιστικού ελέγχου ποιότητας (Rungtusanatham et. Al., 1997:122)[35] έδωσε 14 διαστάσεις που υπογραμμίζουν τον στατιστικό έλεγχο παραγωγής, την εφαρμογή του και την πρακτική του. Η μεταβολή και η ερμηνεία του στατιστικού ελέγχου παραγωγής με τις 14 διαστάσεις παρέχουν μια πιο αναλυτική ερμηνεία του τι εννοείται όταν οι οργανισμοί υποστηρίζουν ότι έχουν πραγματοποιήσει και εφαρμόσει στατιστικό έλεγχο παραγωγής.

Πίνακας 2. 2Διαστάσεις για το στατιστικό έλεγχο παραγωγής

1η διάσταση	*Διοικητικές ενέργειες και τακτικές για υποστήριξη της πραγματοποίησης και πρακτικής του SPC.* Πραγματοποιούνται ενέργειες και τακτικές μεμονωμένα από θέσεις διοικητικές για υποστήριξη της πραγματοποίησης πρακτικών των SPC.
2η διάσταση	*Διάκριση της χρήσης χάρτη ελέγχου για τον έλεγχο διεργασιών.* Η ορατότητα της χρήσης μεθοδολογίας χάρτη ελέγχου σαν ένα εργαλείο για τον έλεγχο διαδικασιών
3η διάσταση	*Αναγνώριση κρίσιμων χαρακτηριστικών προς μέτρηση.* Ενέργειες σχετικές με την αναγνώριση των κρίσιμων ενεργειών και / ή των χαρακτηριστικών προϊόντος, οι οποίες επηρεάζουν την ποιότητα των κρίσιμων ενεργειών.
4η διάσταση	*Τεχνολογική εξέλιξη και αρτιότητα των μετρήσεων.* Τα τεχνολογικά επιτεύγματα χρησιμοποιούνται στη διαδικασία δειγματοληψίας.
5η διάσταση	*Ευθύνη του χειριστή για έλεγχο της διαδικασίας μέσω χάρτη ελέγχου.* Ενέργειες πραγματοποιούνται από τους χειριστές για επιβεβαίωση και εποπτεία της διαδικασίας παραγωγής.
6η διάσταση	*Εξακρίβωση των υποθέσεων μέσω χαρτών ελέγχου.*
7η διάσταση	*Χρήση των πληροφοριών που δίνουν οι χάρτες ελέγχου.* Ενέργειες που σχετίζονται με την ερμηνεία και τη χρήση των πληροφοριών που δίνουν οι χάρτες ελέγχου με σκοπό του ελέγχου της διαδικασίας και της βελτίωσης.
8η διάσταση	*Στρατηγικές δειγματοληψίας για σχεδιασμό χάρτη ελέγχου.* Ενέργειες που σχετίζονται με το πώς δεδομένα αναφορικά με τη διαδικασία συλλέγονται.
9η διάσταση	*Εκπαίδευση στις στατιστικές μεθόδους για τον έλεγχο των διαδικασιών και τη βελτίωση.* Η δυνατότητα και η συχνότητα εκπαιδευτικών μαθημάτων σκοπεύουν στον έλεγχο και τη βελτίωση των διαδικασιών.
10η διάσταση	*Τεχνική υποστήριξη του SPC για πραγματοποίηση και εφαρμογή.*
11η διάσταση	*Η ομάδα ποιοτικού ελέγχου υποστηρίζει τις πρακτικές του SPC.* Ενέργειες όπου οι ομάδες πραγματοποιούν για να υποστηρίξουν τη συνεχή βελτίωση διαδικασιών αναγνωρίζονται μέσω της ερμηνείας των πληροφοριών που παρέχουν οι χάρτες ελέγχου.
12η διάσταση	*Απουσία της τελικής επιθεώρησης ως στρατηγική του ποιοτικού ελέγχου.*
13η διάσταση	*Τεκμηρίωση και ενημέρωση της γνώσης των διαδικασιών.* Οι ενέργειες που πραγματοποιούνται και οι πολιτικές που καθιερώνονται για επιβεβαίωση της γνώσης κάθε κρίσιμης διαδικασίας αναθεωρούνται, καταγράφονται και ενημερώνονται σαν μεταβολές των διαδικασιών.
14η διάσταση	*Επιθεώρηση και ανασκόπηση των πρακτικών και της εκτέλεσης του SPC.*Ενέργειες πραγματοποιούνται και πολιτικές θεσπίζονται για επιβεβαίωση ότι το SPC πραγματοποιείται και εφαρμόζεται σωστά.

Η ιδέα εφαρμογής του στατιστικού ελέγχου παραγωγής σε πιο μεγάλο φάσμα της παραγωγικής διαδικασίας παρουσιάζεται και από άλλους μελετητές. Πολλοί μάλιστα από αυτούς[36] υποστηρίζουν ότι ο στατιστικός έλεγχος διεργασιών εφαρμόζεται τόσο στις παραμέτρους κατά τη διάρκεια της διαδικασίας(in process parameters) όσο και στο τέλος της διεργασίας (end-of-process, product).

Βέβαια, για να αποτελέσει ένας στατιστικός έλεγχος διεργασιών μια αποτελεσματική διαδικασία και όχι μια διαδικασία με μεγάλο κόστος θα πρέπει να γίνεται η κατάλληλη επιλογή των διεργασιών της παραγωγής που είναι σκόπιμο να μετρώνται. Μάλιστα, είναι αναγκαίο να δημιουργούνται οι κατάλληλες μετρήσεις οι οποίες θα επιτρέπουν στους μηχανικούς να εκτιμούν την απόδοση της διαδικασίας. Είναι αναγκαίο να μετρώνται οι συνθήκες των διαδικασιών κατά τρόπο ώστε να συγκρίνονται με την απόδοσή τους. Την ίδια στιγμή μεταβλητές οι οποίες προκαλούν μεταβολή στην εκτέλεση μιας διεργασίας πρέπει να εντοπίζονται. Όταν οι μεταβλητές οι οποίες επηρεάζουν τα αποτελέσματα είναι γνωστές, είναι δυνατό να προσδιοριστούν τα βέλτιστα επίπεδα για τις κρίσιμες παραμέτρους των διαδικασιών. Συνήθη εργαλεία σε αυτό το επίπεδο περιλαμβάνουν χάρτες διαδικασιών, διαγράμματα αιτίας-αποτελέσματος, μέθοδοι αποτυχίας και αναλύσεις αποτελεσμάτων, μετρήσεις αξιοπιστίας και αναπαραγωγικότητας(R&R) καθώς και γραφικές παραστάσεις.

Οι παραπάνω τεχνικές οι οποίες περιλαμβάνονται σε ένα στατιστικό έλεγχο διεργασιών δίνουν τη δυνατότητα να διευκρινιστούν τα αίτια προβλημάτων και να διορθωθούν αυτά. Ο στατιστικός έλεγχος βέβαια δεν σταματά μόνο στη βελτίωση των διαδικασιών αλλά προχωρά στη συνεχή παρακολούθηση και τη διαβεβαίωση του συνεχούς ελέγχου[37]. Βασικό εργαλείο σε αυτό το επίπεδο αποτελούν οι χάρτες ελέγχου. Με αυτούς είναι δυνατό να εξετασθεί κατά πόσο η διεργασία είναι υπό στατιστικό έλεγχο ή όχι. Μάλιστα, πολλές φορές χρησιμοποιούνται και για την πρόβλεψη αν η διεργασία βρίσκεται υπό έλεγχο[38]. Αυτό που τα παραπάνω εργαλεία του στατιστικού ελέγχου δυσχεραίνονται να ικανοποιήσουν είναι ο τρόπος με τον οποίο τα διάφορα αίτια προκαλούν τις όποιες μεταβολές στις διαδικασίες. Παρά το γεγονός ότι με τα συνήθη εργαλεία του στατιστικού ελέγχου διεργασιών εντοπίζονται τα αίτια των μεταβολών στις διεργασίες απαιτούνται άλλα εργαλεία της στατιστικής για να υπάρξει άμεση συσχέτιση μεταξύ τους.

Πολλά προβλήματα στον έλεγχο της ποιότητας απαιτούν τον προσδιορισμό σχέσης μεταξύ δύο ή περισσότερων μεταβλητών. Πολλές φορές το ενδιαφέρον εστιάζεται στην εύρεση εξίσωσης, η οποία θα συσχετίζει μία συγκεκριμένη μεταβλητή με έναν αριθμό άλλων ανεξάρτητων.[39]. Κάποιες μελέτες έχουν αναδείξει τη μέθοδο της παλινδρόμησης για τον εντοπισμό των αιτιών διαφόρων προβλημάτων ή και για τον εντοπισμό των κυριοτέρων παραμέτρων στην παραγωγική διαδικασία.[40]

Η παλινδρόμηση έχει εφαρμοσθεί σε διάφορα πεδία της επιστήμης όπως στη μετεωρολογία[41],[42], στην επιστήμη των τροφίμων[43],[44], στην οικονομική [45], αλλά και σε παραγωγικές διαδικασίες .[46]

Στην επιστήμη και τεχνολογία τσιμέντου είναι απαραίτητη η πρόβλεψη των αντοχών που αυτό αναπτύσσει 7 ή 28 ημέρες μετά την παραγωγή του. Για το λόγο αυτό έχουν πραγματοποιηθεί πολλές μελέτες προσδιορισμού των παραγόντων από τις οποίες εξαρτάται το τσιμέντο.

Η γραμμική παλινδρόμηση έχει αποτελέσει μέθοδο προσδιορισμού των αντοχών ενός τσιμέντου σε κάθε ηλικία, από 1 ημέρα έως 28 ημέρες. Στη γραμμική αυτή παλινδρόμηση λαμβάνονται υπόψη τα φυσικά και χημικά χαρακτηριστικά τα οποία λαμβάνονται από τα εργαστήρια ποιοτικού ελέγχου των εργοστασίων [47].

Οι αντοχές που αναπτύσσει ένα τσιμέντο έχουν άμεση συσχέτιση με την περιεκτικότητα του σε νερό. Οι μελέτες για την ακριβή σχέση μεταξύ του νερού και των αντοχών ξεκινούν από τα τέλη 1800 όταν ο Feret έκανε μία πρώτη προσέγγιση για το θέμα.[48] Στο ίδιο θέμα επικεντρώθηκε λίγα χρόνια αργότερα και ο Abrams[49]. Η συσχέτιση των αντοχών του τσιμέντου με το ποσοστό νερού στο τσιμέντο φαίνεται να απασχόλησε πολλούς μελετητές στη συνέχεια, οι οποίοι στηριζόμενοι στα αποτελέσματα των πρώτων μελετών προσπάθησαν την εύρεση ενός ακριβέστερου μοντέλου χρησιμοποιώντας στοιχεία της στατιστικής [50]. Η συσχέτιση της περιεκτικότητας σε νερό και της αντοχής του τσιμέντου αναδεικνύει τη μεγάλη επιθυμία για πρόβλεψη των αντοχών που θα αναπτύξει ένα τσιμέντο μετά από ένα διάστημα συγκεκριμένο ύστερα από την παραγωγή του. Αυτή η επιθυμία έχει εκφρασθεί με διάφορες μελέτες οι οποίες χρησιμοποιούν σε μεγάλο βαθμό τη γραμμική παλινδρόμηση, η οποία στηρίζεται σε πραγματικές τιμές.[51],[52]

Εκτός από την περιεκτικότητα σε νερό, ο προσδιορισμός και η πρόβλεψη των αντοχών που αναπτύσσει το τσιμέντο κατέστησε επιτακτική την ανάγκη μελέτης της επίδρασης και άλλων χαρακτηριστικών.

Αναπτύχθηκαν πολλά μαθηματικά μοντέλα με σκοπό την ακριβέστερη πρόβλεψη των αντοχών [53],[54],[55]. Πολλοί ερευνητές μάλιστα μελέτησαν σε βάθος την επίδραση της σύστασης του τσιμέντου στις αντοχές[57],[58],[59],[60],[61]

Σε πολλές μελέτες φαίνεται, με τη βοήθεια μαθηματικών μοντέλων ότι η ορυκτολογική σύσταση του τσιμέντου επηρεάζει τις μετέπειτα μηχανολογικές του ιδιότητες [62],ενώ σημαντική επίδραση φαίνεται να έχει και η λεπτότητα του τσιμέντου [63],[64],[65]

Σε ένα μοντέλο που περιλαμβάνει και την ορυκτολογική σύσταση του κλίνκερ αλλά και στοιχεία σύνθεσης του τσιμέντου καθώς και τιμές που δείχνουν τις πρώιμες ιδιότητες του τσιμέντου καταλήγουν άλλες μελέτες οι οποίες, όπως και οι προηγούμενες, χρησιμοποιούν την γραμμική παλινδρόμηση σα μέσω προσδιορισμού του μοντέλου πρόβλεψης.[66],[67],[68],[69]

Η συσχέτιση μεταξύ των θλιπτικών αντοχών κατά τη διάρκεια των 7, 28 ακόμα και 90 ημερών μελετήθηκε και από άλλους ερευνητές. Μάλιστα, στην προσπάθεια βελτίωσης των αντοχών εξετάστηκαν διάφοροι μέθοδοι σκλήρυνσης καθώς και η σχέση που αυτές οι μέθοδοι είχαν με τα τελικά αποτελέσματα [70],[71] Η χρησιμότητα των παραπάνω συσχετίσεων φαίνεται όχι μόνο από την πληθώρα των μελετών αλλά και από το γεγονός ότι πολλές από αυτές πραγματοποιήθηκαν ως μελέτες περιπτώσεων σε βιομηχανικές μονάδες[72]. Η μεγάλη ανάγκη εξάλλου για την πρόβλεψη των μηχανικών ιδιοτήτων του τσιμέντου ώθησε στη δημιουργία νέων ερευνών με τη χρήση αυτοματοποιημένων μεθόδων και νέων εξελιγμένων μεθόδων. Πολλές μελέτες θέτουν ως βάση τη γραμμική παλινδρόμηση της οποίας τα αποτελέσματα βελτιώνουν με τη χρήση αυτών των νέων μεθόδων.[73],[74] Στόχος όλων όσων ασχολούνται με την ποιότητα είναι η υιοθέτηση μιας μεθόδου η οποία θα βοηθά στον έλεγχο των διαδικασιών, στον εντοπισμό προβλημάτων και στην προβολή προτάσεων για την επίλυσή τους. Η επιστήμη της στατιστικής, με τις ποικίλες μεθόδους της δύναται να οδηγήσει στα παραπάνω. Το γεγονός μάλιστα ότι με τη στατιστική είναι δυνατό να αναλυθούν οποιαδήποτε δεδομένα, μειώνει τη δέσμευση χρήσης αυτής της επιστήμης μόνο σε παραγωγικές διαδικασίες. Αντίθετα δίνει τη δυνατότητα εφαρμογής της και σε εταιρίες παροχής υπηρεσιών.

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Κεφάλαιο 2.
ΣΤΟΙΧΕΙΑ ΣΤΑΤΙΣΤΙΚΗΣ ΣΤΑ ΟΠΟΙΑ ΕΧΕΙ ΒΑΣΙΣΘΕΙ Η ΑΝΑΛΥΣΗ.

Οι αναλυτικές μέθοδοι περιγραφής των δεδομένων αποτελούν ένα σημαντικό εργαλείο ερμηνείας των δεδομένων, σύγκρισης μεταξύ της δειγματοληψίας και παραπέρα υπολογισμών. Για την περιγραφή των δεδομένων υπάρχουν δύο κυρίως αναλυτικές μέθοδοι, τα μέτρα της κεντρικής τάσης και θέσης καθώς και τα μέτρα διασποράς, ασυμμετρίας και κύρτωσης.

2.1 Στατιστικά μέτρα κεντρικής τάσεως και θέσης

2.1.1. μέσος αριθμητικός

Το σπουδαιότερο στατιστικό μέτρο είναι ο μέσος αριθμητικός, ο οποίος συμβολίζεται με $\overline{x}$ όταν τα δεδομένα αφορούν ένα δείγμα και με μ όταν τα δεδομένα αφορούν ολόκληρο το στατιστικό πληθυσμό.
Σε μία σειρά μετρήσεων ενός φαινομένου, ο μέσος αριθμητικός της υπόψη σειράς ορίζεται ως το πηλίκο του αθροίσματος των όρων της σειράς δια του πλήθους των όρων της σειράς. Για τον υπολογισμό του μέσου αριθμητικού διακρίνουμε την περίπτωση α) του αστάθμητου και β) του σταθμίσου
Α) αστάθμητος

$$\overline{X} = \frac{X_1 + X_2 + X_3 + ... + X_n}{n} \; ή$$

i=1,2,3,….,n

$$\overline{\mathrm{X}} = \frac{\Sigma \mathrm{X}_i}{n}$$

β) Σταθμικός
σε περίπτωση που κάθε τιμή $X_1, X_2, ..., X_n$ έχει διαφορετική σημασία που εκφράζεται από αριθμούς που λέγονται συντελεστές σταθμίσεως βαρύτητας : w_1, w_2, w_3,..., w_n τότε ο μέσος αριθμητικός υπολογίζεται βάση του τύπου :

$$\overline{X} = \frac{X_1 w_1 + X_2 w_2 + X_3 w_3 + ... + X_n w_n}{n} \; ή$$

i=1,2,3,….,n

$$\overline{\mathrm{X}} = \frac{\Sigma \mathrm{X}_i w_i}{\sum w_i}$$

2.1.2. διάμεσος

Η διάμεσος (Median)είναι το σπουδαιότερο στατιστικό μέτρο θέσεως και συμβολίζεται με το Μ.
Σε αταξινόμητα δεδομένα η διάμεσος είναι ο (n+1)/2 όρος.

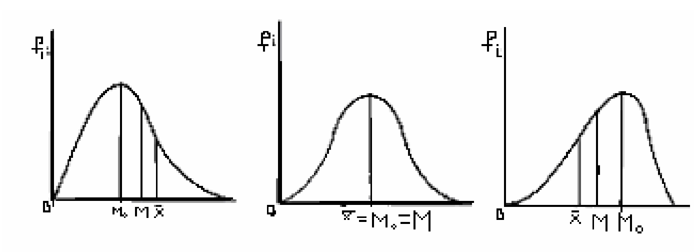
Όταν τα στατιστικά δεδομένα είναι ταξινομημένα σε κατανομή συχνοτήτων, η διάμεσος υπολογίζεται με γραμμική παρεμβολή.

2.1.3. Επικρατούσα τιμή ή τύπος

επικρατούσα τιμή ή τύπος (mode) είναι η τιμή εκείνης της μεταβλητής που αντιστοιχεί στη μεγαλύτερη συχνότητα της κατανομής, γι' αυτό ονομάζεται και σημείο μεγαλύτερης συχνότητας και συμβολίζεται με το M_o ή T_o.

2.1.4. Σχέσεις Μέσου Αριθμητικού, Διαμέσου και Τύπου

Οι σχέσεις που υπάρχουν μεταξύ του μέσου αριθμητικού, της διαμέσου και του τύπου φαίνονται καθαρά στο διάγραμμα.



α) κατανομή με θετική συμμετρία
β) συμμετρική κατανομή
γ) κατανομή με αρνητική συμμετρία

Σχήμα 3. 1Σχέσεις Μέσου Αριθμητικού, Διαμέσου και Τύπου

Ειδικότερα ισχύουν τα ακόλουθα [1]:

Α) Όταν μια κατανομή συχνοτήτων είναι συμμετρική τότε ο Μέσος Αριθμητικός, η Διάμεσος και ο Τύπος συμπίπτουν (βλ. Β). Στην περίπτωση αυτή, ο μέσος αριθμητικός είναι το αντιπροσωπευτικότερο στατιστικό μέτρο.

Β) Όταν μια κατανομή συχνοτήτων έχει θετική ασυμμετρία, τότε ισχύει η σχέση :

$$\overline{x} > M > M_O$$

Γ) Όταν, τέλος, μια κατανομή συχνοτήτων έχει αρνητική ασυμμετρία (δηλ. Η καμπύλη συχνοτήτων στρέφει τα κοίλα προς τα αριστερά, βλ. Διάγραμμα) τότε ισχύει η σχέση :

$$M_O > M > \overline{X}$$

Σε ελαφρώς ή μετρίως ασυμμετρικές κατανομές, μεταξύ Μέσου Αριθμητικού, Διαμέσου και Τύπου ισχύει η σχέση :

$$\overline{X} - M_O = 3(\overline{X} - M)$$

ή

$$\mathrm{M}_o = 3\mathrm{M} - 2\overline{\mathrm{X}}$$

2.2. Στατιστικά μέτρα διασποράς-ασυμμετρίας- κύρτωσης

2.2.1. Μέτρα διασποράς-εύρος

Το εύρος (range) είναι το απλούστερο μέτρο διασποράς και είναι η διαφορά ανάμεσα στη μεγαλύτερη και στη μικρότερη τιμή των δεδομένων.

2.2.2. Μέτρα διασποράς- τυπική απόκλιση

Η τυπική απόκλιση αποτελεί την αριθμητική τιμή στις μονάδες των παρατηρούμενων τιμών οι οποίες μετρούν την τάση διασποράς των δεδομένων. Μια μεγάλη τιμή τυπικής απόκλισης δείχνει μεγαλύτερο εύρος τιμών των δεδομένων από αυτό που δείχνει μια μικρή τιμή τυπικής απόκλισης. Σε σύμβολα δίνεται ο τύπος

$$s = \sqrt{\frac{\sum_{i=1}(X_i - \overline{X})^2}{n-1}}$$

όπου s= τυπική απόκλιση
X_ι= παρατηρούμενη τιμή
$\overline{X} =$ μέση τιμή

n= αριθμός παρατηρούμενων τιμών

2.2.3. Μέτρα ασυμμετρίας

Το στατιστικό μέτρο που προσδιορίζει το βαθμό ασυμμετρίας μιας κατανομής συχνοτήτων ονομάζεται συντελεστής ασυμμετρίας (coefficient of skewness) και συμβολίζονται με το S_k.
Όταν η κατανομή εκτείνεται προς τα δεξιά περισσότερο από ότι προς τα αριστερά τότε λέμε ότι η κατανομή είναι ασύμμετρη προς τα δεξιά.
Ο τύπος υπολογισμού της ασυμμετρίας είναι:

$$a_3 = \frac{\sum_{i=1} f_i (X_i - \overline{X})^3 / n}{s^3}$$

όπου α_3 αντιπροσωπεύει την ασυμμετρία
Το μέτρο ασυμμετρίας υπολογίζεται και αναφέρεται σας ένας αριθμός ο οποίος μπορεί να είναι θετικός, αρνητικός ή ίσος με μηδέν. Ένας θετικός αριθμός υποδηλώνει μία προς τα δεξιά ασύμμετρη κατανομή, ένας αρνητικός αριθμός υποδηλώνει μία προς τα αριστερά ασύμμετρη κατανομή και εάν το μέτρο ασυμμετρίας ισούται με μηδέν η κατανομή είναι κανονική.
.

2.2.4. Κύρτωση

Η κύρτωση μετράει το βαθμό συγκεντρώσεως των τιμών μιας μεταβλητής στην περιοχή του μέσου αριθμητικού και προς τα άκρα δεξιά και αριστερά του μέσου αριθμητικού.
Για τη μέτρηση της κύρτωσης μιας καμπύλης (κατανομής) συχνοτήτων συνήθως χρησιμοποιείται ο τύπος

$$a_4 = \frac{\sum_{i=1} f_i (X_i - \overline{X})^4 / n}{s^4}$$

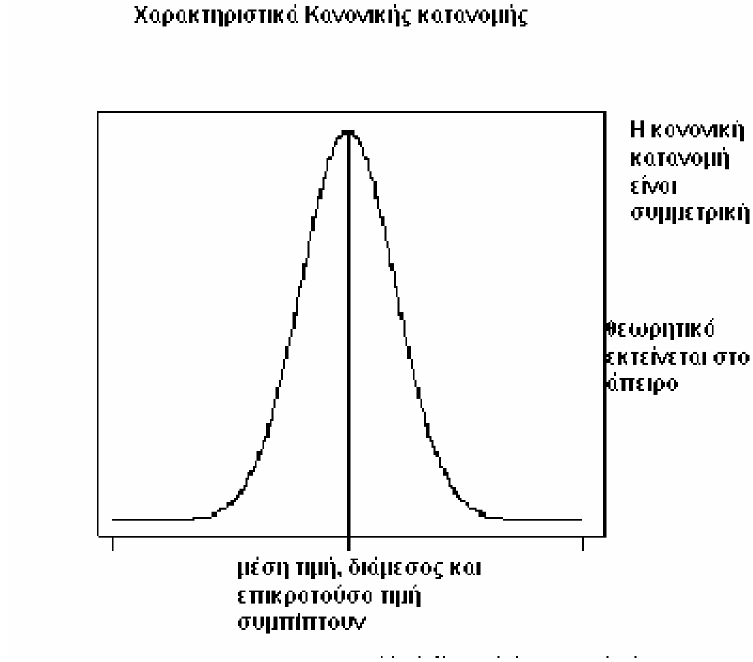
όπου α_4 αντιπροσωπεύει την κύρτωση
Η κύρτωση δεν έχει διαστάσεις και χρησιμοποιείται για να μετρήσει το ύψος της κορυφής της κατανομής.[1]
Η κύρτωση υπολογίζεται και αναφέρεται είτε ως απόλυτη είτε ως σχετική τιμή. Η απόλυτη τιμή κύρτωσης μιας κανονικής κατανομής είναι 3. Ο αριθμός αυτός μάλιστα χρησιμοποιείται ως σημείο αναφοράς για τον υπολογισμό της σχετικής κύρτωσης. Οι δύο τιμές σχετίζονται με την εξίσωση

$$scetik\acute{\eta}k\acute{\upsilon}rtwsh = ap\acute{o}luthk\acute{\upsilon}rtwsh - 3$$

η σχετική τιμή κύρτωσης μπορεί να είναι και αρνητική όπως φαίνεται και από την παραπάνω εξίσωση.
Αρνητική τιμή κύρτωσης υποδηλώνει μία κατανομή πιο επίπεδη από την κανονική. Θετική τιμή κύρτωσης υποδηλώνει μια κατανομή με πιο έντονη κορυφή από ότι η κανονική. [2]

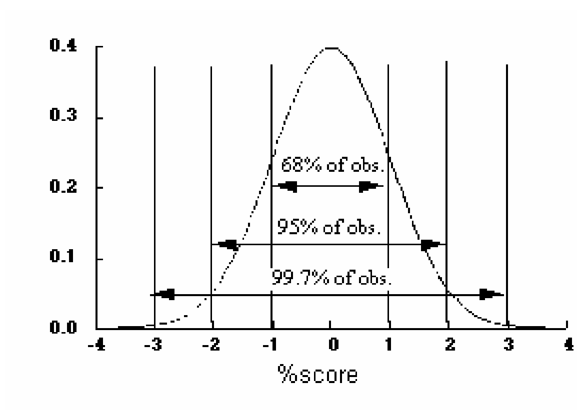
2.3. Κανονική κατανομή

Η κανονική κατανομή έχει το σχήμα της «καμπάνας», είναι συμμετρική και είναι κατανομή δύο παραμέτρων. Γνωρίζοντας δηλαδή μόνο το μέσο ($\overline{X}$) και την τυπική απόκλιση (σ^2) του πληθυσμού έχει κανείς μία ολοκληρωμένη εικόνα της κατανομής. Χαρακτηριστικό της κανονικής κατανομής είναι η συμμετρία της καθώς και ότι ο μέσος , η διάμεσος και η επικρατούσα τιμή συμπίπτουν. Η κανονική κατανομή εκτείνεται ως το άπειρο.



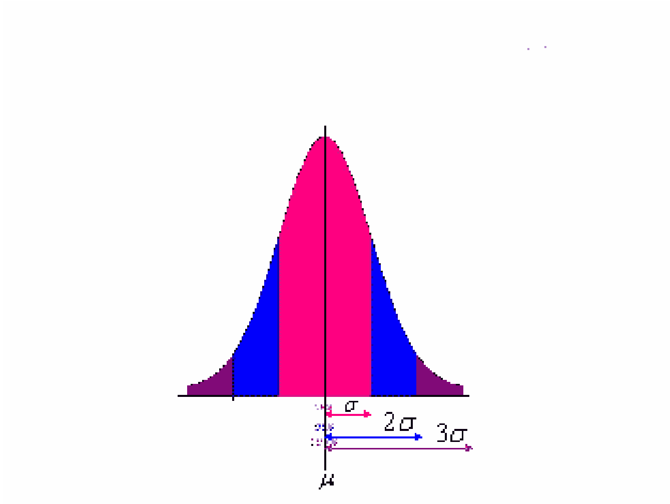
Σχήμα 3. 2 Κανονική κατανομή

Στο σχήμα 3.3 απεικονίζεται η κανονική κατανομή με κάποιες πολύ χρήσιμες τιμές πιθανοτήτων.



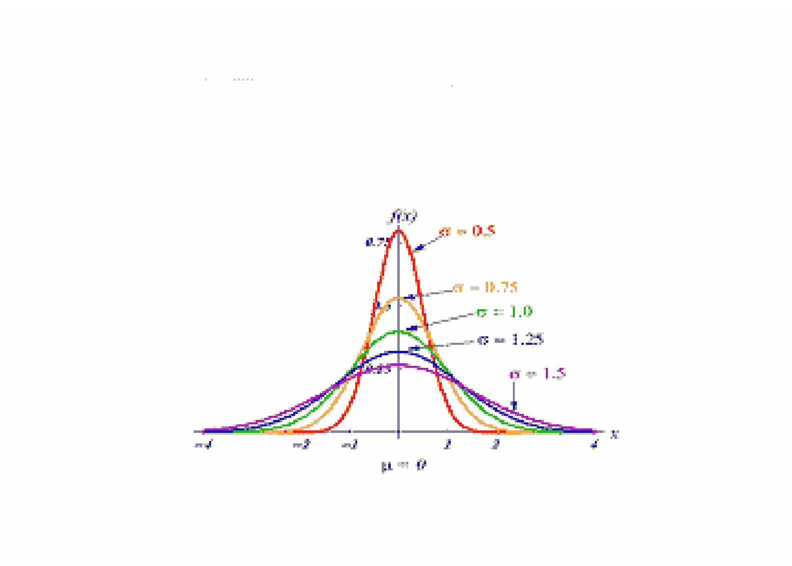
Σχήμα 3. 3 κανονική κατανομή και οι χρησιμότερες τιμές πιθανοτήτων

Και εμπειρικά οι τιμές των πιθανοτήτων ορίζονται γνωρίζοντας τα παραπάνω ποσοστά πιθανοτήτων. Στο διάγραμμα 3.4 παρουσιάζεται η κανονική κατανομή, οι τυπικές αποκλίσεις και ο τρόπος με τον οποίο σχετίζονται μεταξύ τους.



Σχήμα 3. 4 Κανονική κατανομή και τυπικές αποκλίσεις

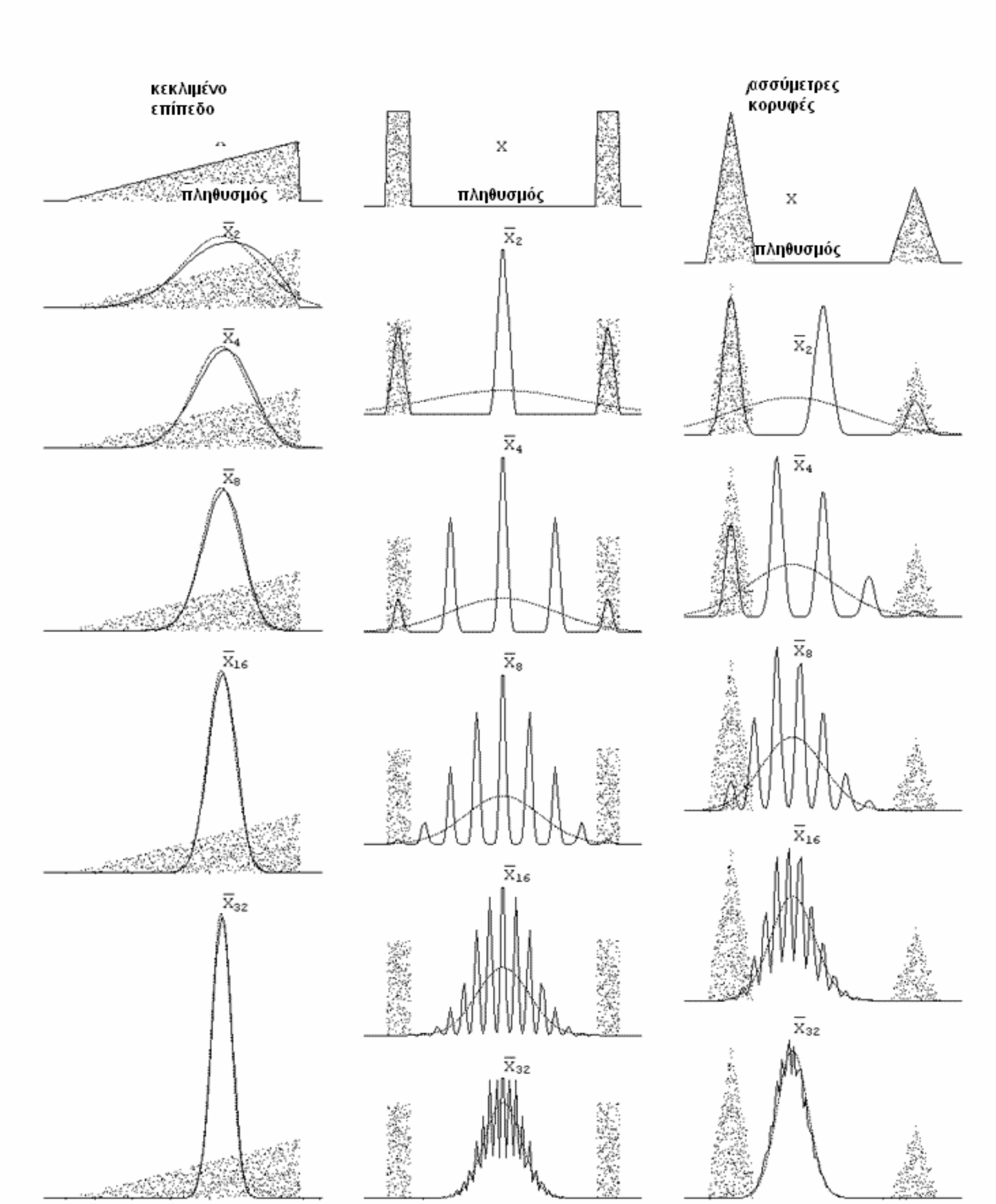
Το παρακάτω διάγραμμα (3.5) δείχνει την επίδραση που έχει η μεταβολή της τυπικής απόκλισης στην κανονική κατανομή. Ο μέσος όρος σε όλες τις περιπτώσεις είναι μηδέν. Καθώς η τυπική απόκλιση γίνεται μεγαλύτερη , η κανονική κατανομή γίνεται πιο πλατιά[3]



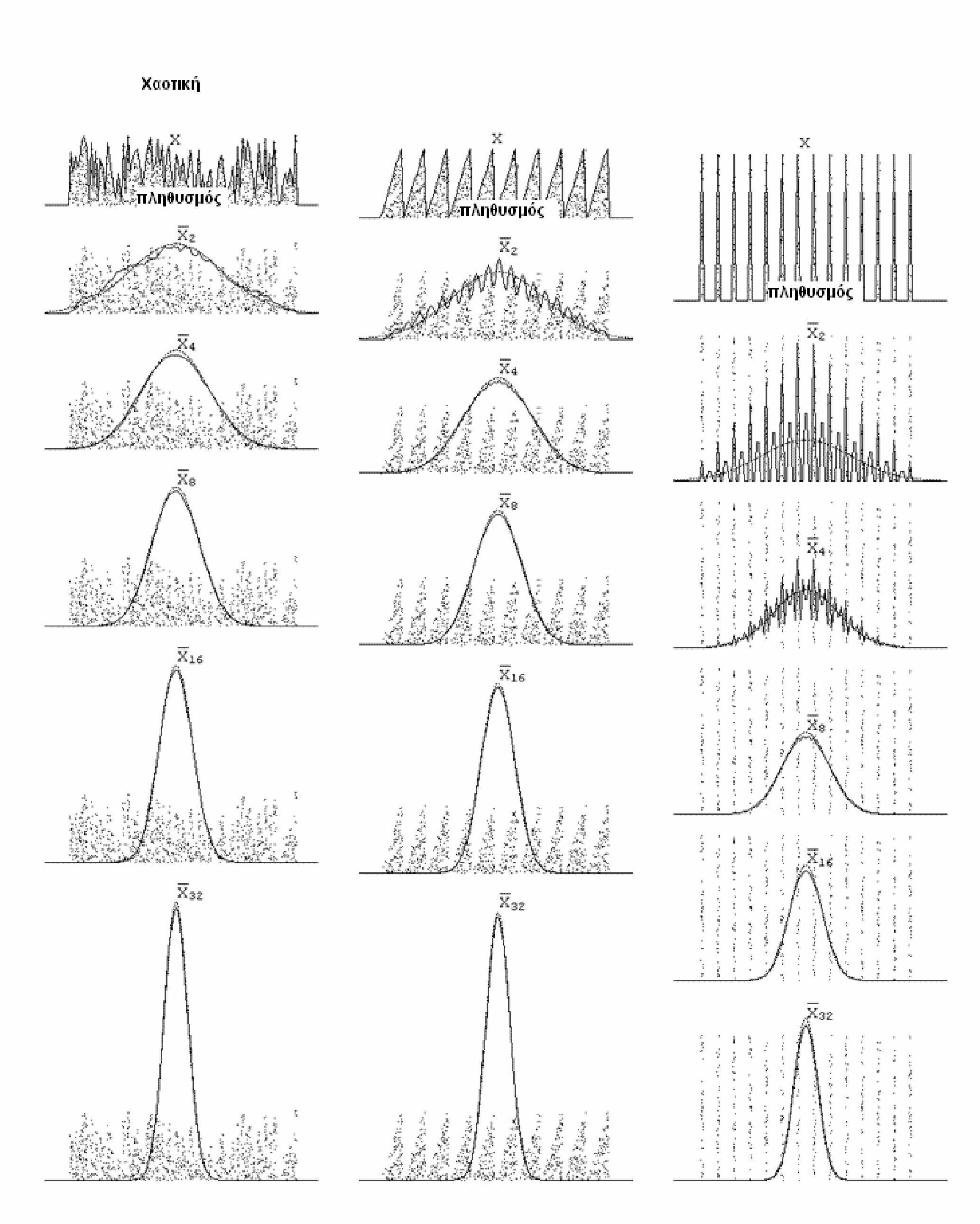
Σχήμα 3. 5 επίδραση των τυπικών αποκλίσεων στην κανονική κατανομή

2.3.1. Κεντρικό Οριακό Θεώρημα

Ένα από τα σημαντικά θεωρήματα που διέπει τη στατιστική και εφαρμόζεται στο στατιστικό έλεγχο διεργασιών είναι το Κεντρικό Οριακό Θεώρημα (Central limit Theorem), το οποίο «επιστρατεύεται» στην περίπτωση που ο πληθυσμός δεν ακολουθεί την κανονική κατανομή. Σύμφωνα με το θεώρημα αυτό «ανεξάρτητα από την κατανομή των μεμονωμένων τιμών, η κατανομή των μέσων τιμών των κ δειγμάτων μεγέθους n θα τείνει προς την κανονική καθώς το μέγεθος του δείγματος n αυξάνει, με τον ίδιο μέσο αλλά μικρότερη τυπική απόκλιση κατανομής (μέσου μ και τυπικής απόκλισης $s' = s/\sqrt{n}$)». Στις περισσότερες περιπτώσεις το n δεν είναι απαραίτητο να είναι πολύ μεγάλο. Συνήθως 20 δείγματα των 4 ή 5 αντικειμένων είναι αρκετά για να υπάρχει μια κανονική κατανομή. Όμως σε περιπτώσεις όπου η καμπύλη αποκλίνει σε πολύ μεγάλο βαθμό από αυτή της κανονικής κατανομής, ακόμα και δείγμα μεγέθους n=25 δε θα ήταν επαρκές. Μία αντιπροσωπευτική απεικόνιση του θεωρήματος φαίνεται στα παρακάτω σχήματα .



Σχήμα 3. 6 Απεικόνιση του Κεντρικού Οριακού Θεωρήματος



Σχήμα 3. 7Απεικόνιση του Κεντρικού Οριακού Θεωρήματος

2.3.2. Έλεγχος κανονικότητας

Η κανονικότητα του πληθυσμού είναι απαραίτητη προϋπόθεση δια την επεξεργασία των δεδομένων. Ο έλεγχος της κανονικότητας του πληθυσμού μπορεί να γίνει με ιστογράμματα, με έλεγχο της κύρτωσης, με τεστ χ^2 ή με διάγραμμα κανονικής κατανομής(normal probability plot).

Ιστόγραμμα

Η οπτική παρακολούθηση ενός ιστογράμματος το οποίο δημιουργείται από ένα μεγάλο αριθμό δεδομένων θα μπορούσε να παρέχει μια ένδειξη της κατανομής του πληθυσμού. Εάν ένα ιστόγραμμα είναι με μία μόνο κορυφή, είναι συμμετρικό και λεπταίνει στα άκρα, η κανονικότητα είναι μια δεδομένη πιθανότητα και μπορεί να αποτελεί επαρκή πληροφορία σε πολλές πρακτικές εφαρμογές. Όσο μεγαλύτερο είναι το μέγεθος του δείγματος , τόσο καλύτερη είναι η δυνατότητα να κρίνουμε την κανονικότητα. Ένα ελάχιστο όριο μεγέθους 50 απαιτείται.

Ασσυμετρία και κύρτωση

Οι μετρήσεις ασυμμετρίας και κύρτωσης αποτελούν άλλο ένα τεστ κανονικότητας. Η τιμή της ασυμμετρίας στην κανονική κατανομή είναι 0.

Έλεγχος χ^2

Ο έλεγχος με χ^2 είναι άλλη μία τεχνική η οποία μπορεί να αποτελέσει προσδιορισμό εαν τα δεδομένα ακολουθούν μία κανονική κατανομή ή κάποια άλλη κατανομή.
Ό έλεγχος χρησιμοποιεί την εξίσωση

$$x^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

όπου $O_ι$=παρατηρούμενη τιμή σε ένα πεδίο
$E_ι$= αναμενόμενη τιμή σε ένα πεδίο

Η αναμενόμενη τιμή προσδιορίζεται από την κανονική κατανομή ή από οποιαδήποτε άλλη κατανομή. Αφού προσδιορισθεί το χ^2, συγκρίνεται με την κατανομή για να προσδιορισθεί κατά πόσο τα παρατηρούμενα δεδομένα προέρχονται από την αναμενόμενη κατανομή.

Διάγραμμα κανονικής κατανομής

Η μέθοδος με διάγραμμα κανονικής κατανομής είναι η πλέον χρησιμοποιούμενη μέθοδος. Τα δεδομένα συλλέγονται και διαμορφώνονται κατάλληλα όπως φαίνεται στον πίνακα των δεδομένων (class intervals), στη δεύτερη το πάνω όριο των διαστημάτων ομαδοποίησης (upper limit), στην Τρίτη και τέταρτη η συχνότητα εμφάνισης των τιμών αυτών στα δεδομένα (frequency) και την αθροιστική συχνότητα παρατήρησης αυτών που αντιστοιχεί σε κάθε διάστημα ομαδοποίησης (plotting points). Στη συνέχεια τα στοιχεία της δεύτερης και τελευταίας στήλης σχεδιάζονται σε κατάλληλο χαρτί, του οποίου ο ένας άξονας έχει πιθανοτική αρίθμηση και σε αυτόν τοποθετούνται τα δεδομένα της τελευταίας στήλης, ενώ ο άλλος είναι χωρισμένος σε ίσα διαστήματα και σε αυτόν τοποθετούνται τα στοιχεία της δεύτερης στήλης. Όλη η παραπάνω διαδικασία γίνεται μέσω Η/Υ.

Αν τα δεδομένα που επεξεργάστηκαν προέρχονται από κανονικό πληθυσμό, τότε τα σχεδιασμένα σημεία δίνουν μια ευθεία γραμμή.

2.4. Παλινδρόμηση και συσχέτιση

Υπάρχουν περιπτώσεις κατά τις οποίες η εξαγωγή χρήσιμων συμπερασμάτων και η λήψη ορθών αποφάσεων δεν είναι δυνατή με τη μελέτη μίας και μόνης μεταβλητής αλλά χρειάζεται η μελέτη (συνεξέταση) δύο ή περισσότερων μεταβλητών, δηλαδή

χρειάζεται να μελετήσουμε ταυτόχρονα τη δομή δύο ή περισσότερων στατιστικών πληθυσμών. Οι πληθυσμοί αυτοί ονομάζονται διμεταβλητοί ή πολυμεταβλητοί στατιστικοί πληθυσμοί και οι αντίστοιχες μαθηματικές σχέσεις, οι οποίες συνδέουν τις συνεξεταζόμενες μεταβλητές λέγονται διμεταβλητά ή πολυμεταβλητά μαθηματικά υποδείγματα. Με τα διμεταβλητά μαθηματικά υποδείγματα εξετάζουμε αν υπάρχει σχέση εξαρτήσεως της μιας μεταβλητής Ψ από μία άλλη μεταβλητή Χ.
Το κεντρικό πρόβλημα της αναλύσεως διμεταβλητών στατιστικών πληθυσμών είναι να διαπιστώσουμε αν υπάρχει σχέση εξαρτήσεως (συσχέτιση) μεταξύ των μεταβλητών Ψ και Χ (δηλαδή αν η ανεξάρτητη μεταβλητή επηρεάζει τη διαμόρφωση των τιμών της εξαρτημένης μεταβλητής) και να μετρήσουμε το βαθμό της συσχέτισης.

Υπάρχουν δύο μέθοδοι σπουδής της εξαρτήσεως (συνάφειας) μεταξύ δύο μεταβλητών Χ και Ψ.

Α) Η πρώτη μέθοδος ονομάζεται ανάλυση παλινδρόμησης (Regression analysis) και αποβλέπει στον προσδιορισμό μίας γενικής σχέσεως εξαρτήσεως μεταξύ των συνεξεταζόμενων μεταβλητών Χ και Ψ, δηλαδή στον προσδιορισμό μιας μαθηματικής εξισώσεως, η οποία ονομάζεται Εξίσωση παλινδρόμησης (regression equation). Με άλλα λόγια, στην ανάλυση παλινδρόμησης εξετάζεται η σχέση εξάρτησης μεταξύ των μεταβλητών Ψ και Χ έτσι , ώστε να είναι δυνατή η μελλοντική πρόβλεψη της τιμής μιας μεταβλητής με βάση την άλλη μεταβλητή.

Η μορφή της εξάρτησης των διαφόρων μεταβλητών μπορεί να είναι γραμμική ή καμπυλόγραμμη. Λέγοντας ότι η σχέση εξαρτήσεως μεταξύ δύο μεταβλητών είναι γραμμική, εννοούμε ότι ο μέσος όρος της εξαρτήσεως μεταξύ των μεταβλητών μπορεί να αναπαρασταθεί με μια ευθεία γραμμή $Ψ=α+βΧ$. Ενώ όταν τα δεδομένα της παρατηρήσεως μπορούν να αναπαρασταθούν με μία καμπύλη, τότε η σχέση εξαρτήσεως μεταξύ των μεταβλητών είναι καμπυλόγραμμη, π.χ. $Ψ=α+βΧ+γχ^2$

Β) η δεύτερη μέθοδος σπουδής της εξαρτήσεως (συσχετίσεως) της μιας μεταβλητής Ψ από μία άλλη μεταβλητή Χ, ονομάζεται Συσχέτιση.(Correlation). Η συσχέτιση ασχολείται με τον ποσοτικό προσδιορισμό του βαθμού (της εντάσεως) της εξαρτήσεως μεταξύ των μεταβλητών και με τη φύση της συσχετίσεως(θετική ή αρνητική). Η μέτρηση του βαθμού της συσχετίσεως μεταξύ των δύο ή περισσότερων μεταβλητών γίνεται με μια στατιστική παράμετρο, η οποία ονομάζεται Συντελεστής Συσχετίσεως. Η συσχέτιση διακρίνεται σε θετική και αρνητική. Θετική καλείται η συσχέτιση όταν σε κάθε αύξηση(ή μείωση) της μίας μεταβλητής αντιστοιχεί αύξηση (ή μείωση) και της άλλης μεταβλητής.

Αρνητική καλείται η συσχέτιση, όταν σε κάθε αύξηση(ή μείωση) της μίας μεταβλητής αντιστοιχεί μείωση (ή αύξηση) της άλλης μεταβλητής.
Αν τα μεταβλητά Χ και Ψ είναι ανεξάρτητα μεταξύ τους, τότε θα είναι και ασυσχέτιστα, δηλαδή η μεταβολή των τιμών της μίας μεταβλητής (=Χ) δε θα προκαλεί επιδράσεις στις τιμές της άλλης μεταβλητής (=Ψ). Άρα δε θα υπάρχει πρόβλημα αναλύσεως παλινδρομήσεως και συσχετίσεως.
Η πρώτη εικόνα για την ύπαρξη ή όχι συσχετίσεως μεταξύ των μεταβλητών Ψ και Χ, δίνεται από την απεικόνιση των τιμών Ψ και Χ πάνω σε ένα σύστημα ορθογώνιων αξόνων. Τα σημεία του επιπέδου, τα οποία έχουν τεταγμένες τις τιμές της μεταβλητής Ψ και τετμημένες τις τιμές της μεταβλητής Χ,δημιουργούν ένα «νέφος» σημείων, το οποίο ονομάζεται Διάγραμμα Διασποράς (scatter diagram).

2.5. Σύγκριση δύο πληθυσμών

Συχνά στη βιομηχανία είναι απαραίτητη η σύγκριση δύο μηχανών για το μέσο χρόνο που χρειάζονται να ξεκινήσουν ή το μέσο χρόνο παραγωγής ενός συγκεκριμένου αριθμού προϊόντων.
Στην περίπτωση ανεξάρτητων και τυχαίων δειγμάτων η σύγκριση δύο πληθυσμών πραγματοποιείται με τη χρήση ελέγχου Z ή t.
Εάν συμβολισθεί το μέγεθος των δειγμάτων n_1 και n_2, η μέση τιμή των πληθυσμών για την πρώτη και δεύτερη μηχανή μ_1 και μ_2 και οι τυπικές αποκλίσεις σ_1 και σ_2 αντίστοιχα, τότε η σύγκριση δύο πληθυσμών ανάγεται σε έλεγχο υποθέσεων. Η αρχική υπόθεση μπορεί να είναι:

- $H_0 : \mu_1-\mu_2 =(\mu_1-\mu_2)_0$
- $H_0 : \mu_1-\mu_2 \geq (\mu_1-\mu_2)_0$
- $H_0 : \mu_1-\mu_2 \leq (\mu_1-\mu_2)_0$

Περιπτώσεις στις οποίες χρησιμοποιείται ο έλεγχος Z

1. το μέγεθος του δείγματος n_1 και n_2 είναι και τα δύο τουλάχιστον 30 και οι τυπικές αποκλίσεις και των δύο πληθυσμών γνωστές.
2. και οι δύο πληθυσμοί ακολουθούν την κανονική κατανομή και οι τυπικές αποκλίσεις και των δύο πληθυσμών είναι γνωστές.

Ο τύπος υπολογισμού του στατιστικού ελέγχου Z είναι ο ακόλουθος

$Z = \frac{(\overline{X_1} - \overline{X_2}) - (m_1 - m_2)_0}{\sqrt{s_1{}^2 / n_1 + s_2{}^2 / n_2}}$ όπου οι μεταβλητές $\overline{X_1}$ και $\overline{X_2}$ είναι οι μέσες τιμές των δειγμάτων και $(\mu_1-\mu_2)_0$ είναι η τιμή της υπόθεσης για τη διαφορά μεταξύ των μέσων τιμών του πληθυσμού.
Επειδή οι τιμές $\overline{X_1}$ και $\overline{X_2}$ ακολουθούν την κανονική κατανομή κατά συνέπεια και η διαφορά αυτών ακολουθεί την κανονική κατανομή. Δεδομένου μάλιστα ότι τα δύο δείγματα είναι ανεξάρτητα ισχύει:
$\mathrm{Var}(\overline{X_1} - \overline{X_2}) = \mathrm{Var}(\overline{X_1}) + \mathrm{Var}(\overline{X_2}) = \sigma_1^2 / n_1 + \sigma_2^2 / n_2$

Εαν η αρχική υπόθεση είναι ορθή τότε η ποσότητα

$\frac{(\overline{X_1} - \overline{X_2}) - (m_1 - m_2)_0}{\sqrt{s_1{}^2 / n_1 + s_2{}^2 / n_2}}$ ακολουθεί την κατανομή Z.

Περιπτώσεις στις οποίες χρησιμοποιείται ο έλεγχος t

Θα πρέπει και οι δύο πληθυσμοί να ακολουθούν την κανονική κατανομή. Οι τυπικές αποκλίσεις σ_1 και σ_2 του πληθυσμού είναι άγνωστες αλλά οι τυπικές αποκλίσεις των δειγμάτων S_1 και S_2 είναι γνωστές. Οι εξισώσεις για τον έλεγχο t εξαρτώνται από δύο υποπεριπτώσεις:

1^η υποπερίπτωση: σ_1 και σ_2 θεωρούνται ίσα αν και άγνωστα. Σε αυτήν την περίπτωση η σχέση που χρησιμοποιείται είναι η ακόλουθη:

$$t = \frac{(\overline{X_1} - \overline{X_2}) - (m_1 - m_2)_0}{\sqrt{S_P{}^2 (1/n_1 + 1/n_2)}}$$

όπου

$$S_p{}^2 = \frac{(n_1 - 1)S_1{}^2 + (n_2 - 1)S_2{}^2}{n_1 + n_2 - 2}$$

οι βαθμοί ελευθερίας είναι (n_1+n_2-2)

2^η^ υποπερίπτωση: σ_1 και σ_2 θεωρούνται άνισα αν και άγνωστα. Σε αυτήν την περίπτωση η σχέση που χρησιμοποιείται είναι η ακόλουθη:

$$t = \frac{(\overline{X_1} - \overline{X_2}) - (m_1 - m_2)_0}{\sqrt{(S_1{}^2 / n_1 + S_2{}^2 / n_2)}}$$

Οι βαθμοί ελευθερίας δίνονται από την εξής σχέση

$$df = \frac{(s_1{}^2 / n_1 + s_2{}^2 / n_2)^2}{(s_1{}^2 / n_1)^2 / (n_1 - 1) + (s_2{}^2 / n_2)^2 / (n_2 - 1)}$$

2.6. Αιτίες διακύμανσης

Βάσει της θεωρίας και των αρχών του ελέγχου διεργασιών, υπάρχουν διάφορες αιτίες διακύμανσης των ποιοτικών χαρακτηριστικών των προϊόντων κατά τη διάρκεια της παραγωγικής διαδικασίας. Πιο συγκεκριμένα υπάρχουν δύο είδη διακύμανσης:

η εγγενής ή τυχαία διακύμανση (inherent or random or common cause variability)
Η παραπάνω διακύμανση συμβαίνει τυχαία, η ύπαρξή της οφείλεται στον τρόπο σχεδιασμού της διεργασίας και έτσι λίγα πράγματα μπορούν να γίνουν γι' αυτή, εκτός και αν αναθεωρηθεί όλη η διεργασία από τη βάση της. Αποτελεί το αποτέλεσμα του συνόλου όλων των τυχαίων γεγονότων που μπορεί να συμβούν ανά πάσα στιγμή στη διεργασία και πλέον αποτελούν μέρος αυτής. Γι αυτό το λόγο αν η διεργασία διατηρηθεί σταθερή, οι διακυμάνσεις θα είναι ίδιες σε κάθε παρτίδα. Όταν τέτοιου είδους αιτία διακύμανσης υφίσταται μόνη της στην παραγωγική διαδικασία και οι διακυμάνσεις είναι πολύ μικρές, τότε η διεργασία μπορεί να θεωρηθεί ως μία «ελεγχόμενη στατιστική κατάσταση» ή απλά ότι βρίσκεται υπό έλεγχο (in statistical control or in control). Παρόλα αυτά η κατάσταση στατιστικού ελέγχου δεν μπορεί να θεωρηθεί φυσιολογική, αφού ακόμα και τότε δεν γνωρίζει κανείς για παράδειγμα την ακριβή τιμή μίας παραμέτρου στο επόμενο παραγόμενο προϊόν, απλά γνωρίζει το εύρος στο οποίο μπορεί να κυμαίνεται. Επομένως ακόμα και σε αυτήν την περίπτωση χρειάζεται επιπλέον δουλειά για περισσότερη βελτίωση της διεργασίας.

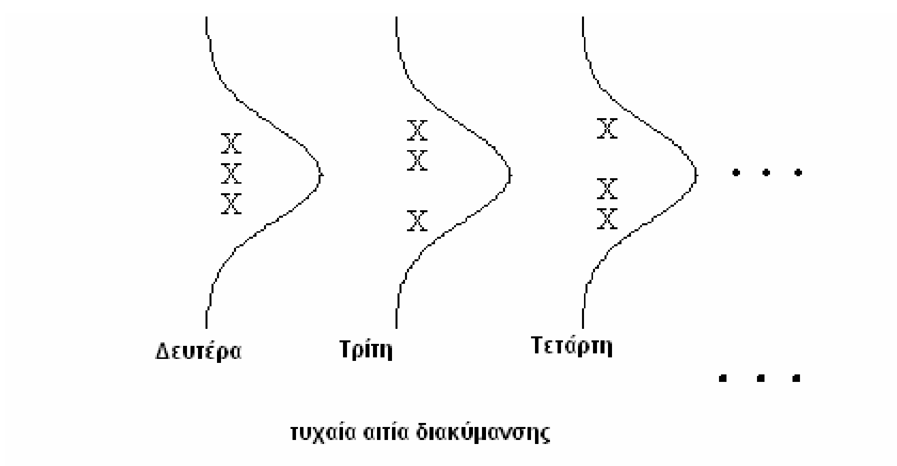
Ειδική ή αξιοσημείωτη αιτία διακύμανσης(special or assignable cause)
Η παρουσία τέτοιων αιτιών στη διεργασία είναι σπάνια και δεν μπορεί να προβλεφθεί, αλλά μπορεί εύκολα να εντοπιστεί και σχετίζεται συνήθως με μία μηχανή, έναν εργαζόμενο, ένα είδος πρώτων υλών, κάποιες ξαφνικές αλλαγές στις

συνθήκες περιβάλλοντος κτλ. Δεν σχετίζεται με τον τρόπο σχεδιασμού της διεργασίας και προκαλεί διακυμάνσεις μεγαλύτερου μεγέθους οι οποίες είναι προσδιορίσιμες. Η ύπαρξη αυτών των διακυμάνσεων σε μία διεργασία τη θέτουν σε «κατάσταση εκτός στατιστικού ελέγχου» ή απλά «εκτός ελέγχου» (out of statistical control) .
Αν συμβολίσουμε τις τιμές του ποιοτικού χαρακτηριστικού ενός προϊόντος σαν
$X_1, X_2, \ldots, X_n, \ldots$
Η διεργασία που παράγει αυτές τις τιμές χαρακτηρίζεται ευσταθής (stable process) όταν υπάρχουν μόνο κοινές αιτίες διακύμανσης. Δηλαδή δεν υπάρχουν ειδικά γεγονότα που προκαλούν ασυνήθιστη μεταβλητότητα.

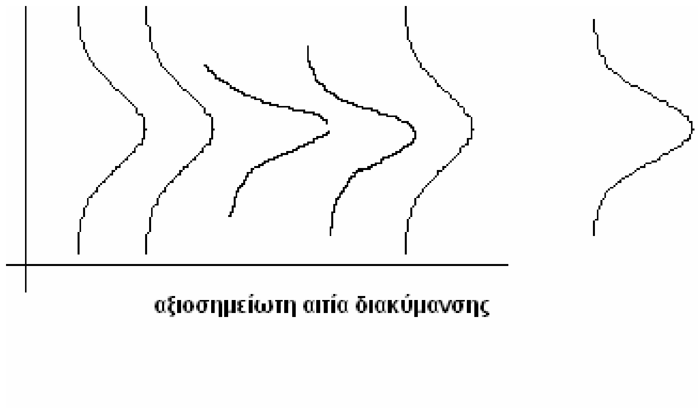
Το εύρος της μεταβλητότητας παραμένει κατ'ουσία σταθερό και οι τιμές του ποιοτικού χαρακτηριστικού Xi είναι προβλέψιμες.
Πιο συγκεκριμένα, μια διαδικασία είναι ευσταθής, δηλαδή προβλέψιμη, όταν οι τιμές Xi προέρχονται από ένα παραμετρικό στατιστικό μοντέλο. [4]

Είναι πολύ σημαντικό να διακρίνει κανείς τις δύο αυτές διαφορετικές αιτίες διακύμανσης, γιατί η βελτίωση των ποιοτικών χαρακτηριστικών των προϊόντων της διεργασίας βασίζεται σε πιο από τα δύο είδη διακυμάνσεων εμφανίζεται κάθε φορά στη διεργασία. Ο μόνος τρόπος για αποτελεσματικό διαχωρισμό αυτών είναι η χρήση των διαγραμμάτων ελέγχου, τα οποία δίνουν μία ολοκληρωμένη εικόνα της διεργασίας σε κάθε χρονική στιγμή και μπορούν να ερμηνευτούν εποικοδομητικά. Οι εγγενείς ή τυχαίες διακυμάνσεις είναι ευθύνη του τμήματος διαχείρισης της εταιρίας, αφού εξαρτώνται από το σύστημα ή τη διεργασία. Αντίθετα, η αντιμετώπιση και των ειδικών διακυμάνσεων είναι ευθύνη του προσωπικού πρώτης γραμμής παραγωγής.

Η παρουσία αυτών των διαφορετικών ειδών διακύμανσης και η επίδρασή τους σε μία διεργασία φαίνεται στα σχήματα 3.8 και 3.9.



Σχήμα 3. 8 επίδραση της τυχαίας διακύμανσης σε μια διεργασία



Σχήμα 3. 9 επίδραση της διακύμανσης από αξιοσημείωτη αιτία σε μια διεργασία

2.7. Χάρτες ελέγχου (Control chart)

Ένας χάρτης ελέγχου είναι η γραφική παράσταση μιας μεταβολής στην υπολογιστική στατιστική η οποία πραγματοποιείται κατά την πραγματοποίηση μιας διαδικασίας. Πλεονεκτεί έναντι της εμφάνισης δεδομένων υπό τη μορφή ιστογράμματος στο ότι δείχνει τη συχνότητα στην οποία τα δεδομένα παράγονται. Τα βασικά διαγράμματα ελέγχου, τα οποία αναπτύχθηκαν από τον Dr.Shewhart, είναι ουσιαστικά διαγράμματα «μέσης τιμής» και «τυπικών αποκλίσεων». Άλλα διαγράμματα αναπτύχθηκαν για τη διακύμανση δειγμάτων, ποσοστό μη συμμόρφωσης, αριθμός μη συμμορφώσεων ανά τεμάχιο ή ανά 100 τεμαχίων. Περαιτέρω βελτιώσεις και βελτιστοποιήσεις στα βασικά διαγράμματα έχουν πραγματοποιηθεί κατά το πέρασμα των χρόνων. Τέτοια διαγράμματα όπως είναι τα αθροιστικά και τα εκθετικά σταθμισμένου μέσου επιτρέπουν γρηγορότερη αναγνώριση μικρών αλλαγών στην παράμετρο που παρακολουθείται.

2.7.1. Βήματα χάραξης ενός χάρτη ελέγχου

1. **επιλογή των χαρακτηριστικών** που θα παρουσιαστούν στους χάρτες. Στην επιλογή αυτή υπάρχουν πολλά στοιχεία τα οποία θα πρέπει να ληφθούν υπ' όψη.

   α. Επιλογή ενός χαρακτηριστικού στο οποίο υπάρχει μεγάλος αριθμός μη συμμορφωμένων προϊόντων.

   β. Αναγνώριση των μεταβλητών της διαδικασίας που σχετίζονται με τα χαρακτηριστικά του τελικού προϊόντος προς αναγνώριση πιθανές δυνατότητες αποτύπωσης σε διάγραμμα.

   γ. Επιλογή χαρακτηριστικών τα οποία θα παρέχουν κατάλληλα δεδομένα για την αναγνώριση και διάγνωση προβλημάτων. Στην επιλογή χαρακτηριστικών , είναι απαραίτητο να είναι κατανοητό ότι χαρακτηριστικά γνωρίσματα παρέχουν δεδομένα περιληπτικά και μπορούν να χρησιμοποιηθούν για οποιοδήποτε αριθμό χαρακτηριστικών.

   δ. Καθορισμός προσβάσιμου σημείου στην παραγωγική διαδικασία για δημιουργία χάρτη ελέγχου. Αυτός ο χάρτης ελέγχου είναι καλό να υπάρχει αρκετά νωρίς για να αποτρέπει την ύπαρξη μη συμμορφωμένων προϊόντων και για να προστατεύει από την παραπάνω εργασία στα ήδη ελαττωματικά προϊόντα.

2. **επιλογή του κατάλληλου χάρτη ελέγχου**
   α. Η πρώτη απόφαση είναι κατά πόσο θα χρησιμοποιηθούν διαγράμματα ποιοτικών χαρακτηριστικών ή μεταβλητών. Ένα διάγραμμα μεταβλητών χρησιμοποιείται για τον έλεγχο μεμονωμένων , μετρήσιμων χαρακτηριστικών, ενώ ένα διάγραμμα ποιοτικών χαρακτηριστικών χρησιμοποιείται με έλεγχο τύπου «δεκτό-απορριπτέο». Χρησιμοποιείται για τον έλεγχο και του επιπέδου της διαδικασίας και της μεταβλητότητας της διαδικασίας. Το διάγραμμα ιδιοτήτων παρέχει συνοπτικά δεδομένα τα οποία μπορούν να χρησιμοποιηθούν για τη βελτίωση της διαδικασίας με τον έλεγχο μεμονωμένων ποιοτικών χαρακτηριστικών.
   β. Επιλογή κατάλληλου τύπου χάρτη ελέγχου που θα χρησιμοποιηθεί. Εάν θα χρησιμοποιηθεί διάγραμμα μεταβλητών , θα πρέπει να αποφασιστεί αν θα πραγματοποιηθεί διάγραμμα μέσου και κατανομής ή μέσου και μέσου και τυπικής απόκλισης. Για μικρές αλλαγές στη μέση τιμή, οι οποίες όμως θεωρούνται σημαντικές είναι απαραίτητο να χρησιμοποιηθούν αθροιστικά ή εκθετικά διαγράμματα. Το μειονέκτημα των διαγραμμάτων αυτών είναι ότι τα συμπεράσματα που εξάγονται δεν είναι εύκολο να αναλυθούν. **Σε περίπτωση που δεν είναι δυνατή αλλά και δεν χρησιμεύει η ύπαρξη υποομάδων , μεμονωμένες τιμές μπορούν να χρησιμοποιηθούν** αν και είναι καλό να αποφεύγεται η χρήση τους . Για ιδιότητες, ο αριθμός μη συμμορφώσεων ανά τεμάχιο ή ο αριθμός μη συμμορφωμένων προϊόντων μπορούν να καταγραφούν διαγραμματικά. Σε μερικές περιπτώσεις χρησιμοποιούνται αποτελεσματικότερα τα διαγράμματα στα οποία καταγράφεται ο αριθμός ελαττωμάτων ανά έλεγχο .

3. **επιλογή της κεντρικής γραμμής του διαγράμματος και της βάσης για υπολογισμό των *ορίων ελέγχου*.** Η κεντρική γραμμή μπορεί να είναι ο μέσος όρος παλαιότερων δεδομένων, ο μέσος όρος των δεδομένων που θα πρέπει να συλλεχθούν η μια επιθυμητή (δεδομένη) τιμή. *Τα όρια* συνήθως τοποθετούνται $\pm$ 3σ τυπικές αποκλίσεις, αλλά πολλαπλάσια των τυπικών αποκλίσεων μπορούν επίσης να χρησιμοποιηθούν. Η χρήση 3 τυπικών αποκλίσεων είναι αποτέλεσμα του αμελητέου κινδύνου ανίχνευσης προβλημάτων τα οποία δεν υφίστανται, δηλαδή λάθος συναγερμού(false alarm). Υπάρχει όμως και η πιθανότητα αυτό το πολλαπλάσιο να οδηγήσει σε αδυναμία ανεύρεσης μικρής μεταβολής στην παράμετρο η οποία μελετάται. Μικρότερα πολλαπλάσια αυξάνουν τον κίνδυνο να ψάχνουμε λανθασμένα κάποιο πρόβλημα *(false alarm)* αλλά μειώνουν την πιθανότητα αποτυχίας να βρεθεί κάποια μικρή μεταβολή. Ο λόγος ότι είναι πολύ πιο κοστοβόρο να γίνεται μελέτη για προβλήματα τα οποία δεν υπάρχουν από το να ανιχνεύονται ακόμα και τα πιο μικρά προβλήματα είναι ο λόγος για τον οποίο τα όρια των $\pm$ 3σ τυπικών αποκλίσεων επιλέγονται.

4. **επιλογή της υποομάδας ή δείγματος[1].** Για διαγράμματα μεταβλητών, ένα δείγμα μεγέθους 4-5 χρησιμοποιείται πιο συχνά, ενώ για διάγραμμα ιδιοτήτων

[1] Θα πρέπει να τονισθεί ότι ο όρος δείγμα χρησιμοποιείται πολύ συχνά αλλά ο όρος αυτός μπορεί να αντιστοιχεί σε μεμονωμένη τιμή, αν και για χάρτες ελέγχου είναι προτιμότερη η χρήση δειγμάτων με περισσότερες από μία μεμονωμένη τιμή.

(attributes), δείγματα των 50 με 100 χρησιμοποιούνται πιο συχνά. Τα διαγράμματα ιδιοτήτων μπορούν για την ακρίβεια να χρησιμοποιηθούν με 100% επιθεώρηση σαν αποτύπωση της βασικής διαδικασίας η οποία μελετάται. Εκτός από το μέγεθος του δείγματος, είναι απαραίτητο να προσεχθεί και ο τρόπος με τον οποίο επιλέγεται το δείγμα. Είναι απαραίτητο να επιλέγεται το δείγμα κατά τρόπο ώστε η πιθανότητα μιας μεταβολής της διαδικασίας να περιορίζεται κατά τη διάρκεια λήψης του δείγματος (γι' αυτό και είναι απαραίτητη η λήψη ενός μικρού δείγματος)· όπου η πιθανότητα μεταβολής, εάν πρόκειται να συμβεί , να είναι μέγιστη μεταξύ των δειγμάτων. Αυτή είναι η λογική της υποομάδας. Είναι προτιμότερο να λαμβάνονται μικρά δείγματα περιοδικά από το να λαμβάνεται ένα μεγάλο δείγμα.

5. **δημιουργία συστήματος συλλογής δεδομένων**. Εάν οι χάρτες ελέγχου πρόκειται να χρησιμοποιηθούν άμεσα στην παραγωγή, η συλλογή πληροφοριών πρέπει να αποτελεί μία εύκολη διαδικασία. Οι μετρήσεις πρέπει να είναι απλές και χωρίς λάθη. Τα εργαλεία μέτρησης θα πρέπει να δίνουν γρήγορα και αξιόπιστα δεδομένα. Εάν είναι δυνατό, τα εργαλεία μέτρησης θα πρέπει να καταγράφουν τα δεδομένα, αφού κάτι τέτοιο θα περιόριζε τη συνήθη πηγή λαθών. Τα φύλλα δεδομένων (*data sheets)* θα πρέπει να σχεδιάζονται προσεκτικά ώστε να γίνονται τα δεδομένα άμεσα αξιοποιήσιμα.

6. **υπολογισμός των ορίων ελέγχου και παροχή επιπλέον οδηγιών σε όλους τους ενδιαφερόμενους για τη σημασία σωστής ερμηνείας των αποτελεσμάτων**. Το προσωπικό παραγωγής πρέπει να είναι σε θέση να εκτελεί διορθωτικές ενέργειες όπου οι χάρτες ελέγχου το επιβάλουν. [6]

2.7.1.1. Επιλογή χαρακτηριστικών προς προσδιορισμό ποιότητας

Τα δεδομένα που επεξεργάζονται κατά τη διεργασία στατιστικού ελέγχου διακρίνονται σε
α) Ιδιότητες (attributes) και β)μεταβλητές(Variables)

Στην πρώτη κατηγορία ανήκουν τα δεδομένα που έχουν προκύψει από παρατήρηση – αρίθμηση (counting), ενώ στη δεύτερη δεδομένα που έχουν προέλθει από μέτρηση.(measurement).

Στον παρακάτω πίνακα (πίνακας 3.1) παρουσιάζονται παραδείγματα από δεδομένα που ανήκουν σε αυτές τις κατηγορίες.

Τα δεδομένα από αρίθμηση μπορούν να ληφθούν από ένα πεπερασμένο αριθμό σημείων (countable) ή από την κατηγοριοποίηση κάποιου δεδομένου σε έναν αριθμό καταστάσεων που συνήθως είναι δύο. Ανάλογα με το είδος των δεδομένων θα πρέπει να χρησιμοποιηθεί και διαφορετικός τύπος διαγράμματος ελέγχου.

Πίνακας 2. 1 παραδείγματα από δεδομένα που αποτελούν ιδιότητες ή μεταβλητές

ΙΔΙΟΤΗΤΕΣ (ATTRIBUTES)		***ΜΕΤΑΒΛΗΤΕΣ (VARIABLES)***
Δεδομένα από αρίθμηση	Δεδομένα από κατηγοριοποίηση σε αριθμό καταστάσεων	
Αριθμός κατεστραμμένου προϊόντος	Αποδεκτό ή απορριπτέο προϊόν	Θερμοκρασία διεργασίας
Αριθμός ελαττωμάτων σε ένα προϊόν	Προϊόν που ελέγχεται για την παρουσία στοιχείου μέσα σε κάποια όρια	Βάρος συσκευασμένου προϊόντος
		Συγκέντρωση κάποιου διαλύματος σε κάποια ουσία
		πίεση πραγματοποίησης μιας διεργασίας

2.7.1.2. Επιλογή κατάλληλου χάρτη ελέγχου

Τα δεδομένα στα οποία πραγματοποιείται επεξεργασία μέσω στατιστικού ελέγχου διεργασιών διακρίνονται σε α) ιδιότητες (attributes) και β) μεταβλητές(variables)

Στην πρώτη κατηγορία ανήκουν τα δεδομένα που έχουν προκύψει από παρατήρηση-αρίθμηση(counting), ενώ στη δεύτερη δεδομένα που έχουν προέλθει από μέτρηση (measurement). Στον πίνακα 3.1 παρουσιάζονται παραδείγματα από δεδομένα που ανήκουν στις δύο αυτές κατηγορίες. Τα δεδομένα από αρίθμηση μπορούν να ληφθούν από ένα πεπερασμένο αριθμό σημείων (countable) ή από την κατηγοριοποίηση κάποιου δεδομένου σε έναν αριθμό καταστάσεων που συνήθως είναι δύο. Ανάλογα με το είδος των δεδομένων θα πρέπει να χρησιμοποιηθεί και διαφορετικός τύπος διαγράμματος ελέγχου.

2.7.2. Διαγράμματα ελέγχου για μεταβλητές

2.7.2.1. Κατάστρωση χάρτη ελέγχου για μεταβλητές με σκοπό την προσέγγιση κατάστασης ελέγχου(διαγράμματα χωρίς να δίνεται κάποιο πρότυπο)

Σε αυτήν την περίπτωση υποθέτουμε ότι δε γνωρίζουμε τίποτα για την διαδικασία, αλλά επιθυμούμε να αναγνωρίσουμε εάν είναι σε κατάσταση στατιστικού ελέγχου., δηλαδή να δούμε εάν υπάρχουν μόνο τυχαίες αιτίες στην ύπαρξη μεταβολής. Η διαδικασία για όλους τους τύπους διαγραμμάτων είναι:

1. λήψη μια σειρά 20-30 δειγμάτων από τη διαδικασία.
2. κατά τη λήψη αυτών των δειγμάτων , η καταγραφή κάθε μεταβολής στη διαδικασία η πιθανή μεταβολή σε χειριστές, μηχανήματα ή υλικά που χρησιμοποιούνται.
3. υπολογισμός δοκιμαστικών ορίων ελέγχου γι’ αυτά τα δεδομένα
4. καταγραφή των δεδομένων σε διάγραμμα μαζί με τα δοκιμαστικά όρια προς ανίχνευση εάν κάποιο από τα δείγματα βρίσκεται εκτός ορίων ελέγχου.

Εάν κανένα από τα σημεία τα οποία καταγράφηκαν σε χάρτες ελέγχου δεν βρίσκεται εκτός των δοκιμαστικών ορίων , μπορούμε να θεωρήσουμε τη διαδικασία «εντός στατιστικού ελέγχου». Και αυτά τα όρια μπορούν να χρησιμοποιηθούν για τη διατήρηση του ελέγχου. Εάν αντιθέτως κάποια από τα σχεδιασμένα σημεία είναι εκτός των δοκιμαστικών ορίων ελέγχου, τότε μπορούμε να θεωρήσουμε τη διαδικασία εκτός στατιστικού ελέγχου. Αυτό σημαίνει ότι υπάρχουν αποδοτέες αιτίες (*assignable causes)* στην ύπαρξη μεταβολής. Σε αυτήν την περίπτωση θα πρέπει να καθορισθούν από τα αρχεία κατά το 2^o στάδιο της διαδικασίας, τα αίτια για τα οποία το συγκεκριμένο σημείο βρίσκεται εκτός στατιστικού ελέγχου, να περιορισθούν αυτά τα δείγματα από τα δεδομένα και να επαναπροσδιορισθούν τα δοκιμαστικά όρια ελέγχου. Εάν κάποια στοιχεία είναι και πάλι εκτός των νέων ορίων θα πρέπει αυτό το βήμα να επαναληφθεί έως ότου κανένα από τα σημεία δεν βρίσκεται εκτός των ορίων ελέγχου. Αυτά τα τελικά όρια μπορούν στη συνέχεια να χρησιμοποιηθούν για μελλοντικό έλεγχο.[6],[7]

2.7.2.2. Διάγραμμα μέσης τιμής ($\overline{x}$)

Το διάγραμμα μέσης τιμής είναι το περισσότερο χρησιμοποιούμενο διάγραμμα για έλεγχο ιδιοτήτων. Παρέχει εύκολα μια αρχική εκτίμηση για την πορεία της διεργασίας δίνοντας τη δυνατότητα παρακολούθησης και σύγκρισης των δειγμάτων μεταξύ τους . χρησιμοποιείται κάθε φορά που είναι επιθυμητός ο έλεγχος ενός συγκεκριμένου χαρακτηριστικού καθώς τα διαγράμματα μπορούν να χρησιμοποιηθούν με ένα χαρακτηριστικό κάθε φορά. Φυσικά το χαρακτηριστικό θα πρέπει να είναι μετρήσιμο ή τύπου μεταβλητής.

Για τη δημιουργία των διαγραμμάτων μέσης τιμής πρέπει να μαζευτούν τα κατάλληλα δεδομένα (βλ. 3.7). Συνήθως μαζεύονται 25- 30 δείγματα-υποομάδες. Κάθε υποομάδα αποτελείται από 3 έως 10 δείγματα-τεμάχια, με τον αριθμό 5 να είναι το πιο σύνηθες. Για κάθε υποομάδα Ι υπολογίζεται η μέση τιμή $\overline{x}$. Αυτές οι τιμές καταγράφονται σε ένα χάρτη ελέγχου. Έπειτα υπολογίζεται η συνολική μέση τιμή . αυτή η τιμή καθορίζει την *κεντρική γραμμή (central line*). Η ολική μέση τιμή είναι ο μέσος όρος των μέσων τιμών των δειγμάτων

$$\overline{\overline{x}} = \frac{\sum_{i=1}^{k} \overline{x_i}}{k}$$

όπου η μέση τιμή κάθε υποομάδας υπολογίζεται :

$$\overline{x} = \sum \frac{x}{n}$$

Αν η διεργασία βαίνει ικανοποιητικά αναμένεται, βάση των γνώσεων από την κανονική κατανομή, ότι το 99,8% -σχεδόν δηλαδή το σύνολο των μέσων δειγμάτων να βρίσκεται μεταξύ των άνω και κάτω ορίων ελέγχου. (action limits), δηλαδή μέσα στην περιοχή

$\mu \pm 3\ s_{\overline{x}} = \mu \pm 3\sigma/\sqrt{n}$

όπου μ= ο μέσος της διαδικασίας
σ= η τυπική απόκλιση της διαδικασίας
n= το μέγεθος της υποομάδας

Από τη στιγμή που οι παράμετροι μ και σ είναι άγνωστοι, πρέπει να τους εκτιμήσουμε από τα δεδομένα. Η καλύτερη προσέγγιση του μ είναι το $\bar{\bar{x}}$.
Τα όρια ελέγχου για ένα διάγραμμα μέσης τιμής υπολογίζονται [8]

$$UCL_{\bar{X}} = \bar{\bar{X}} + 3\frac{\bar{R}}{\left(d_2\sqrt{n}\right)} = \bar{\bar{x}} + A_2\bar{R}$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - 3\frac{\bar{R}}{\left(d_2\sqrt{n}\right)} = \bar{\bar{x}} - A_2\bar{R}$$

όπου $A_2 = 3/(d_2\sqrt{n})$

2.7.2.3 διάγραμμα εύρους (range R)

Τα διαγράμματα εύρους παρουσιάζεται πάντα μαζί με το διάγραμμα μέσης τιμής . το διάγραμμα εύρους χρησιμοποιείται για τον έλεγχο της μεταβλητότητας. Στη θέση του διαγράμματος εύρους πολλές φορές χρησιμοποιείται το διάγραμμα της τυπικής απόκλισης , αλλά το διάγραμμα εύρους είναι πιο εύκολο να υπολογισθεί και πιο εύκολο να κατανοηθεί από τους χειριστές.

Το διάγραμμα εύρους μπορεί να υπολογισθεί παρόμοια με το διάγραμμα μέσης τιμής σε $\mu_R \pm 3\ s_R$ όπου μ_R και σ_R είναι η μέση τιμή και η τυπική απόκληση της κατανομής του εύρους των υποομάδων, αντιστοίχως. Η μέση τιμή του εύρους εκτιμάται από το $\bar{R}$, και η τυπική απόκλιση του εύρους είναι $\sigma_R = d_3\sigma$. Αυτό μπορεί να εκτιμηθεί από $d_3\ \bar{R}/d_2$.Γι' αυτό υπολογίζουμε τα όρια ελέγχου για το διάγραμμα εύρους ακολούθως

$$UCL_{\bar{R}} = \bar{R} + 3d_3\frac{\bar{R}}{d_2} = (1 + 3\frac{d_3}{d_2})\bar{R} = D_4\bar{R}$$

$$UCL_{\bar{R}} = \bar{R} - 3d_3\frac{\bar{R}}{d_2} = (1 - 3\frac{d_3}{d_2})\bar{R} = D_3\bar{R}$$

όπου οι παράγοντες A_2 ,D_3 και D_4 είναι συναρτήσεις του μεγέθους της υποομάδας n και καταγράφονται σε πίνακα του παραρτήματος Ε, πίνακας Α

2.7.2.4. Διάγραμμα τυπικών αποκλίσεων (s)

Η τυπική απόκλιση s των υποομάδων μπορεί να χρησιμοποιηθεί με το διάγραμμα της μέσης τιμής σε αντικατάσταση του εύρους των υποομάδων ώστε να μετρηθεί η διασπορά της διαδικασίας. Σε αυτές τις περιπτώσεις θα μπορούσαμε να υπολογίσουμε την τυπική απόκλιση κάθε υποομάδας, να βρούμε το μέσο όρο των τυπικών αποκλίσεων των υποομάδων και να υπολογίσουμε τα όρια ελέγχου από τις παρακάτω εξισώσεις

$$UCL_s = B_4\bar{s}$$

$$LCL_s = B_3\bar{s}$$

όπου οι τιμές των B_3 και B_4 μπορούν να βρεθούν στον πίνακα Α του παραρτήματος Ε η τυπική απόκλιση έχει ανώτερες μαθηματικές ιδιότητες έναντι του εύρους,και με την παρουσία των σημερινών υπολογιστών είναι αρκετά απλός ο υπολογισμός. Παρόλαυτά το εύρος είναι πιο εύκολο να γίνει κατανοητό στο χειριστή με τη μέση εκπαίδευση στη στατιστική και γι' αυτό το λόγο χρησιμοποιείται πιο συχνά.[6],[9]

2.7.2.5. Διαγράμματα για μεμονωμένες τιμές (individuals Control Chart)

πολλές φορές δεν είναι πρακτικό να ληφθεί υποομάδα από μία διαδικασία. Αυτό είναι πραγματικότητα κυρίως σε χημικές ή άλλες συνεχείς διεργασίες ή όταν μελετώνται μεταβλητές όπως η θερμοκρασία και η πίεση. Επίσης χρησιμοποιούνται συχνά σε λογιστικά δεδομένα,στη μέτρηση αποτελεσματικότητας,σε λόγους, σε δαπάνες ή σε κόστη ποιότητας. Σε τέτοιες περιπτώσεις η λήψη παραπάνω δειγμάτων δεν ωφελεί σε τίποτα πέρα από τον έλεγχο ουσιαστικά της ικανότητας λήψης των δεδομένων και μέτρησης του προς μελέτη χαρακτηριστικού. Ένα διάγραμμα που βασίζεται σε μία παρατήρηση καλείται διάγραμμα μεμονωμένης τιμής ή χ διάγραμμα. Από τη στιγμή που δεν χρησιμοποιούμε μέσο όρο των τιμών των δειγμάτων δεν έχουμε το πλεονέκτημα του κεντρικού οριακού θεωρήματος, το οποίο υποστηρίζει ότι η κατανομή των μέσων είναι κανονική ανεξάρτητα από την κάθε κατανομή. Το διάγραμμα $\bar{x}$ πρέπει να αντικατασταθεί από κάποιο άλλο διάγραμμα μέσης τιμής που προσαρμόζεται στις συνθήκες αυτές το οποίο μπορεί να εφαρμόζεται με μεγάλη προσοχή, αφού βασίζεται σε πολύ μικρό αριθμό δεδομένων. Επιπλέον, αφού το μέγεθος του δείγματος είναι n=1, δεν μπορεί να βγει κάποιο συμπέρασμα σχετικά με την κατάσταση της διεργασίας (εντός ή εκτός ελέγχου) με τον παραδοσιακό τρόπο, ούτε σχετικά με τη διασπορά και την ικανότητα αυτής. Για την περίπτωση αυτή υπάρχουν δύο επιλογές: να χρησιμοποιήσουμε ένα μεταβλητό εύρος, για παράδειγμα η διαφορά μεταξύ δύο διαφορετικών παρατηρήσεων ή να υπολογίσουμε την τυπική απόκλιση 20 και πλέον επιτυχών παρατηρήσεων. Εαν η διαδικασία δεν μεταβάλλεται, τότε και οι δύο στατιστικές μέθοδοι θα δώσουν τα ίδια αποτελέσματα. Εάν η διαδικασία μεταβάλλεται, το μεταβλητό εύρος θα μειώσει τη συνέπεια της μεταβολής. Γι αυτό και αυτή η μέθοδος χρησιμοποιείται πιο συχνά. Η βασική μέθοδος για τη δημιουργία διαγραμμάτων χ είναι η ακόλουθη:

1. επιλογή των μετρήσιμων χαρακτηριστικών που θα μετρηθούν,
2. λήψη αρκετών παρατηρήσεων(20 ή παραπάνω) για μελέτη δοκιμαστική. Οι παρατηρήσεις θα πρέπει να είναι αρκετά απόμακρες μεταξύ τους για να επιτρέψουν στην διαδικασία να έχει πιθανές μεταβολές.
3. υπολογισμός των ορίων ελέγχου και της κεντρικής γραμμής για τη μελέτη δοκιμής χρησιμοποιώντας τις εξισώσεις που παρατίθενται παρακάτω
4. κατάστρωση του δοκιμαστικού διαγράμματος χρησιμοποιώντας την κεντρική γραμμή και όρια, σχεδιασμός των παρατηρήσεων που λήφθηκα (βήμα 2). Εάν όλα τα σημεία είναι μέσα στα όρια ελέγχου και δεν υπάρχουν μη

φυσιολογικές διακυμάνσεις τα όρια αυτά θα χρησιμοποιηθούν και για επόμενους ελέγχους.

5. αναθεώρηση των ορίων ελέγχου και της κεντρική γραμμής όπως χρειάζεται (με το να απορρίπτονται σημεία εκτός ελέγχου) με σκοπό τη βελτίωση της διαδικασίας.
6. περιοδικός καταλογισμός της ικανότητας του διαγράμματος μετατρέποντας το όπως επιβάλλεται.

Υπολογισμός των ορίων ελέγχου- κινητό εύρος

Τα όρια ελέγχου για ένα χ διάγραμμα υπολογίζονται με τον ίδιο τρόπο που υπολογίζονται και τα διαγράμματα των $\overline{x}$

Μπορούνε να τοποθετηθούνε έτσι σε
μ±3σ
ο μέσος όρος των παρατηρήσεων $\overline{x}$ χρησιμοποιείται συχνά για να εκτιμηθεί η μέση τιμή της διαδικασίας μ. Σε περιπτώσεις που δίνονται πρότυπα , η γνωστή τυπική απόκλιση θα μπορούσε να χρησιμοποιηθεί σε προηγούμενη εξίσωση. Σε περιπτώσεις που δεν δίνονται πρότυπα θα πρέπει να εκτιμήσουμε την τυπική απόκλιση. Σε περιπτώσεις που δεν δίνονται πρότυπα είτε χρησιμοποιούμε το κινητό εύρος ή την τυπική απόκλιση.

Το κινητό εύρος είναι η διαφορά μεταξύ της μεγαλύτερης και της μικρότερης από δύο επιτυχημένες παρατηρήσεις. Γι αυτό το λόγο σε ένα σύνολο n παρατηρήσεων θα είναι n-1 κινητά εύρη. Χρησιμοποιείται ο μέσος όρος για τη λήψη ενός κινητού μέσου εύρους $\overline{R}$.Τα όρια ελέγχου θα μπορούσαν να τοποθετηθούν κατά παρόμοιο τρόπο όπως και προηγουμένως :

$$UCL_{\overline{X}} = \overline{X} + 3\frac{\overline{R}}{(d_2)} = \overline{X} + E_2\overline{R}$$

$$LCL_{\overline{X}} = \overline{X} - 3\frac{\overline{R}}{(d_2)} = \overline{X} - E_2\overline{R}$$

όπου οι τιμές των $E_2=3/d_2$ μπορούν να βρεθούν στον πίνακα Β του παραρτήματος Ε. Εάν υιοθετήσουμε τον συνήθη κανόνα κατά τον οποίο χρησιμοποιούμε κινητά εύρη μεγέθους 2, το E_2 διαιρείται με το 1,13 ή το 2,66. Τα όρια ελέγχου για διαγράμματα μεμονωμένων τιμών είναι τότε

$$UCL_{\overline{X}} = \overline{X} + 2{,}66\overline{R}$$

$$LCL_{\overline{X}} = \overline{X} - 2{,}66\overline{R}$$

με $\overline{X} = \dfrac{\sum R}{N}$ και

$$UCL_R = 3{,}267\overline{R}$$

$$LCL_R = (0)\overline{R}$$

για αναθεωρημένη κεντρική γραμμή και όρια ελέγχου υπάρχουν οι παρακάτω τύποι

$$X_0 = \overline{X_{new}} \qquad R_0 = \overline{R_{new}}$$

$$UCL_X = X_0 + 3s_0 \qquad UCL_R = 3{,}686s_0$$

$$LCL_X = X_0 - 3s_0 \qquad LCL_R = (0)s_0$$

όπου σ_0=0,8865R_0

Τυπική απόκλιση

Σαν εναλλακτική του κινητού εύρους, πολλές φορές υπολογίζεται η τυπική απόκλιση s όλων των δοκιμαστικών παρατηρήσεων. Σε αυτήν την περίπτωση τα όρια ελέγχου θα μπορούσαν να τοποθετηθούν σε

$$\overline{X} \pm 3s$$

εάν ο μέσος όρος της διαδικασίας μεταβληθεί, π.χ. σε περίπτωση μιας τάσης, η μέθοδος της τυπική απόκλισης θα τείνει να μεγαλώσει τη μεταβολή. Εάν ο μέσος όρος της διαδικασίας παραμένει σταθερός και οι δύο μέθοδοι θα έχουν σαν αποτέλεσμα να δώσουν τα ίδια όρια ελέγχου.

2.7.2.6. Σχεδιασμός χάρτη ελέγχου για δοσμένες τιμές παραμέτρων

Εάν πρότυπες τιμές των παραμέτρων δίνονται , το διάγραμμα που κατασκευάζεται ονομάζεται δοσμένων-προτύπων διάγραμμα. Σε αυτήν την περίπτωση , η πρότυπη τιμή για την μέση τιμή φαίνεται ως $\overline{X_0}$ και η πρότυπη τιμή για την τυπική απόκλιση ως σ_0. Τα όρια ελέγχου για ένα διάγραμμα μέσης τιμής $\overline{X}$ θα είναι

$$\overline{X_0} \pm 3s_0 / \sqrt{n} = \overline{X_0} \pm As_0$$

όπου A είναι μια συνάρτηση του μεγέθους της υποομάδας n και βρίσκεται από τον πίνακα A του παραρτήματος E. Στην περίπτωση ενός χάρτη ελέγχου για μεμονωμένες τιμές , τα όρια ελέγχου θα είναι τα ίδια εκτός από το γεγονός ότι εάν το μέγεθος κάθε υποομάδας είναι 1 τα όρια θα είναι

$$\overline{X_0} \pm 3s_0$$

2.7.2.7. Διαγράμματα ελέγχου με γραμμές τάσης (chart for trends)

Τα κλασικά διαγράμματα που περιγράφηκαν έχουν σκοπό τον εντοπισμό αποκλίσεων της μέσης τιμής κάθε δείγματος από το μέσο όρο αυτών ή την απόκλιση του εύρους κάθε δείγματος από το μέσο όρο όλων των δειγμάτων. Δηλαδή την απόκλιση από μια σταθερή οριζόντια τιμή της ελεγχόμενης παραμέτρου. Υπάρχουν όμως και πολλές διεργασίες όπου η μέση τιμή δεν είναι σταθερή με την πάροδο του χρόνου αλλά αλλάζει με ένα γνωστό και προβλέψιμο τρόπο. Μπορεί δηλαδή να αυξάνεται ή να μειώνεται, επομένως η χρήση των προηγούμενων διαγραμμάτων θα οδηγούσε στο συμπέρασμα ότι η διεργασία είναι εκτός ελέγχου. [11]

Συνήθως σε τέτοιες περιπτώσεις η κεντρική γραμμή έχει κλίση. Σε αυτήν την περίπτωση η εξίσωση τις κεντρικής γραμμής πρέπει να προσδιορισθεί. Κάτι τέτοιο επιτυγχάνεται καλύτερα με τη χρησιμοποίηση τη μέθοδο ελαχίστων τετραγώνων με την οποία προσαρμόζεται μια γραμμή σε ένα σύνολο σημείων. Η εξίσωση για μια γραμμή τάσης, χρησιμοποιώντας την κλίση είναι

$$\overline{X} = a + bG$$

όπου $\overline{X}$ = ο μέσος όρος της υποομάδα και παριστάνει τον κάθετο άξονα
G= ο αριθμός των υποομάδων και παριστάνει τον οριζόντιο άξονα
α = σημείο στον κάθετο άξονα όπου η γραμμή τέμνει τον κάθετο άξονα

$$a = \frac{\left(\sum \overline{X}\right) * \left(\sum G^2\right) - \left(\sum G\right) * \left(\sum G\overline{X}\right)}{g\sum G^2 - \left(\sum G\right)^2}$$

b= η κλίση της γραμμής

$$b = \frac{g\sum G\overline{X} - \left(\sum G\right)\left(\sum \overline{X}\right)}{g\sum G^2 - \left(\sum G\right)^2}$$

g= ο αριθμός των υποομάδων

από τη στιγμή που η εξίσωση της τάσης είναι γνωστή, μπορεί να σχεδιαστεί στο διάγραμμα με την επιλογή τιμών για το G και υπολογίζοντας το $\overline{X}$.Όταν δύο σημεία σχεδιάζονται, η γραμμή τάσης σχεδιάζεται μεταξύ αυτών. Τα όρια ελέγχου σχεδιάζονται σε κάθε πλευρά της κλίσης της γραμμής σε απόσταση (σε κατακόρυφη διεύθυνση) που ισούται με $A_2\overline{R}$ ή $A\sigma_o$.[11]

Πιο συγκεκριμένα η διαδικασία σχεδιασμού των ορίων ελέγχου καταγράφεται ως εξής:
Τα όρια ελέγχου για χάρτη ελέγχου διακύμανσης εξαρτώνται από τί σχεδιάζεται. Εάν σχεδιάζονται τα αποτελέσματα μεμονωμένων δειγμάτων , τα όρια ελέγχου για το χάρτη ελέγχου εύρους είναι

$UCLr = 3.267\overline{R}$ και $LCLr = none$

εάν χρησιμοποιούνται μέσες τιμές υποομάδων, τα όρια ελέγχου για το χάρτη ελέγχου εύρους θα είναι τα ίδια με τα διαγράμματα X-R και θα δίνονται από τις σχέσεις:

$$LCLr = D_3 \overline{R}$$

όπου τα D_3 και D_4 είναι σταθερές του χάρτη ελέγχου οι οποίες εξαρτώνται από το μέγεθος της υποομάδας.

Αλλά και τα όρια ελέγχου για το ίδιο το διάγραμμα τάσης είναι συνάρτηση του τι καταγράφεται.

Εάν σχεδιάζονται τα αποτελέσματα μεμονωμένων δειγμάτων , τα όρια ελέγχου είναι:

$$UCL_x = X_t + 2{,}66\overline{R} = mt + b + 2{,}66\overline{R}$$

$$LCL_x = X_t - 2{,}66\overline{R} = mt + b - 2{,}66\overline{R}$$

Εάν χρησιμοποιούνται μέσες τιμές υποομάδων, τα όρια ελέγχου είναι:

$$UCL_x = X_t + A_2 \overline{R} = mt + b + A_2 \overline{R}$$

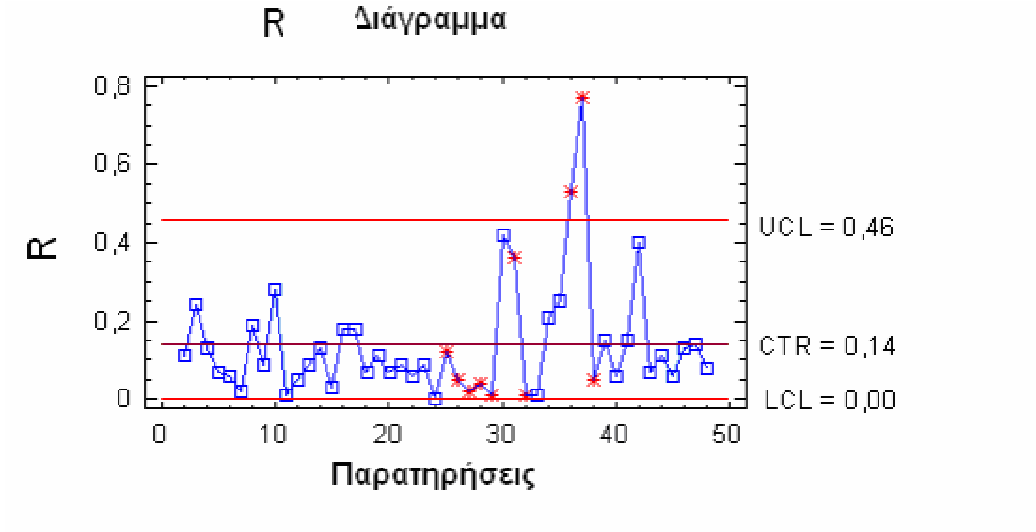
$$LCL_x = X_t - A_2 \overline{R} = mt + b - A_2 \overline{R}$$

Όπου A_2 είναι μία σταθερά η οποία εξαρτάται από το μέγεθος της υποομάδας.

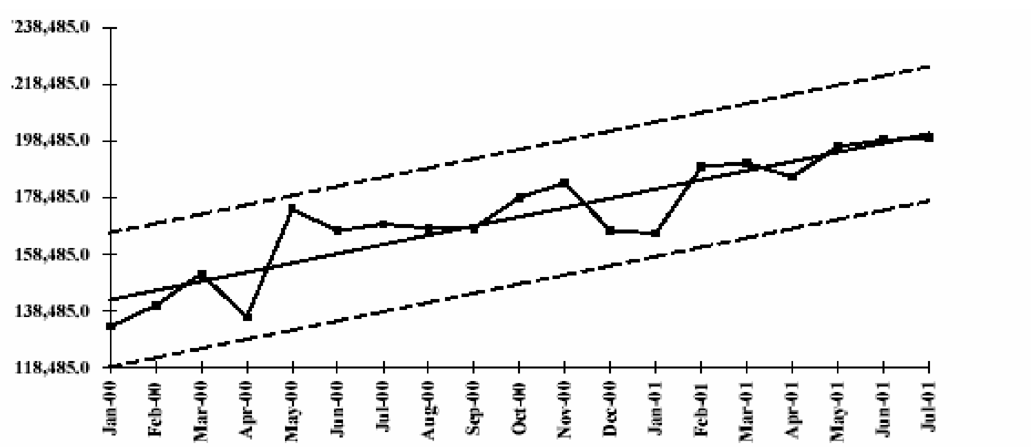
Στα κλασικά διαγράμματα Shewhart η εκτίμηση της τυπικής απόκλισης της διαδικασίας είναι δυνατό να υπολογιστεί από το διάγραμμα εύρους αν είναι σε στατιστικό έλεγχο η διεργασία.

Η τυπική απόκλιση είναι μία τιμή, η ο οποία αποτελεί ουσιαστικά μέτρηση της μεταβολής των μεμονωμένων τιμών. Κάτι τέτοιο σε αυτήν την περίπτωση δεν μπορεί να υπολογισθεί, γιατί η μέση τιμή της διαδικασίας δεν είναι σταθερή με αποτέλεσμα η αληθινή μεταβολή να είναι πολύ μεγαλύτερη. [12]

Ένα διάγραμμα R θα έχει γενικά τη μορφή του διαγράμματος 3.1. ενώ ένα διάγραμμα τάσης τη μορφή του διαγράμματος 3.2



Διάγραμμα 3. 1 Γενική μορφή διαγράμματος εύρους



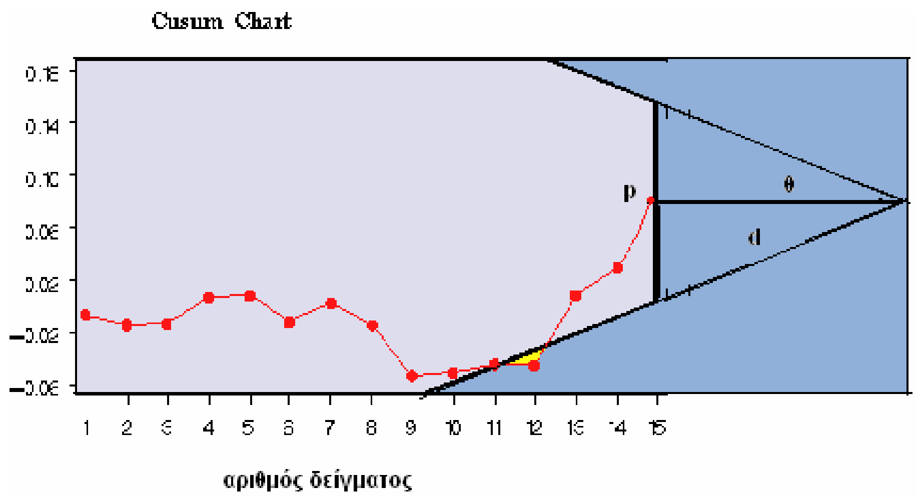
Διάγραμμα 3. 2 Γενική μορφή διαγράμματος ελέγχου τάσης

2.7.2.8. Αθροιστικά διαγράμματα ελέγχου (cumulative sum control charts).

Τα αθροιστικά διαγράμματα ελέγχου σχεδιάστηκαν για την αναγνώριση μικρών αλλά συνεχών αλλαγών σε μία διεργασία πολύ πιο γρήγορα από ότι τα συνήθη διαγράμματα $\overline{X}$.Επειδή δίνει μία αρχική ένδειξη των αλλαγών των διαδικασιών, είναι σύμφωνο με τη φιλοσοφία που υποδεικνύει να γίνονται εξ αρχής οι βελτιώσεις και να μην παραμένει μια διαδικασία η οποία οδηγεί σε μη συμμορφούμενα προϊόντα. Τα διαγράμματα CuSum συγχωνεύουν όλα τα παλαιότερα δεδομένα με τη διαδικασία χάραξης αθροίσματα όλων των αποκλίσεων των αξιών των δειγμάτων από την αξία-στόχο, κάτι που φαίνεται από τη σχέση :

$$S_t = \sum_{i=1} (\overline{x_i} - \overline{x_o})$$

όπου το $\overline{x_i}$ είναι ο μέσος όρος των υποομάδων i, $\overline{x_o}$ είναι η σταθερή ή ενδεικτική τιμή, και S_t είναι το άθροισμα όπου το η παρατήρηση i έχει ληφθεί. Θα πρέπει να επισημανθεί ότι όπου n=1, $\overline{x_i}$ είναι η τιμή της i παρατήρησης. Τα αθροιστικά διαγράμματα είναι διαφορετικά από ότι είναι τα συνήθη $\overline{X}$-R διαγράμματα όπως φαίνεται και στο διάγραμμα 3.3. Στη θέση της κεντρικής γραμμής και των οριζόντιων ορίων ελέγχου τοποθετείται μία ακίδα και δύο γωνίες οι οποίες αποτελούν τα όρια ελέγχου. Η ακίδα είναι τοποθετημένη έτσι ώστε το σημείο p να είναι πάνω στο τελευταίο σημείο που έχει σχεδιαστεί. Η απόσταση d και η γωνία θ είναι σχεδιαστικές παράμετροι του όλου σχεδίου. Εάν κανένα από τα σημεία που έχουν σχεδιασθεί δεν βρίσκεται εκτός των ορίων ελέγχου, τότε θεωρείται ότι η διαδικασία είναι εντός στατιστικού ελέγχου.



Διάγραμμα 2. 3 Γενική μορφή αθροιστικού διαγράμματος

2.7.2.9. Εκθετικά διαγράμματα ελέγχου (Exponentially Weighted Moving Average Control Charts-EWMA)

Τα κλασικά διαγράμματα Shewhart ($\overline{X}$-R, $\overline{X}$-s, κλπ.) χρησιμοποιούνται ευρέως στην παραγωγική διαδικασία, όμως σε πολλές περιπτώσεις δεν είναι εφαρμόσιμα. Στις βιομηχανίες οι πηγές διακύμανσης είναι πολλές και συνεχώς τείνουν τη διαδικασία σε κατάσταση εκτός στατιστικού ελέγχου αποκλίνοντας έτσι από τον στόχο. Τα διαγράμματα Shewhart δεν μπορούν να εντοπίσουν τόσο μικρές αλλαγές και επιδράσεις στη διεργασία ιδιαίτερα όταν δεν εφαρμόζονται δοκιμές των ζωνών και των υποομάδων. Το διάγραμμα EWMA όμως έχει τη δυνατότητα εντοπισμού μικρών αλλαγών. Διαφέρει από τα επόμενα διαγράμματα στο ότι προβλέπει ποιο θα είναι το επόμενο σημείο.

Το διάγραμμα EWMA παρακολουθεί τις διακυμάνσεις του μέσου της διεργασίας και σκοπός του είναι ο εντοπισμός μικρών διακυμάνσεων, χωρίς να συνοδεύεται από παλιότερες τιμές δεδομένων. Η διαδικασία υπολογισμού των σημείων του διαγράμματος EWMA περιγράφεται παρακάτω.

Για κάθε πραγματική τιμή μέσου που μετράται σε κάθε δείγμα υπολογίζεται η τιμή EWMA η οποία ορίζεται ως η παρούσα προβλεπόμενη τιμή συν λ φορές το παρόν παρατηρούμενο λάθος.

$$EWMA = \hat{x}_{t+1} = \hat{x}_t + l\,e_t = \hat{x}_t + l\,(x_t - \hat{x}_t)$$

όπου $\hat{x}_{t+1}$= προβλεπόμενη τιμή τη χρονική στιγμή t+1

x_t =παρατηρούμενη τιμή τη χρονική στιγμή t

$\hat{x}_t$ =προβλεπόμενη τιμή τη χρονική στιγμή t

$e_t = (x_t - \hat{x}_t)$ =παρατηρούμενο λάθος τη χρονική στιγμή t

l =σταθμισμένη σταθερά (0<λ≤1)

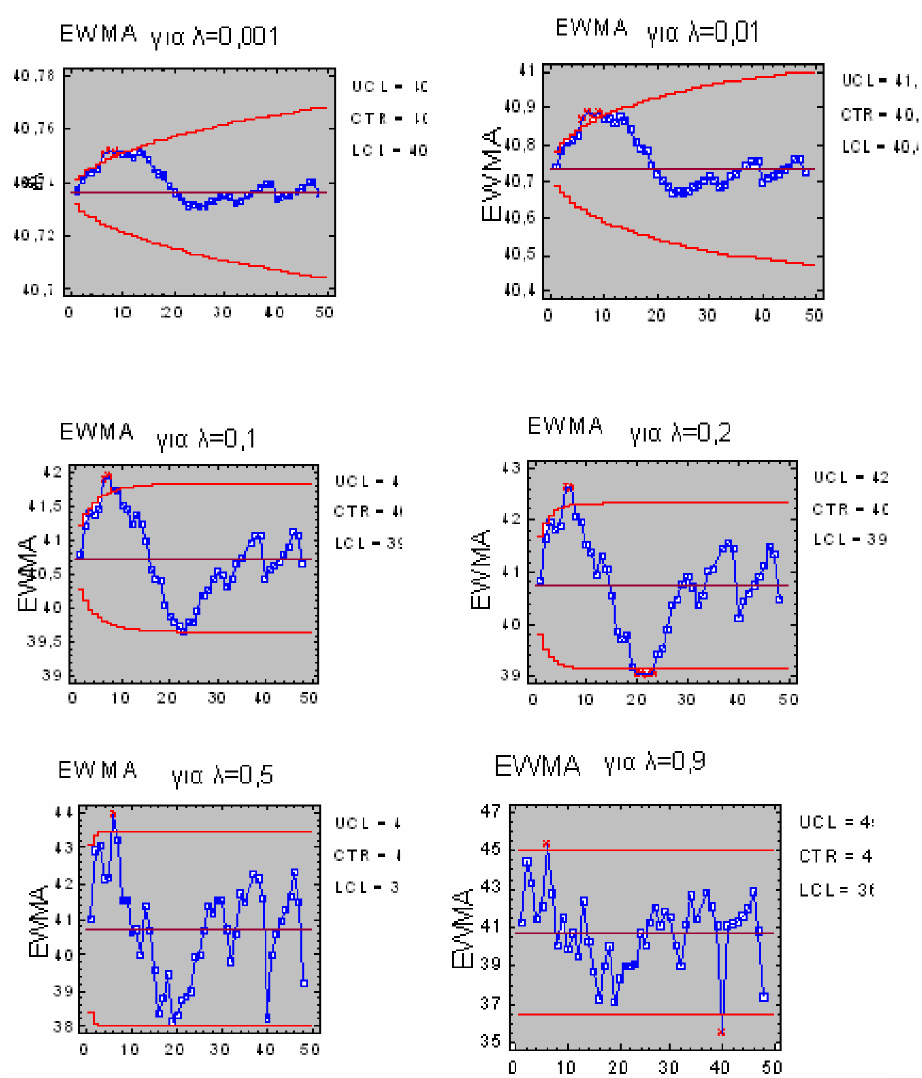
οι τιμές δηλαδή EWMA είναι οι τιμές που γίνεται η πρόβλεψη. Θα πρέπει μάλιστα να τονισθεί ότι κανένα από αυτά τα τεστ για σταθερότητα δεν παραβιάζεται αν ληφθούν υπόψη και οι χάρτες ελέγχου για μεμονωμένες τιμές. Οι χάρτες ελέγχου EWMA δίνουν ένα πιο γρήγορο δείκτη για μικρές μεταβολές στη διαδικασία από ότι δίνουν οι χάρτες ελέγχου για μεμονωμένες τιμές. Αυτό είναι κι ένα από τα πλεονεκτήματα χρήσης των EWMA. Σε γενικές γραμμές οι χάρτες ελέγχου EWMA αναγνωρίζουν μικρότερες μεταβολές (λιγότερες από 2 s’) πιο γρήγορα από τους χάρτες ελέγχου των μεμονωμένων τιμών ή τους χάρτες ελέγχου $\overline{X}$-R .Παρόλ’αυτά αν όλοι οι έλεγχοι για σταθερότητα (ζώνες, κλπ) χρησιμοποιηθούν , η ικανότητα των μεμονωμένων τιμών καθώς και των $\overline{X}$-R διαγραμμάτων για τον προσδιορισμό μικρών μεταβολών προσεγγίζει αυτή των EWMA χαρτών ελέγχου.

Υπολογισμός της σταθεράς λ

Η σταθερά βαρύτητας λ, καθορίζει την επίδραση των ιστορικών παλιών δεδομένων στα σημεία του EWMA. Αποτελεί μία από τις σημαντικότερες διαφορές μεταξύ των κλασικών διαγραμμάτων Shewhart, του CuSum και του EWMA διαγράμματος.

Στα διαγράμματα Shewhart, η κατάσταση εκτός ελέγχου υφίσταται όταν ένα σημείο βρεθεί εκτός των ορίων ελέγχου και το οποίο είναι το τελευταίο σημείο και αντιπροσωπεύει τη συγκεκριμένη χρονική στιγμή και κανένα άλλο κοντινό σημείο δεν περιλαμβάνεται. Σε αυτήν την περίπτωση όλο το βάρος «πέφτει» στο τελευταίο σημείο και θεωρώντας wi ως σταθμισμένο, τότε w_1=1 για το τελευταίο σημείο που σχεδιάστηκε και w_i=0 για όλα τα προηγούμενα σημεία (ι≤t-1).Αντίθετα, στο διάγραμμα CUSUM η κατάσταση εντός ή εκτός στατιστικού ελέγχου εξαρτάται από το άθροισμα και σε κάθε προηγούμενο σημείο δίνεται ίδια βαρύτητα (για παράδειγμα w_t=1/n για όλα τα σημεία). Το διάγραμμα κινητού μέσου είναι μία προσπάθεια να χρησιμοποιηθούν λίγα από τα προηγούμενα σημεία, συνήθως τα τρία προηγούμενα, στα οποία επίσης δίνεται η ίδια βαρύτητα.

Το διάγραμμα όμως EWMA παρέχει ένα διαφορετικό τρόπο να εξαρτάται από τα παλιά σημεία μέσω της σταθεράς λ, δίνοντας έτσι συνεχώς λιγότερη βαρύτητα στα παλιά αυτά δεδομένα όσο περνά ο χρόνος, όπως φαίνεται και στο σχήμα 3.10 όταν το λ είναι κοντά στο 0, το EWMA προσεγγίζει τη δυνατότητα ανίχνευσης αλλαγών του διαγράμματος CUSUM δίνοντας μεγαλύτερη βαρύτητα στα προηγούμενα δεδομένα, ενώ όταν η τιμή του λ είναι κοντά στο 1 το EWMA προσεγγίζει την ικανότητα ανίχνευσης των διαγραμμάτων Shewhart αφού δε λαμβάνονται υπόψη τα προηγούμενα σημεία.



Σχήμα 2. 10 διαγράμματα EWMA για διαφορετικές τιμές του λ

Υπάρχουν πολλοί τρόποι για την επιλογή της τιμής του λ. Η πιο εύκολη μέθοδος είναι να βρεθεί η τιμή του λ ώστε το άθροισμα των τετραγώνων των λαθών (ε_t^2) να είναι όσο το δυνατό ελάχιστο. Συνήθως τουλάχιστον 50 σημεία πρέπει να συλλεχθούν ώστε να αποφασιστεί η τιμή του λ. Στο σχήμα 3.10 φαίνεται η επίδραση της τιμής λ στην καμπύλη του διαγράμματος EWMA. Όσο το λ παίρνει μικρότερες τιμές τόσο περισσότερα προηγούμενα σημεία λαμβάνονται υπόψη, και τόσο η καμπύλη γίνεται πιο ομαλή. Αντίθετα όσο το λ αυξάνεται, η μορφή του διαγράμματος EWMA προσεγγίζει αυτή του διαγράμματος μεμονωμένων τιμών.

Η βαρύτητα που δίνεται σε κάθε ένα από τα σημεία-δεδομένα μπορεί να υπολογισθεί από τη σχέση:

$w_i = l(1-l)^{t-1}$

υπολογισμός των ορίων ελέγχου

Τα όρια ελέγχου του διαγράμματος EWMA υπολογίζονται βάσει της τυπικής απόκλισης των μεμονωμένων μετρήσεων (σ'):

$\sigma'_{EWMA}=\sigma' \sqrt{\frac{1}{2-l}}$

και δίνονται από τις σχέσεις:

- Άνω όριο ελέγχου (Upper Action Limit) :UAL_{EWMA}=στόχος+3,09 σ'_{EWMA}
- Κάτω όριο ελέγχου (Lower Action Limit): LAL_{EWMA}=στόχος – 3,09 σ'_{EWMA}

Όπως φαίνεται και από τις παραπάνω σχέσεις τα όρια εξαρτώνται άμεσα από τη σταθερά λ. Όσο αυτή αυξάνει τιμή, τα όρια ελέγχου γίνονται πλατύτερα.
Η μόνη δοκιμή που μπορεί να γίνει κατά την ερμηνεία του διαγράμματος είναι ο εντοπισμός σημείων εκτός των ορίων ελέγχου, αφού τα δεδομένα δεν είναι ανεξάρτητα.

Επειδή η τυπική απόκλιση του EWMA υπολογίζεται βάσει της τυπικής απόκλισης των μεμονωμένων μετρήσεων, γεννάται το ερώτημα σχετικά με τη σταθερότητα της διεργασίας για τη διακύμανση αυτη. Αν δηλαδή σχεδιαζόταν ένα διάγραμμα κινητού μέσου για τις μονωμένες τιμές, θα ήταν εντός στατιστικού ελέγχου; Στην περίπτωση που υπάρχου υποψίες για διεργασία εκτός στατιστικού ελέγχου, ένα διάγραμμα εύρους είναι απαραίτητο. Η τυπική απόκλιση τότε των μεμονωμένων τιμών υπολογίζεται από τη σχέση : $\overline{R}/d_2$

Γενικά τα διαγράμματα EWMA χρησιμοποιούνται με δεδομένα μεμονωμένων τιμών και όχι με μέσες τιμές υποομάδων. Παρόλαυτά δεν εμποδίζει τίποτα τη χρήση των EWMA με μέσες τιμές υποομάδων. Χρησιμοποιείται κυρίως σαν δυναμικό εργαλείο στον έλεγχο διαδικασιών αφού προβλέπει πιο θα είναι το επόμενο σημείο. Αυτό μπορεί να παρέχει μια πρώιμη ανακάλυψη πιθανών προβλημάτων.

Τα διαγράμματα EWMA μπορούν να χρησιμοποιηθούν μικρές μεταβολές στη διαδικασία. Η επιλογή λ επηρεάζει πόσο γρήγορα η μεταβολή της διαδικασίας θα ανακαλυφθεί. Χρησιμοποιείται πολύ συχνά σαν μέθοδος πρόβλεψης αφού έχει την ικανότητα να προβλέπει το επόμενο σημείο. Για πρόβλεψη η τιμή του λ είναι συνήθως ο,2±0,1. [12]

2.7.2.10. Διαγράμματα Moving Average, Moving Range (MA, MR)

Τα διάγραμμα αυτά είναι κατάλληλα για μικρής διάρκειας διεργασίες. Χρησιμοποιούνται σε περιπτώσεις όπου μπορούν να ληφθούν λίγα μόνο μεμονωμένα δεδομένα τα οποία όμως αντιπροσωπεύουν μια κατάσταση σε δεδομένη χρονική στιγμή-οπότε και τα $\overline{X}$-R διαγράμματα δεν μπορούν να χρησιμοποιηθούν, αφού η συχνότητα δειγματοληψίας είναι μικρή, σε περιπτώσεις όπου τα δεδομένα δεν ακολουθούν την κανονική κατανομή- οπότε το διάγραμμα μεμονωμένων τιμών δεν ενδείκνυνται, ή σε περιπτώσεις όπου η δειγματοληψία είναι δύσκολη ή χρονοβόρα.

Τα διαγράμματα MA και MR είναι παρόμοια με τα διαγράμματα $\overline{X}$-R με μια πρώτη ματιά αλλά τα σημεία των διαγραμμάτων προκύπτουν από την ομαδοποίηση των μεμονωμένων τιμών όπως περιγράφεται παρακάτω: Αρχικά θα πρέπει να οριστεί ο αριθμός των διαδοχικών μετρήσεων που θα αποτελέσουν τις υποομάδες των δεδομένων . Συνήθως η διαδικασία γίνεται μεταξύ των δύο, τριών, τεσσάρων ή πέντε διαδοχικών μετρήσεων, όμως η καλύτερη επιλογή είναι για n=3 ¨η 4. Ως πρώτη μέτρηση για τη στήλη του κινητού μέσου , όπως φαίνεται και στον πίνακα 3.2 είναι η μέση τιμή των τεσσάρων πρώτων μετρήσεων. Η επόμενη τιμή στην ίδια στήλη προκύπτει από το μέσο όρο της δεύτερης, τρίτης, τέταρτης και πέμπτης μέτρησης χωρίς να ληφθεί υπόψη η πρώτη μέτρηση κ.ο.κ. Με τον ίδιο τρόπο υπολογίζονται και οι τιμές της στήλης moving range, δημιουργώντας δηλαδή ομάδες των τεσσάρων παραλείποντας κάθε φορά την τελευταία μέτρηση της προηγούμενης ομάδας και υπολογίζοντας τη διαφορά R_{max}-R_{min} σε κάθε μία από αυτές.

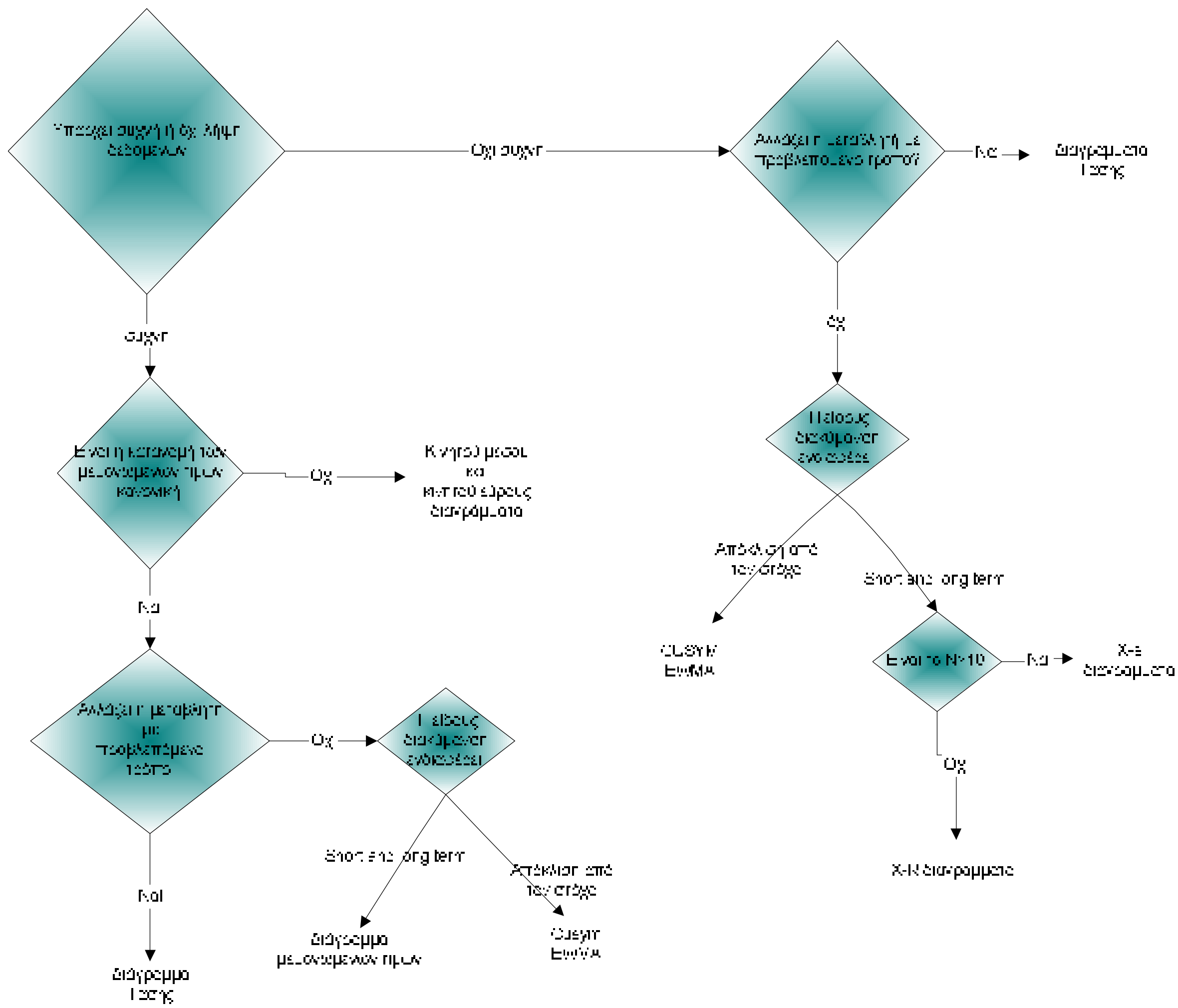
Πίνακας 3. 2 υπολογισμός κινητού μέσου και κινητού εύρους

Χρόνος(hr)	Μεμονωμένες τιμές	Moving total (n=4)	Κινητό μέσο	Κινητό εύρος
00:00	0,17	-	-	-
04:00	0,24	-	-	-
08:00	0,06	-	-	-
12:00	0,14	0,61	0,153	0,18
16:00	0,2	0,64	0,160	0,18
20:00	0,31	0,71	0,178	0,25

Συγκρίνοντας τα διαγράμματα κινητού μέσου και κινητού εύρους με τα τυπικά διαγράμματα, μπορεί να παρατηρηθεί ότι μία ακραία τιμή μπορεί να έχει μεγαλύτερη επίδραση στα πρώτα . Αυτό βασίζεται στο γεγονός ότι μία ακραία τιμή χρησιμοποιείται κατά μεγάλο μέρος στους υπολογισμούς.[13]

2.7.2.11. Επιλογή κατάλληλου διαγράμματος ελέγχου για μεταβλητές

Η επιλογή του κατάλληλου διαγράμματος ελέγχου είναι πολύ σημαντικό στάδιο στο στατιστικό έλεγχο μιας διεργασία. Στο σχήμα 3.11 φαίνεται ένα σχεδιάγραμμα για την ορθή επιλογή του διαγράμματος ελέγχου βάσει παραμέτρων διαφορετικών σε κάθε περίπτωση.[14]



Σχήμα 3. 11 επιλογή κατάλληλου διαγράμματος ελέγχου για μεταβλητές

2.7.3. Διαγράμματα ελέγχου για ιδιότητες

Η ποιότητα πολλών προϊόντων εξαρτάται από χαρακτηριστικά τα οποία δεν μπορούν να μετρηθούν όπως οι μεταβλητές. Είναι οι ιδιότητες των προϊόντων, όπως ήδη αναφέρθηκε , και μπορούν απλά να χαρακτηριστούν ως παρούσες οι απούσες και αποδεκτές ή απορριπτέες. Προφανώς δεν μπορούν να αντιμετωπιστούν μέσω των μεθόδων και των διαγραμμάτων που ήδη αναφέρθηκαν.
Η στατιστική συμπεριφορά τέτοιων δεδομένων είναι τελείως διαφορετική από αυτή των μεταβλητών, γεγονός που πρέπει να λαμβάνεται υπόψη κατά το σχεδιασμό

συστημάτων ελέγχου διεργασιών. Για να αποφασιστεί το είδος των δεδομένων που θα επεξεργαστούν στατιστικά πρέπει να γνωρίζει κανείς αρκετά σχετικά με το προϊόν και τις ιδιότητες που επιθυμεί να ελέγξει. Οι παρακάτω δύο κατηγορίες οδηγούν στη χρήση διαφορετικών τύπων διαγραμμάτων που βασίζονται σε δύο διαφορετικές στατιστικές κατανομές :

1. ένα προϊόν παραγόμενο σε μονάδες οι οποίες μπορούν να χαρακτηριστούν ως αποδεκτές ή ελαττωματικές
2. ένα προϊόν παραγόμενο σε μονάδες οι οποίες παρουσιάζουν έναν αριθμό ελαττωμάτων.

Βάσει των παραπάνω, τα διαγράμματα που μπορούν να χρησιμοποιηθούν είναι τα:

1. διαγράμματα ελέγχου για ελαττωματικά προϊόντα
   α. για σταθερό μέγεθος δείγματος (np)
   β. για μεταβλητό μέγεθος δείγματος (p)

2. διαγράμματα ελέγχου για ελαττώματα σε προϊόντα
   α. για σταθερό μέγεθος δείγματος
   β. για μεταβλητό μέγεθος δείγματος

πρέπει να τονισθεί ότι ένα προϊόν πιθανόν να έχει αρκετά ελαττώματα. Χωρίς αυτό να χαρακτηρίζεται ελαττωματικό. Εξαρτάται από τις προδιαγραφές του προϊόντος .

2.7.3.1. Διαγράμματα ελέγχου για ελαττωματικά προϊόντα για σταθερό μέγεθος δείγματος (διαγράμματα np).

Τα np διαγράμματα χρησιμοποιούνται στο δεύτερο στάδιο του μοντέλου επίλυσης προβλημάτων και παρακολουθούν τις διακυμάνσεις δεδομένου ΄τυπου Ναι/Όχι. Μέσω αυτών υπολογίζεται ο αριθμός των ελαττωματικών προϊόντων σε μία ομάδα αντικειμένων σε όλη την παραγωγική διαδικασία, δηλαδή προϊόντων που δεν πληρούν ως ένα βαθμό τος προδιαγραφές και τα πρότυπα που έχει θέσει η εταιρεία.
Η διαδικασία είναι η εξής: αφού έχει καθοριστεί η ιδιότητα που θα πρέπει να παρατηρηθεί, αποφασίζεται η συχνότητα δειγματοληψίας και το μέγεθος του δείγματος. Έπειτα σε κάθε δείγμα καταγράφεται ο αριθμός των ελαττωματικών προϊόντων και τα σημεία αυτά μεταφέρονται στο διάγραμμα np. Τα δεδομένα αυτά ακολουθούν τη διωνυμική κατανομή και βάσει της οποίας θα γίνει και ο υπολογισμός των ορίων του διαγράμματος ελέγχου.

Ο μέσος αριθμός ελαττωματικών προϊόντων σε κάθε δείγμα υπολογίζεται από τη σχέση

$$n\overline{p} = \frac{\sum_{i=1}^{k} np_i}{k}$$

Η τίμη n $\overline{p}$ είναι το μέγεθος του δείγματος επί το ποσοστό ελαττωματικών προϊόντων στη διεργασία.
Τα άνω και κάτω όρια ελέγχου στα διαγράμματα ελέγχου για μεταβλητές υπολογίστηκαν για τέτοια απόσταση, ώστε η πιθανότητα να βρεθεί ένα σημείο εκτός αυτών να είναι 0,001. Για να υπολογιστούν τα αντίστοιχα όρια και στα διαγράμματα

ελέγχου ιδιοτήτων, θα πρέπει να υπολογιστούν αθροιστικά οι πιθανότητες για κάθε ένα παραπάνω σημείο εκτός αυτών μέχρι την πιθανότητα 0,001.

Για παράδειγμα, αν σε μία διεργασία υπάρχει ένα ποσοστό $\overline{p}$=0,02, τότε τα μη ελαττωματικά είναι (1-0,02)=0,98. Η πιθανότητα να βρεθεί κανένα ή περισσότερα ελαττωματικά προϊόντα είναι:
$P(\geq 0)=1.000$
Η πιθανότητα να βρεθεί ένα ή περισσότερα ελαττωματικά προϊόντα είναι:
$P(\geq 1)=1-P(0)$
Από τη θεωρία των πιθανοτήτων, ο γενικός τύπος υπολογισμού της πιθανότητας εύρεσης χ ελαττωματικών προϊόντων σε ένα δείγμα μεγέθους n είναι :
$P(x)= [n!/(n-x)!\ x!\ ]*p^{x}*(1-p)^{(n-x)}$

Επομένως : $P(0)=\dfrac{100!}{100!0!}*0{,}98^{100}=0{,}1326$ άρα

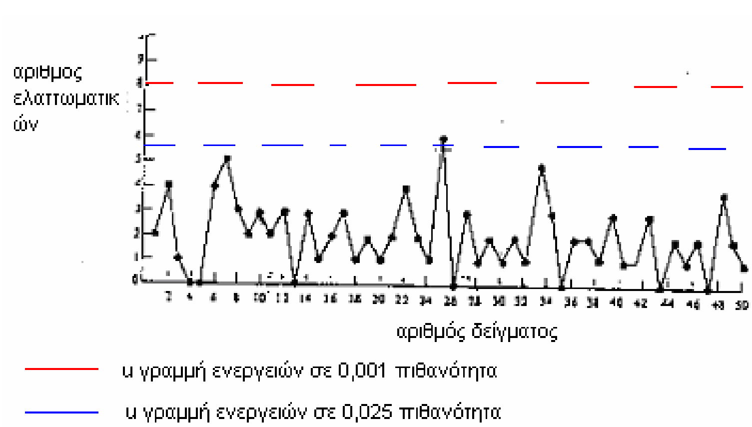
$P(\geq 1)=1-0{,}1326=0{,}8674$ ομοίως

$P(\geq 2)=1-P(0)-P(1)=\ldots=0{,}5967$ κ.ο.κ.

στην πράξη όμως περισσότερο χρησιμοποιούνται τα όρια που δίνονται από τα παρακάτω όρια ελέγχου :

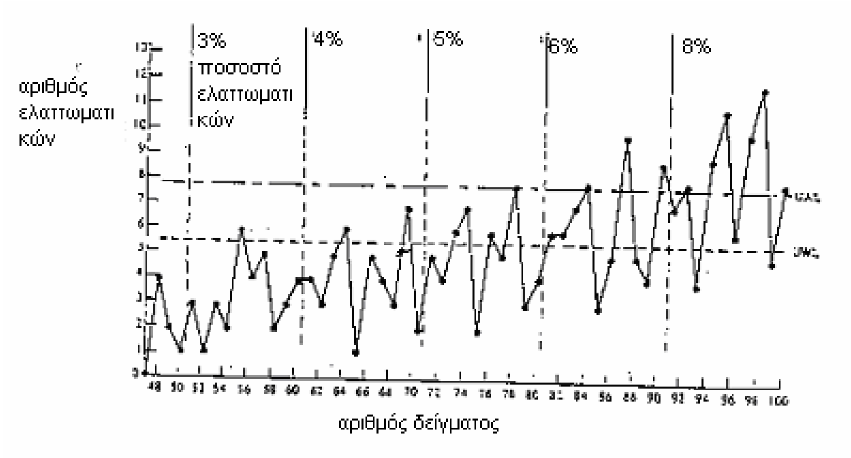
- Άνω όριο ελέγχου(UCL) : $n\overline{p}+3{,}09\sqrt{n\overline{p}(1-\overline{p})}$
- Άνω όριο προειδοποίησης : $n\overline{p}+1{,}96\sqrt{n\overline{p}(1-\overline{p})}$

Στο σχήμα 3.12 φαίνεται το διάγραμμα ελέγχου του παραδείγματος που αναφέρθηκε παραπάνω. Αφού μόνο ένα σημείο στα 50 βρίσκεται εκτός των ορίων προειδοποίησης, η διεργασία, με μέσο αριθμό ελαττωματικών προϊόντων ανά δείγμα , μπορεί να χαρακτηριστεί ως εντός ελέγχου.



Σχήμα 3. 12 διάγραμμα ελέγχου np

Στο σχήμα 3.13 φαίνεται η επίδραση της αύξησης του ποσοστού ελαττωματικών προϊόντων από 2% στο 8% σταδιακά.[14]



Σχήμα 3. 13 επίδραση της αύξησης του ποσοστού ελαττωματικών

2.7.3.2. Διαγράμματα ελέγχου για ελαττωματικά προϊόντα για μεταβλητό μέγεθος δείγματος(διάγραμμα p)

Τα p διαγράμματα χρησιμοποιούνται στο δεύτερο στάδιο του μοντέλου επίλυσης και παρακολουθούν τις διακυμάνσεις δεδομένων τύπου ΝΑΙ/ΟΧΙ. Μέσω αυτών υπολογίζεται το ποσοστό ελαττωματικών προϊόντων σε μια ομάδα αντικειμένων κατά τη διάρκεια της παραγωγικής διαδικασίας, δηλαδή προϊόντων που δεν πληρούν ως ένα βαθμό τις προδιαγραφές και τα πρότυπα που έχει θέσει η εταιρεία.

Τα p διαγράμματα χρησιμοποιούνται σε περιπτώσεις όπου το μέγεθος του δείγματος για τον έλεγχο μίας ιδιότητας δεν μπορεί να διατηρηθεί σταθερό. Μπορούν επίσης να χρησιμοποιηθούν και σε περιπτώσεις, όπου το μέγεθος δείγματος είναι σταθερό έναντι των np διαγραμμάτων. Παρόλα αυτά η μεταφορά των δεδομένων για τον αριθμό ελαττωματικών δείγματος σε διάγραμμα np είναι πιο ασφαλής από την μετατροπή τους πρώτα σε ποσοστό και μετά τη δημιουργία του p διαγράμματος. Υπάρχει διαφορά στην πολυπλοκότητα του σχεδιασμού και στην ερμηνεία τους. Τα δεδομένα που απαιτούνται για ένα p διάγραμμα είναι παρόμοια με αυτά του np διαγράμματος, με τη διαφορά ότι καταγράφεται το διαφορετικό μέγεθος δείγματος κάθε φορά. Το ποσοστό ελαττωματικών προϊόντων σε κάθε δείγμα δίνεται από το πηλίκο των ελαττωματικών προϊόντων του δείγματος προς το μέγεθος αυτού:

$$p_i = \frac{x_i}{n_i}$$

όπως και στα np διαγράμματα, αρχικά υπολογίζεται το μέσο ποσοστό ελαττωματικών προϊόντων σε όλα τα δείγματα, το οποίο δίνεται από τη διαίρεση του συνολικού αριθμού ελαττωματικών προϊόντων που καταγράφηκε με το σύνολο αριθμό προϊόντων όλων των δειγμάτων

$$\overline{p} = \frac{\sum_{i=1}^{k} x_i}{\sum_{i=1}^{k} n_i}$$

Αν το μέγεθος όλων των δειγμάτων παραμένει σταθερό, τα όρια ελέγχου θα έχουν και αυτά μία σταθερή τιμή, όπως υπολογίζεται από τις παρακάτω σχέσεις

- Άνω όριο ελέγχου (UAL) : $\overline{p} + 3{,}09\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}}$

- Άνω όριο προειδοποίησης : $\overline{p} + 1{,}96\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}}$

Αν το μέγεθος του δείγματος δεν παραμένει σταθερό για όλα τα δείγματα, τα όρια ελέγχου αλλάζουν και για κάθε μέγεθος δείγματος υπολογίζεται και το αντίστοιχο όριο. Παρόλα αυτά για πρακτικούς λόγους, υπολογίζεται το μέσο μέγεθος δείγματος:

$$\overline{n} = \sum_{i=1}^{k} \frac{n_i}{k}$$

μέσω του οποίου υπολογίζονται έπειτα τα όρια ελέγχου και προειδοποίησης, με τον περιορισμό το μέγεθος των δειγμάτων να μη βρίσκεται εκτός του διαστήματος που ορίζει η σχέση :

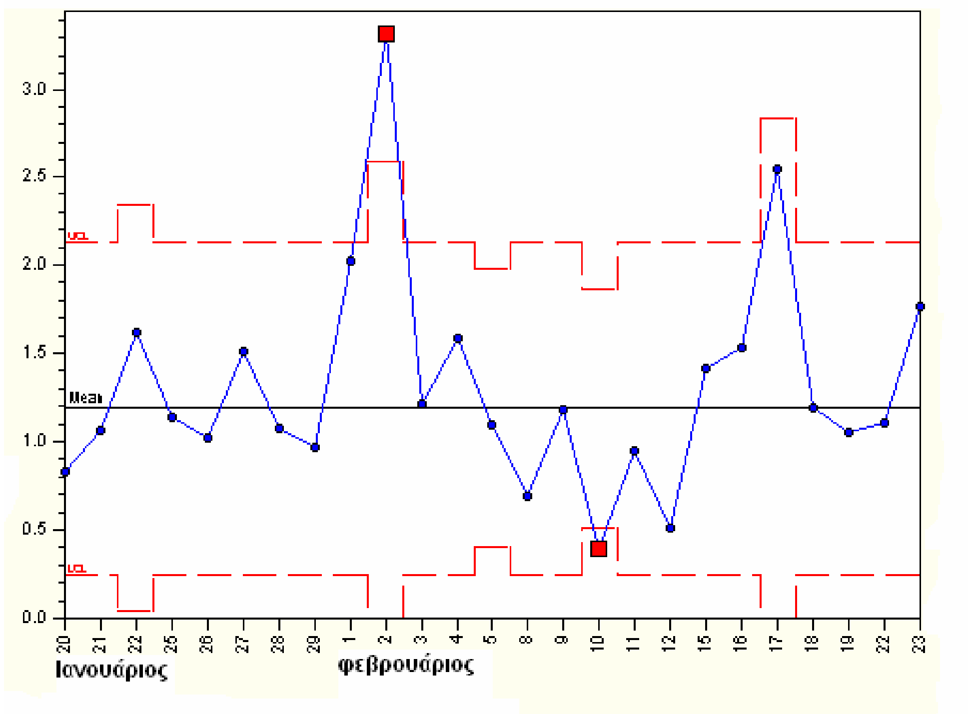
$$\overline{n} \pm (\overline{n} * 0{,}25)$$

αν κάποιο δείγμα έχει μεγαλύτερο ή μικρότερο μέγεθος, τότε για το συγκεκριμένο δείγμα υπολογίζονται χωριστά όρια. Σε αυτήν την περίπτωση αλλά και γενικότερα, τα όρια ελέγχου για μεταβλητό μέγεθος δείγματος δίνονται από τις σχέσεις :

- Άνω όριο ελέγχου (UAL) : $\overline{p} + 3{,}09\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}}$

- Άνω όριο προειδοποίησης : $\overline{p} + 1{,}96\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}}$

Στο σχήμα 3.14 φαίνεται ένα παράδειγμα διαγράμματος p και παρατηρείται ότι ο σχεδιασμός του, οι υπολογισμοί και η ερμηνεία του απαιτούν ιδιαίτερη προσοχή σε σχέση με τα np διαγράμματος. Έτσι λοιπόν μπορεί να παρατηρήσει κανείς ότι το ποσοστό ελαττωματικών προϊόντων στο δείγμα των 2 Φεβρουαρίου είναι μεγαλύτερο από αυτό του ορίου ελέγχου και σαφώς η διεργασία είναι εκτός στατιστικού ελέγχου και το επόμενο βήμα είναι η αναζήτηση των ειδικών αιτιών αυτής της διακύμανσης. Τα διαγράμματα p δε θα πρέπει να χρησιμοποιηθούν μέχρι να υπάρξει διορθωτική παρέμβαση στο σύστημα.



Σχήμα 3. 14 παράδειγμα διαγράμματος np

Συνήθως τα κάτω όρια ελέγχου και προειδοποίησης δεν σχεδιάζονται, αλλά επιπλέον ούτε ελέγχεται αν κάποια σημεία βρεθούν κάτω από αυτά, αφού όσο λιγότερο το ποσοστό ελαττωματικών ή αριθμός των ελαττωματικών τόσο το καλύτερο. Όμως η ύπαρξη των κάτω ορίων ελέγχου μπορεί να υποδείξει μία ασυνήθιστα καλή συμπεριφορά της διεργασίας, γεγονός πολύ χρήσιμο για τους υπεύθυνους ποιότητας.

2.7.3.3. Διαγράμματα ελέγχου για αριθμό ελαττωμάτων σε προϊόντα (c)

Τα διαγράμματα c χρησιμοποιούνται στο δεύτερο στάδιο του μοντέλου επίλυσης προβλημάτων και παρακολουθούν τη διακύμανση των ελαττωμάτων που παρουσιάζονται σε σταθερού μεγέθους δείγματα.

Για να χρησιμοποιήσει κανείς τα c διαγράμματα θα πρέπει οι πιθανότητες για εύρεση ελαττωμάτων να είναι μεγάλες, αλλά ο αριθμός που στην πραγματικότητα εντοπίζεται τελικά να είναι μικρός.

Το γεγονός ότι υπάρχουν ελαττώματα δε σημαίνει ότι τα προϊόντα είναι ελαττωματικά, αφού κα΄θε δείγμα μπορεί να περιλαμβάνει διαφόρων ειδών ελαττώματα. Αυτό θα καθοριστεί από τις προδιαγραφές και τις πατήσεις των καταναλωτών.

Τα δεδομένα του διαγράμματος αυτού ακολουθούν την κατανομή Poisson, με τυπική απόκλιση:

$$s = \sqrt{c}$$

όπου (c) ο μέσος αριθμός ελαττωμάτων που δίνεται από τη σχέση :

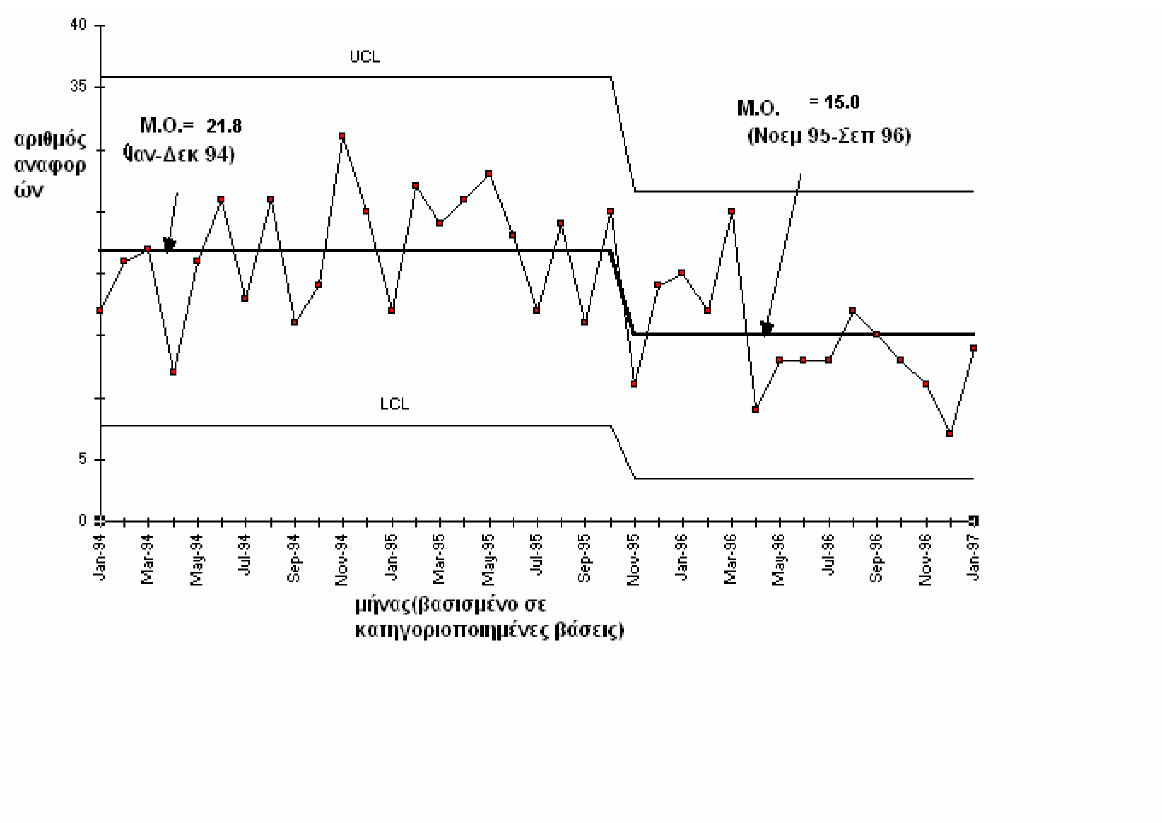
$$\bar{c} = \sum_{i=1}^{k} \frac{c_i}{k}$$

τα όρια ελέγχου είναι:

- Άνω όρια ελέγχου (UAL) : $\bar{c} + 3{,}09\sqrt{\bar{c}}$

- Άνω όριο προειδοποίησης (UWL): $\bar{c} + 1{,}96\sqrt{\bar{c}}$

Στο σχήμα 3.15 φαίνεται ένα παράδειγμα διαγράμματος c, το οποίο βρίσκεται σε κατάσταση στατιστικού ελέγχου



Σχήμα 3. 15 παράδειγμα διαγράμματος c

Όπως όλα τα διαγράμματα που αναφέρθηκαν, έτσι και το διάγραμμα c αποτελεί σημαντικό παράγοντα για τη βελτίωση της ποιότητας και παραγωγής. Η εμπιστοσύνη που εμπνέουν τα καλά συστήματα ελέγχου, τα οποία παρέχουν όσο το δυνατό περισσότερες πληροφορίες για το πότε μία διεργασία θα πρέπει να αφήνεται στην κατάσταση που ήδη είναι ή να επιδέχεται παρεμβάσεις, οδηγεί σε πιο σταθερές διεργασίες, μικρότερες διακυμάνσεις και λιγότερες παρεμβάσεις με περιττές αλλαγές.[14]

2.7.3.4. Διαγράμματα ελέγχου για αριθμό ελαττωμάτων ανα μονάδα(u)

Το διάγραμμα u χρησιμοποιείται στον έλεγχο της διεργασίας για τυχόν ελαττώματα, όταν δεν είναι δυνατό να ληφθεί δείγμα σταθερού μεγέθους.

Είναι παρόμοιο του c διαγράμματος με τη διαφορά της μεταβλητότητας του μεγέθους δείγματος, ενώ τα δεδομένα που επηρεάζεται κανείς μέσω αυτού του διαγράμματος είναι δεδομένα αρίθμησης. Στη συγκεκριμένη περίπτωση, ως μέγεθος δείγματος ορίζεται ο αριθμός των μονάδων που παρατηρήθηκαν. Μία τέτοια μονάδα μπορεί να είναι ένα μόνο αντικείμενο ή σύνολο αντικειμένων.

Κατά την εφαρμογή του, θα πρέπει οι πιθανότητες για εύρεση ελαττωμάτων να είναι μεγάλες, αλλά ο αριθμός που στην πραγματικότητα εντοπίζεται τελικά να είναι μικρός.

Τα όρια ελέγχου ενός διαγράμματος u δίνονται από τις σχέσεις:

- Άνω όριο ελέγχου(UCL): $\overline{u} + 3\sqrt{\frac{\overline{u}}{\overline{n}}}$
- Κάτω όριο ελέγχου (LSL): $\overline{u} - 3\sqrt{\frac{\overline{u}}{\overline{n}}}$

Όπου $\overline{u}$ ο μέσος αριθμός ελαττωμάτων ανά μονάδα-δείγμα που υπολογίζεται μέσω της σχέσης :

$$\overline{u} = \frac{\sum_{i=1}^{k} c}{\sum_{i=1}^{k} n}$$

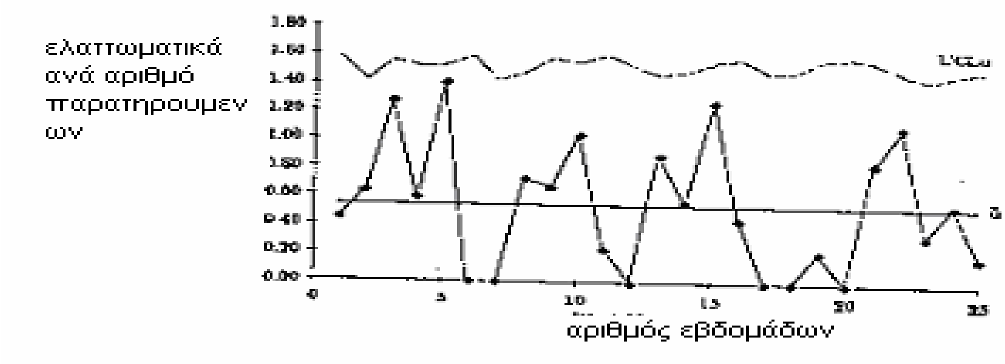
και $\overline{n}$ ο μέσος όρος όλων των μεγεθών των δειγμάτων :

$$\overline{n} = \frac{\sum_{i=1}^{k} n_i}{k}$$

στο σχήμα 3.16 φαίνεται ένα τέτοιο διάγραμμα u, το οποίο βρίσκεται σε κατάσταση στατιστικού ελέγχου.

Σχήμα 3. 16 παράδειγμα διαγράμματος u

Θεωρητικά τα όρια ελέγχου πρέπει να υπολογίζονται για κάθε διαφορετικό μέγεθος δείγματος. Η τιμή $\overline{n}$ στις σχέσεις προσδιορισμού των ορίων ελέγχου, αντικαθίστανται τότε από το n κάθε διαφορετικού δείγματος. Για πρακτικούς όμως λόγους αυτό δεν είναι απαραίτητο, όταν τα μεγέθη των δειγμάτων δεν παρουσιάζουν μεγαλύτερη απόκλιση από το μέγεθος της τάξης του ± 25%. Ένα τέτοιο διάγραμμα με μεταβλητά όρια φαίνεται στο σχήμα 3.17



Σχήμα 3. 17 παράδειγμα διαγράμματος u με μεταβλητά όρια

2.7.3.5. Ειδικά θέματα για τα διαγράμματα ελέγχου ιδιοτήτων

Οι τέσσερις τύποι διαγραμμάτων για τον έλεγχο ιδιοτήτων (np, p,c, u) μπορούν να διαχωριστούν ως προς τη χρήση τους βάση των δύο παρακάτω ερωτήσεων:

- Είναι τα δεδομένα τύπου ναι/όχι ή δεδομένα αρίθμησης(counting data)?
- Είναι το μέγεθος του δείγματος σταθερό ή μεταβάλλεται από δείγμα σε δείγμα?
- Αν τα δεδομένα είναι ναι/όχι τότε χρησιμοποιούνται χάρτες ελέγχου τύπου ναι/όχι.

Εάν η υποομάδα έχει σταθερό μέγεθος, χρησιμοποιείται διάγραμμα np. Εάν η υποομάδα έχει μέγεθος το οποίο δεν παραμένει σταθερό , τότε χρησιμοποιείται διάγραμμα p. υπάρχουν βέβαια και περιπτώσεις όπου χρησιμοποιείται ένα p διάγραμμα ακόμα και αν το μέγεθος της υποομάδας είναι σταθερό απλά επειδή το κλάσμα των ελαττωματικών είναι ποιο απαραίτητο από τον αριθμό των ελαττωματικών. Το παρακάτω σχήμα χρησιμοποιείται για τον προσδιορισμό του τύπου χάρτη ιδιοτήτων που είναι κατάλληλος.[14]

Τύπος δεδομένων ιδιοτήτων

	Ναι/Οχι	Αριθμίσιμα(countable)
Σταθερό μέγεθος υποομάδας	np διάγραμμα ή p διάγραμμα	c διάγραμμα
Μεταβλητό μέγεθος υποομάδας	p διάγραμμα	u διάγραμμα

Σχήμα 3. 18 τρόπος προσδιορισμού χάρτη ελέγχου ιδιοτήτων

Σχήμα3. 1

2.8. Επιλογή κατάλληλης υποομάδας (subgroup)

Τα δεδομένα τα οποία καταγράφονται σε ένα χάρτη ελέγχου (control chart) συνίστανται από ομάδες δειγμάτων οι οποίες αποκαλούνται υποομάδες. Πρέπει να τονισθεί ότι ένα τυχαίο δείγμα δεν μπορεί να θεωρηθεί συστηματικό. Μία συστηματική υποομάδα μπορεί να θεωρηθεί αυτή του οποίου η μεταβλητότητα οφείλεται σε τυχαίες αιτίες. Αυτή η μεταβλητότητα μέσα στην υποομάδα χρησιμοποιείται για να προσδιοριστούν τα όρια ελέγχου. Η μεταβολή μεταξύ των υποομάδων χρησιμοποιείται για την εκτίμηση μακράς σταθερότητας. Υπάρχουν δύο τρόποι επιλογής της υποομάδας

1. επιλογή δειγμάτων της υποομάδας από προϊόντα που παράγονται μία δεδομένη στιγμή ή όσο κοντινότερα γίνεται σε αυτή τη δεδομένη στιγμή. Τέσσερα ακόλουθα μεταξύ τους δείγματα από ένα μηχάνημα ή τέσσερα δείγματα από την ομάδα των προσφάτως παραγόμενων δειγμάτων θα μπορούσαν να αποτελούν παράδειγμα της τεχνικής για επιλογή υποομάδας. Η επόμενη υποομάδα θα ήταν παρόμοια αλλά για προϊόντα που παρήχθησαν σε επόμενη χρονική στιγμή, για παράδειγμα σε 1 ώρα αργότερα. Αυτή η τεχνική ονομάζεται **μέθοδος στιγμιαίας δειγματοληψίας.**
2. η δεύτερη τεχνική βασίζεται στην επιλογή προϊόντος το οποίο παράγεται σε μια χρονική περίοδο και το οποίο είναι αντιπροσωπευτικό όλων των προϊόντων(του πληθυσμού). Ο ελεγκτής επισκέπτεται την παραγωγική διαδικασία για παράδειγμα κάθε μία ώρα. Το δείγμα της υποομάδας αποτελείται έστω από τέσσερα τυχαία δείγματα που παρήχθησαν μέσα στην προηγούμενη ώρα. Στην επόμενη επίσκεψή του, η υποομάδα θα επιλεγεί από

τα τελικά προϊόντα που παρήχθησαν εντός των δύο επισκέψεων κ.ο.κ. αυτή η μέθοδος αποκαλείται **μέθοδος δειγματοληψίας περιόδου.**

Συγκρίνοντας τις δύο παραπάνω τεχνικές , η μέθοδος στιγμιαίας δειγματοληψίας θα έχει μικρή μεταβλητότητα εντός της υποομάδας και μεγάλη μεταβλητότητα μεταξύ των υποομάδων. Κατά τη μέθοδο δειγματοληψίας περιόδου θα υπάρχει μεγάλη μεταβλητότητα εντός της υποομάδας και μικρή μεταβλητότητα μεταξύ των υποομάδων.

Η απόφαση για το μέγεθος του δείγματος ή των υποομάδων απαιτούν κριτική που βασίζεται στην εμπειρία. Κάποια βοηθητικά στοιχεία μπορούν να αποτελέσουν τα παρακάτω:

1. καθώς το μέγεθος της υποομάδας μεγαλώνει , τα όρια ελέγχου έρχονται πιο κοντά στην κεντρική τιμή, κάτι που καθιστά τον χάρτη ελέγχου πιο ευαίσθητο σε μικρές μεταβολές στη μέση διαδικασία.
2. καθώς το μέγεθος της υποομάδας αυξάνει, το κόστος επιθεώρησης ανα υποομάδα αυξάνει. Το ζήτημα είναι αν αιτιολογεί το αυξημένο κόστος των μεγάλων υποομάδων τη μεγάλη ευαισθησία.
3. σε περιπτώσεις καταστρεπτικής δειγματοληψίας σε συνδυασμό με ακριβό προϊόν, είναι απαραίτητο το μέγεθος 2 ή 3 προϊόντων ως δείγματα στην υποομάδα, κάτι που θα μειώσει την καταστροφή των ακριβών προϊόντων.
4. λόγω της ευκολίας των υπολογισμών ένα μέγεθος 5 δειγμάτων θεωρείται ικανοποιητικό και είναι σύνηθες στη βιομηχανία, αλλά όταν οι υπολογισμοί δεν γίνονται με ηλεκτρονικές άμεσες μεθόδους κάτι τέτοιο δεν είναι υφίσταται.
5. από στατιστική βάση, μια κατανομή από μέσα των υποομάδων είναι κοντά στην κανονική όταν τα αυτές αποτελούνται από 4 ή παραπάνω τεμάχια, ακόμα και όταν τα δείγματα λαμβάνονται από μη κανονικό πληθυσμό.
6. όταν το μέγεθος των υποομάδων υπερβαίνει τα 10, θα πρέπει να χρησιμοποιηθούν τα s διαγράμματα αντί των R διαγραμμάτων για τον έλεγχο της διασποράς.

Δεν υπάρχει συγκεκριμένος κανονισμός για τη συχνότητα λήψης δείγματος· απλά ότι η συχνότητα θα πρέπει να είναι τέτοια ώστε να εντοπίζονται οι όποιες αλλαγές στη διεργασία. Η αναστάτωση και το κόστος λήψης δειγμάτων υποομάδων θα πρέπει να ισορροπείται από την αξία των δεδομένων που λαμβάνονται.

2.8.1 «μικρής διάρκειας» και «μεγάλης διάρκειας» διακύμανση

Οι διακυμάνσεις που εντοπίζονται σε μία διεργασία είναι δύο ειδών, “μεγάλης διάρκειας” και “μικρής διάρκειας”. Η “μικρής διάρκειας” που συμβολίζεται με σ_{st}, αντιπροσωπεύει τη διακύμανση μεταξύ των αντικειμένων ενός μοναδικού δείγματος, δηλαδή τη διακύμανση που εντοπίζεται σε μικρό χρονικό διάστημα μέσα σε συγκεκριμένο δείγμα. Δηλαδή

$\sigma_{st}=\sigma_{within}$

Σε περίπτωση όμως όπου μία ειδική αιτία διακύμανσης παρουσιαστεί, τότε υπάρχει και διακύμανση μεταξύ δύο διαδοχικών δειγμάτων, η οποία συμβολίζεται με $\sigma_{between}$. Επομένως ο υπολογισμός της τυπικής απόκλισης της διεργασίας για μεγάλο χρονικό διάστημα σ_{st}, συμπεριλαμβάνει τόσο την τυπική απόκλιση μέσα σε ένα δείγμα αλλά και αυτή μεταξύ των διαδοχικών δειγμάτων, δηλ:

$$s_{LT}^{2} = s_{within}^{2} + s_{between}^{2} \Rightarrow$$

$$s_{LT} = \sqrt{s_{within}^{2} + s_{between}^{2}}$$

Σε καταστάσεις πλήρους στατιστικού ελέγχου, οι οποίες είναι πολύ σπάνιες, η τυπική απόκλιση μεταξύ των διαδοχικών δειγμάτων $\sigma_{between}$ είναι μηδέν, οπότε και η τυπική απόκλιση για μεγάλο χρονικό διάστημα ισούται με την τυπική απόκλιση μεταξύ των αντικειμένων των δειγμάτων , σ_{within} δηλαδή την «μικρής διάρκειας»

$$s_{LT} = \sqrt{s_{within}^{2} + s_{between}^{2}} \Rightarrow s_{LT} = \sqrt{s_{within}^{2} + 0^{2}} \Rightarrow s_{LT} = s_{within} = s_{ST}$$

Συνήθως οι καταστάσεις των περισσότερων διεργασιών δεν είναι ποτέ υπό απόλυτο στατιστικό έλεγχο, με αποτέλεσμα η $\sigma_{between}$ να είναι μεγαλύτερη από το μηδέν και η «μεγάλης διάρκειας» διακύμανση μεγαλύτερη ή ίση της «μικρής διάρκειας».

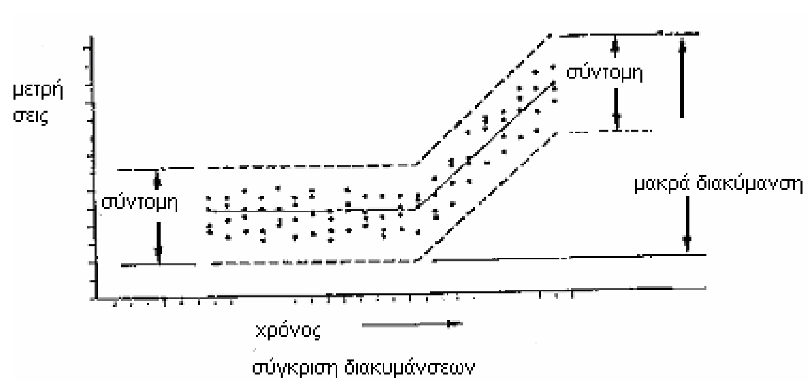
$$s_{between}^{2} \geq 0$$

$$s_{between}^{2} + s_{within}^{2} \geq s_{within}^{2}$$

$$\sqrt{s_{within}^{2} + s_{between}^{2}} \geq s_{within}$$

$$s_{LT} \geq s_{ST}$$

Τα παραπάνω μπορούν να παρασταθούν σχηματικά μέσω του σχήματος 3.19.



Σχήμα 3. 19 τύποι διακυμάνσεων

Παρατηρείται ότι καθ'όλη τη διάρκεια η τιμή της τυπικής απόκλισης για κάθε δείγμα των τεσσάρων είναι σχεδόν σταθερή, ακόμα και μετά την ξαφνική αλλαγή στην παραγωγή, αφού το εύρος κάθε δείγματος αντιπροσωπεύει τη διακύμανση μόνο κατά τη διάρκεια της παραγωγής των τεσσάρων αυτών διαδοχικών προϊόντων.

Ένας τρόπος υπολογισμού της σ_{st} είναι μέσω του $\overline{R}$ και $\overline{S}$ ή του $\overline{MR}$ μόνο αν τα διαγράμματα ελέγχου υποδεικνύουν μία σταθερή κατάσταση της διεργασίας:

$$s_{ST} = s_R = \frac{\overline{R}}{d_2}$$

$$s_{ST} = s_S = \frac{\overline{S}}{c_4}$$

ή

$$s_{ST} = s_{MR} = \frac{\overline{MR}}{d_2}$$

Ο υπολογισμός της τυπικής απόκλισης μίας διεργασίας δεν μπορεί να γίνει βάσει του σ_{st}, αφού θα υπερεκτιμηθεί η ικανότητά της δεδομένου ότι η απόκλιση μεταξύ των αντικειμένων ενός δείγματος είναι η ελάχιστη που μπορεί να αναμένεται από μία διεργασία.

Ένα διάγραμμα ελέγχου μπορεί να μην υποδεικνύει κάποια μεγάλη αλλαγή στο σύστημα, όμως μικρές αλλαγές πάντα υπάρχουν, γι αυτό και το σ_{LT} είναι πάντα μεγαλύτερο από το σ_{ST}. Το σ_{LT} υπολογίζεται μέσω του S_{TOTAL}:

$$S_{TOT} = \sqrt{\frac{\sum_{i=1}^{kn}(X_i - m)^2}{kn-1}}$$

Όπου είναι η διασπορά για όλες τις μετρήσεις kn.διαιρώντας με τη σταθερά Duncan c4 προκύπτει

$$s_{LT} = s_S = \frac{S_{TOT}}{c_4}$$

Μπορεί ο υπολογισμός της «long term» διακύμανσης να είναι πιο δύσκολη και χρονοβόρα, αλλά εξασφαλίζει το χωρίς σφάλμα υπολογισμό της ολικής τυπικής απόκλισης της διεργασίας. Άλλωστε η χρήση Η/Υ έχει λύσει αυτό το πρόβλημα .
Γενικά όμως στα διαγράμματα ελέγχου διεργασιών λαμβάνεται υπόψη μόνο η «μικρής διάρκειας» διακύμανση, η οποία συνήθως υπολογίζεται μέσω του μέσου εύρους.[15],[14]

2.9. έλεγχος ικανότητας διεργασίας

2.9.1. Δείκτες ικανότητας

Έστω μία διεργασία όπου βρίσκεται υπό στατιστικό έλεγχο, όσον αφορά στο χαρακτηριστικό που παρακολουθείται και ότι τα δεδομένα ακολουθούν την κανονική κατανομή (αν όχι οι μεμονωμένες τιμές, τα μέσα δείγματος). Τότε, ακόμα και όταν έχει ανιχνευθεί και εξαλειφθεί κάθε ειδική αιτία διακύμανσης, οι μετρούμενες τιμές δε θα είναι ίδιες, λόγω των εγγενών ή των τυχαίων διακυμάνσεων του πληθυσμού. Αυτού του είδους η διακύμανση ονομάζεται φυσική ανοχή της διεργασίας ΝΤ

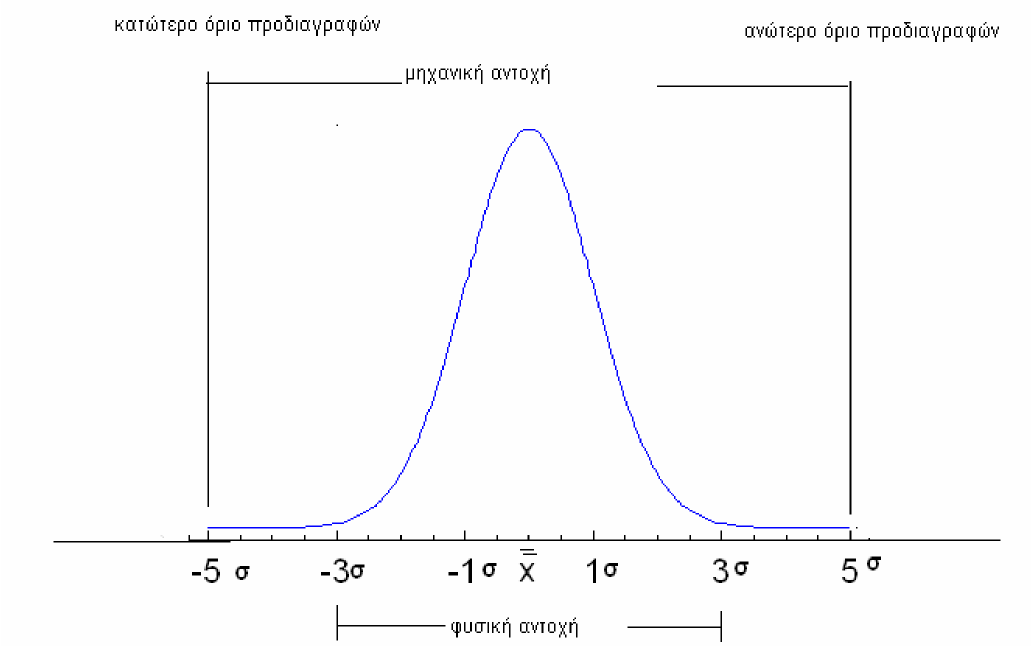
(Natural Tolerance) και αντιστοιχεί στην απόσταση 6σ της καμπύλης της κανονικής κατανομής. Εισαγωγικά πρέπει να αναφερθεί ότι το μήκος 6σ πρέπει να εμπεριέχεται μεταξύ των ορίων προδιαγραφών (USL,LSL), η διαφορά των οποίων ονομάζεται μηχανική ανοχή της διεργασίας ET(engineering tolerance).
Σε μια τέτοια διεργασία ενδιαφέρει πολύ τόσο η συσσωρευτικότητα όσο και η εκκεντρότητα της διεργασίας. Έτσι λοιπόν η συμπεριφορά μίας διεργασίας υπό στατιστικό έλεγχο μπορεί να προσδιοριστεί μέσω κάποιων δεικτών ικανότητας.[14],[16]

Δείκτης cp

Ο δείκτης ικανότητας cp ορίζεται ως το πηλίκο της επιτρεπόμενης απόκλισης (μηχανικής ανοχής) προς τη μεταβλητότητα (φυσική ανοχή) της διεργασίας, δηλαδή:

$$C_p = \frac{mhcanikhanoc\acute{\eta}}{fusik\acute{\eta}anoc\acute{\eta}} = \frac{\mathrm{EN}}{\mathrm{NT}} = \frac{USL - LSL}{6s}$$

Όπως παρατηρείται από την παραπάνω σχέση η καμπύλη των μετρήσεων θα πρέπει τουλάχιστον να καλύπτει μία φορά το μήκος μεταξύ των ορίων προδιαγραφών, όπως φαίνεται και στο σχήμα 3.20
Σκοπός του υπολογισμού αυτού του δείκτη είναι η αξιολόγηση της διεργασίας σχετικά με το αν τα προϊόντα αυτής ικανοποιούν τις προδιαγραφές που έχουν τεθεί είτε από την εταιρεία είτε από τους πελάτες καταναλωτές. Με άλλα λόγια λοιπόν ο δείκτης C_p εκφράζει το επίπεδο συσσωρευτότητας της διεργασίας, χωρίς όμως κανένα στοιχείο για την εκκεντρότητα αυτής.
Συμπεραίνεται επομένως ότι όταν C_p=1 η διεργασία ικανοποιεί οριακά τις ελάχιστες δυνατές απαιτήσεις των πελατών, ενώ οποιαδήποτε τιμή μικρότερη της μονάδας δηλώνει ότι η διεργασία αδυνατεί να ικανοποιήσει τις απαιτήσεις αυτές και ένα ποσοστό των προϊόντων βρίσκονται εκτός των ορίων προδιαγραφών. Επιπλέον κάθε τιμή μεγαλύτερη της μονάδας εκφράζει μεγάλη ικανότητα της διεργασίας να παράγει προϊόντα μεγάλης συσσωρευτότητας.



Σχήμα 3. 20 γραφική απεικόνιση του ελέγχου ικανότητας διεργασιών

Το ποσοστό των προϊόντων που παράγονται εκτός των προδιαγραφών μπορεί να υπολογιστεί μέσω της χρήσης του Γ πίνακα του παραρτήματος Ε. Έτσι το ποσοστό των μη αποδεκτών προϊόντων που βρίσκεται άνω και κάτω των ορίων προδιαγραφών δίνεται από τις παρακάτω σχέσεις:

$$z = \frac{(USL - \overline{X})}{s} \quad \text{και} \quad z = \frac{\overline{\overline{c}} - LSL}{s}$$

παρόλα αυτά όμως, όπως ήδη αναφέρθηκε, ο δείκτης αυτός παρουσιάζει ένα κενό όσο αφορά την εκκεντρότητα των μετρήσεων, δίνοντας έτσι πληροφορίες μόνο για μικρή ή μεγάλη διασπορά γύρω από τη μέση τιμή της διεργασίας, χωρίς όμως να ελέγχει αν η συσσώρευση αυτή γύρω από τη $\overline{\overline{X}}$ είναι η επιθυμητή και ταυτίζεται με την τιμή στόχο. Μπορεί δηλαδή μια διεργασία να έχει δείκτη Cp≥1 και να παράγει προϊόντα εκτός προδιαγραφών, δηλαδή να υπάρχει μεγάλη συγκέντρωση γύρω από μία τιμή (μέσο διεργασίας) η οποία δεν είναι η τιμή στόχος. Το κενό αυτό έρχεται να καλύψει ο δείκτης Cpk.

Ο δείκτης Cpk

Ο δείκτης Cpk ορίζεται ως ο ελάχιστος από τους δύο επιμέρους δείκτες ικανότητας Cpu και Cpl

Cpk=minimum {Cpu, Cpl}

Όπου

$$C_{pu} = \frac{(USL - \overline{X})}{3s} \quad \text{και} \quad C_{pl} = \frac{(\overline{\overline{X}} - LSL)}{3s}$$

Σύμφωνα με όσα αναφέρθηκαν στην προηγούμενη παράγραφο, ο δείκτης Cpk δίνει πληροφορίες σχετικά με την εκκεντρότητα της διεργασίας, δηλαδή αν ο μέσος των δειγμάτων βρίσκεται κοντά στην επιθυμητή τιμή στόχο. Έτσι, αν ο δείκτης είναι μεγαλύτερος ή ίσος της μονάδας, τότε σημαίνει ότι η διεργασία ή η μηχανική είναι ικανή ως προς την αρχική ρύθμιση(setting). Αν η τιμή αυτού είναι μικρότερη της μονάδας, τότε υπάρχουν προϊόντα τα οποία βρίσκονται εκτός των προδιαγραφών και ο υπολογισμός του ποσοστού αυτών βρίσκεται στις τιμές των Cpu και Cpl. Ομοίως χρησιμοποιείται ο z-πίνακας του παραρτήματος 1 για το πάνω και κάτω όριο αντίστοιχα
Z=3Cpu
Και στην περίπτωση όπου είναι μικρότερη της μονάδας Z=3Cpl

Η τιμή του δείκτη Cpk μπορεί να αυξηθεί με τρεις τρόπους:

Με μείωση της διακύμανσης, με διεύρυνση των ορίων προδιαγραφών και με κεντράρισμα των τιμών των παραμέτρων στην επιθυμητή τιμή. Δεδομένου ότι κανένας πελάτης δε θα δεχόταν διεύρυνση των ορίων προδιαγραφών η εκδοχή αυτή έχει αποκλειστεί[15]

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Κεφάλαιο 3.
ΒΑΣΙΚΕΣ ΓΝΩΣΕΙΣ ΓΙΑ ΤΗ ΒΙΟΜΗΧΑΝΙΑ ΠΑΡΑΓΩΓΗΣ ΤΣΙΜΕΝΤΟΥ

Με τον όρο τσιμέντο χαρακτηρίζονται υλικά με συνδετικές ιδιότητες και κυρίως κονιάματα ή μίγματα ασβεστίου, ποζολάνης, νερού κλπ. Το τσιμέντο είναι μία λεπτόκοκκη σκόνη με υδραυλικές ιδιότητες. Αποτελείται από οξείδια του ασβεστίου, πυριτίου, αργιλίου και σιδήρου που είναι ενωμένα μεταξύ τους και αποτελούν το 90% του βάρους του. Το υπόλοιπο μέρος είναι γύψος και μικρές ποσότητες αλάτων μαγνησίου, καλίου, νατρίου και άλλων στοιχείων. Όταν αναμιγνύεται με νερό έχει την ιδιότητα να πήζει και να σκληραίνει, είτε στον αέρα, είτε κάτω από το νερό.[1],[2]

3.1. Στάδια παραγωγής

1ο στάδιο-εξόρυξη Α' υλών:
Οι πρώτες ύλες εξορύσσονται με τη χρήση ισχυρών εκσκαπτικών μηχανημάτων ή με τη χρήση εκρηκτικών υλών.

2ο στάδιο-θραύση Α' υλών:

Η ελάττωση μεγέθους περιλαμβάνει το στάδιο της θραύσης η οποία πραγματοποιείται σε μεγάλους θραυστήρες. Η ελάττωση του μεγέθους γίνεται σε τεμάχια, συνήθως μικρότερα των 30 χιλιοστών. Εκτός από τη θραύση η ελάττωση του μεγέθους πραγματοποιείται και με την άλεση η οποία και αναφέρεται παρακάτω.

3ο στάδιο-αποθήκευση και προομοιογένεια Α' υλών:

Οι θραυσμένες πρώτες ύλες αποθηκεύονται (με σύγχρονη ανάμιξη) χωριστά κατά κατηγορία και από εκεί οδεύουν προς τους μύλους συνάλεσης σε αυστηρά καθορισμένη και συνεχώς ελεγχόμενη δοσολογία. Η ομοιογένεια αποκτά ιδιαίτερο ενδιαφέρον καθόσον πολλές φορές το μίγμα των πρώτων υλών αποτελείται από τρία ή και τέσσερα συστατικά τελείως διαφορετικής σύστασης. Εξάλλου με την προομοιογενοποίηση εξυπηρετείται και η ανάγκη δημιουργίας αποθεμάτων πρώτων υλών σε διάφορα σημεία της παραγωγικής διαδικασίας.

4ο στάδιο-ξήρανση και άλεση πρώτων υλών:

Η άλεση μαζί με τη θραύση είναι τα δύο βασικά στάδια της ελάττωσης μεγέθους των διαφόρων στερεών σωμάτων. Οι μύλοι είναι μεταλλικοί κύλινδροι, με ισχυρή εσωτερική μεταλλική θωράκιση και περιέχουν πολλούς τόνους από σφαιρικά χαλύβδινα αλεστικά σώματα. Κατά την περιστροφική κίνηση των μύλων οι σφαίρες κονιοποιούν τις προθραυσμένες πρώτες ύλες σε κόκκους μέσης διαμέτρου. Το προϊόν αυτό ονομάζεται φαρίνα.

5ο στάδιο-ομοιογενοποίηση και αποθήκευση φαρίνας:

Η φαρίνα οδηγείται στα ειδικά σιλό όπου συντελείται η ομοιογενοποίηση.

6ο στάδιο-έψηση:

Μετά την ομοιογενοποίηση η φαρίνα περνάει από ένα σύστημα κυκλώνων που ονομάζεται προθερμαντής και υφίσταται μια προοδευτική θερμική κατεργασία σε θερμοκρασία μέχρι 900° C. Στη συνέχεια οι περιστροφικοί κλίβανοι αναλαμβάνουν την έψηση. Οι περιστροφικοί κλίβανοι είναι μεταλλικοί κύλινδροι μήκους 50-150 μέτρων και διαμέτρου 3-5 μέτρων με εσωτερική επένδυση από ειδικά πυρότουβλα. Η περιστροφική κίνηση του κλίβανου και η κλίση του εξωθούν τη φαρίνα προς την έξοδο. Στην πορεία της συναντάει θερμοκρασίες που φτάνουν τους 1400 C. Μέσα στον κλίβανο χάρη στις φυσικοχημικές διεργασίες, η φαρίνα μετατρέπεται σε ένα κοκκώδες προϊόν που λέγεται *κλίνκερ*.

7ο στάδιο-άλεση τσιμέντου:

Το κλίνκερ αποτελεί το βασικό συστατικό του τσιμέντου και από την ποιότητά του εξαρτάται στο μέγιστο βαθμό η ποιότητά του. Το τσιμέντο ως τελικό προϊόν είναι μία πολύ λεπτή σκόνη και για τη δημιουργία του απαιτείται συνάλεση κλίνκερ γύψου και ορισμένων φυσικών ή τεχνητών υλικών, που προσδίδουν στο τσιμέντο ωφέλιμες ιδιότητες. Τέτοιες ύλες είναι οι ποζολάνες. Οι μύλοι τσιμέντου μοιάζουν με τους μύλους φαρίνας. Οι δοσολογίες των υλικών συνάλεσης είναι αυστηρά καθορισμένες και συνεχώς ελεγχόμενες. Οι διάφοροι τύποι τσιμέντων και το επίπεδο των αντοχών τους, που αποτελεί και το σημαντικότερο χαρακτηριστικό τους, διαμορφώνονται από τη χημική σύσταση του κλίνκερ, το βαθμό άλεσης του τσιμέντου και την παρουσία ή όχι των διαφόρων πρόσθετων.

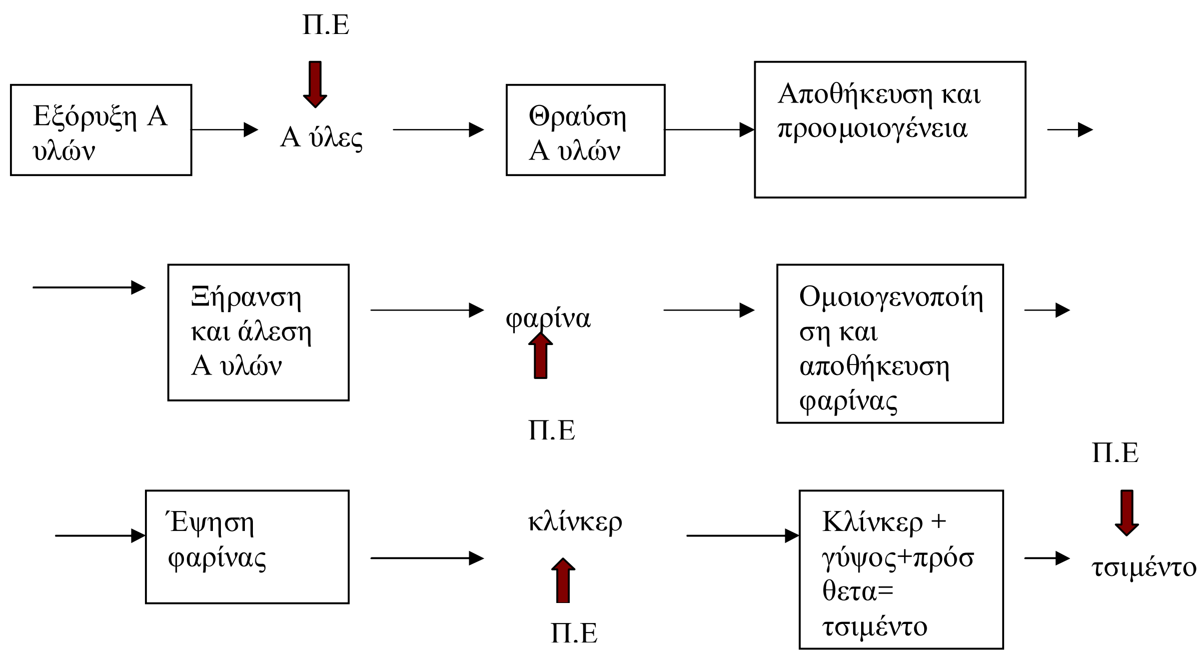
8ο στάδιο-σιλό τσιμέντου:

Το τσιμέντο αποθηκεύεται σε σιλό, που αποτελούν χώρους αποθήκευσης μέσης χρονικής διάρκειας.

9ο στάδιο-κατανάλωση:

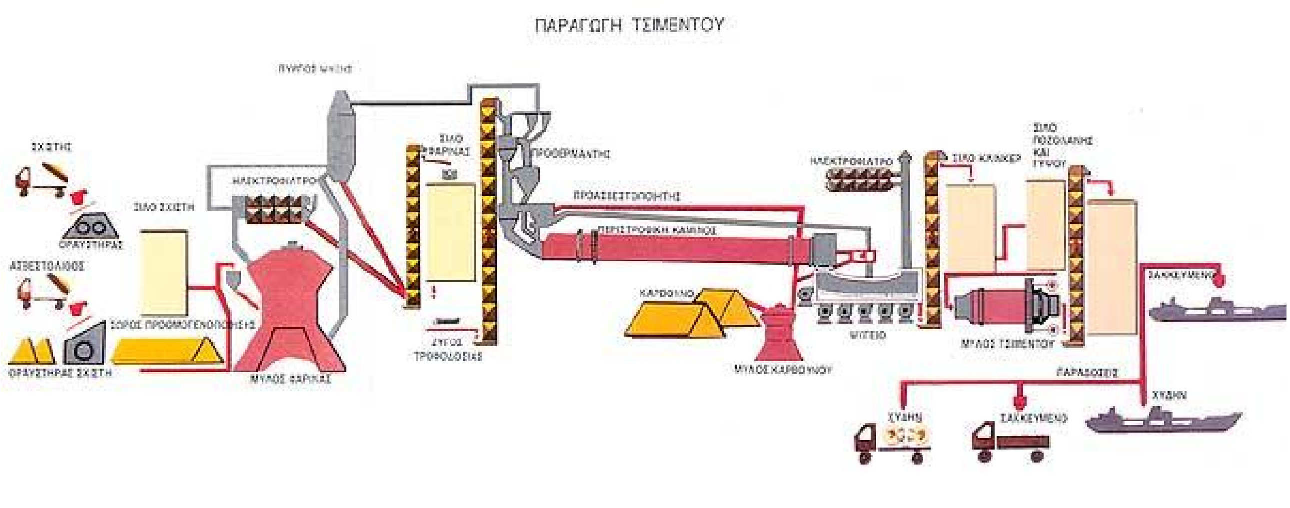
Το τσιμέντο διατίθεται στην κατανάλωση χύμα ή σε σάκους. Η μεγαλύτερες ποσότητες διατίθενται χύμα με ειδικά σιλοφόρα αυτοκίνητα ή πλοία.

Το σχεδιάγραμμα που ακολουθεί δείχνει τα στάδια παραγωγής από την εξόρυξη μέχρι τη στιγμή που το τσιμέντο είναι έτοιμο να παραδοθεί στον καταναλωτή.[2]



Όπου Π.Ε. = Ποιοτικός Έλεγχος

Σχήμα 3. 21. Διάγραμμα ροής παραγωγικής διαδικασίας τσιμέντου



Σχήμα 3. 22 σχηματική απεικόνιση σταδίων παραγωγικής διαδικασίας τσιμέντου

3.2. Ιδιότητες τσιμέντου

Το τσιμέντο χαρακτηρίζεται από φυσικοχημικές και μηχανικές ιδιότητες, η μέτρηση των οποίων φανερώνει την ποιότητά του.

Οι κύριες φυσικοχημικές ιδιότητες οι οποίες κυρίως μετρώνται κατά την παραγωγή του τσιμέντου είναι η απώλεια πύρωσης, το αδιάλυτο υπόλειμμα η λεπτότητα, η υγρασία, η σύσταση του τσιμέντου όπως η περιεκτικότητα σε οξείδια του αργιλίου, του πυριτίου, του νατρίου και του ασβεστίου καθώς και σε θειικά.

Η κυριότερη μηχανική ιδιότητα του τσιμέντου είναι η αντοχή του στη θλίψη . Μελετάται μάλιστα κατά πόσο αναπτύσσει το τσιμέντο αυτήν την ιδιότητα σε χρονική διάρκεια μίας, δύο και επτά ημέρες (πρώιμη αντοχή) καθώς και κατά πόσο αναπτύσσει την μηχανική αυτή ιδιότητα κατά τη διάρκεια είκοσι οκτώ ημερών(τυπική αντοχή). Άλλες μηχανικές ιδιότητες οι οποίες πολλές φορές μετρώνται είναι ο χρόνος πήξης καθώς και η σταθερότητα όγκου.
Η σύνθεση του τσιμέντου επηρεάζει άμεσα τις ιδιότητες αυτού, όπως φαίνεται και στον παρακάτω πίνακα.

Για το λόγο αυτό κατά την παραγωγή τσιμέντου πολλές φορές χρησιμοποιούνται διάφορα πρόσθετα τα οποία χρησιμοποιούνται σαν «λειτουργικά πρόσθετα» με σκοπό την ενίσχυση ή την τροποποίηση των ιδιοτήτων του τελικού προϊόντος. [1]Ιδιαίτερα στις αντοχές τα πρόσθετα έχουν σημαντική επίδραση όπως φαίνεται και στον παρακάτω πίνακα.

Πίνακας 3 3 Επίδραση των πρόσθετων στις αντοχές του τσιμέντου

	Αντοχές (Nt/mm^2)
100 mon. Blaine	0,8
1% Ποζολάνης	-0,3
1% Ασβ/θος	-0,5
1%Ι.Τ.	-0,1
1% SiO_2 λόγω ποζολάνης	-0,65

Γενικότερα οι αντοχές επηρεάζονται από διάφορους παράγοντες όπως το ποσοστό πυριτικού τριασβεστίου (C_3S),από την κοκκομετρία του τσιμέντου(λεπτότητα τσιμέντου), από τα υδατοδιαλυτά αλκάλια, από το ρυθμό ψύξης κλίνκερ, από την προενυδάτωση του τσιμέντου και από το ιδανικό ποσοστό θειικών. Στην προσπάθεια αύξησης των μηχανικών ιδιοτήτων των τσιμέντων εκτός από τα πρόσθετα κατά τη διάρκεια της παραγωγής χρησιμοποιούνται και ειδικά βελτιωτικά υγρά (π.χ. TIPA).

3.3. Προτυποποίηση τσιμέντου

Κάθε χώρα παρασκευάζει τσιμέντο χρησιμοποιώντας τις πηγές πρώτων υλών που διαθέτει. Ανάλογα με τις υπάρχουσες πρώτες ύλες, παράγονται διάφοροι τύποι τσιμέντων (καθαρό ή αμιγές, με ποζολάνη, με ιπτάμενη τέφρα, σκωρία υψικαμίνου, πυριτική παιπάλη, ασβεστόλιθο κλπ.), ποιότητες που δεν κυκλοφορούν σε όλες τις χώρες-μέλη της Ενωμένης Ευρώπης.

Τα τελευταία χρόνια και στα πλαίσια της έκδοσης κοινών Ευρωπαϊκών κανονισμών για όλες τις χώρες της CEN (Committee Europeenne de Normalisation) στην οποία μετέχει και η Ελλάδα, έχουν διαμορφωθεί σειρές προτύπων που αφορούν το τσιμέντο και το σκυρόδεμα.

Τα νέα ευρωπαϊκά πρότυπα προδιαγράφουν το είδος και το ποσοστό των συστατικών που χρησιμοποιούνται στην παραγωγή 27 τύπων προϊόντων τσιμέντου και τα κατατάσσουν σε κατηγορίες αντοχών, ανάλογα με την αντοχή τους σε θλίψη κονιάματος πρότυπης σύνθεσης και τρόπου παρασκευής.

Από την 1η Απριλίου του 2001, με απόφαση της Ευρωπαϊκής Επιτροπής, οι ποιότητες τσιμέντου που κυκλοφορούν στις χώρες-μέλη της Ευρωπαϊκής Ένωσης μπορούν να είναι πιστοποιημένες, σύμφωνα με τα νέα ευρωπαϊκά πρότυπα και να φέρουν τη διακριτική σήμανση CE. Από την 1η Απριλίου του 2002 η σήμανση είναι υποχρεωτική.

3.4. Ευρωπαϊκό πρότυπο prEN 197-1

Στο πρότυπο αυτό κάθε χώρα έχει συμπεριλάβει εκτός του κλίνκερ, τα δικά της κύρια συστατικά τα οποία είναι υποπροϊόντα βασικών βιομηχανικών δραστηριοτήτων της ή αποτελούν μέρος του ορυκτού της πλούτου και τα οποία «συνεργάζονται» με το τσιμέντο βελτιώνοντας τις ιδιότητές του.

Στο σχετικό πρότυπο που αναφέρεται στην ενοποίηση των επιμέρους τύπων τσιμέντου προβλέπονται οι πέντε τύποι και πολλές υποδιαιρέσεις.

- CEM I, τσιμέντο Πορτλαντ
- CEM II, Σύνθετα τσιμέντα Πόρτλαντ
- CEM III, σκωριοτσιμέντα
- CEM IV, Ποζολανικά τσιμέντα
- CEM V, σύνθετα τσιμέντα[3]

3.4.1. ASTM πρότυπο

Το ASTM καλύπτει 8 τύπους τσιμέντων:

- Τύπος Ι : για χρήση όταν δεν απαιτούνται οι ειδικές απαιτήσεις που προδιαγράφονται για τους άλλους τύπους. Δεν τίθενται όρια για καθένα από τα τέσσερα κύρια ορυκτολογικά συστατικά.

- Τύπος Ι Α: Αερακτικό τσιμέντο τύπου Ι

- Τύπος ΙΙ: Γενικής χρήσης και ειδικότερα όταν απαιτούνται ενδιάμεση αντοχή στην επίδραση των θειικών αλάτων ή ενδιάμεση θερμότητα ενυδάτωσης.

- Τύπος II A : Αερακτικό τσιμέντο τύπου II
- Τύπος III : Για χρήση όταν απαιτούνται υψηλές αρχικές αντοχές.
- Τύπος III A : Αερακτικό τσιμέντο τύπου III
- Τύπος IV: Για χρήση όταν απαιτείται χαμηλή θερμότητα ενυδάτωσης.
- Τύπος V: Για χρήση όταν απαιτείται αυξημένη αντοχή σε περιβάλλον θειικών αλάτων.[2]

3.4.2. Ελληνικός κανονισμός-ΕΛΟΤ ΕΝ

Ο Ελληνικός Οργανισμός Τυποποίησης (ΕΛΟΤ) και ειδικότερα η Επιτροπή "Τσιμέντο και Δομικοί Άσβεστοι" έχουν εκδώσει τα αντίστοιχα ελληνικά πρότυπα ήδη από τον Οκτώβριο του 2000.

Το τσιμέντο - όπως και άλλα δομικά υλικά - πρέπει να πληροί συγκεκριμένες προδιαγραφές και να ανταποκρίνεται στα νέα ευρωπαϊκά πρότυπα, όσον αφορά στις ιδιότητες και τη σταθερότητα της παραγωγής του, για να μπορεί να διακινείται στο εξής ελεύθερα στις χώρες της Ευρωπαϊκής Ένωσης. Η σήμανση CE, επάνω στο σακί και στα συνοδευτικά έγγραφα, θα επιβεβαιώνει ότι το τσιμέντο εναρμονίζεται με τις απαιτήσεις των ευρωπαϊκών προτύπων και τις οδηγίες υγιεινής και ασφάλειας που αφορούν στα δομικά προϊόντα.

Πριν από τη σύνταξη των ευρωπαϊκών προτύπων, προηγήθηκε η κωδικοποίηση όλων των ποιοτήτων τσιμέντων κοινής αποδοχής και ευρείας χρήσεως που παράγονται στις χώρες-μέλη της Ευρωπαϊκής Ένωσης και, παράλληλα, δημιουργήθηκε κοινή ορολογία, που θα διευκολύνει τη συνεννόηση μεταξύ μελετητών, χρηστών και κατασκευαστών.

Σημειώνεται ότι η πιστοποίηση παρέχεται με βάση αυστηρότατα κριτήρια αξιολόγησης, κατόπιν εξωτερικής δειγματοληψίας και έλεγχο των παραγωγικών διεργασιών από ανεξάρτητο φορέα πιστοποίησης, διαπιστευμένο και κοινοποιημένο στην Ευρωπαϊκή Ένωση

Στην Ελλάδα, τα πρότυπα του ΕΛΟΤ ΕΝ 197-1 και ΕΛΟΤ ΕΝ 197-2 τέθηκαν σε εφαρμογή από την 1η Απριλίου 2001. Σύμφωνα με αυτά οι τύποι τσιμέντου που χρησιμοποιούνται
είναι τα παρακάτω :

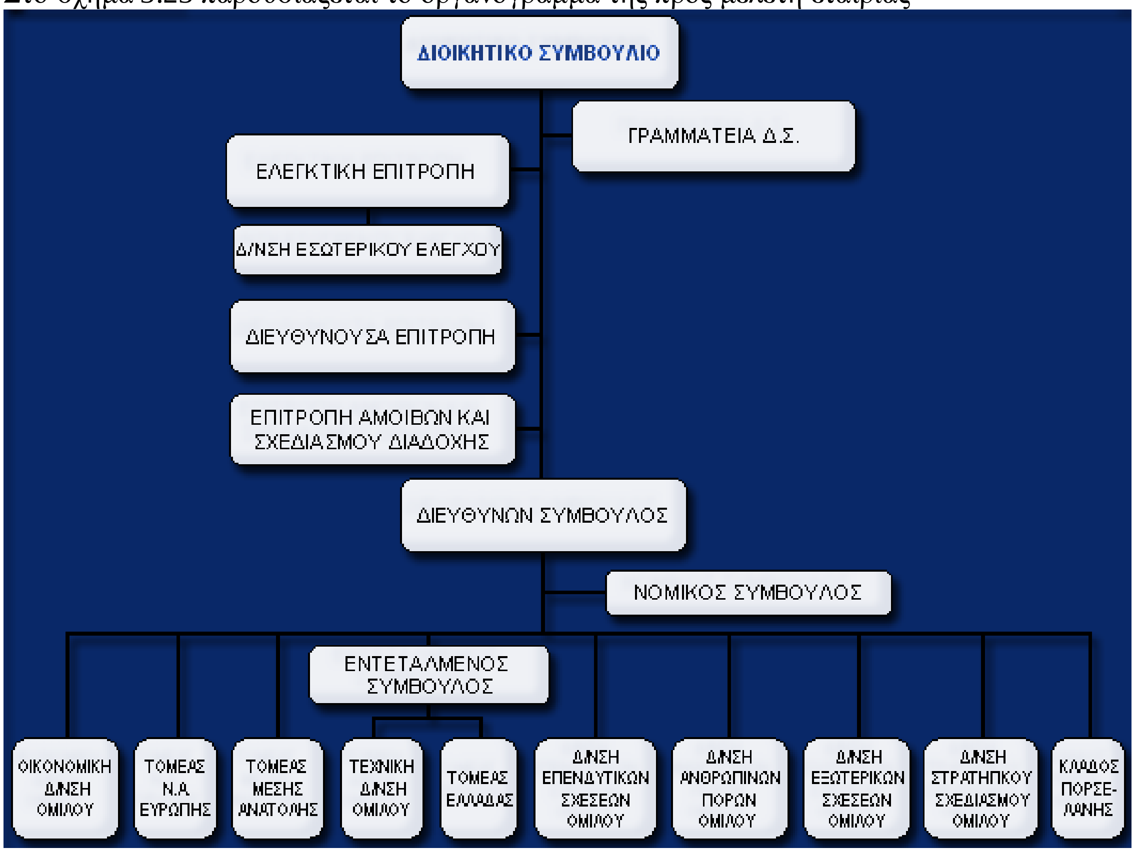
- CEM I ΤΣΙΜΕΝΤΟ ΠΟΡΤΛΑΝΤ
- CEM II ΣΥΝΘΕΤΟ ΤΣΙΜΕΝΤΟ ΠΟΡΤΛΑΝΤ
- CEM III ΣΚΩΡΙΟΤΣΙΜΕΝΤΟ
- CEM IV ΠΟΖΟΛΑΝΙΚΟ ΤΣΙΜΕΝΤΟ
- CEM V ΣΥΝΘΕΤΟ ΤΣΙΜΕΝΤΟ

3.5. Προς μελέτη εταιρία

Το εργοστάσιο το οποίο μελετήθηκε ανήκει σε όμιλο. Η εταιρία είναι εισηγμένη στο Χρηματιστήριο Αξιών Αθηνών και η πλειοψηφία των μετοχών της ελέγχεται από τους ιδρυτές της. Η εταιρία απαρτίζεται από 4 εργοστάσια στην Ελλάδα, 2 στις ΗΠΑ, 3 στα Βαλκάνια και 2 στη Μέση Ανατολή. Επίσης ο όμιλος έχει στην κατοχή του 7 κέντρα διανομής τσιμέντου , 67 μονάδες έτοιμου σκυροδέματος, 10 λατομεία και 3 ορυχεία, 1 μονάδα κονιαμάτων και 1 μονάδα παραγωγής επιτραπέζιας πορσελάνης. Η ετήσια παραγωγική ικανότητα του ομίλου σε τσιμέντο, είναι περίπου 16 εκατομμύρια τόνοι εκ των οποίων οι 6 τόνοι αποτελούν τη συνολική παραγωγική ικανότητα των 4 εργοστασίων στην Ελλάδα. Ο όμιλος κατέχει το 40% της εγχώριας αγοράς σε τσιμέντο.

3.5.1. Οργανόγραμμα

Στο σχήμα 3.23 παρουσιάζεται το οργανόγραμμα της προς μελέτη εταιρίας



Σχήμα 3. 23 Οργανόγραμμα εταιρίας

3.5.2. Στρατηγική

Η στρατηγική του Ομίλου συνοψίζεται ως εξής:

- Ειδικά για το 2004 προσπάθεια εγχώριας απορρόφησης όλων των δυνατοτήτων παραγωγής.

- Συνέχιση της διεθνούς επέκτασης στον κλάδο τσιμέντου με σκοπό την ενδυνάμωση της περιφερειακής παρουσίας στις 4 περιοχές που ήδη διατηρεί παραγωγική δραστηριότητα (Ελλάδα, ΗΠΑ, Βαλκάνια, Μέση Ανατολή).
- Καθετοποίηση δραστηριοτήτων όπου οι συνθήκες αγοράς και ανταγωνισμού την ευνοούν.
- Συνεχής βελτίωση κόστους και παραγωγικότητας.
- Βέλτιστη αξιοποίηση του ανθρώπινου δυναμικού του και προσαρμογή του στην διεθνοποιημένη μορφή του.

3.5.3. Παραγωγή

Ο Όμιλος απαρτίζεται από περισσότερες των 40 Εταιριών που καλύπτουν όλο το φάσμα των δομικών υλικών, από αδρανή έως διάφορους τύπους φαιού και λευκού τσιμέντου, σκυροδέματος, ιπτάμενης τέφρας, θαλάσσιων και οδικών μεταφορών και συναφών υπηρεσιών, καθώς και των ξηρών κονιαμάτων INTERMIX.

Η παραγωγή της συγκεκριμένης βιομηχανικής μονάδας αποτελείται από τους κατωτέρω τύπους τσιμέντου:
- CEM I 52,5 N
- CEM I 42,5R
- CEM II/B-M(W-P-LL) 32,5 N
- CEM II/A-M(P-LL) 42,5 N
- ASTM TYPE I/II
- DIN1 164-CEM I52,5N(Κ/Ξ ΓΕΦΥΡΑ)

Κάθε τύπος τσιμέντου έχει διαφορετική σύνθεση, διαφορετικές ιδιότητες και πρέπει να υπακούει σε διαφορετικές απαιτήσεις σύμφωνα με τα πρότυπα του ΕΛΟΤ ΕΝ 197-1 και ΕΛΟΤ ΕΝ 197-2.

Στο εργοστάσιο λειτουργούν 4 διαφορετικοί μύλοι τσιμέντου και κάθε ένας από αυτούς έχει τη δυνατότητα παραγωγής όλους τους τύπους τσιμέντου.
Το εργοστάσιο λειτουργεί 24 ώρες το 24ωρο και 360 ημέρες το χρόνο. Κάθε 24ωρο απασχολούνται 3 βάρδιες εργαζομένων.

3.5.4. Ποιοτικός έλεγχος

Ο έλεγχος για την ποιότητα αποτελεί ιδιαιτέρως σημαντική διαδικασία καθώς αποτελεί και πρώτη αιτία για αποκοπή της συνεργασίας του πελάτη με την εταιρεία.[5]Ο έλεγχος της ποιότητας του τσιμέντου στηρίζεται τόσο στην εταιρική πολιτική ποιότητας όσο και στην ελληνική και ξένη νομοθεσία. Οι δύο αυτοί παράγοντες έχουν καθοριστικό ρόλο στον προσδιορισμό των στόχων.

Οι στόχοι με τη σειρά τους καθορίζουν τις όποιες διορθωτικές ενέργειες στον τρόπο λειτουργίας του εργοστασίου. Το εργοστάσιο αποτελείται από συγκεκριμένο αναλυτικό εργαστήριο , το οποίο λειτουργεί σε κάθε βάρδια και εκτελεί ποιοτικό έλεγχο ενδιάμεσων καθώς και τελικών προϊόντων.

Σε κάθε βάρδια γίνεται έλεγχος τόσο στις πρώτες ύλες όσο και στη φαρίνα, στο καύσιμο, στο κλίνκερ και στο τελικό τσιμέντο.(βλ. Και σχήμα 3.21) Πιο συγκεκριμένα οι δοκιμές που πραγματοποιούνται είναι οι παρακάτω

Πίνακας 3. 4 Δοκιμές που πραγματοποιεί ο ποιοτικός έλεγχος της εταιρίας

Υλικό	Δοκιμές	Συχνότητα
1. Α ύλες σωρών	XRF	1/υλικό/βάρδια
2. Φαρίνα	XRF	2 h
	+90μm	4 h
3. Καύσιμο	XRF	2h
	+90μm	2h
	υγρασία	1 βάρδια
4. Κλίνκερ	FCaO	2 h
	XRF	1MD/ημέρα
5. Τσιμέντο	FCaO	4 h
	Blaine	2h
	XRF	2h
	+90μm	4h
	LOI	2 ανά βάρδια όπου πρ. ασβ

Τα δείγματα τσιμέντου που λαμβάνονται για τον παραπάνω έλεγχο μετατρέπονται σε δοκίμια στα οποία πραγματοποιείται έλεγχος αντοχών. Ο έλεγχος αντοχών πραγματοποιείται 1 ημέρα ύστερα από την κατασκευή των δοκιμίων, 2 ημέρες, 7 ημέρες και 28 ημέρες και πρόκειται για έλεγχο της αντοχής του τσιμέντου σε εφελκυσμό.

Η ακρίβεια των αναλύσεων βασίζεται στην αντιπροσωπευτικότητα του δείγματος («στιγμιαίο» δείγμα), στο σωστό διαμερισμό (ομογενοποίηση) του δείγματος και στη σωστή βαθμονόμηση των συσκευών ανάλυσης (standard, stability, ακρίβεια, συμμετοχή σε διεργαστηριακούς ελέγχους).[6]

3.5.5. Μεθοδολογία έρευνας

Στην προκείμενη εργασία πραγματοποιείται μελέτη της παραγωγής δύο τύπων τσιμέντου του CEM II 42,5 N και του OPC(Ordinary Portland Cement). Η σύνθεση καθώς και οι μύλοι από τους οποίους κατά κύριο λόγο παράγεται κάθε τύπος τσιμέντου παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 3. 5 Σύνθεση παραγωγής των προς μελέτη τύπων τσιμέντου

	OPC	***II 42,5 N***
Κλίνκερ	95%	81%
Γύψος	5%	5%
Ποζολάνη	-	5%
ασβεστόλιθος	-	9%
Μύλος παραγωγής	3&4	1&4

Αρχικά μελετώνται τα δεδομένα όπως έχουν ληφθεί από τον ποιοτικό έλεγχο. Γίνεται ανάλυση των δεδομένων που αναφέρονται στις φυσικές, χημικές και μηχανικές ιδιότητες του τσιμέντου. Παράλληλα πραγματοποιείται στατιστικός έλεγχος στα δεδομένα με χάρτες ελέγχου. Από την ανάλυση των δεδομένων προκύπτουν τα όρια στα οποία κινούνται οι διάφορες ιδιότητες των παραγόμενων τσιμέντων. Γνωρίζοντας τις προδιαγραφές στις οποίες πρέπει να υπακούουν τα δείγματα γίνεται σύγκριση μεταξύ αυτών και των ορίων που προέκυψαν από την ανάλυση των δεδομένων. Πραγματοποιείται δηλαδή ανάλυση ικανότητας των διεργασιών.
Από τα αποτελέσματα της ανάλυσης ικανότητας των διεργασιών διαφαίνονται ποιες ιδιότητες ακολουθούν τις προδιαγραφές, ποιες ιδιότητες αποκλίνουν και κατά πόσο από τα επιτρεπτά όρια.

Από τη θεωρία του τσιμέντου είναι γνωστό ότι οι διάφορες ιδιότητες συνδέονται μεταξύ τους και αλληλοεξαρτώνται. Στην εργασία αυτή πραγματοποιείται προσπάθεια εύρεσης αυτής της συσχέτισης μεταξύ των ιδιοτήτων. Πιο συγκεκριμένα πραγματοποιείται γραμμική παλινδρόμηση με σκοπό να συσχετισθούν οι μηχανικές ιδιότητες του τσιμέντου (αντοχές) με τις φυσικοχημικές. Από τη παλινδρόμηση προκύπτουν κάποια μοντέλα τα οποία και σχολιάζονται ενώ παράλληλα διαμορφώνονται οι μεταβλητές αυτές οι οποίες είναι οι κρισιμότερες για τον καθορισμό των αντοχών των τσιμέντου.
Από τις παραπάνω αναλύσεις διαφαίνεται ότι τα αποτελέσματα είναι διαφορετικά για κάθε μύλο παραγωγής ακόμα και όταν μελετάται η ίδια ποιότητα τσιμέντου. Το μέγεθος της διαφοράς των μύλων διαφαίνεται από τη μελέτη δύο δειγμάτων κατά την οποία εξακριβώνεται κατά πόσο διαφέρουν οι δύο μύλοι στο τσιμέντο το οποίο παράγουν.

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Κεφάλαιο 4.
ΑΠΟΤΕΛΕΣΜΑΤΑ

ΣΥΜΒΟΛΙΣΜΟΙ

Οι συμβολισμοί που χρησιμοποιήθηκαν στη μελέτη παρουσιάζονται αναλυτικά παρακάτω.

OPC=Ordinary Portland cement = τύπος τσιμέντου
CEM II 42,5 = τύπος τσιμέντου

UCL=upper control limit= ανώτερο όριο ελέγχου
LCL= lower control limit= κατώτερο όριο ελέγχου
CTR=center line= κεντρική γραμμή(θέση)

IR = αδιάλυτο υπόλειμμα (Insoluble residue)
IR MT1 = αδιάλυτο υπόλειμμα για το μύλο1
IR MT3 = αδιάλυτο υπόλειμμα για το μύλο3
IR MT4 = αδιάλυτο υπόλειμμα για το μύλο4

Al_2O_3= οξείδιο του Αργιλίου
Al_2O_3 MT1= οξείδιο του Αργιλίου για το μύλο 1
Al_2O_3 MT3= οξείδιο του Αργιλίου για το μύλο 3
Al_2O_3 MT4= οξείδιο του Αργιλίου για το μύλο 4

SiO_2 = οξείδιο του πυριτίου
SiO_2MT1=οξείδιο του πυριτίου για τον μύλο 1
SiO_2MT3=οξείδιο του πυριτίου για τον μύλο 3
SiO_2MT4=οξείδιο του πυριτίου για τον μύλο 4

Blaine = λεπτότητα
BlaineMT1 = λεπτότητα για τον μύλο1
BlaineMT3 = λεπτότητα για τον μύλο3
BlaineMT4 = λεπτότητα για τον μύλο4

LOI= απώλεια πύρωσης (Lost Of Ignition)
LOIMT1 = απώλεια πύρωσης για το μύλο1
LOIMT3=απώλεια πύρωσης για το μύλο 3
LOIMT4 = απώλεια πύρωσης για το μύλο 4

Est1 = αντοχή σε θλίψη κατά την πρώτη ημέρα
EstxMTy = αντοχή σε θλίψη κατά την χ ημέρα (όπου χ είναι πρώτη, δεύτερη, έβδομη, 28^{η}) τσιμέντου που παράγεται από τον y μύλος(όπου y , μύλος 1,2,3 ή 4)

Clk= κλίνκερ

ClkMTy= κλίνκερ που περιέχεται σε τσιμέντο το οποίο έχει παραχθεί από τον y μύλο(όπου y , μύλος 1,2,3 ή 4)

G=Gyp= γύψος
GMTy=GypMTy= γύψος που περιέχεται σε τσιμέντο το οποίο έχει παραχθεί από τον y μύλο(όπου y , μύλος 1,2,3 ή 4)

P= ποζολάνη
PMTy= ποζολάνη που περιέχεται σε τσιμέντο το οποίο έχει παραχθεί από τον y μύλο(όπου y , μύλος 1,2,3 ή 4)

L=ασβεστόλιθος
Ly=ασβεστόλιθος που περιέχεται σε τσιμέντο το οποίο έχει παραχθεί από τον y μύλο(όπου y , μύλος 1,2,3 ή 4)

4.1. Στατιστική ανάλυση δεδομένων

4.1.1. Σκοπός

Σκοπό της ανάλυσης αποτελεί η μελέτη των δεδομένων, η εύρεση της διασποράς των τιμών και των ορίων στα οποία κυμαίνονται. Επίσης γίνεται προσπάθεια μελέτης της παραγωγικής διαδικασίας και ελέγχου κατά πόσο αυτή βρίσκεται υπό στατιστικό έλεγχο.

4.1.2. Ανάλυση

4.1.2.1. Ποιότητα τσιμέντου CEM II 42,5

Η παραγωγή αυτού του τύπου τσιμέντου έγινε κυρίως από τους μύλους 1 και 4. Πραγματοποιήθηκε στατιστικός έλεγχος για τη χημική ανάλυση που πραγματοποιείται στα δείγματα για κάθε μύλο.

Μύλος 1

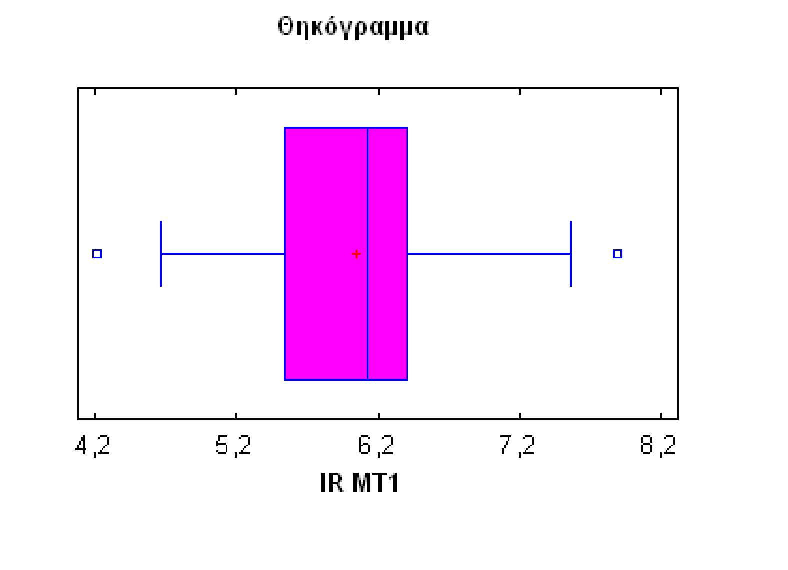
IR

Μέτρα κεντρικής τάσης και θέσης

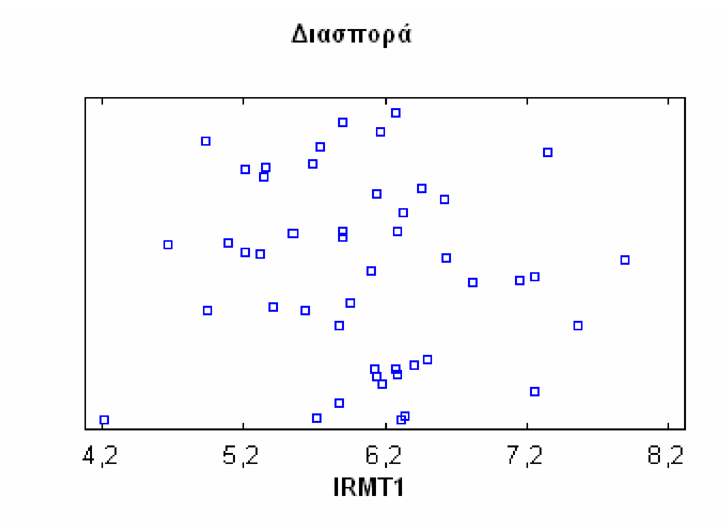
Το πλήθος του δείγματος είναι 47. Οι τιμές κυμαίνονται από 4,22 έως 7,89 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω.

```
τιμές = 47
μέσος όρος = 6, 04468
Διασπορά = 0,576382
Τυπική απόκλιση = 0,759198
Ελάχιστη τιμή= 4, 22
Μέγιστη τιμή = 7, 89
έκταση = 3, 67
τυπική ασυμμετρία = 0,440299
τυπική κύρτωση = 0,373963
```

Μέσω του θηκογράμματος (διάγραμμα 4.1) φαίνεται ή τάση των τιμών ενώ με το διάγραμμα που παρουσιάζει τη διασπορά (διάγραμμα 4.2) δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



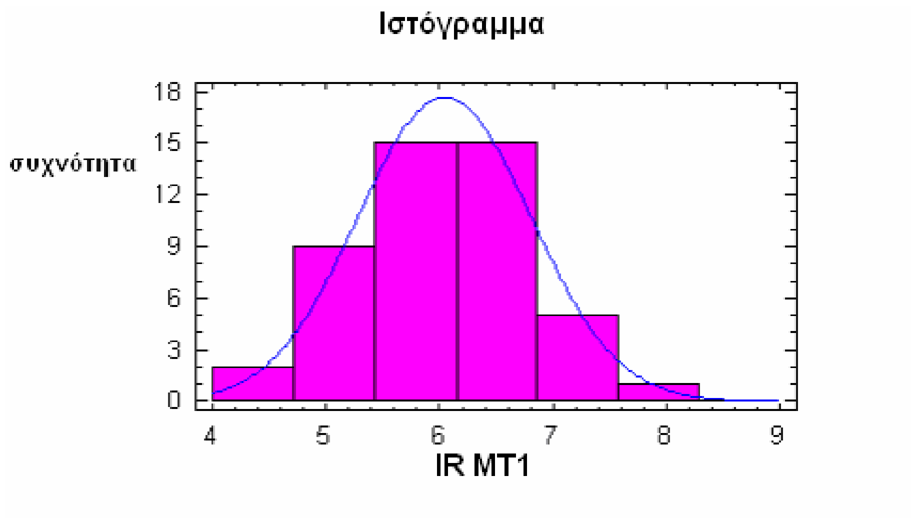
Διάγραμμα5. 1*θηκόγραμμα της μεταβλητής IR*



Διάγραμμα5. 2Διασπορά για τη μεταβλητή IR

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, είναι συμμετρικό και λεπταίνει στα άκρα.



Διάγραμμα5. 3 ιστόγραμμα για τη μεταβλητή IRMT2

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με 0,440299< 2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 0,373963< 2, δηλαδή με τιμή η οποία επίσης βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Από τον έλεγχο με βάση το χ^2 προκύπτει ότι

Πίνακας 5. 1*έλεγχος κανονικότητας με χ^2 για τη μεταβλητή IRMT2*

κατώτερο όριο	ανώτερο όριο	παρατηρούμενη συχνότητα	αναμενόμενη συχνότητα	χ^2
ίση ή μικρότερη	5, 23418	7	6, 71	0, 01
5, 23418	5, 61501	5	6, 71	0, 44
5, 61501	5, 90801	9	6, 71	0, 78
5, 90801	6, 18135	7	6, 71	0, 01
6, 18135	6, 47435	9	6, 71	0, 78
6, 47435	6, 85518	4	6, 71	1, 10
μεγαλύτερη 6, 85518		6	6, 71	0, 08

χ^2 = 3, 19147 με 4 d.f. τιμή p = 0,526309

όπως φαίνεται η τιμή P είναι 0,526309

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0, 526309> 0, 1, δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή με 90% βεβαιότητα.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

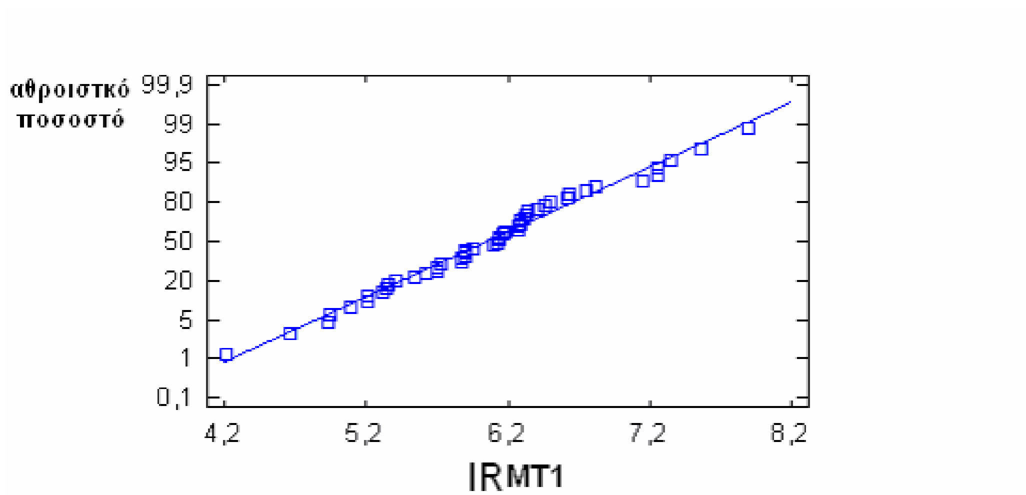
P=0, 526309>0, 05 .Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks

```
W  = 0,983113
P-τιμή= 0,846182
```

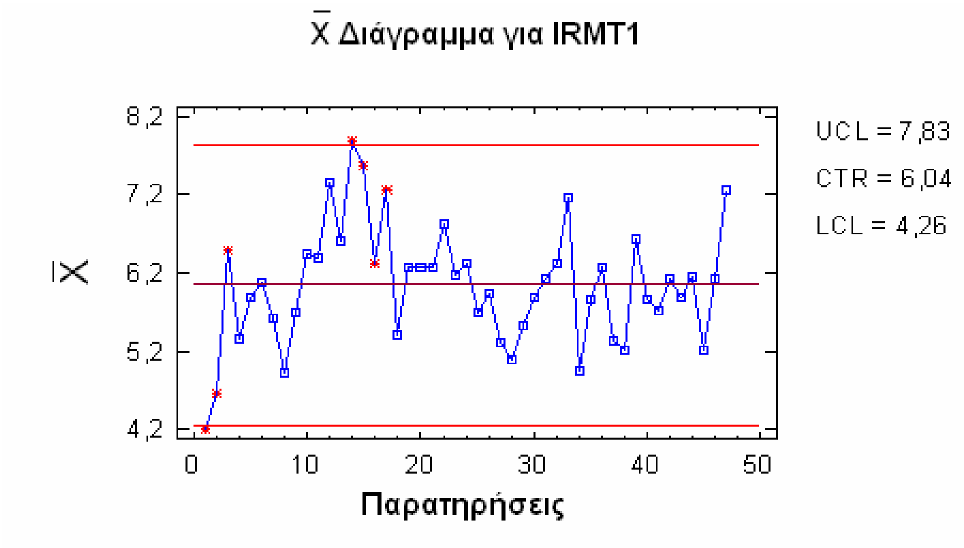
Δηλαδή $W \approx 1$ και P-τιμή= 0,846182 > 0, 01. Οπότε μπορεί να θεωρηθεί κανονικότητα της κατανομής

έλεγχος κανονικότητας με ***normal probability plot***

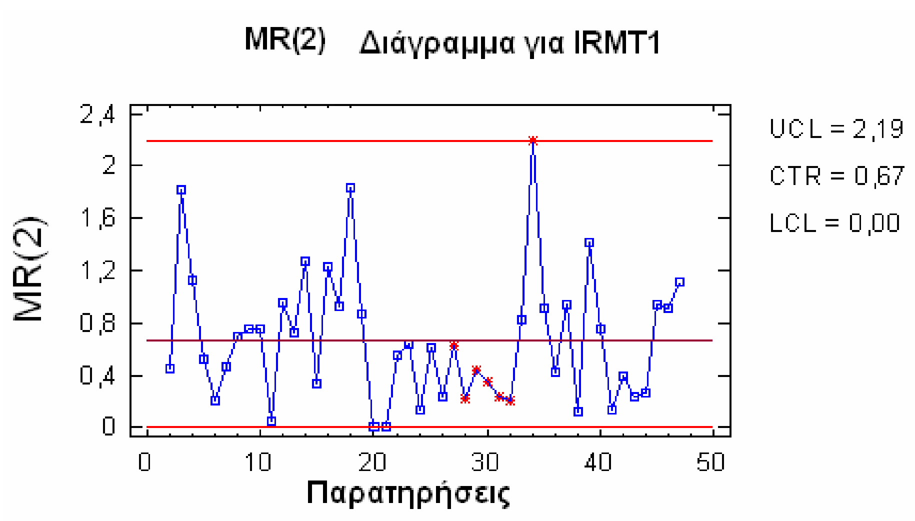


Διάγραμμα5. 4Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή IR MT1

Χάρτες ελέγχου
σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι μεμονωμένων τιμών. Η ανάλυση παρουσιάζει τα παρακάτω δεδομένα.



Διάγραμμα5. 5 Διάγραμμα μέσης τιμής για τη μεταβλητή IR



Διάγραμμα5. 6 Διάγραμμα εύρους για τη μεταβλητή IR

```
X διάγραμμα
-------
UCL:ανώτερο όριο +3,0 σίγμα = 7,82833
CTR=Κεντρική θέση    = 6,04468
LCL:κατώτερο όριο= -3, 0 σίγμα = 4, 26103

2 εκτός ορίων

MR (2) Chart
-----------
UCL: +3, 0 σ = 2, 19211
Κεντρική θέση      = 0,670652
LCL: -3,0 σ = 0,0

1 εκτός ορίων

εκτιμήσεις
---------
μέση τιμή = 6, 04468
σίγμα = 0, 59455
μέση τιμή για MR(2) = 0,670652
```

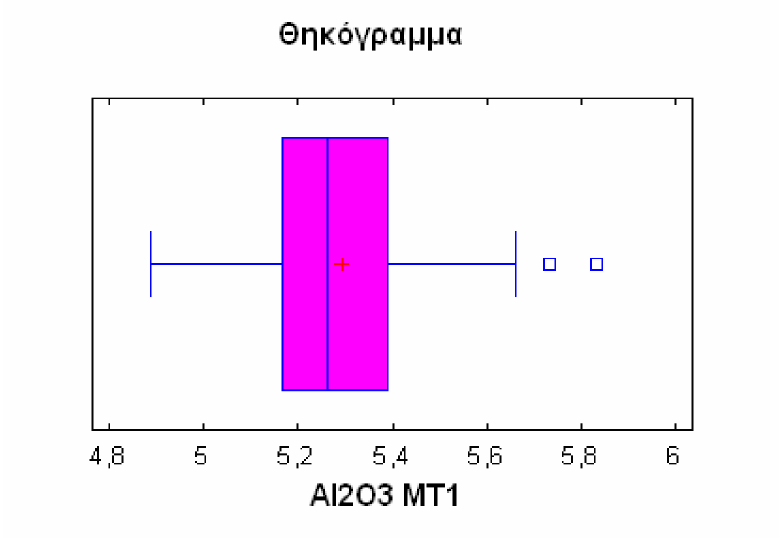
Al_2O_3

Μέτρα κεντρικής τάσης και θέσης

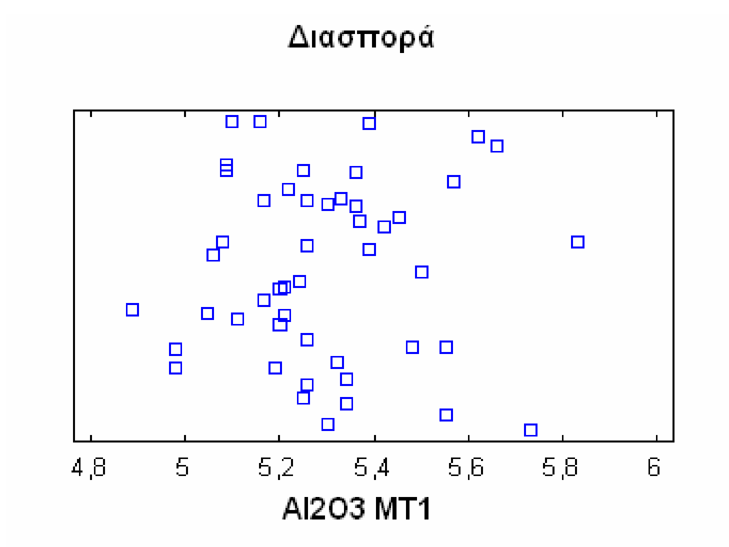
Το πλήθος του δείγματος είναι 48. Οι τιμές κυμαίνονται από 4,68 έως 5,85 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω.

```
Τιμές = 48                          Μεγαλύτερη τιμή = 5, 83
Μέσος όρος = 5, 29375               έκταση = 0, 94
Διακύμανση = 0,039675               Τυπική ασυμμετρία = 1, 54116
Τυπική απόκλιση = 0,199186          Τυπική κύρτωση = 0,436727
Μικρότερη τιμή = 4, 89
```

Μέσω του θαηκογράμματος φαίνεται ή τάση των τιμών ενώ με το διάγραμμα διασποράς δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



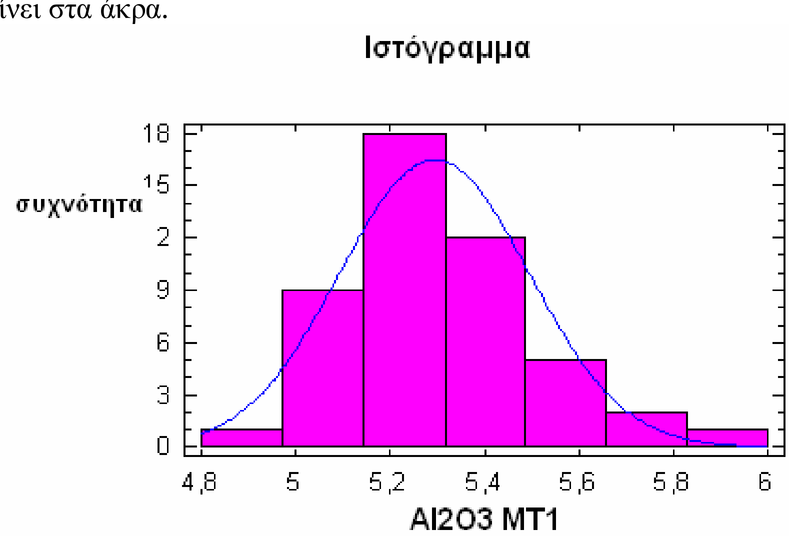
Διάγραμμα5. 7 θηκόγραμμα για την Al_2O_3



Διάγραμμα5. 8 Διάγραμμα διασποράς για τη μεταβλητή Al_2O_3

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, είναι συμμετρικό και λεπταίνει στα άκρα.



Διάγραμμα5. 9Ιστόγραμμα για τη μεταβλητή Al_2O_3

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με 1,54116< 2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 0,436727< 2, δηλαδή με τιμή η οποία επίσης βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Από τον έλεγχο με βάση το χ^2 προκύπτει ότι

Πίνακας 5. 2 έλεγχος κανονικότητας με χ^2 για τη μεταβλητή $AL_2\ O_3^{MT1}$

κατώτερο όριο	ανώτερο όριο	παρατηρούμενη συχνότητα	αναμενόμενη συχνότητα	χ^2
μικρότερο ή ίσο	5, 0811	6	6, 86	0, 11
5, 0811	5, 18102	7	6, 86	0, 00
5, 18102	5, 25789	9	6, 86	0, 67
5, 25789	5, 32961	7	6, 86	0, 00
5, 32961	5, 40648	8	6, 86	0, 19
5, 40648	5, 5064	4	6, 86	1, 19
περισσότερο 5, 5064		7	6, 86	0, 00

χ^2 = 2, 16666 with 4 d.f.   P-τιμή = 0,705138

όπως φαίνεται η τιμή P είναι 0,705138

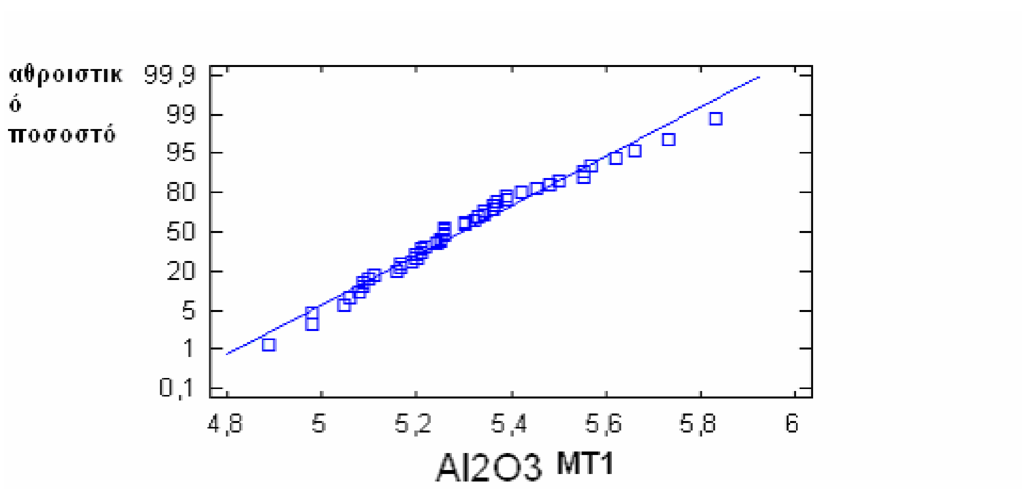
Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0, 705138> 0, 1, δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή με 90% βεβαιότητα.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05
P=0, 705138>0, 05 . Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.
.

Shapiro-Wilks test

W statistic = 0,974027
P-τιμή = 0,524208
Δηλαδή $W \approx 1$ και P-Value = 0,974027 > 0, 01. Οπότε μπορεί να θεωρηθεί κανονικότητα της κατανομής

έλεγχος κανονικότητας με normal probability plot

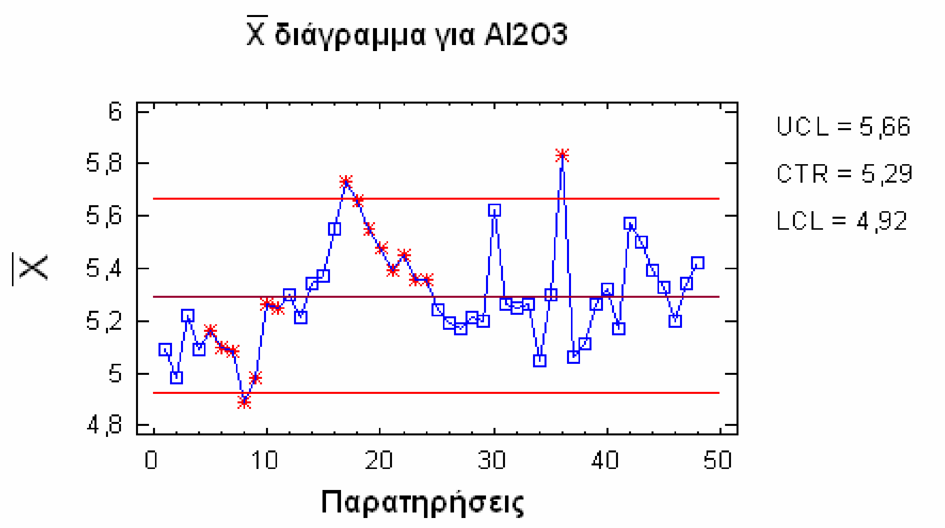


Διάγραμμα5. 10 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή Al_2O_3

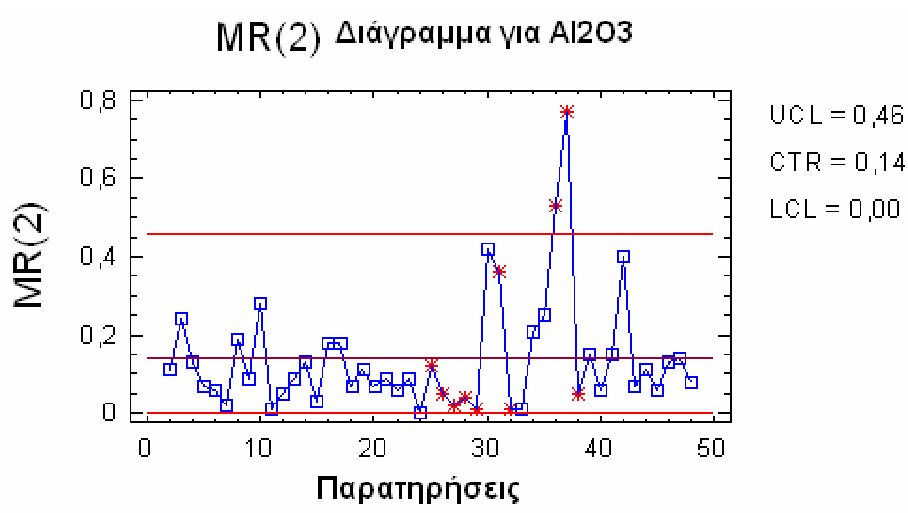
Χάρτες ελέγχου

Σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι αυτός των μεμονωμένων τιμών.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 11 Διάγραμμα ελέγχου μέσης τιμής για τη μεταβλητή Al_2O_3



Διάγραμμα5. 12 Διάγραμμα ελέγχου εύρους για τη μεταβλητή Al_2O_3

```
Μεμονωμένων τιμών διαγράμματα - Al2O3_2

X and MR(2) - Initial Study for Al2O3_2
Αριθμός παρατηρήσεων = 48
0 παρατηρήσεις παραλήφθηκαν
```

```
Διάγραμμα X
-------
UCL: +3,0 σ = 5,66439
Κεντρική γραμμή     = 5, 29375
LCL: -3, 0 σ = 4, 92311
3 εκτός ορίων

MR(2) Chart
-----------
UCL: +3, 0 σ = 0, 45552
Κεντρική γραμμή     = 0,139362
LCL: -3, 0 σ = 0, 0
2 εκτός ορίων

Εκτιμήσεις
---------
Μέση τιμή = 5,29375
σίγμα = 0,123548
μέση τιμή MR(2) = 0,139362
```

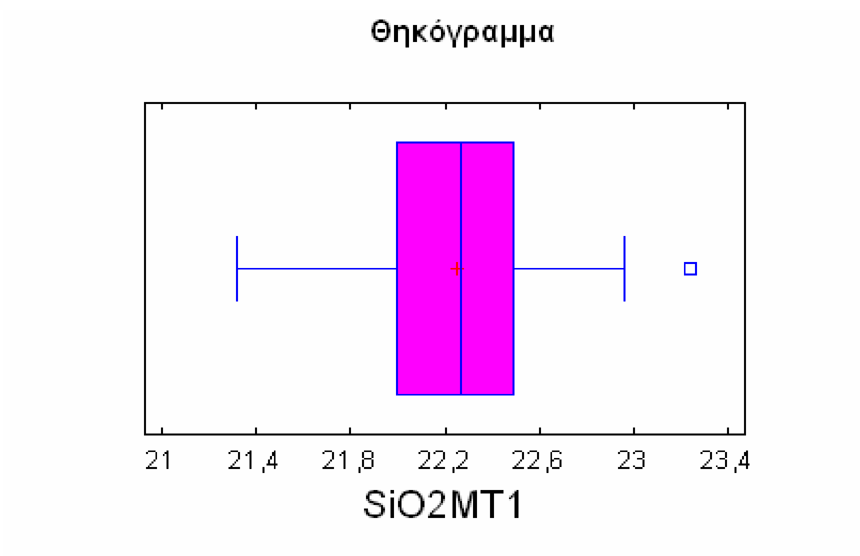
SiO_2

Μέτρα κεντρικής τάσης και θέσης

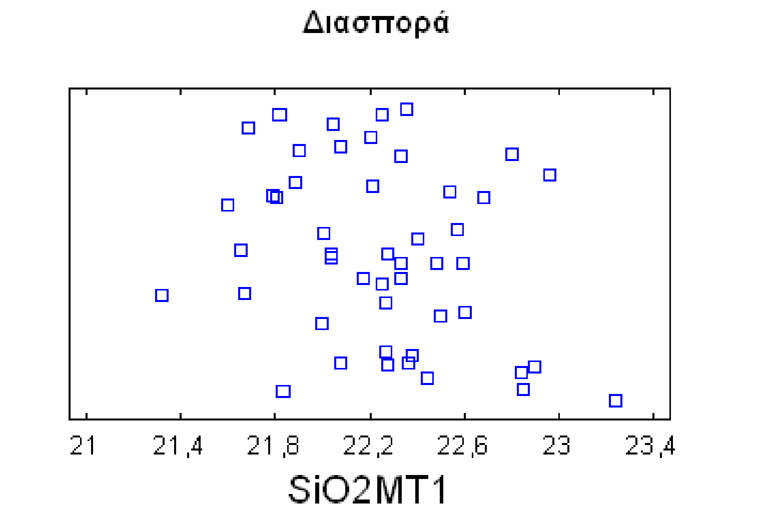
Το πλήθος του δείγματος είναι 48. Οι τιμές κυμαίνονται από 21,32 έως 23,24 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω.

```
Τιμές = 48
Μέσος όρος = 22,2463
Διακύμανση = 0,157654
Τυπική απόκλιση = 0,397056
Μικρότερη τιμή = 21,32
Μεγαλύτερη τιμή = 23,24
Έκταση = 1,92
Τυπική ασυμμετρία = 0,381248
Τυπική κύρτωση = -0,00786868
```

Μέσω του Box and Whisket plot φαίνεται ή τάση των τιμών ενώ με το scatterplot δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



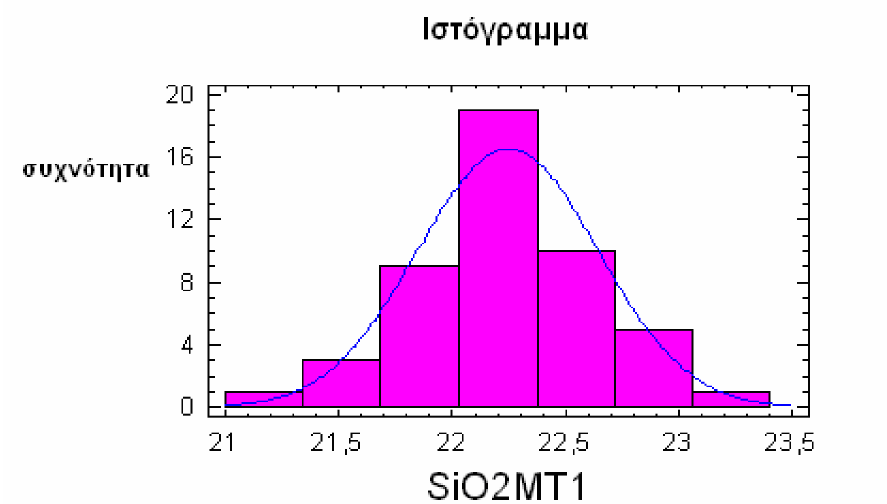
Διάγραμμα5. 13 Θηκόγραμμα της SiO_2



Διάγραμμα5. 14 Διασπορά για τη μεταβλητή SiO_2MT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, είναι συμμετρικό και λεπταίνει στα άκρα.



Διάγραμμα5. 15 ιστόγραμμα για τη μεταβλητή SiO_2MT1

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με 0,381248 < 2, δηλαδή δεν είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με -0,00786868>- 2, δηλαδή με τιμή η οποία δε βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Από τον έλεγχο με βάση το χ^2 προκύπτει ότι

Πίνακας 5. 3 έλεγχος κανονικότητας με χ^2 για τη μεταβλητή SiO_2 ^{MT1}

	κατώτερο όριο	ανώτερο όριο	παρατηρούμενη συχνότητα	αναμενόμενη συχνότητα	χ^2
	μικρότερο ή ίσο	21,8224	8	6,86	0,19
	21,8224	22,0215	5	6,86	0,50
	22,0215	22,1748	6	6,86	0,11
	22,1748	22,3177	8	6,86	0,19
	22,3177	22,471	8	6,86	0,19
	22,471	22,6701	6	6,86	0,11
παραπάνω	22,6701		7	6,86	0,00

χ^2 = 1,29156 with 4 d.f. P-τιμή = 0,862806

όπως φαίνεται η τιμή P είναι 0,862806

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,862806> 0, 1, δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

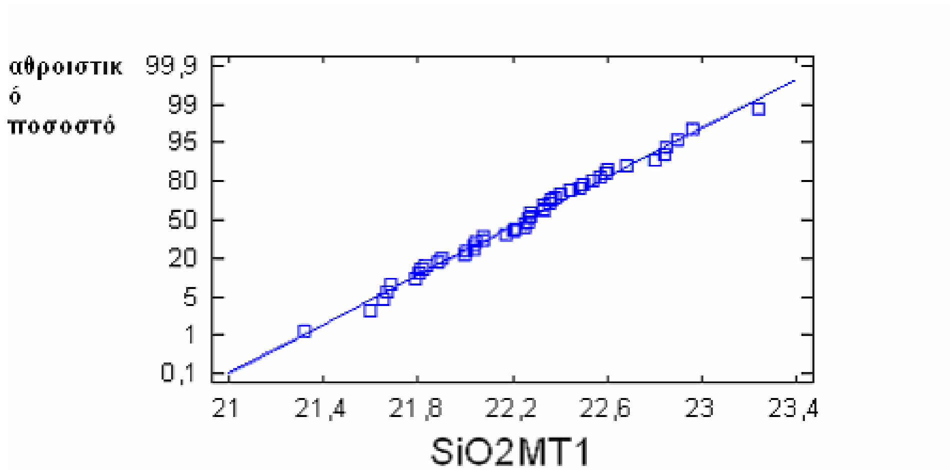
Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

P=0,862806>0, 05 . Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks

W = 0,990185
P-τιμή = 0,982257
Όπως φαίνεται $W \approx 1$ και P-τιμή = 0,982257> 0,01. Οπότε μπορεί να θεωρηθεί ότι τα δεδομένα προσαρμόζονται ικανοποιητικά στην κανονική κατανομή.

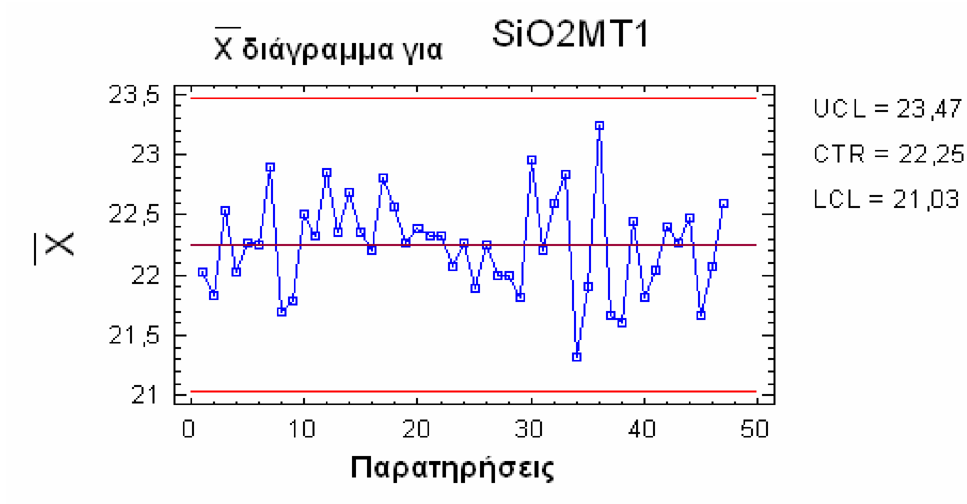
έλεγχος κανονικότητας με normal probability plot



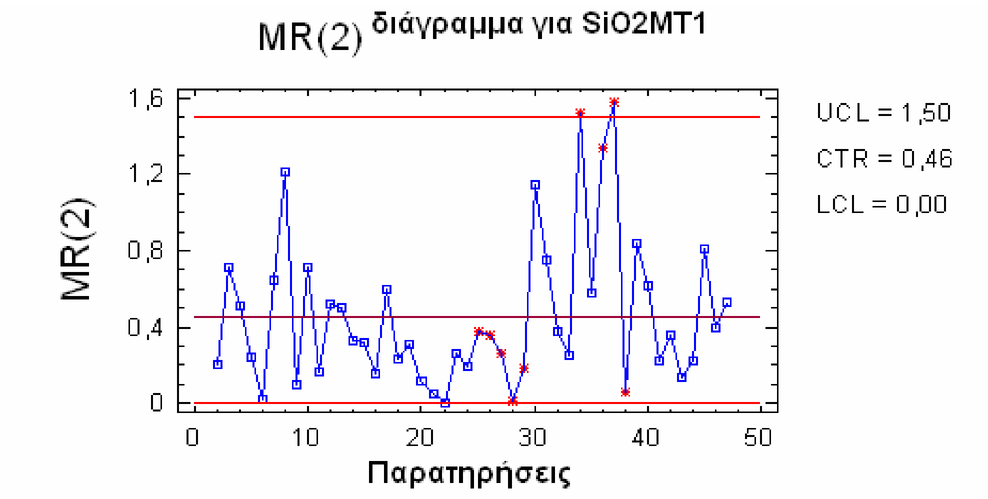
Διάγραμμα5. 16 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή SiO_2 MT1

Χάρτες ελέγχου

Σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου, ο χάρτης ελέγχου που επιλέγεται είναι αυτός των μεμονωμένων τιμών . Η ανάλυση παρουσιάζει τα παρακάτω δεδομένα.



Διάγραμμα5. 17 διάγραμμα ελέγχου μέσης τιμής για τη μεταβλητή SiO_2MT1



Διάγραμμα5. 18 Διάγραμμα ελέγχου εύρους για τη μεταβλητή SiO_2MT1

X και MR(2) SiO_2 ^{MT1}

```
Αριθμός παρατηρήσεων = 47
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 23,4661
Κεντρική γραμμή      = 22,2479
LCL: -3,0 σ = 21,0297

0 εκτός ορίων
```

```
MR(2)Διάγραμμα
-----------
UCL: +3,0 σ = 1,49717
Κεντρική γραμμή      = 0,458043
LCL: -3,0 σ = 0,0
2 εκτός ορίων

Εκτιμήσεις
---------
μέση τιμή = 22,2479
σίγμα = 0,406067
Μέση τιμή για MR(2) = 0,458043
```

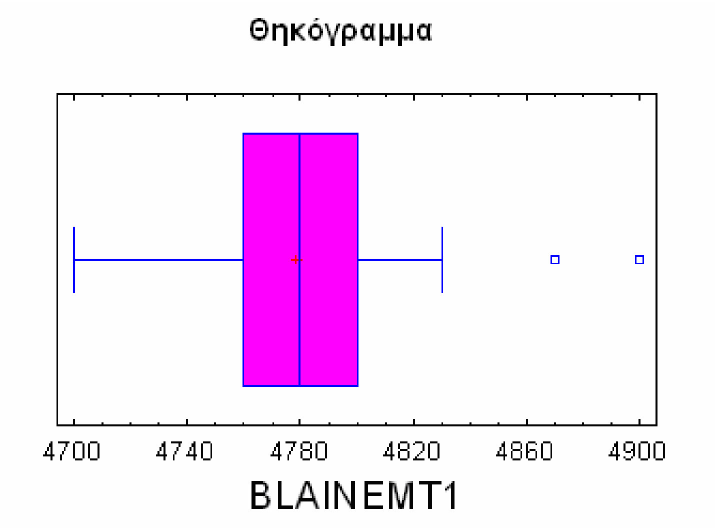
Blaine

Μέτρα κεντρικής τάσης και θέσης

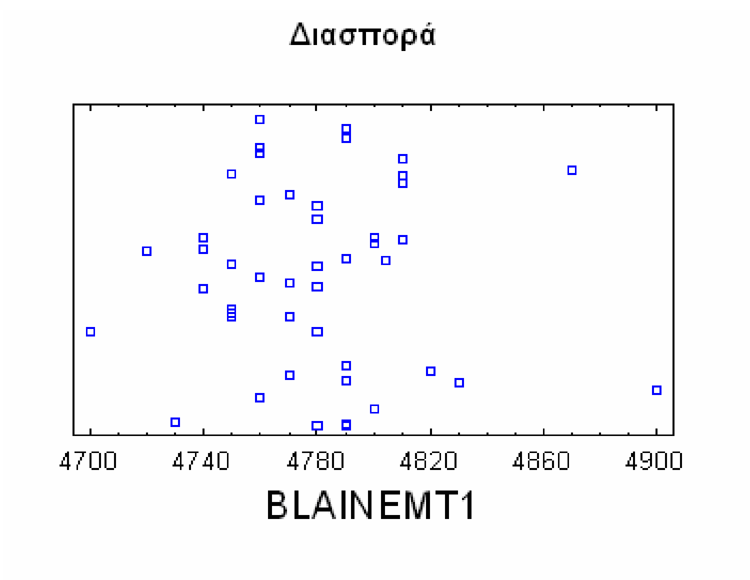
Το πλήθος του δείγματος είναι 48. Οι τιμές κυμαίνονται από 4700 έως 4900 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω

```
Τιμές = 47
Μέσος όρος = 4778,81
Διακύμανση = 1245,85
Τυπική απόκλιση = 35,2967
Ελάχιστη τιμή = 4700,0
Μέγιστη τιμή = 4900,0
Έκταση = 200,0
Τυπική ασυμμετρία = 2,55893
Τυπική κύρτωση = 3,70393
```

Μέσω του Box and Whisket plot φαίνεται ή τάση των τιμών ενώ με το διάγραμμα διασποράς δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



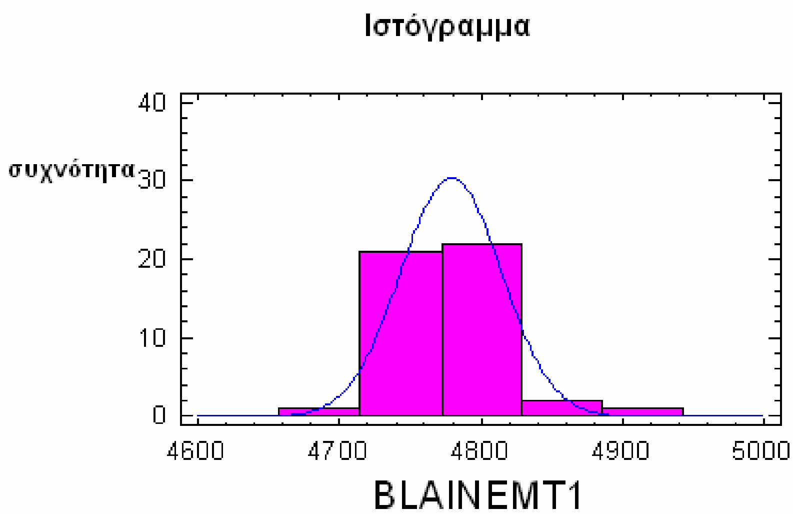
Διάγραμμα5. 19 Θηκόγραμμα για τη μεταβλητή BLAINEMT1



Διάγραμμα5. 20 Διασπορά για τη μεταβλητή BLAINEMT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, αλλά δεν είναι συμμετρικό.



Διάγραμμα5. 21Ιστόγραμμα για τη μεταβλητή BLAINEMT1

Άρα τα δεδομένα δεν παρουσιάζουν καλή προσαρμοστικότητα στην κανονική κατανομή σύμφωνα με αυτόν τον έλεγχο.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με 2,55893> 2, δηλαδή δεν είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 3,70393> 2, δηλαδή με τιμή η οποία δε βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Από τον έλεγχο με βάση το χ^2 προκύπτει ότι

Πίνακας 5. 4 Έλεγχος κανονικότητας με χ^2 για τη μεταβλητήBlaine MT1

κατώτερο όριο	ανώτερο όριο	παρατηρ. συχνότητα	αναμεν. συχνότητα	χ^2
μικρότερο-ίσο	4741,13	6	6,71	0,08
4741,13	4758,83	5	6,71	0,44
4758,83	4772,45	11	6,71	2,74
4772,45	4785,16	6	6,71	0,08
4785,16	4798,78	7	6,71	0,01
4798,78	4816,49	8	6,71	0,25
μεγαλ. 4816,49		4	6,71	1,10

χ^2 = 4,68093 with 4 β.ε. P-τιμή = 0,321629

όπως φαίνεται η τιμή P είναι 0,321629

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,321629>0, 1, δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

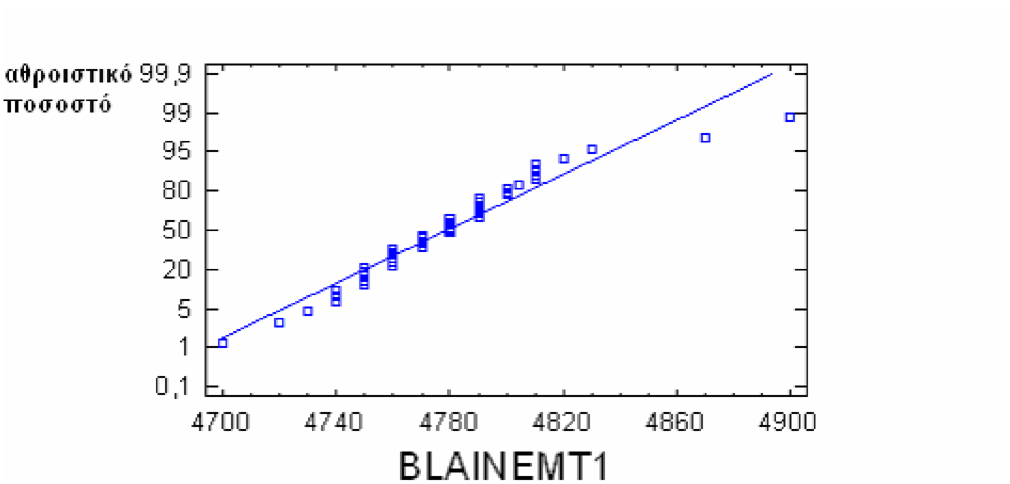
Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

P=0,321629>0, 05 . Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks

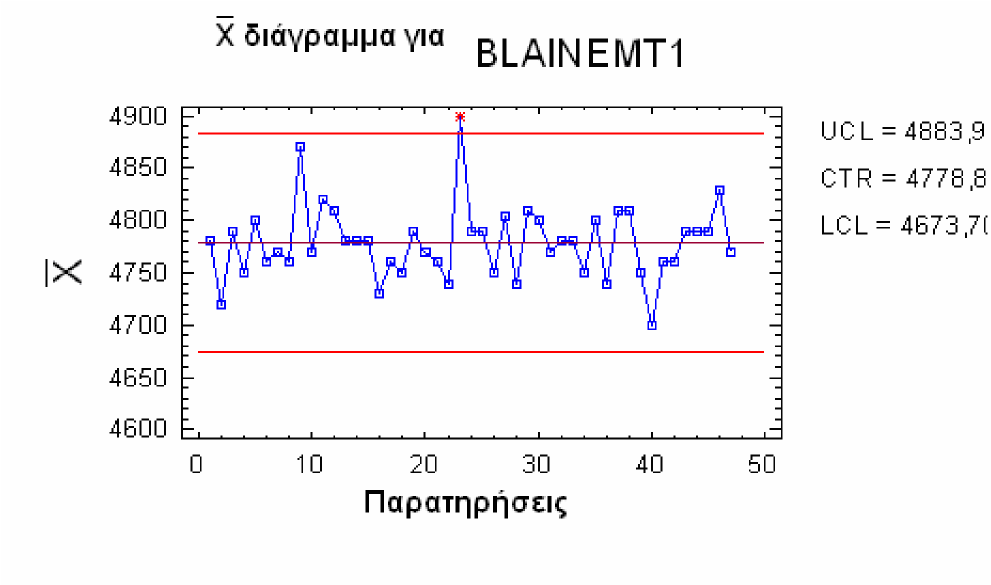
```
W = 0,946815
P-Value = 0,0512854
```
Δηλαδή $W \approx 1$ και P-Value = 0,051285> 0,01

*έλεγχος κανονικότητας με **normal probability plot***

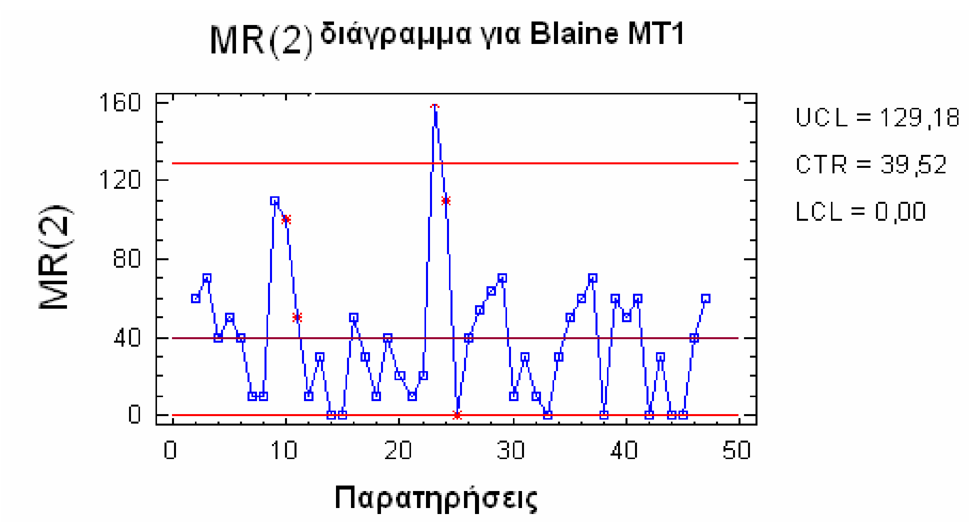


Διάγραμμα5. 22 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή BLAINEMT1

σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι μεμονωμένων τιμών . Η ανάλυση παρουσιάζει τα παρακάτω δεδομένα.



Διάγραμμα5. 23 Διάγραμμα ελέγχου ποιότητας μέσης τιμής για τη μεταβλητή BLAINEMT1



Διάγραμμα5. 24 Ελέγχου εύρους για τη μεταβλητή BLAINEMT1

```
Διαγράμματα μεμονωμένων τιμών - BLAINEMT1

X καιMR(2) BLAINEMT1

Αριθμός παρατηρήσεων = 47
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 4883,92
Κεντρική γραμμή       = 4778,81
LCL: -3,0 σ = 4673,7

1 εκτός ορίων

MR(2) Chart
-----------
UCL: +3,0 σ = 129,181
Κεντρική γραμμή       = 39,5217
LCL: -3,0 σ = 0,0

1 εκτός ορίων

Εκτιμήσεις
---------
Μέση τιμή = 4778,81
σίγμα = 35,037
Μέση τιμή MR(2) = 39,5217
```

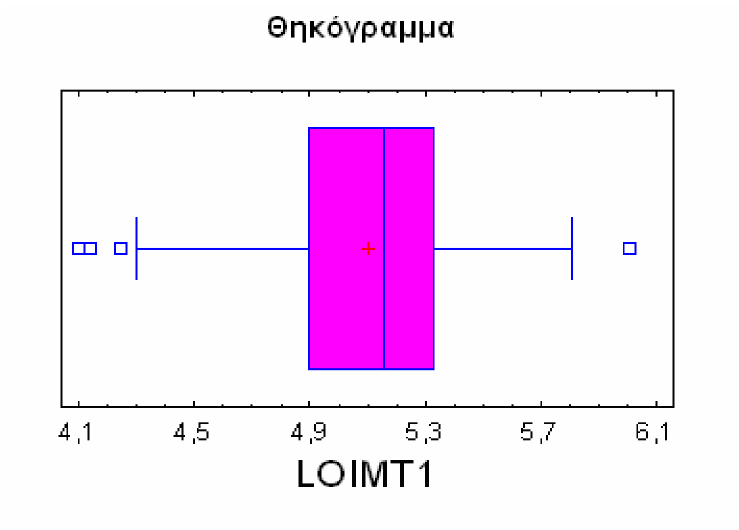
LOI

Μέτρα κεντρικής τάσης και θέσης

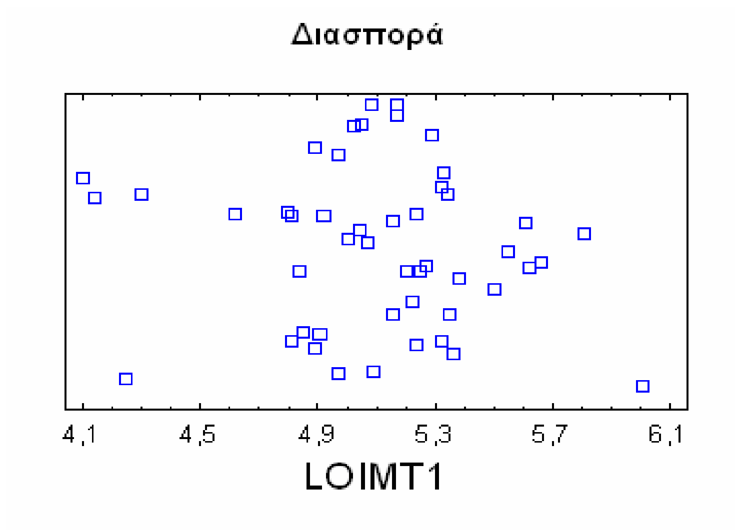
Το πλήθος του δείγματος είναι 48. Οι τιμές κυμαίνονται από 4,1 έως 6,01 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω

```
Τιμές = 48                                  Μέγιστη τιμή = 6,01
Μέσος όρος = 5,10229                        Έκταση = 1,91
Διακύμανση = 0,153873                       Τυπική ασυμμετρία = -1,53612
Τυπική απόκλιση = 0,392267                  Τυπική          κύρτωση=         1,47884
Ελάχιστη τιμή = 4,1
```

Μέσω του θηκογράμματος φαίνεται ή τάση των τιμών ενώ με το διάγραμμα διασποράς δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



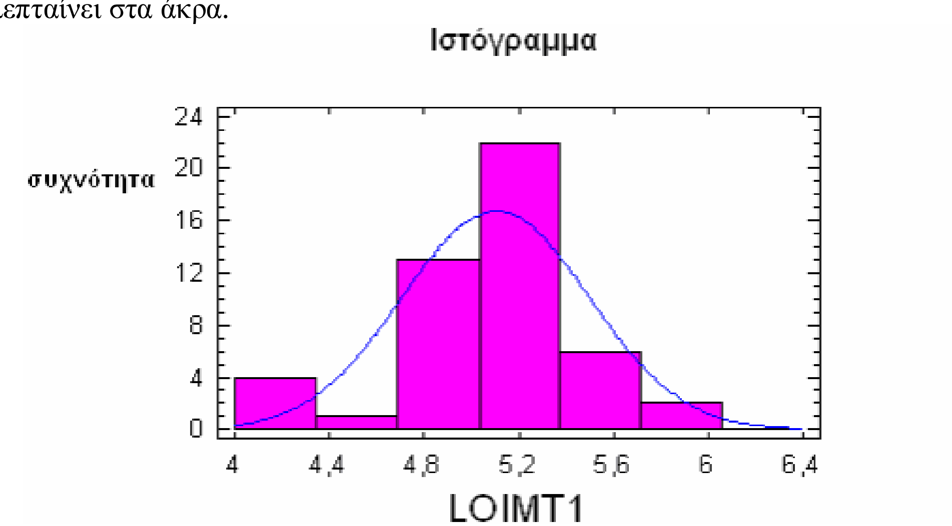
Διάγραμμα5. 25 Θηκόγραμμα για τη μεταβλητή LOIMT1



Διάγραμμα5. 26 Διασπορά για τη μεταβλητή LOIMT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, είναι συμμετρικό και λεπταίνει στα άκρα.



Διάγραμμα5. 27 ιστόγραμμα για τη μεταβλητή LOIMT1

Άρα η πιθανότητα να υπάρχει καλή προσαρμογή των δεδομένων στην κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με -1,53612>- 2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 1,47884< 2, δηλαδή με τιμή η οποία βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Πίνακας 5. 5 έλεγχος κανονικότητας με χ^2για τη μεταβλητή LOIMT1

κατώτερο όριο	ανώτερο όριο	παρατηρούμενη συχν.	Αναμεν. συχνότητα	χ^2
σε ή λιγότερο από	4,68352	5	6,86	0,50
4,68352	4,88029	5	6,86	0,50
4,88029	5,03168	8	6,86	0,19
5,03168	5,17291	9	6,86	0,67
5,17291	5,3243	9	6,86	0,67
5,3243	5,52107	6	6,86	0,11
πάνω από 5,52107		6	6,86	0,11

χ^2 = 2,74977 with 4 d.f. P-τιμή = 0,600535

όπως φαίνεται η τιμή P είναι 0,600535

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,600535> 0, 1, δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

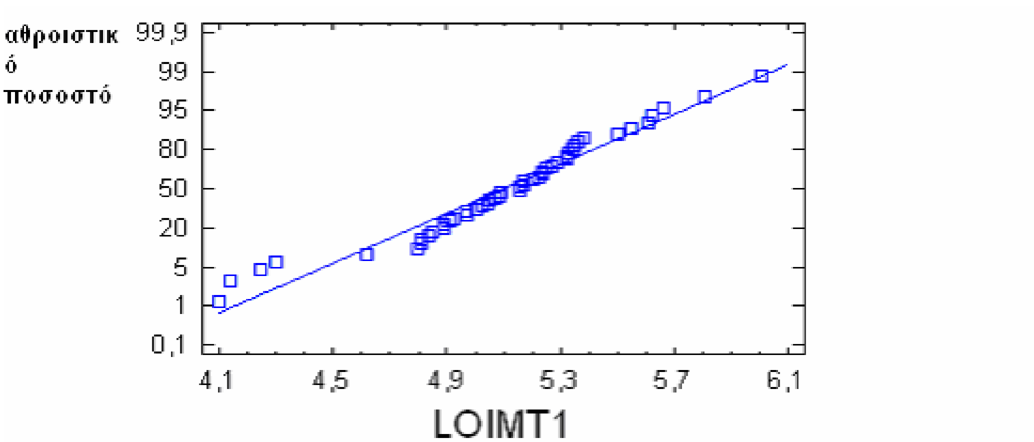
Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05
P=0,600535> 0, 05. Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks

```
W statistic = 0,953874
P-τιμή = 0,0956679
```

Δηλαδή W≈1 και P-Value = 0,0956679> 0,01

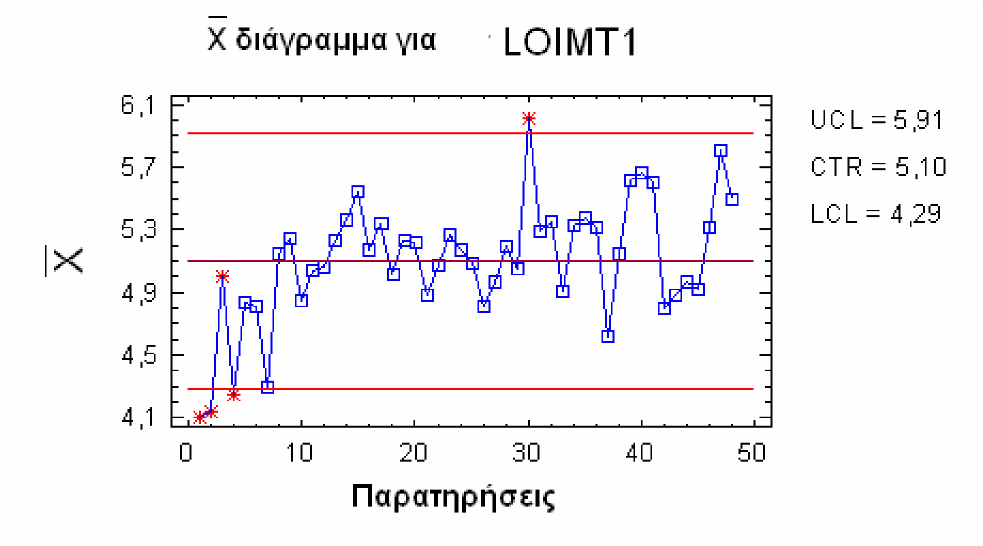
*έλεγχος κανονικότητας με **normal probability plot***



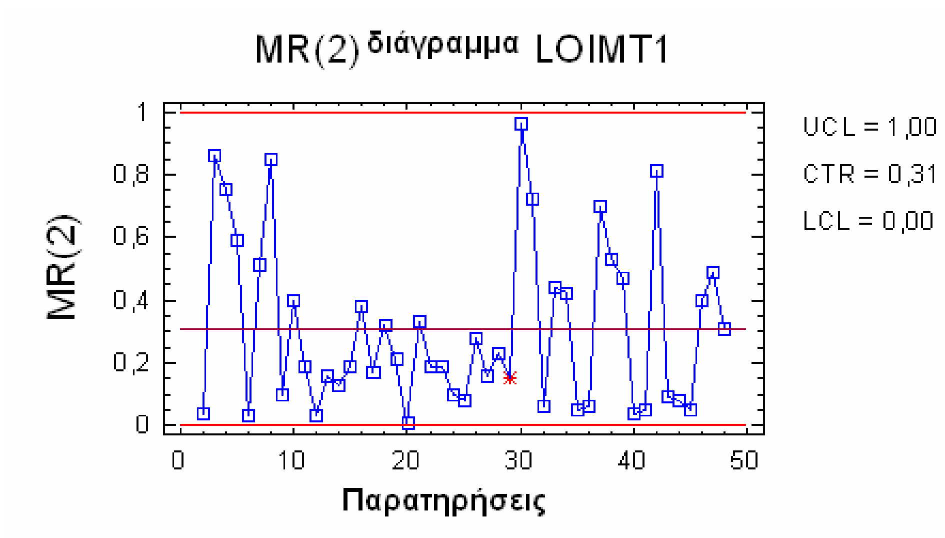
Διάγραμμα5. 28 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή LOIMT1

σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι αυτός των μεμονωμένων τιμών.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 29 Έλεγχος ποιότητας μέσης τιμής για μεταβλητή LOIMT1



Διάγραμμα5. 30 Έλεγχος ποιότητας εύρους για τη μεταβλητή LOIMT1

```
Διαγράμματα μεμονωμένων τιμών - LOIMT1

X and MR(2) - LOIMT1

Αριθμός παρατηρήσεων= 48
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 5,91488
Κεντρική γραμμή       = 5,10229
LCL: -3,0 σ = 4,28971

4 εκτός ορίων

MR(2) Διάγραμμα
-----------
UCL: +3,0 σ = 0,998667
Κεντρική γραμμή       = 0,305532
LCL: -3,0 σ = 0,0

0 εκτός ορίων

Εκτιμήσεις
---------
Μέση τιμή = 5,10229
σίγμα = 0,270862
Μέση τιμή MR(2) = 0,305532
```

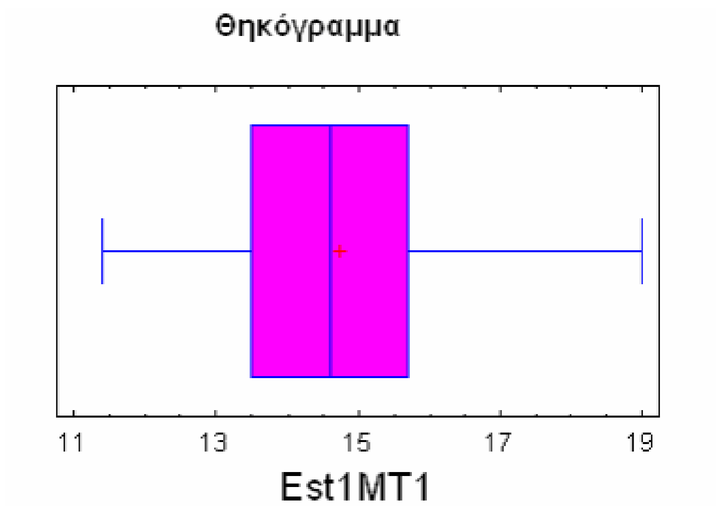
Est 1

Μέτρα κεντρικής τάσης και θέσης

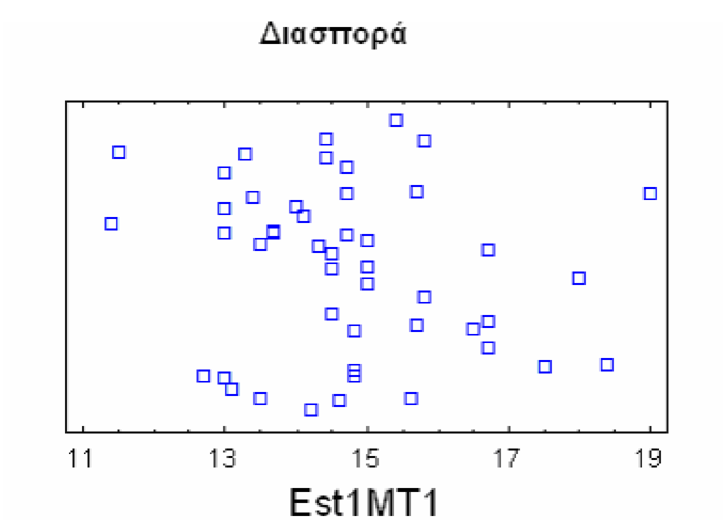
Τ πλήθος του δείγματος είναι 47. Οι τιμές κυμαίνονται από 11,4 έως 19 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω

```
Τιμές = 47
Μέσος όρος = 14,7298
Διασπορά = 2,64083
Τυπική απόκλιση = 1,62506
Ελάχιστη τιμή= 11,4
Μέγιστη τιμή = 19,0
Έκταση = 7,6
Τυπική ασυμμετρία = 1,49803
Τυπική κύρτωση = 0,750746
```

Μέσω του θηκογράμματος φαίνεται ή τάση των τιμών ενώ με το διάγραμμα διασποράς δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



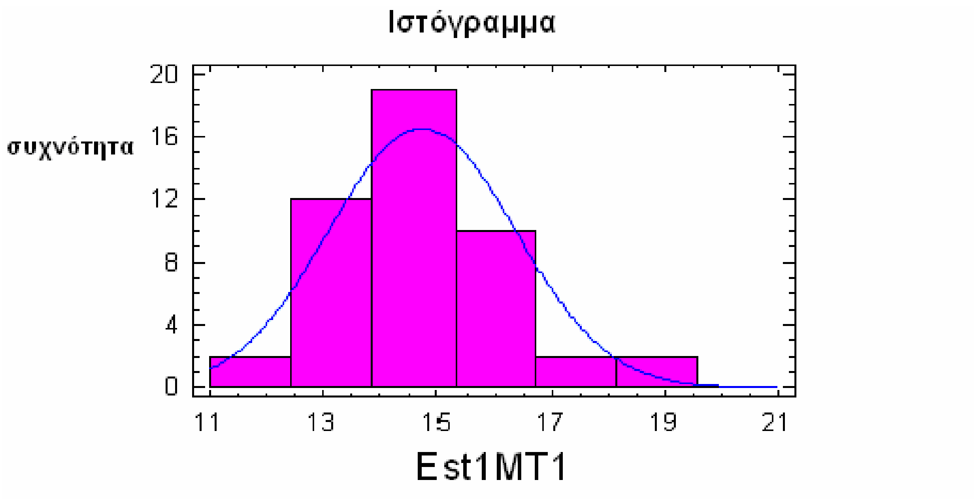
Διάγραμμα5. 31 Θηκόγραμμα της μεταβλητής Est1MT1



Διάγραμμα5. 32 Διασπορά για τη μεταβλητή Est1MT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, με μια συμμετρία.



Διάγραμμα5. 33 ιστόγραμμα για τη μεταβλητή Est1MT1

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με 1,49803<2, δηλαδή δεν είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 0,750746< 2, δηλαδή με τιμή η οποία βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Πίνακας 5. 6 έλεγχος κανονικότητας με χ^2 για τη μεταβλητή Est1MT1

κατώτερο όριο	ανώτερο όριο	παρατηρ. Συχν.	αναμεν. Συχν.	χ^2
μικρότερο από	12,9949	3	6,71	2,05
12,9949	13,8101	11	6,71	2,74
13,8101	14,4373	6	6,71	0,08
14,4373	15,0223	13	6,71	5,88
15,0223	15,6495	2	6,71	3,31
15,6495	16,4647	4	6,71	1,10
μεγαλύτερο 16,4647		8	6,71	0,25

χ^2 = 15,4035 με 4 β.ε. P-τιμή = 0,00393356

όπως φαίνεται η τιμή P είναι 0,00393356

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,00393356< 0, 1, μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή με 90% βεβαιότητα.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

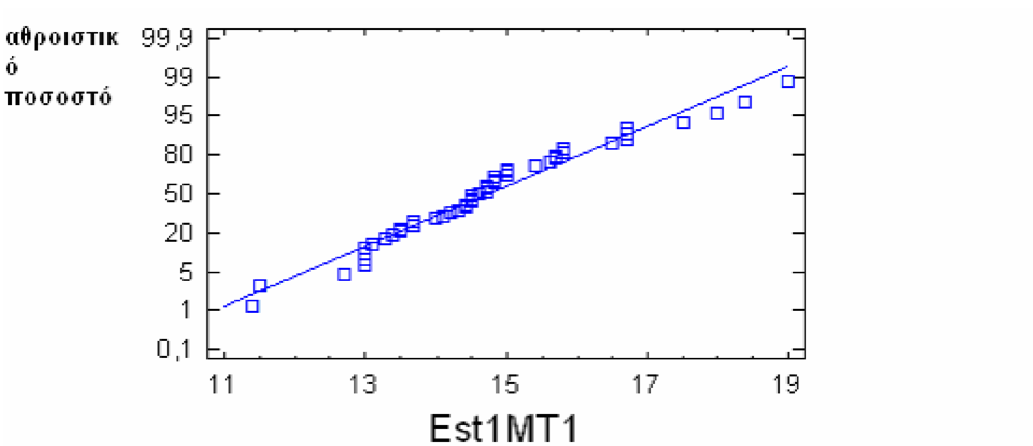
P=0,00393356< 0, 05, μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

Shapiro-Wilks

```
W = 0,962556
P-τιμή = 0,220985
```

Δηλαδή W≈1 και P-τιμή = 0,220985> 0,01

*έλεγχος κανονικότητας με **normal probability plot***

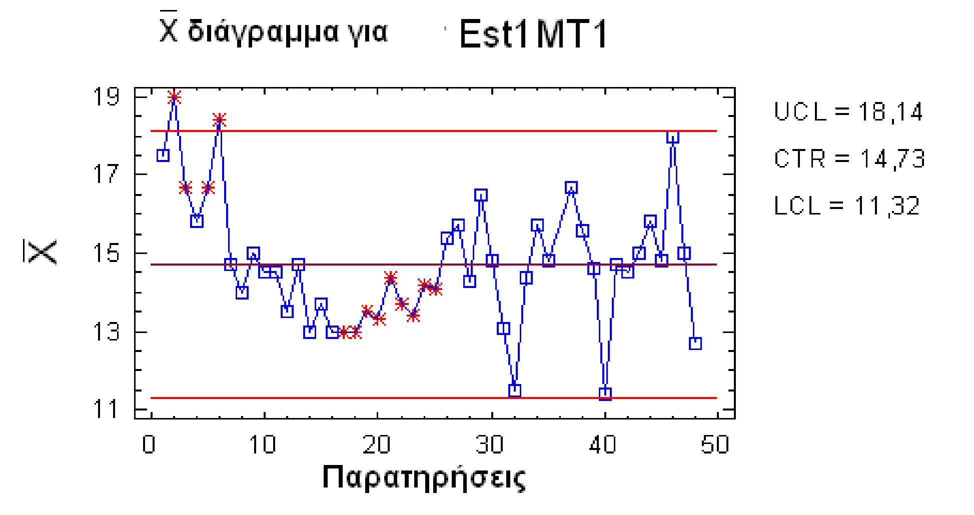


Διάγραμμα5. 34 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή Est1MT1

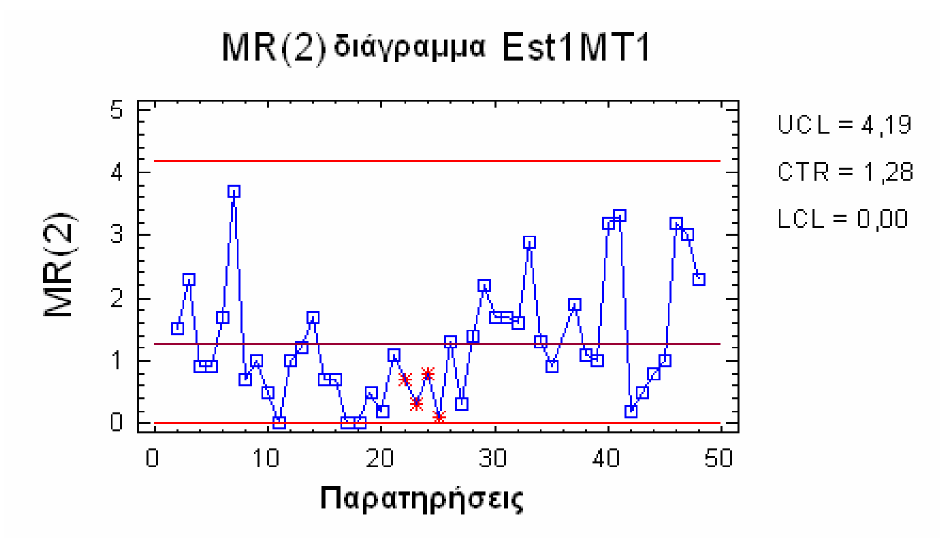
Χάρτες ελέγχου

σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι αυτός του κινούμενου μέσου.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 35 Διάγραμμα ελέγχου ποιότητας για τη μεταβλητή Est1MT1



Διάγραμμα5. 36 Διάγραμμα εύρους για τη μεταβλητή Est1MT1

```
Διάγραμμα μεμονωμένων τιμών - Est1MT1

X and MR(2) - για Est1MT1

Αριθμός παρατηρήσεων = 47
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 18,141
Κεντρική γραμμή      = 14,7298
LCL: -3,0 σ = 11,3186

2 εκτός ορίων

MR(2) Chart
-----------
UCL: +3,0 σ = 4,19236
Κεντρική γραμμή      = 1,28261
LCL: -3,0 σ = 0,0

0 εκτός ορίων

Εκτιμήσεις
---------
μέση τιμή = 14,7298
σίγμα = 1,13706
μέση τιμή για MR(2) = 1,28261
```

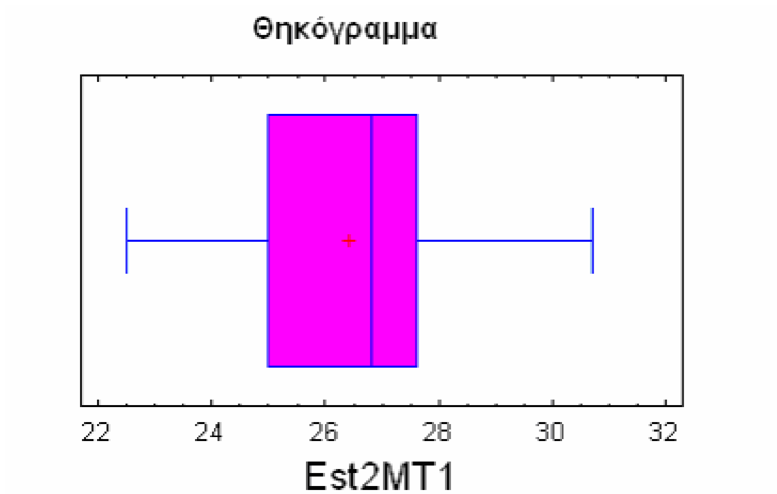
Est 2

Μέτρα κεντρικής τάσης και θέσης

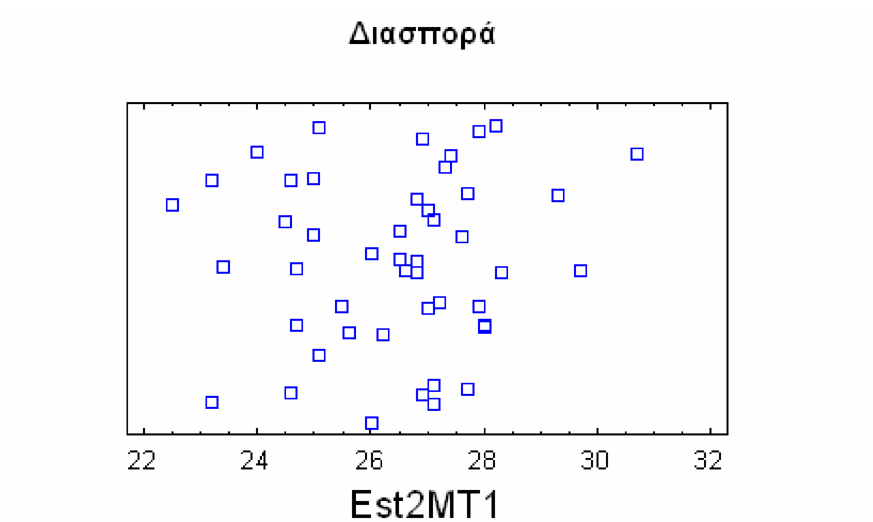
Τ πλήθος του δείγματος είναι 47. Οι τιμές κυμαίνονται από 22,5 έως 30,7 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω.

```
Τιμές = 47                              Μέγιστη τιμή = 30,7
Μέσος όρος = 26,4021                    Έκταση = 8,2
Διασπορά = 3,0476                       Τυπική ασυμμετρία = -0,339696
Τυπική απόκλιση = 1,74574               Τυπική κύρτωση = 0,0280958
Ελάχιστη τιμή = 22,5
```

Μέσω του Box and Whisket plot φαίνεται ή τάση των τιμών ενώ με το scatter plot δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



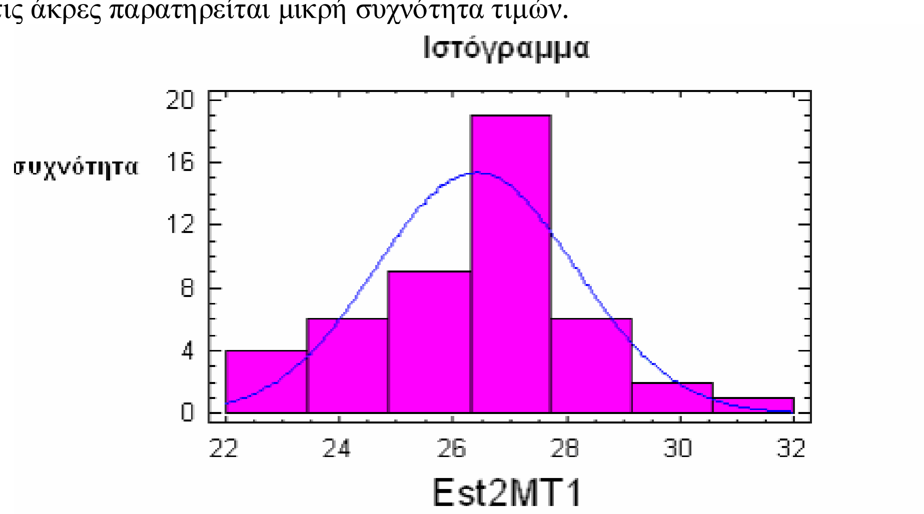
Διάγραμμα5. 37 Θηκόγραμμα για τη μεταβλητή Est2MT1



Διάγραμμα5. 38 Διασπορά για τη μεταβλητή Est2MT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, είναι συμμετρικό και στις άκρες παρατηρείται μικρή συχνότητα τιμών.



Διάγραμμα5. 39 ιστόγραμμα για τη μεταβλητή Est2MT1

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με -0,339696>- 2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 0,0280958< 2, δηλαδή με τιμή η οποία βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Πίνακας 5. 7 έλεγχος κανονικότητας με χ^2για τη μεταβλητή Est2MT1

κατώτερο όριο	ανώτερο όριο	παρατηρ. Συχν.	αναμεν. Συχν.	χ^2
μικρότερο από	24,5384	6	6,71	0,08
24,5384	25,4141	8	6,71	0,25
25,4141	26,0879	4	6,71	1,10
26,0879	26,7164	4	6,71	1,10
26,7164	27,3901	12	6,71	4,16
27,3901	28,2658	9	6,71	0,78
μεγαλύτερο 28,2658		4	6,71	1,10

X^2 = 8,55345 με 4 β.ε. P-τιμή = 0,0732836

όπως φαίνεται η τιμή P είναι 0,0732836

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,0732836<0, 1. Μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή κατά 90% εμπιστοσύνη.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

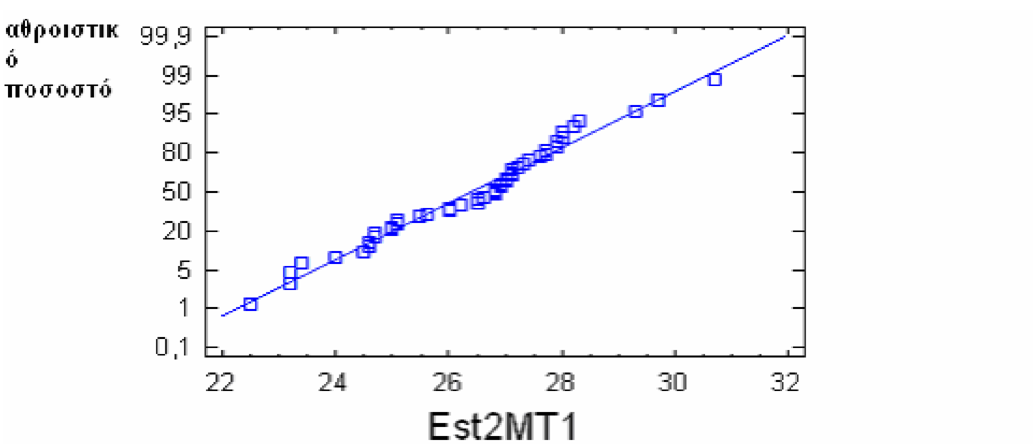
P=0,0732836> 0, 05. Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks W

```
W = 0,974384
P-τιμή = 0,544778
```

W ≈ 1
P-τιμή = 0,544778> 0,01

έλεγχος κανονικότητας με ***normal probability plot***

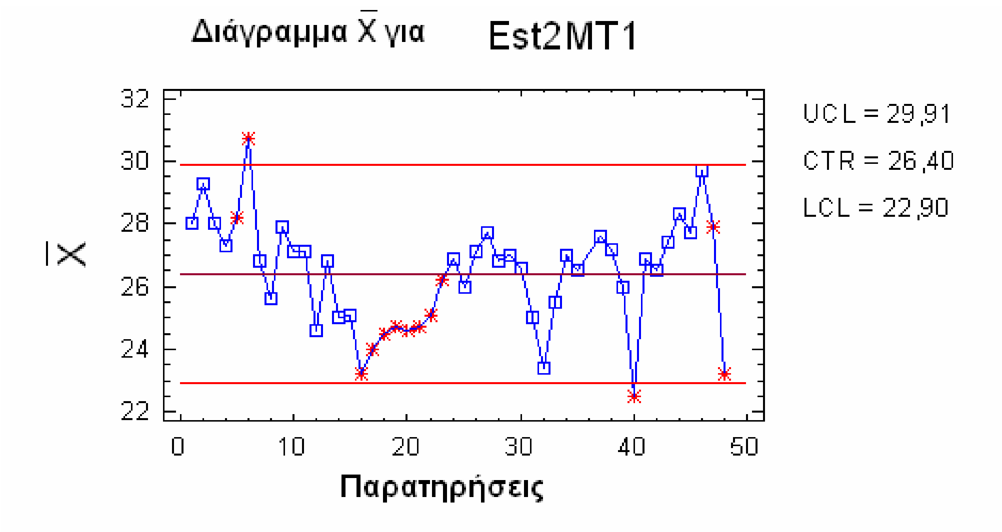


Διάγραμμα5. 40 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή Est2MT1

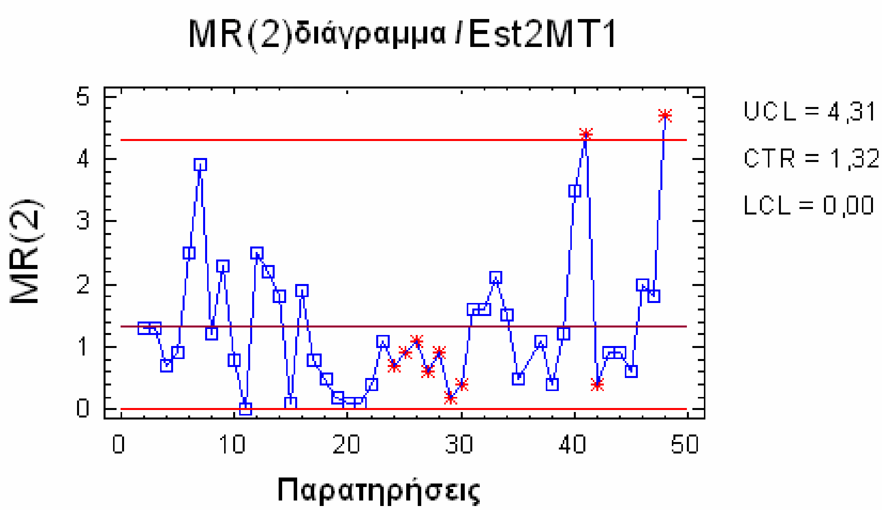
Χάρτες ελέγχου

Σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι μεμονωμένων τιμών.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 41 Διάγραμμα ελέγχου ποιότητας μέσης τιμής για τη μεταβλητή Est2MT1



Διάγραμμα5. 42 Διάγραμμα ελέγχου ποιότητας εύρους για τη μεταβλητή EST2MT1

Από τα παραπάνω γραφήματα προκύπτει ότι:

```
Διάγραμμα μεμονωμένων τιμών - Est2MT1

X και MR(2) – για Est2MT1

Αριθμός παρατηρήσεων = 47
0 παρατηρήσεις παραλήφθηκαν

X διάγραμμα
-------
UCL: +3,0 σ = 29,9058
Κεντρική γραμμή      = 26,4021
LCL: -3,0 σ = 22,8984

2 εκτός ορίων

MR(2) Chart
-----------
UCL: +3,0 σ = 4,30605
Κεντρική γραμμή      = 1,31739
LCL: -3,0 σ = 0,0

2 εκτός ορίων

Παρατηρήσεις
---------
Μέση τιμή = 26,4021
σίγμα = 1,1679
Μέση τιμή MR(2) = 1,31739
```

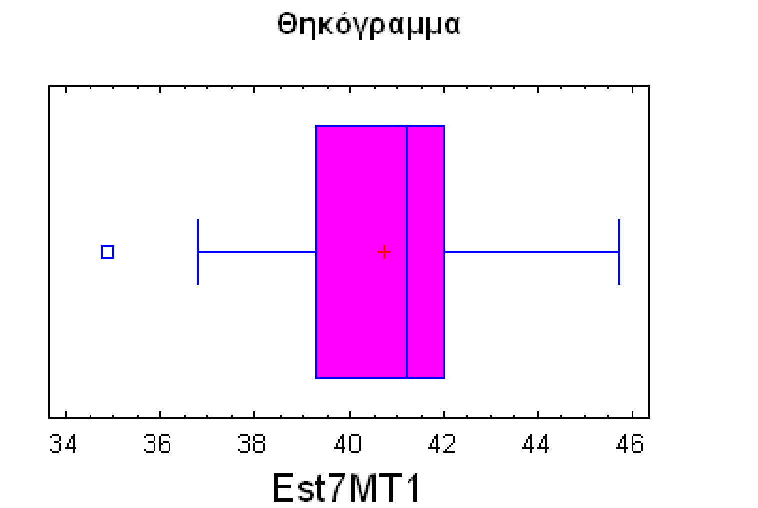
Est 7

Μέτρα κεντρικής τάσης και θέσης

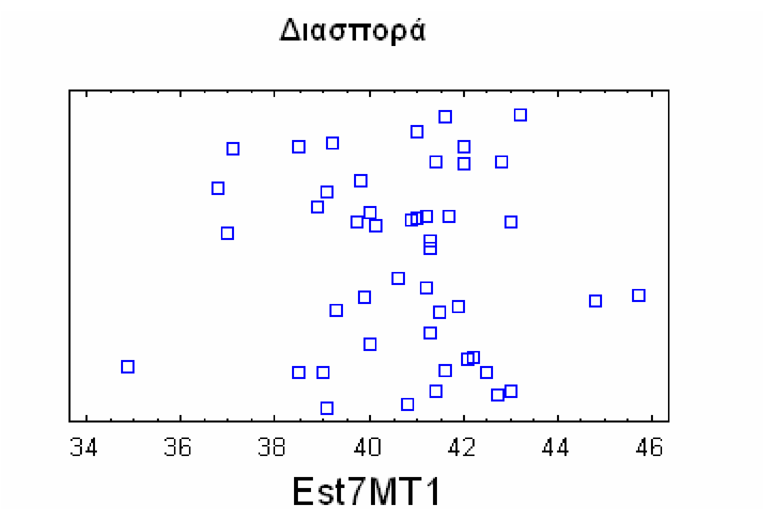
Τ πλήθος του δείγματος είναι 47. Οι τιμές κυμαίνονται από 34,9 έως 45,7 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω

```
Τιμές= 47
Μέσος όρος = 40,7362
Διασπορά = 4,12497
Τυπική απόκλιση = 2,031
Ελάχιστη τιμή= 34,9
Μέγιστη τιμή = 45,7
Έκταση = 10,8
Τυπική ασυμμετρία = -1,12259
Τυπική κύρτωση = 1,41632
```

Μέσω του Box and Whisket plot φαίνεται ή τάση των τιμών ενώ με το scatter plot δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



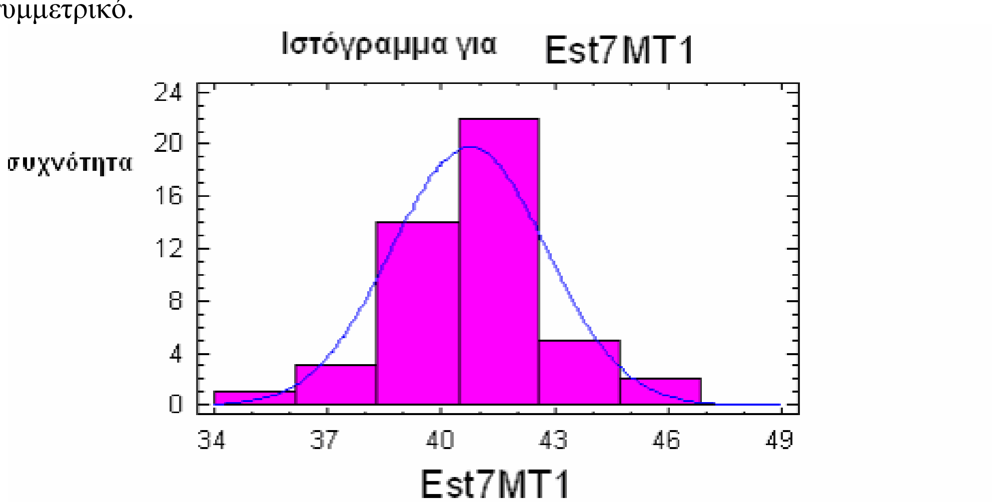
Διάγραμμα5. 43 Θηκόγραμμα για τη μεταβλητή Est7MT1



Διάγραμμα5. 44 Διασπορά για τη μεταβλητή Est7MT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή και είναι σχετικά συμμετρικό.



Διάγραμμα5. 45 ιστόγραμμα για τη μεταβλητή Est7MT1

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με -1,12259>-2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 1,41632<2, δηλαδή με τιμή η οποία βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Πίνακας 5. 8 έλεγχος κανονικότητας με χ^2 για τη μεταβλητή Est7MT1

κατώτερο όριο	ανώτερο όριο	παρατηρ. Συχν.	αναμεν. Συχν.	χ^2
μικρότερο από	38,5679	6	6,71	0,08
38,5679	39,5867	6	6,71	0,08
39,5867	40,3706	6	6,71	0,08
40,3706	41,1018	5	6,71	0,44
41,1018	41,8856	11	6,71	2,74
41,8856	42,9044	8	6,71	0,25
μεγαλύτερο 42,9044		5	6,71	0,44

χ^2 = 4,08527 με 4 β.ε. P-τιμή = 0,394589

όπως φαίνεται η τιμή P είναι 0,394589

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,394589> 0, 1. Δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

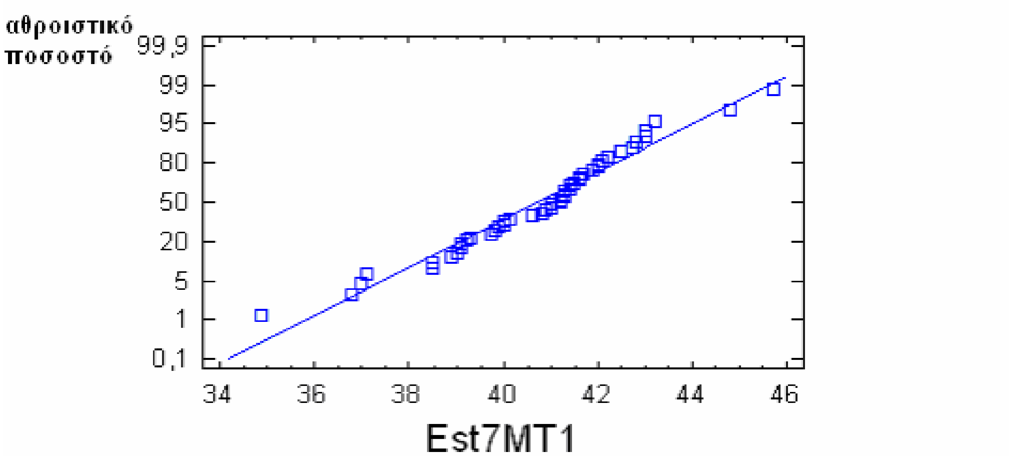
P=0,394589>0, 05. Δεν μπορούμε να απορρίψουμε ότι τα δεδομένα έχουν καλή προσαρμοστικότητα στην κανονική κατανομή.

Shapiro-Wilks

```
 W  = 0,973938
P-τιμή = 0,529335
```

Οπότε $W \approx 1$ και P-τιμή = 0,529335> 0,01

έλεγχος κανονικότητας με normal probability plot

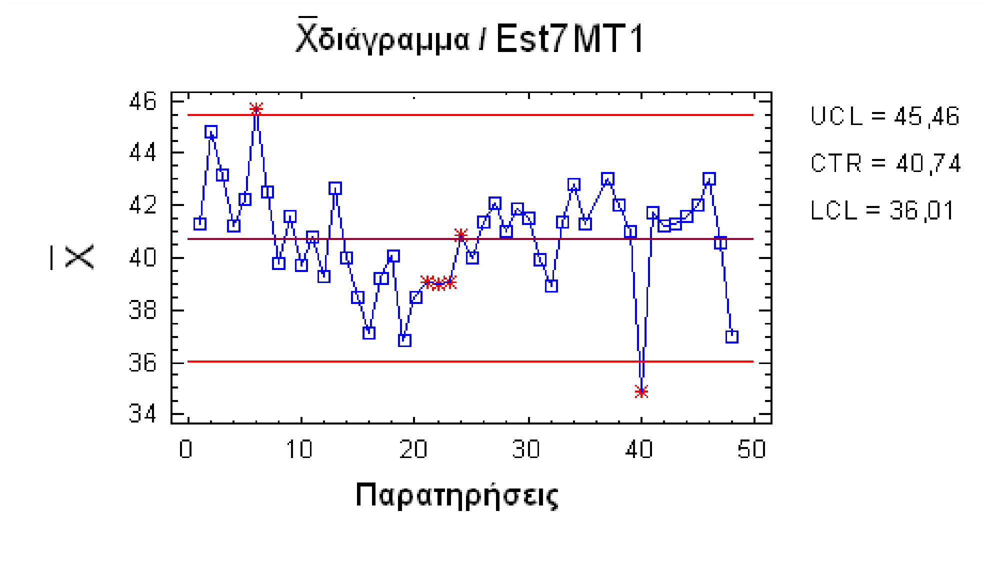


Διάγραμμα5. 46 Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή Est7MT1

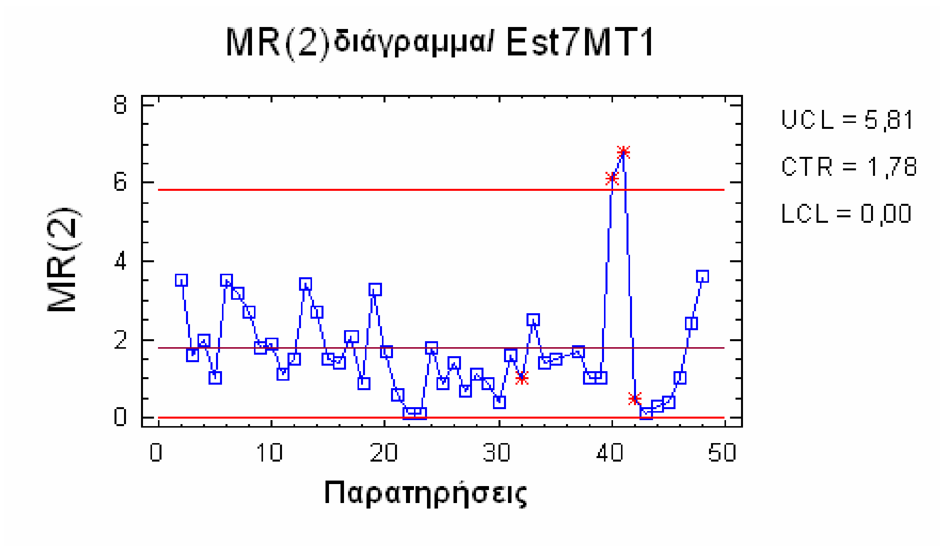
Χάρτες ελέγχου

σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι αυτός των μεμονωμένων τιμών.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 47 Διάγραμμα ελέγχου ποιότητας μέσης τιμής για τη μεταβλητή Est7MT1



Διάγραμμα5. 48 Διάγραμμα ελέγχου ποιότητας εύρους για τη μεταβλητή Est7MT1

```
Διαγράμματα μεμονωμένων τιμών - Est7MT1

X and MR(2) - για Est7MT1

Αριθμός παρατηρήσεων = 47
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 45,4598
Κεντρική γραμμή       = 40,7362
LCL: -3,0 σ = 36,0125

2 εκτός ορίων

MR(2) Διάγραμμα
-----------
UCL: +3,0 σ = 5,80535
Κεντρική γραμμή       = 1,77609
LCL: -3,0 σ = 0,0

2 εκτός ορίων

Εκτιμήσεις
---------
Μέση τιμή = 40,7362
σίγμα = 1,57455
Μέση τιμή MR(2) = 1,77609
```

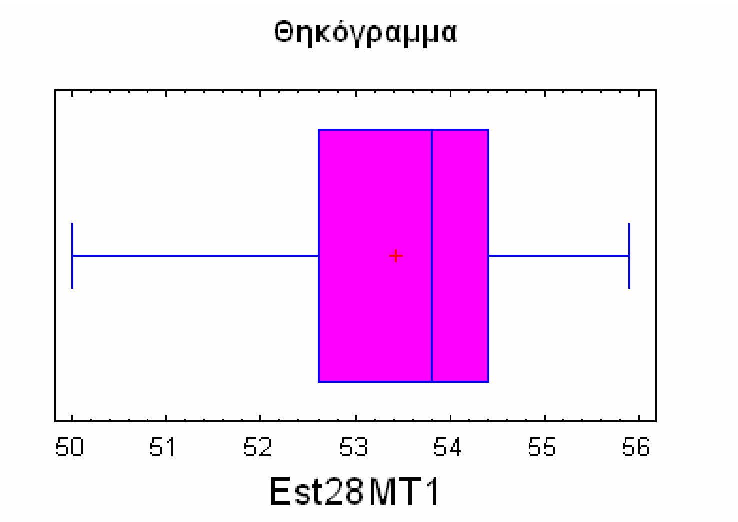
Est 28

Μέτρα κεντρικής τάσης και θέσης

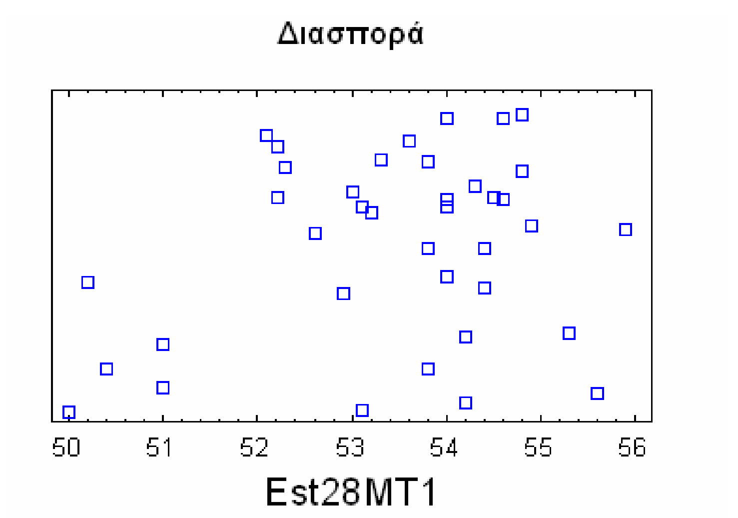
Τ πλήθος του δείγματος είναι 38. Οι τιμές κυμαίνονται από 50,0 έως 55,9 . Οι τιμές του μέσου, της διασποράς, της τυπικής απόκλισης, της διακύμανσης, της ασυμμετρίας και της κύρτωσης φαίνονται παρακάτω

```
Τιμές = 38
Μέσος όρος = 53,4237
Διασπορά = 2,17213
Τυπική απόκλιση = 1,47381
Ελάχιστη τιμή = 50,0
Μέγιστη τιμή = 55,9
Έκταση= 5,9
Τυπική ασυμμετρία = -1,98657
Τυπική κύρτωση= 0,145137
```

Μέσω του Box and Whisket plot φαίνεται ή τάση των τιμών ενώ με το scatter plot δίνεται μια εικόνα της έκτασης που καταλαμβάνουν οι τιμές.



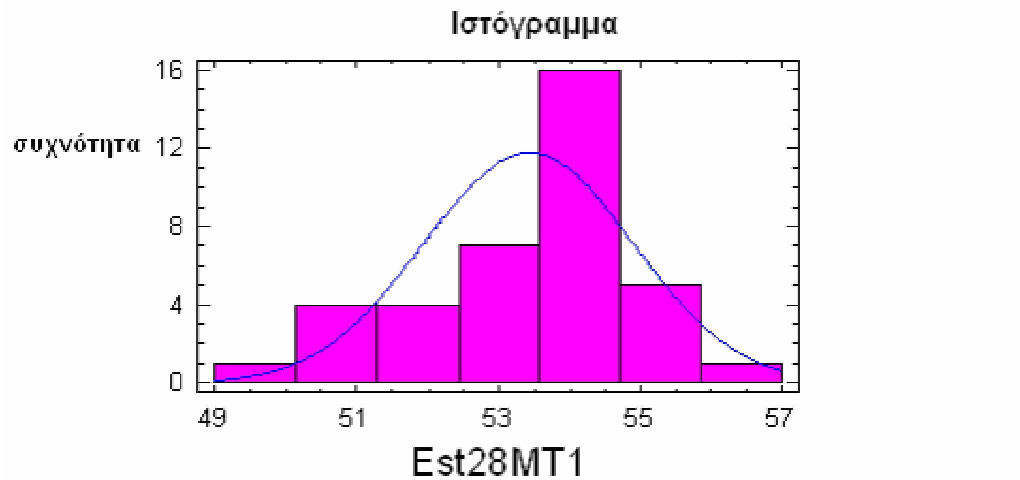
Διάγραμμα5. 49 Θηκόγραμμα για τη μεταβλητή Est28MT1



Διάγραμμα5. 50 Διασπορά για τη μεταβλητή Est28MT1

έλεγχος κανονικότητας

Η κανονικότητα ελέγχεται οπτικά από το ιστόγραμμα. Από την παρατήρηση του ιστογράμματος φαίνεται ότι αυτό είναι με μία μόνο κορυφή, με σχετική συμμετρία.



Διάγραμμα5. 51 ιστόγραμμα για τη μεταβλητή Est28MT1

Άρα η πιθανότητα να προέρχονται τα δεδομένα από κανονική κατανομή είναι μεγάλη.

Έλεγχος ασυμμετρίας και κύρτωσης

Μεγάλο ενδιαφέρον παρουσιάζουν η τυποποιημένη ασυμμετρία και η τυποποιημένη κύρτωση. Τιμές αυτών οι οποίες εκτείνονται εκτός των ορίων -2, +2 φανερώνουν μεγάλες αποκλίσεις από την κανονική κατανομή, οι οποίες τείνουν να ακυρώσουν κάθε έλεγχο που σχετίζεται με την τυπική απόκλιση.

Στη συγκεκριμένη περίπτωση η τυποποιημένη ασυμμετρία ισούται με -1,98657>- 2, δηλαδή είναι μέσα στα αναμενόμενα όρια των τιμών που προέρχονται από κανονική κατανομή.

Η τυποποιημένη κύρτωση ισούται με 0,145137< 2, δηλαδή με τιμή η οποία βρίσκεται εντός των αναμενόμενων τιμών οι οποίες προέρχονται από την κανονική κατανομή.

Έλεγχος κανονικότητας με χ^2

Goodness-of-Fit Tests for Est28MT1

Chi-Square Test

κατώτερο όριο	ανώτερο όριο	παρατηρούμενη συχνότητα	αναμενόμενη συχνότητα	χ^2
μικρότερο από	51,8503	5	5,43	0,03
51,8503	52,5896	4	5,43	0,38
52,5896	53,1584	5	5,43	0,03
53,1584	53,689	3	5,43	1,09
53,689	54,2578	9	5,43	2,35
54,2578	54,9971	9	5,43	2,35
μεγαλύτερο 54,9971		3	5,43	1,09

χ^2 = 7,31601 with 4 d.f. P-τιμή = 0,120101

όπως φαίνεται η τιμή P είναι 0,120101

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,1
P=0,120101>0, 1, οπότε δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

Για επιθυμητό επίπεδο εμπιστοσύνης α=0,05

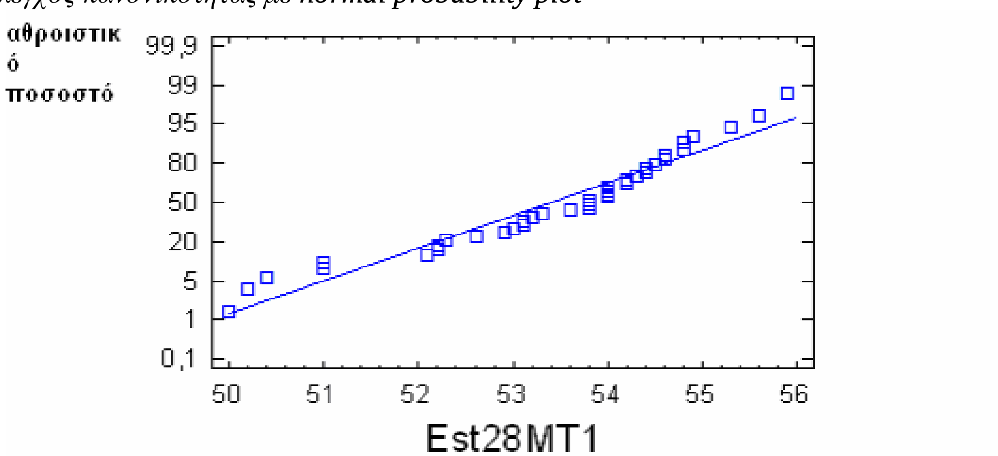
P=0,120101>0, 05 και κατά συνέπεια δεν μπορούμε να απορρίψουμε την υπόθεση ότι προέρχεται από κανονική κατανομή.

Shapiro-Wilks

```
 W  = 0,930875
P-τιμή = 0,0270984
```

Οπότε $W \approx 1$ και P-τιμή = 0,0270984> 0,01

έλεγχος κανονικότητας με ***normal probability plot***

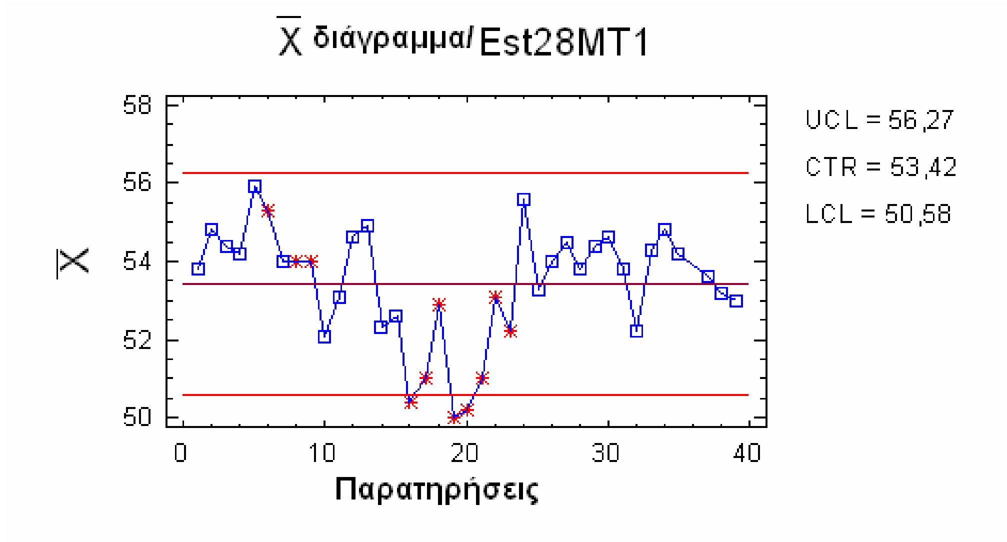


Διάγραμμα5. 52Διάγραμμα ελέγχου κανονικότητας για τη μεταβλητή Est28MT1

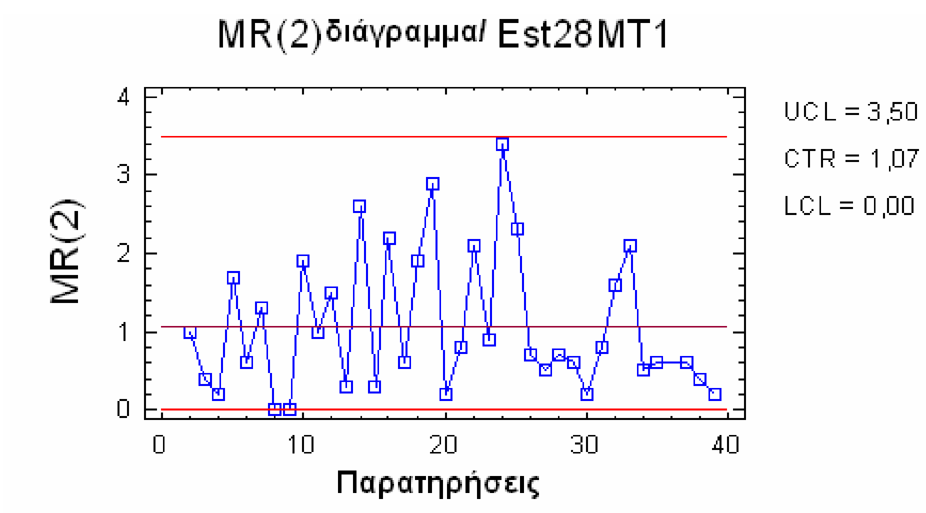
Χάρτες ελέγχου

Σύμφωνα με τα κριτήρια επιλογής χάρτη ελέγχου που θα χρησιμοποιήσουμε ο χάρτης ελέγχου που επιλέγεται είναι αυτός του κινούμενου μέσου.

Η ανάλυση φαίνεται παρακάτω. Οι τιμές οι οποίες βρίσκονται εκτός των ορίων έχουν σημειωθεί στο διάγραμμα με έντονο κόκκινο χρώμα.



Διάγραμμα5. 53 Έλεγχος ποιότητας μέσης τιμής για τη μεταβλητή Est28MT1



Διάγραμμα5. 54 Έλεγχος εύρους για τη μεταβλητή Est28MT1

```
Διάγραμμα μεμονωμένων τιμών - Est28MT1

X and MR(2) - για Est28MT1

Αριθμός παρατηρήσεων = 38
0 παρατηρήσεις παραλήφθηκαν

X Διάγραμμα
-------
UCL: +3,0 σ = 56,2701
Κεντρική γραμμή      = 53,4237
LCL: -3,0 σ = 50,5772

3 εκτός ορίων

MR(2)Διάγραμμα
-----------
UCL: +3,0 σ = 3,4983
Κεντρική γραμμή = 1,07027
LCL: -3,0 σ = 0,0

0 εκτός ορίων

Εκτιμήσεις
---------
Μέση τιμή = 53,4237
σίγμα = 0,948821
μέση  τιμή  για  MR(2)  =  1,07027
```

Από τη μελέτη όλων των ιδιοτήτων της ποιότητας τσιμέντου CEM II42,5 προκύπτει ο παρακάτω πίνακας.

Πίνακας 5. 9 Ανάλυση δεδομένων ποιότητας τσιμέντου CEM II 42,5- Μύλος 1

	IR	Al2O3	SiO2	Λεπτότητα (Blaine) (cm³/gr)	LOI (%w/w)	Est1 (N/mm²)	Est2 (N/mm²)	Est7 (N/mm²)	Est28 (N/mm²)
	MT1	**MT1**	**MT1**	**MT1**	**MT1**	**MT1**	**MT1**	**MT1**	**MT1**
Κανονική κατανομή	Ναι	Ναί	Ναι	Ναί	Ναι	Ναί	Ναι	Ναί	Ναί
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές
$UCL_χ$	7,82	5,664	23,47	4883,92	5,915	18,141	29,906	45,460	56,270
$LCL_χ$	5,430	4,923	21,03	4673,7	4,289	11,319	22,898	23,601	50,577
$CTR_χ$	6,06	5,294	22,25	4778,81	5,102	14,730	26,402	40,736	53,424
Εκτός ορίων	2	3	0	1	4	2	2	2	3
UCL_R	2,16	0,456	1,50	129,181	0,999	4,192	4,306	5,805	3,498
LCL_R	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CTR_R	0,66	0,139	0,46	39,522	0,306	1,283	1,317	1,776	1,070
Εκτός ορίων	1	2	2	1	0	0	2	2	0

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

Μύλος 4

Πραγματοποιήθηκε μελέτη των ιδιοτήτων και πιο συγκεκριμένα μελέτη του ποσοστού Al_2O_3, SiO_2, απώλειας πύρωσης, αδιάλυτου υπολείμματος, λεπτότητας και των αντοχών σε θλίψη για τσιμέντο που παράγεται από το μύλο 4 του εργοστασίου. Η μελέτη έγινε κατά τον ίδιο τρόπο με αυτήν που πραγματοποιήθηκε για τις ιδιότητες τσιμέντου που παράχθηκε από το μύλο 1. Τα αποτελέσματα της μελέτης παρουσιάζονται στον παρακάτω πίνακα.

Πίνακας 5. 10 Ανάλυση δεδομένων ποιότητας τσιμέντου CEM II 42,5- Μύλος 4

	IR MT4	*Al2O3* MT4	*SiO2* MT4	*Λεπτότητα (Blaine)(cm³/gr)* MT4	*LOI (%w/w)* MT4	*Est1 (N/mm²)* MT4	*Est2 (N/mm²)* MT4	*Est7 (N/mm²)* MT4	*Est28 (N/mm²)* MT4
Κανονική κατανομή	Ναι	Ναί	Ναι	Ναί	Ναι	Ναί	Ναι	Ναί	Ναί
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές
$UCL_χ$	7,309	5,368	23,033	4409,48	5,981	15,767	27,968	46,699	56,46
$LCL_χ$	3,605	4,638	20,870	4100,52	3,678	11,128	21,674	33,574	48,58
$CTR_χ$	5,457	5,003	21,951	4255,0	4,829	13,448	24,821	40,136	52,52
Εκτός ορίων	0	1	1	0	2	2	1	0	0
UCL_R	2,276	0,449	1,330	189,858	1,415	2,851	3,868	8,065	4,838
LCL_R	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CTR_R	0,693	0,137	0,407	58,0851	0,433	0,872	1,183	2,467	1,48
Εκτός ορίων	0	2	0	1	2	1	0	0	2

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

4.1.2.2. Ποιότητα τσιμέντου OPC

Μύλος 1

Σε αντιστοιχία με την προηγούμενη μελέτη, πραγματοποιήθηκε στατιστικός έλεγχος και ανάλυση των χημικών, φυσικών και μηχανικών ιδιοτήτων του τσιμέντου τύπου OPC(=Ordinary Portland Cement). Παράλληλα, πραγματοποιήθηκε μελέτη της σύνθεσης αυτού του τύπου τσιμέντου.

Τα αποτελέσματα του στατιστικού ελέγχου παρουσιάζονται στους παρακάτω πίνακες.

Πίνακας 5. 11 Ανάλυση δεδομένων ποιότητας τσιμέντου OPC- Μύλος 3

	Al2O3 MT3	*SiO2* MT3	*Λεπτότητα (Blaine)(cm^3/gr)* MT3	*LOI (%w/w)* MT3	*Est1 (N/mm^2)* MT3	*Est2 (N/mm^2)* MT3	*Est7 (N/mm^2)* MT3	*Est28 (N/mm^2)* MT3
Κανονική κατανομή	Ναί	Όχι	Ναί	Όχι	Ναί	Ναι	Ναί	Ναί
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Κινητού μέσου	Μεμονωμένες τιμές	Κινητού μέσου	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές
$UCL_χ$	4,938	20,800	3770,68	1,276	20,567	32,281	47,664	65,922
$LCL_χ$	4,615	20,494	3562,75	1,028	15,425	26,064	40,278	58,700
$CTR_χ$	4,777	20,647	3666,72	1,152	17,997	29,172	43,971	62,310
Εκτός ορίων	9	0	2	3	2	1	0	0
UCL_R	0,199	0,564	127,773	0,457	3,1580	3,820	4,5386	4,438
LCL_R	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CTR_R	0,061	0,173	39,091	0,140	0,966	1,1688	1,389	1,358
Εκτός ορίων	1	3	2	1	1	1	0	2

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

Πίνακας 5. 12 Ανάλυση σύνθεσης, ποιότητας τσιμέντου OPC – Μύλος 3

	Clk (%) MT3	*Gyp (%)* MT3
Κανονική κατανομή	Ναι	Ναι
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Μεμονωμένες τιμές
Ανώτερο όριο ελέγχου ($UCL_χ$)	97,03	4,207
Κατώτερο όριο ελέγχου($LCL_χ$)	95,79	2,971
Στόχος ($CTR_χ$)	96,41	3,589
Εκτός ορίων	1	1
Ανώτερο όριο ελέγχου (UCL_R)	0,759	0,759
Κατώτερο όριο ελέγχου(LCL_R)	0,0	0,0
Στόχος (CTR_R)	0,232	0,232
Εκτός ορίων	2	2

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

Μύλος 4

Αντίστοιχα με τις παραπάνω αναλύσεις πραγματοποιήθηκαν αναλύσεις και για το μύλο 4. Τα αποτελέσματα φαίνονται παρακάτω.

Πίνακας 5. 13 Ανάλυση δεδομένων ποιότητας τσιμέντου OPC- Μύλος 4

	Al2O3 MT4	*SiO2* MT4	*Λεπτότητα (Blaine)(cm^3/gr)* MT4	*LOI (%w/w)* MT4	*Est1 (N/mm^2)* MT4	*Est2 (N/mm^2)* MT4	*Est7 (N/mm^2)* MT4	*Est28 (N/mm^2)* MT4
Κανονική κατανομή	Ναι	Ναι	Ναι	Όχι	Ναι	Ναι	Ναι	Ναι
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές	Μεμονωμένες τιμές
$UCL_χ$	4,851	20,99	3822,32	1,535	18,735	28,443	45,405	67,091
$LCL_χ$	4,537	20,253	3564,64	0,852	14,493	26,864	39,635	55,503
$CTR_χ$	4,694	20,621	3693,48	1,193	16,614	27,653	42,52	61,297
Εκτός ορίων	3	2	1	0	0	2	1	0
UCL_R	0,193	0,453	158,346	0,420	2,607	2,911	3,545	7,121
LCL_R	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CTR_R	0,059	0,139	48,444	0,128	0,798	0,890	1,085	2,179
Εκτός ορίων	1	2	1	0	0	1	0	0

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

Πίνακας 5. 14 Ανάλυση σύνθεσης, ποιότητας τσιμέντου OPC – Μύλος 4

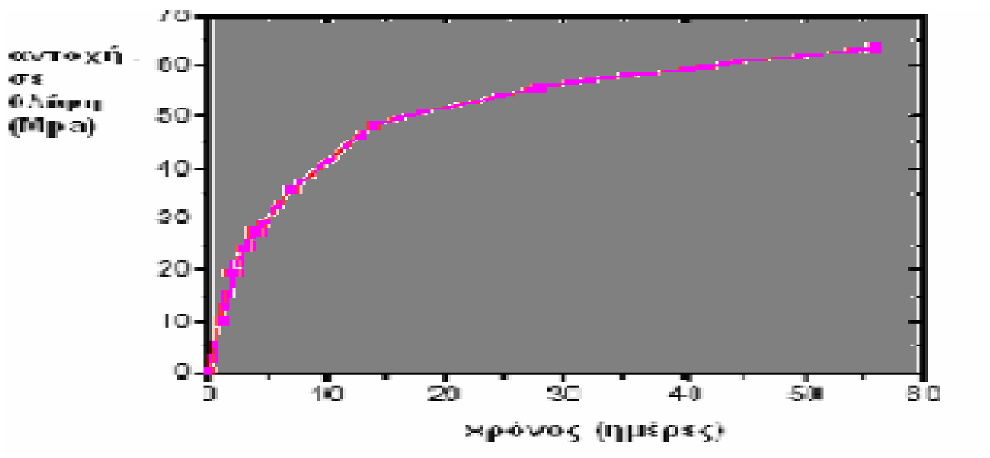
	Clk (%) MT4	*Gyp (%)* MT4
Κανονική κατανομή	Ναι	Ναι
Επιλογή χάρτη ελέγχου	Μεμονωμένες τιμές	Μεμονωμένες τιμές
Ανώτερο όριο ελέγχου ($UCL_χ$)	97,061	4,065
Κατώτερο όριο ελέγχου($LCL_χ$)	95,935	2,939
Στόχος ($CTR_χ$)	96,498	3,502
Εκτός ορίων	1	1
Ανώτερο όριο ελέγχου (UCL_R)	0,692	0,692
Κατώτερο όριο ελέγχου(LCL_R)	0,0	0,0
Στόχος (CTR_R)	0,212	0,212
Εκτός ορίων	1	1

$UCL_χ$: Ανώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$LCL_χ$: Κατώτατο όριο ελέγχου για τις μεμονωμένες τιμές
$CTR_χ$: Κεντρική γραμμή(μέση τιμή) για τις μεμονωμένες τιμές

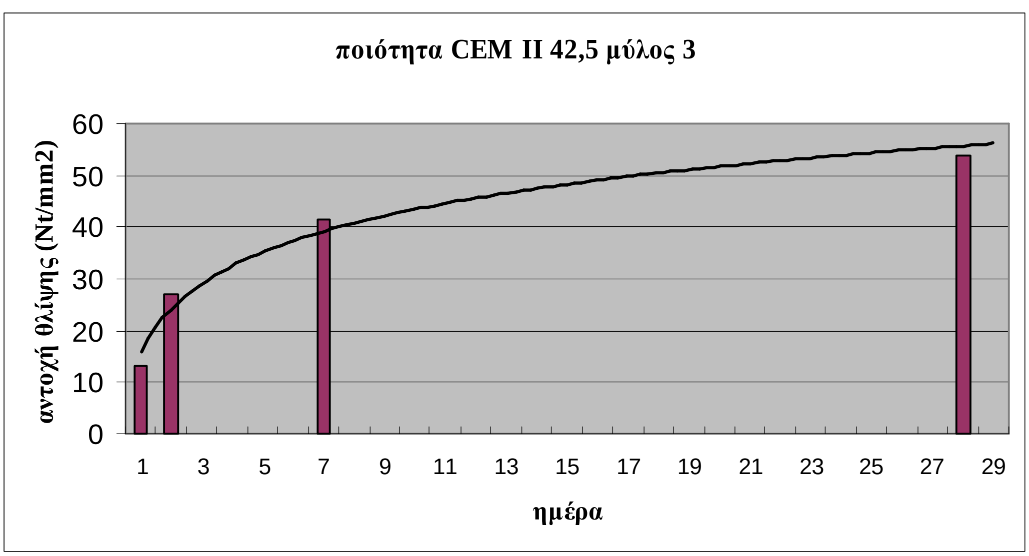
UCL_R :Ανώτατο όριο ελέγχου για το εύρος
LCL_R :Κατώτερο όριο ελέγχου για το εύρος
CTR_R: Κεντρική γραμμή(μέση τιμή) για το εύρος

4.1.3. Συμπεράσματα

Από την παραπάνω μελέτη φαίνεται ότι οι περισσότερες ιδιότητες ακολουθούν την κανονική κατανομή.
Σε ότι αφορά στις αντοχές, είναι ενδιαφέρον η μελέτη της επικρατούσας τιμής. Σε διάγραμμα αντοχών – χρόνου όπου μπορούν να φανούν οι αντοχές κατά την $1^{η}$, $2^{η}$, $7^{η}$ και $28^{η}$ ημέρα παρουσιάζεται μία καμπύλη η οποία ερμηνεύεται πλήρως από την κινητική . Η χημεία του τσιμέντου υπαγορεύει ότι οι αντοχές αυτού αυξάνονται κατά τρόπο όπως φαίνεται στο διάγραμμα 4.1. Τα αποτελέσματα των μετρήσεων, όπως φαίνεται από το διάγραμμα 4.2 αλλά και από τα διαγράμματα και των άλλων τύπων τσιμέντου που υπάρχουν στο παράρτημα Δ, πράγματι ακολουθούν τη γραφική παράσταση, που υπαγορεύει η θεωρία. [1]



Διάγραμμα5. 55 Σχέση αντοχής- χρόνου όπως περιγράφεται από τη θεωρία τσιμέντου



Διάγραμμα5. 56 Σχέση αντοχής- χρόνου όπως διαμορφώνεται από τα πειραματικά δεδομένα

4.2. Ανάλυση ικανότητας των διεργασιών

4.2.1. Σκοπός

Σκοπός της μελέτης είναι ο έλεγχος ικανοποίησης των ελάχιστων ορίων αντοχών όπως αυτές αναφέρονται στο πρότυπο prEN 197-1. Παράλληλα μελετάται η ικανοποίηση των ορίων για τις υπόλοιπες ιδιότητες του τσιμέντου.

4.2.2. προδιαγραφές

Το εργοστάσιο παράγει τσιμέντο σύμφωνα με τις προδιαγραφές που υπαγορεύουν τα πρότυπα prEN 196-1 και prEN 197-1[2]. Παράλληλα το εργοστάσιο θέτει και τους δικούς του στόχους και προδιαγραφές οι οποίες συμφωνούν με τα παραπάνω πρότυπα και ικανοποιούν και τους πελάτες τους.
Οι προδιαγραφές για τις φυσικές, χημικές και μηχανικές ιδιότητες του τσιμέντου παρουσιάζονται παρακάτω.

Πίνακας 5. 15 Φυσικές, χημικές και μηχανικές απαιτήσεις τσιμέντων σύμφωνα με το πρότυπο prEN197-1 και τους στόχους του εργοστασίου.

ΧΑΡΑΚΤ/ΚΑ	II/A-M 42,5 N		TYPE I/II USA			ΠΑΡΑΤΗΡΗΣΕΙΣ
	MT1,2	MT4	MT3	MT4	MT1,2	
Blaine (cm^2/gr) ΣΤΟΧΟΣ	4750	4300	3700	3700	3700	
Blaine MIN	4500	3900	3400	3400	3400	
Blaine MAX	-	-	3950	3950	3950	
SiO_2 ΣΤΟΧΟΣ (%κ.β)	22,5	22	20,3	20,3	20,3	
SiO_2 MIN	-		20,0	20,0	20,0	
Al_2O_3 ΣΤΟΧΟΣ (%κ.β.)	5,0	5,0	-	-	-	
Al_2O_3 MAX	-		-	-	-	
L.O.I. ΣΤΟΧΟΣ (%)	5,5	5,0	-	-	-	
L.O.I. MAX	-	-	2,0	2,0	2,0	
I.R. MAX (%)	-	-	0,7	0,7	0,7	
ΑΣΒ/ΘΟΣ (%)	10	16	-	-	-	

Αντοχές	II/A-M 42,5 N		TYPE I/II USA			ΠΑΡΑΤΗΡΗΣΕΙΣ
	MT1,2	MT4	MT3	MT4	MT1,2	
$2^{η}$ ημέρα						
ΣΤΟΧΟΣ	24		29			
MIN	22		27			
$7^{η}$ ημέρα						
ΣΤΟΧΟΣ	38		44			
MIN	36		42			
$28^{η}$ ημέρα						
ΣΤΟΧΟΣ	52		61			
MIN	50		59			

Σύνθεση	II/A-M 42,5 N		TYPE I/II USA			ΠΑΡΑΤΗΡΗΣΕΙΣ
	MT1,2	MT4	MT3	MT4	MT1,2	
Κλίνκερ(%)	81		96			
Ασβεστόλιθος(%)	10	16	-			
Γύψος(%)	5		5			
Ποζολάνη(%)	6,5		-			

4.2.3. Μέθοδος ανάλυσης ικανότητας

4.2.3.1. ανάλυση ικανότητας για τσιμέντο τύπου ΙΙ 42,5

φυσικές – χημικές ιδιότητες

Σε ότι αφορά στις φυσικές και χημικές ιδιότητες πραγματοποιήθηκε ανάλυση ικανότητας με όρια προδιαγραφών (Upper Specification Limit –Lower Specification Limit) όπως ορίζονται από τους παραπάνω πίνακες. Τα αποτελέσματα παρουσιάζονται παρακάτω

Πίνακας 5. 16 Ανάλυση ικανότητας για τσιμέντοII 42,5 και μεταβλητή Al_2O_3

Al_2O_3 (% κ.β)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο	6,6	0%	0%	0,00
	Στόχος	5,6			
	Κάτω όριο	4,6	0%	0,028001%	280,01
MT4	Άνω όριο	6,6	0%	0 %	
	Στόχος	5,6			
	Κάτω όριο	4,6	0%	0,898144%	8981,44

Πίνακας 5. 17 Ανάλυση ικανότητας για τσιμέντο ΙΙ 42,5 και μεταβλητή SiO_2

SiO_2 (%κ.β)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο	25	0%	0%	0,00
	Στόχος	22,5			
	Κάτω όριο	-	-	-	-
MT4	Άνω όριο	25	0%	0%	0,00
	Στόχος	22			
	Κάτω όριο	-	-	-	-

Πίνακας 5. 18 Ανάλυση ικανότητας για τσιμέντο ΙΙ 42,5 και για μεταβλητή Blaine

Blaine(cm^3/gr)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο	-	-	-	-
	Στόχος	4750			
	Κάτω όριο	4500	0%	0%	-
MT4	Άνω όριο	-			
	Στόχος	4300			
	Κάτω όριο	3900	0%	0%	-

Για τις υπόλοιπες ιδιότητες δεν υπάρχουν σαφή όρια στις προδιαγραφές.

Μηχανικές ιδιότητες – αντοχές

Πίνακας 5. 19Ανάλυση ικανότητας για τσιμέντο II 42,5 και για τη μεταβλητή Est2

Est2(Nt/mm^2)		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο		-	-	-
	Στόχος	24			
	Κάτω όριο	22	0%	0,620075%	6200,75
MT4	Άνω όριο				
	Στόχος	24			
	Κάτω όριο	22	2,272727%	1,787073%	17870,73

Πίνακας 5. 20 Ανάλυση ικανότητας για τσιμέντο II 42,5 και για τη μεταβλητή Est7

Est7(Nt/mm^2)		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο		-	-	-
	Στόχος	38			
	Κάτω όριο	36	2,173913%	1,060872%	10608,72
MT4	Άνω όριο				
	Στόχος	38			
	Κάτω όριο	36	2,222222%	3,673247%	36732,47

Πίνακας 5. 21 Ανάλυση ικανότητας για τσιμέντο II 42,5 και μεταβλητή Est28

Est28(Nt/mm^2)		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT1	Άνω όριο		-	-	-
	Στόχος	52			
	Κάτω όριο	50	0%	1,067575%	10675,75
MT4	Άνω όριο				
	Στόχος	52			
	Κάτω όριο	50	5,405405%	5,610550%	56105,50

Μύλος 1

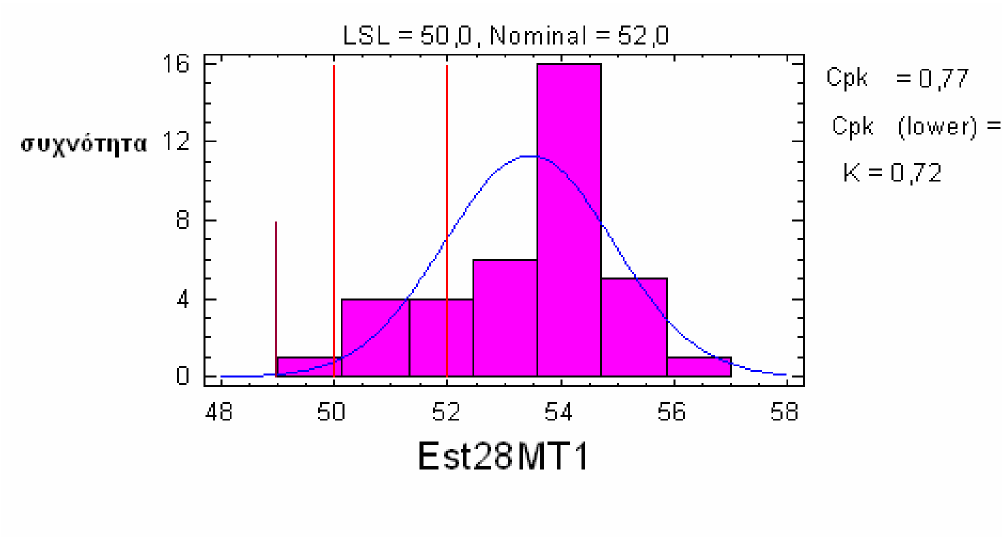
Το πλήθος του δείγματος, η μέση τιμή και η τυπική απόκλιση των τιμών φαίνονται παρακάτω.

```
     Πλήθος δείγματος = 37
     Μέση τιμή = 53,4351
     Τυπική απόκλιση = 1,49243

Όρια 6,0 σίγμα
     +3,0 σ = 57,9124
     Μέση τιμή= 53,4351
     -3,0 σ = 48,9579
```

επίσης υπολογίζονται οι δείκτες ικανότητας της διεργασίας

```
Cp =
Cpk = 0,767236
Cpk (ανώτερο) =
Cpk (κατώτερο) = 0,767236
K = 0,717568
```



Διάγραμμα5. 57 Έλεγχος ικανότητας για τη μεταβλητή EST28MT1

Μύλος 4

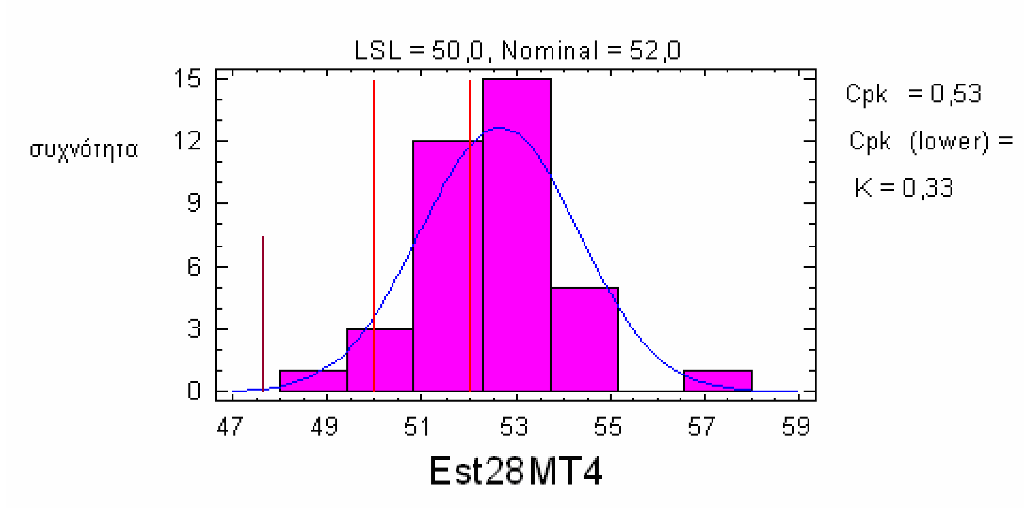
Το πλήθος του δείγματος, η μέση τιμή και η τυπική απόκλιση των τιμών φαίνονται παρακάτω.

```
     Πλήθος δείγματος = 37
     Μέση τιμή = 52,6514
     Τυπική απόκλιση = 1,66927

Όρια 6,0 σίγμα
     +3,0 σίγμα = 57,6592
     μέση τιμή = 52,6514
     -3,0 σίγμα = 47,6435
```

επίσης υπολογίζονται οι δείκτες ικανότητας της διεργασίας

```
Cp =
Cpk = 0,529444
Cpk (ανώτερο) =
Cpk (κατώτερο) = 0,529444
K = 0,325676
```



Διάγραμμα5. 58 Έλεγχος ικανότητας για τη μεταβλητή Est28MT4

4.2.3.2. ανάλυση ικανότητας για τσιμέντο τύπου OPC

<u>φυσικές – χημικές ιδιότητες</u>

Σε ότι αφορά στις φυσικές και χημικές ιδιότητες πραγματοποιήθηκε ανάλυση ικανότητας με όρια προδιαγραφών (Upper Specification Limit –Lower Specification Limit) όπως ορίζονται από τους παραπάνω πίνακες. Τα αποτελέσματα παρουσιάζονται παρακάτω

Πίνακας 5. 22Ανάλυση ικανότητας για τσιμέντο OPCκαι μεταβλητή SiO_2

SiO_2 (% κ.β)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο				
	Στόχος	20,3			
	Κάτω όριο	20	0%	0,138797%	1387,97
MT4	Άνω όριο				
	Στόχος	20,3			
	Κάτω όριο	20	0%	0,023663%	236,63

Πίνακας 5. 23Ανάλυση ικανότητας για τσιμέντο OPC και μεταβλητή LOI

LOI		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο	2	0%	0%	0,00
	Στόχος	-			
	Κάτω όριο	-	-	0,000001%	0,01
MT4	Άνω όριο	2	0%	0%	0,00
	Στόχος	-			
	Κάτω όριο	-	-	-	-

Πίνακας 5. 24Ανάλυση ικανότητας για τσιμέντο OPC και μεταβλητή Blaine

Blaine(cm^3/gr)		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο	3950	-	0,000024%	0,24
	Στόχος	3700			
	Κάτω όριο	3400	0%	0,000095%	0,95
MT4	Άνω όριο	3950	-	0,000021%	0,21
	Στόχος	3700			
	Κάτω όριο	3400	0%	0,000001%	0,01

Για τις υπόλοιπες ιδιότητες δεν υπάρχουν σαφή όρια στις προδιαγραφές.

Μηχανικές ιδιότητες – αντοχές

Πίνακας 5. 25 Ανάλυση ικανότητας για τσιμέντο και μεταβλητή Est2

Est2(Nt/mm^2)		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο		-	-	-
	Στόχος	29			
	Κάτω όριο	27	1,562500%	3,937152%	39371,52
MT4	Άνω όριο				
	Στόχος	29			
	Κάτω όριο	27	6,976744%	24,362716%	243627,16

Πίνακας 5. 26 Ανάλυση ικανότητας για τσιμέντο και μεταβλητή Est7

Est7(Nt/mm^2)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο		-	-	-
	Στόχος	44			
	Κάτω όριο	42	8,196721%	9,896309%	98963,09
MT4	Άνω όριο				
	Στόχος	44			
	Κάτω όριο	42	32,500000%	34,086518%	340865,18

Πίνακας 5. 27Ανάλυση ικανότητας για τσιμέντο και μεταβλητή Est28

Est28(Nt/mm^2)					
		Προδιαγραφές	Παρατηρούμενα εκτός προδιαγραφών	Υπολογιζόμενα εκτός ορίων	Εκτός ορίων ανά εκατομμύριο
MT3	Άνω όριο		-	-	-
	Στόχος	61			
	Κάτω όριο	59	0%	0,905142%	9051,42
MT4	Άνω όριο				
	Στόχος	61			
	Κάτω όριο	59	17,241379%	14,870375%	148703,75

Μύλος 3

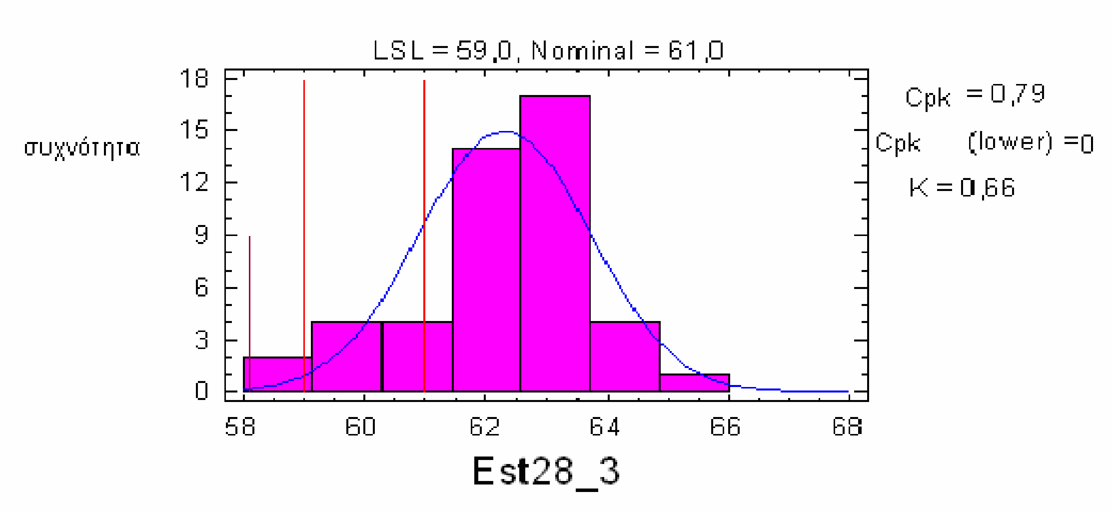
Το πλήθος του δείγματος, η μέση τιμή και η τυπική απόκλιση των τιμών φαίνονται παρακάτω.

```
    Πλήθος δείγματος = 46
    Μέση τιμή = 62,3109
    Τυπική απόκλιση = 1,40083

Όρια 6,0 σίγμα
    +3,0 σ = 66,5134
    μέση τιμή = 62,3109
    -3,0 σ = 58,1084
```

επίσης υπολογίζονται οι δείκτες ικανότητας της διεργασίας

```
Cp =
Cpk = 0,787835
Cpk (ανώτερο) =
Cpk (κατώτερο) = 0,787835
K = 0,655435
```



Διάγραμμα5. 59 Έλεγχος ικανότητας για τη μεταβλητή Est28MT3

Μύλος 4

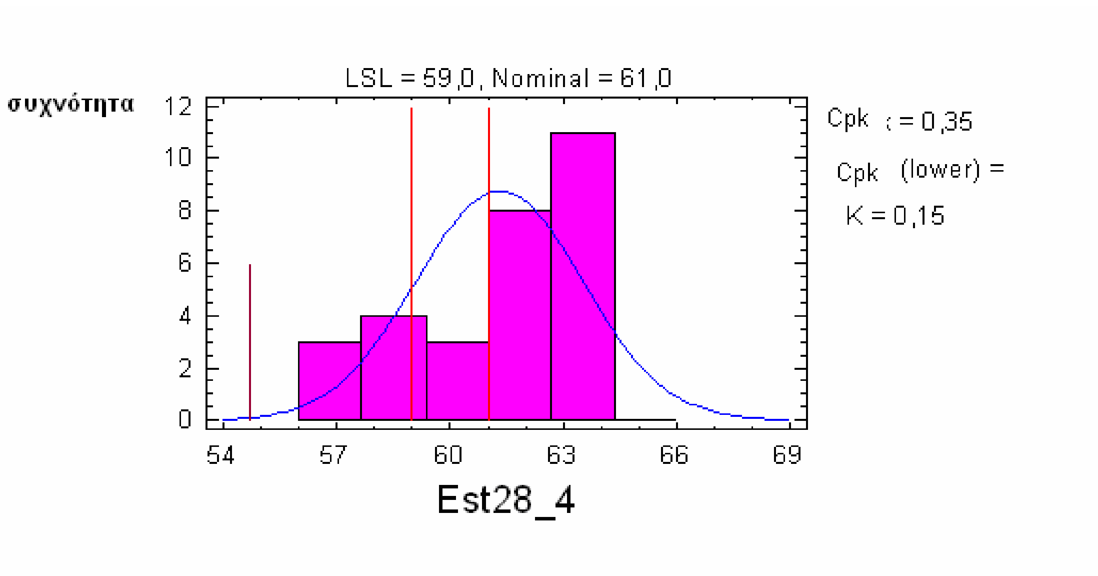
Το πλήθος του δείγματος, η μέση τιμή και η τυπική απόκλιση των τιμών φαίνονται παρακάτω.

```
Πλήθος δείγματος = 29
     Μέση τιμή = 61,2966
     Τυπική απόκλιση = 2,20397

Όρια 6,0 σίγμα
     +3,0 σ = 67,9085
     μέση τιμή= 61,2966
     -3,0 σ = 54,6846
```

επίσης υπολογίζονται οι δείκτες ικανότητας της διεργασίας

```
Cp =
Cpk = 0,347335
Cpk (ανώτερο) =
Cpk (κατώτερο) = 0,347335
K = 0,148276
```



Διάγραμμα5. 60 Έλεγχος ικανότητας για τη μεταβλητή Est28MT4

4.2.4. Συμπεράσματα

Κύριο μέλημα της παραγωγικής διαδικασίας είναι η παραγωγή τσιμέντου, το οποίο θα εναρμονίζεται ως προς τις αντοχές με τις απαιτήσεις, όπως αυτές καθορίζονται από το πρότυπο prEN 197-1. Για το λόγο αυτό και παρουσιάζεται αναλυτικότερα η ανάλυση ικανότητας της παραγωγής τσιμέντου με τις προβλεπόμενες αντοχές κατά την 28^{η} ημέρα.

Παρατηρείται ότι μερικές από τις φυσικές και χημικές ιδιότητες δεν εναρμονίζονται πλήρως στις απαιτήσεις του προτύπου, με αποτέλεσμα ένα ποσοστό του παραγόμενου τσιμέντου να καθίσταται εκτός προδιαγραφών σε ότι αφορά σε αυτές τις ιδιότητες. Το κρίσιμο σημείο μελέτης παρόλαυτά αποτελεί η αντοχή του τσιμέντου κατά τις 28 ημέρες.

Για το μύλο 4 και για τον τύπο τσιμέντου CEM II 42,5 θα πρέπει να επισημανθεί ότι ενώ οι περισσότερες από τις ιδιότητες δε φαίνεται να αποκλίνουν σημαντικά από τις προδιαγραφές, εντούτοις οι τελικές ιδιότητες παρουσιάζονται μειωμένες συγκριτικά με τις απαιτούμενες. Από την παρατήρηση αυτή διεξάγεται το συμπέρασμα ότι εκτός των ιδιοτήτων που αναλύθηκαν, οι αντοχές του τσιμέντου κατά την 28^{η} ημέρα εξαρτώνται και από άλλους παράγοντες.

Η μελέτη μάλιστα των αντοχών τσιμέντου που παράγεται από τον 4^{ο} μύλο και τσιμέντου που παράγεται από τον 3^{ο} μύλο, καθιστά φανερή την επίδραση των τεχνικών χαρακτηριστικών των μύλων στις τελικές μηχανικές ιδιότητες του τσιμέντου. Κάτι τέτοιο ενισχύεται και από το γεγονός ότι οι δύο μύλοι διαφέρουν καθώς ο μύλος 4 είναι ένας κάθετος μύλος με τελείως διαφορετική τεχνολογία από τους υπόλοιπους.

Σε ότι αφορά στο τσιμέντο τύπου OPC, θα πρέπει να τονισθεί ότι ενώ έως και την 7^{η} ημέρα το παραγόμενο τσιμέντο σε ποσοστό 10% για τον μύλο 3 και 34% για τον μύλο 4 δεν προσεγγίζουν τις αναμενόμενες αντοχές, κατά την 28^{η} ημέρα τα νούμερα αυτά μεταβάλλονται. Πιο συγκεκριμένα, τα μη συμμορφούμενα με τις προδιαγραφές μειώνονται σε 1% για τον μύλο 3και 15% περίπου για τον μύλο 4. Αυτή η παρατήρηση δικαιολογείται απόλυτα από το γεγονός ότι για την παραγωγή αυτού του τύπου τσιμέντου χρησιμοποιούνται βελτιωτικά τα οποία ενεργούν μετά την 7^{η} ημέρα.

Η διαπίστωση ότι οι φυσικές και χημικές ιδιότητες αποτελούν κάποιους αλλά όχι τους μοναδικούς παράγοντες που επιδρούν στη διαμόρφωση των αντοχών του τσιμέντου, καθιστά απαραίτητη τη μελέτη της συσχέτισης των ιδιοτήτων αυτών με τις μηχανικές ιδιότητες.

4.3. Παλινδρόμηση και συσχέτιση των μεταβλητών

4.3.1. Σκοπός της μελέτης

Στόχο αποτελεί η εύρεση της όποιας σχέσης υπάρχει μεταξύ των αντοχών των τσιμέντων διαφόρων ημερών και των χημικών και φυσικών ιδιοτήτων αυτών.

4.3.2. Ποιότητα τσιμέντου CEM II 42,5

4.3.2.1. Συσχέτιση ανεξάρτητων μεταβλητών – μύλος 1

Προτού πραγματοποιηθεί η ανάλυση των αντοχών και η μελέτη συσχέτισης με τις ιδιότητες του τσιμέντου, κρίνεται απαραίτητο να πραγματοποιηθεί μελέτη συσχέτισης μεταξύ των χημικών και φυσικών ιδιοτήτων του τσιμέντου. Οι ιδιότητες αυτές θα αποτελέσουν τις ανεξάρτητες μεταβλητές στο προτεινόμενο μοντέλο για τον προσδιορισμό των αντοχών.

Πιο συγκεκριμένα μελετάται η συσχέτιση μεταξύ των μεταβλητών **Al_2O_3, SiO_2, Blaine, Loss Of Ignition(LOI), IR.**

Από τη μελέτη προέκυψαν τα παρακάτω αποτελέσματα που παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Pearson, επειδή έχει αποδειχθεί στο κεφάλαιο 4.1.2.1 η καλή προσαρμογή των δεδομένων στην κανονική κατανομή).

Πίνακας 5. 28 ***Συσχετίσεις ανεξάρτητων μεταβλητών***

	Al2O3MT1	BLAINEMT1	IRMT1	LOIMT1	SiO_2 MT1
Al2O3MT1		-0,1341 (47) 0,3688	**0,4813** (47) **0,0006**	**0,3980** (47) **0,0056**	**0,6129** (47) 0,0000
BLAINEMT1	-0,1341 (47) 0,3688		0,0576 (47) 0,7006	0,1563 (47) 0,2942	-0,1057 (47) 0,4794
IRMT1	**0,4813** (47) **0,0006**	0,0576 (47) 0,7006		**0,4355** (47) **0,0022**	**0,6487** (47) **0,0000**
LOIMT1	**0,3980** (47) **0,0056**	0,1563 (47) 0,2942	0,4355 (47) 0,0022		0,1229 (47) 0,4105
SiO MT1	**0,6129** (47) **0,0000**	-0,1057 (47) 0,4794	**0,6487** (47) **0,0000**	0,1229 (47) 0,4105	

Όπως φαίνεται από τον παραπάνω πίνακα υπάρχει συσχέτιση μεταξύ των μεταβλητών :

Al2O3MT1 και IRMT1

Al2O3MT1 και LOIMT1

Al2O3MT1 και SiO_2 MT1

IRMT1 και LOIMT1

IRMT1 και SiO_2 MT1

4.3.2.2. Αντοχές πρώτης ημέρας – μύλος 1

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

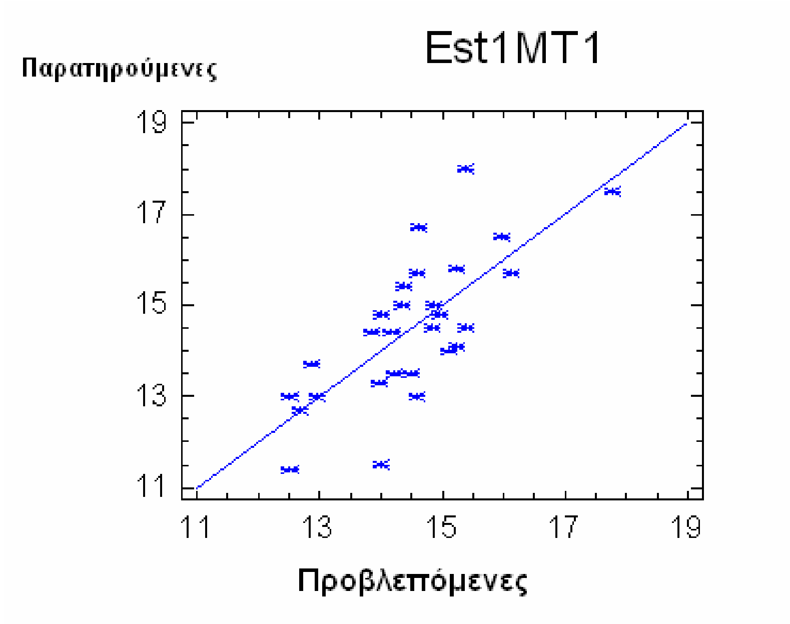
Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την πρώτη ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI), IR.** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές:
LOI, BLAINE και IR.
Το τελικό μοντέλο που προκύπτει από τη διαδικασία είναι :
Est1MT1 = -96,0784 + 0,0258737*BLAINEMT1 - 0,961588*IRMT1 – 1,40371*LOIMT1
και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 29 Πολλαπλή παλινδρόμηση για την εξαρτημένη μεταβλητή Est1MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
CONSTANT	-96,0784	42,6785	-2,25121	0,0338
BLAINEMT1	0,0258737	0,00903367	2,86414	0,0085
IRMT1	-0,961588	0,295551	-3,25354	0,0034
LOIMT1	-1,40371	0,675116	-2,07922	0,0485

Όπως φαίνεται και παραπάνω τα P-values είναι μικρότερα του 0,05. Άρα οι συντελεστές είναι στατιστικά σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης. Στο ακόλουθο διάγραμμα (διάγραμμα 4.61), απεικονίζονται οι παρατηρούμενες τιμές των αντοχών της πρώτης ημέρας σε σχέση με τις προβλεπόμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 61 Σύγκριση παρατηρούμενων – προβλεπόμενων τιμών για τη μεταβλητή Est1MT1

Πίνακας 5. 30 ανάλυση διασποράς για το προτεινόμενο μοντέλο (Est1MT1)

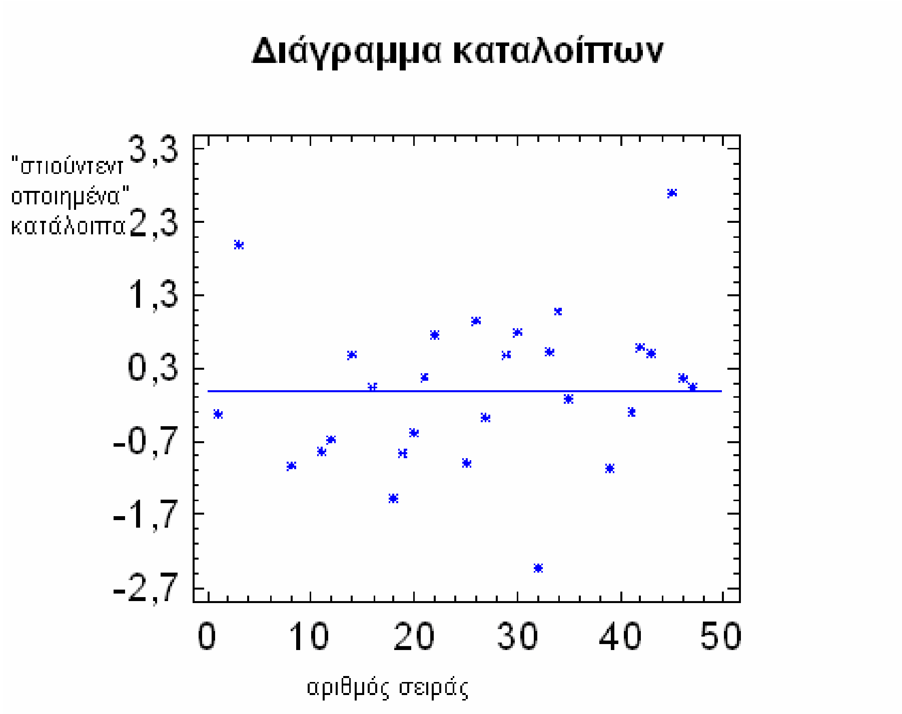
	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
Model	36,9057	3	12,3019	9,13	0,0003
κατάλοιπα	32,3414	24	1,34756		
Total (Corr.)	69,2471	27			

R^2 = 53,2957 %
R^2 (προσαρμοσμένα σε β.ε.) = 47,4577 %
Τυπική απόκλιση εκτίμησης. = 1,16084
Μέση τιμή απόλυτου σφάλματος = 0,8467
Durbin-Watson στατιστική συνάρτηση= 2,1273 (P=0,3204)
Lag 1 αυτοσυσχέτιση κατάλοιπων = -0,0649478

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 53,2957% τη μεταβλητότητα της αντοχής Est1MT1.

Η τιμή P-value του Durbin-Watson είναι 0,3204>0,05. Άρα δεν υπάρχει ένδειξη αυτοσυσχέτισης των κατάλοιπων.

Από την κατανομή μάλιστα των κατάλοιπων (διάγραμμα 4.62), επιβεβαιώνεται ότι τα κατάλοιπα δεν ακολουθούν ένα συγκεκριμένο πρότυπο.

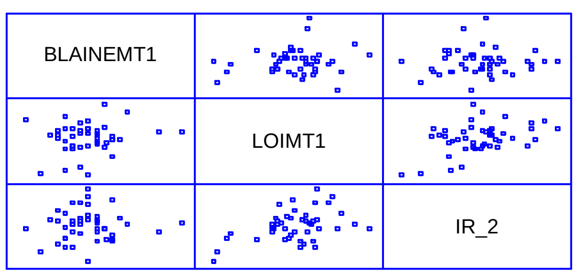


Διάγραμμα5. 62 Διάγραμμα κατάλοιπων

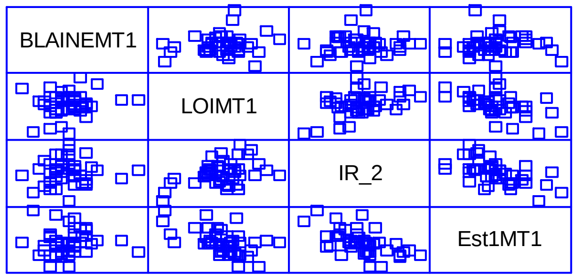
Η τιμή P-value του πίνακα ανάλυσης είναι 0,0003< 0,01 υπάρχει η ένδειξη στατιστικά σημαντικής συσχέτισης μεταξύ των συντελεστών του μοντέλου.

Συσχέτιση

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στα επόμενα γραφήματα



Διάγραμμα5. 63 Συσχέτιση ανεξάρτητων μεταβλητών



Διάγραμμα5. 64 Συσχέτιση ανεξάρτητων- εξαρτημένων μεταβλητών

καθώς και στον πίνακα που ακολουθεί

Πίνακας 5. 31 συσχετίσεις ανεξάρτητων – εξαρτημένης (Est1MT1)μεταβλητής

	BLAINEMT1	LOIMT1	IRMT1	Est1MT1
BLAINEMT1		0,1737 (46) 0,2484	0,0661 (46) 0,6624	0,0279 (46) 0,8542
LOIMT1	0,1737 (46) 0,2484		0,4336 (46) 0,0026	-0,5266 (46) 0,0002
IRMT1	0,0661 (46) 0,6624	**0,4336** (46) **0,0026**		-0,5779 (46) 0,0000
Est1MT1	0,0279 (46) 0,8542	**-0,5266** (46) **0,0002**	**-0,5779** (46) **0,0000**	

συσχέτιση
(αριθμός δείγματος)
P-τιμή

Ο παραπάνω πίνακας παρουσιάζει τις συσχετίσεις κατά Spearman.Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%. Οι μεταβλητές οι οποίες φαίνεται να συσχετίζονται μεταξύ τους είναι η IR και η LOI, αφού η τιμή P είναι 0,0258<0,05, αλλά και οι Est1 με τη LOI και την IR. Από τον παραπάνω πίνακα δεν παρουσιάζεται συσχέτιση της μεταβλητής BLAINE με τη μεταβλητή Est1.

Για τη συσχέτιση μεταξύ των μεταβλητών IR και LOI πραγματοποιείται απλή γραμμική παλινδρόμηση η οποία δίνει ως αποτέλεσμα ότι οι δύο μεταβλητές σχετίζονται μεταξύ τους σε επίπεδο εμπιστοσύνης 99 % με καλύτερο μοντέλο το ακόλουθο

IRMT1 = 1/(0,0324261 + 0,686419/LOIMT1)

το οποίο περιγράφει τη μεταβλητότητα του IR σε σχέση με τη μεταβλητή LOI κατά 25,6518%

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Είναι γνωστό ότι σε μια παραγωγική διαδικασία όπως είναι η παραγωγή τσιμέντου, όλοι οι παράγοντες που σχετίζονται με τα τελικά αποτελέσματα είναι ιδιαίτερα σημαντικοί. Προσδιορίζεται λοιπόν ένα γραμμικό μοντέλο συσχέτισης όλων των μεταβλητών οι οποίες δύναται να επηρεάσουν τις αντοχές του τσιμέντου και μελετάται το ποσοστό σημαντικότητας κάθε μεταβλητής στο μοντέλο.

Η πολλαπλή παλινδρόμηση δίνει το παρακάτω μοντέλο

Est1MT1 = 30,4443 - 1,61101*Al2O3_2 + 0,00385866*BLAINEMT1 - 0,496853*IRMT1 - 1,47793*LOIMT1 - 0,68055*SiO_2 ^{MT1}

Το μοντέλο περιγράφει την μεταβολή της μεταβλητής Est1 κατά 49,0043%. Δεδομένου ότι η τιμή p του μοντέλου είναι μικρότερη του 0,01 φαίνεται ότι υπάρχει συσχέτιση μεταξύ των μεταβλητών .

Περαιτέρω μελέτη των μεταβλητών δείχνει ότι στο μοντέλο παρουσιάζεται πολυσυγγραμικότητα, δεδομένου ότι οι μεταβλητές σχετίζονται μεταξύ τους. Πιο συγκεκριμένα οι μεταβλητές που φαίνεται να έχουν γραμμική συσχέτιση μεταξύ τους είναι αυτή που εκφράζει το ποσοστό SiO_2 με τη μεταβλητή που εκφράζει το ποσό αδιάλυτου υπολείμματος IR.

Αν υπάρχει επιθυμία απλοποίησης του παραπάνω μοντέλου, τότε θα πρέπει να μελετηθούν οι τιμές p κάθε μεταβλητής και να εξαιρεθούν αυτές με τιμή p μεγαλύτερη του 0,1. Μια τέτοια μελέτη θα οδηγούσε στο μοντέλο που προέκυψε από την ανιούσα επιλογή(forward selection).

4.3.2.3. Αντοχές 2^{ης} ημέρας – μύλος 1

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την 7^{η} ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI), IR.** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

Με τη χρήση «forward selection» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές:
Al_2O_3 και IR

Το τελικό μοντέλο που προκύπτει είναι:
Est2MT1 = 48,3906 - 3,22561*Al2O3MT1 - 0,817849*IRMT1

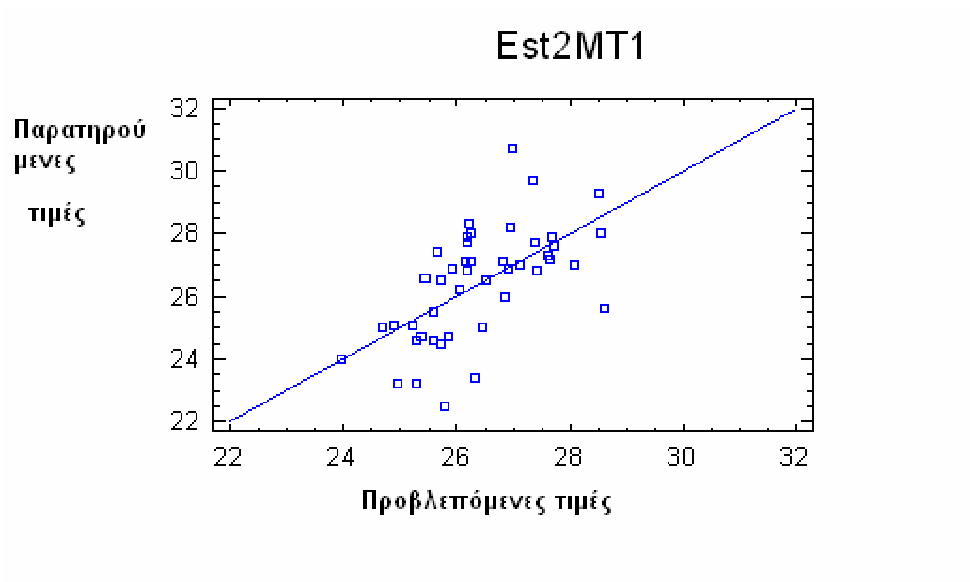
Και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 32 Ανάλυση διασποράς για το μοντέλο Est2MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
CONSTANT	48,3906	6,26672	7,72185	0,0000
Al2O3MT1	-3,22561	1,32854	-2,42793	0,0194
IRMT1	-0,817849	0,323689	-2,52665	0,0153

Όπως φαίνεται και παραπάνω τα P-values είναι μικρότερα του 0,05. Άρα οι συντελεστές είναι στατιστικά σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης και δε θα έπρεπε να αφαιρεθεί άλλος συντελεστής.

Στο ακόλουθο διάγραμμα, απεικονίζονται οι παρατηρούμενες τιμές των αντοχών της δεύτερης ημέρας σε σχέση με τις προβλεπόμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 65 Διάγραμμα παρατηρούμενων- προβλεπόμενων τιμών

Από την ανάλυση διασποράς προκύπτει

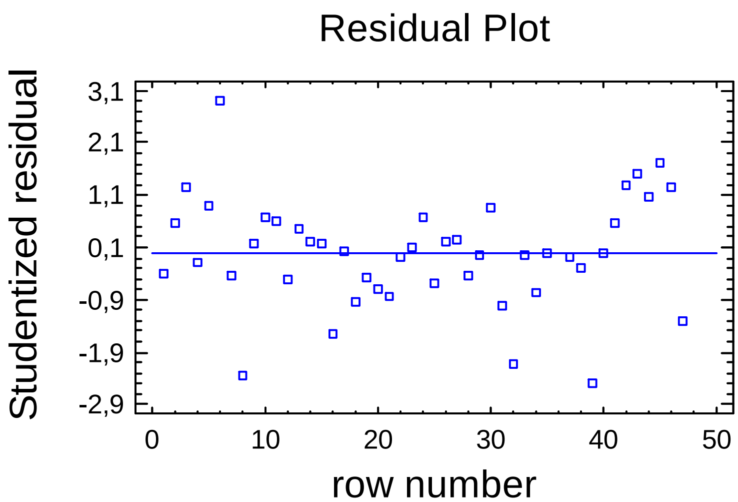
Πίνακας 5. 33 Ανάλυση διασποράς για το μοντέλο προσδιορισμού της μεταβλητής Est2MT1

Source	άθροισμα τετραγώνων	β.ε.	$\overline{X}^2$	F-αναλογία	P-τιμή
μοντέλο	51,207	2	25,6035	12,40	0,0001
κατάλοιπα	88,8176	43	2,06552		
τελικό (συσχ.)	140,025	45			

R^2 = 36,57 percent
R^2 (προσαρμοσμένο στους β.ε.) = 33,6198 %
Τυπικό σφάλμα εκτ. = 1,43719
Μέσο απόλυτο σφάλμα = 1,04148
Durbin-Watson = 1,4573 (P=0,0191)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,252017

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 33,6198% της μεταβλητότητας της αντοχής Est2MT1.

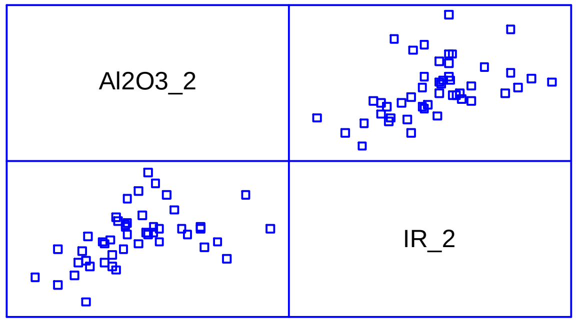
Η τιμή P-value του Durbin-Watson είναι 0,0191<0,05. Θα πρέπει λοιπόν να αναλυθεί εάν υπάρχει αυτοσυσχέτιση των κατάλοιπων. Από το διάγραμμα που ακολουθεί δεν μπορεί να εξαχθεί ασφαλές συμπέρασμα ότι τα κατάλοιπα αυτοσυσχετίζονται.



Διάγραμμα5. 66 Διάγραμμα κατάλοιπων

Συσχέτιση

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στα επόμενα γραφήματα



Διάγραμμα5. 67 Διάγραμμα συσχετίσεων ανεξάρτητων μεταβλητών

καθώς και στον πίνακα που ακολουθεί

Πίνακας 5. 34 Συσχετίσεις

	Al2O3MT1	IRMT1	Est2MT1
Al2O3MT1		**0,5048** (46) **0,0003**	**-0,5211** (46) **0,0002**
IRMT1	**0,5048** (46) **0,0003**		**-0,5280** (46) **0,0002**
Est2MT1	**-0,5211** (46) **0,0002**	**-0,5280** (46) **0,0002**	

Ο παραπάνω πίνακας (3.44) παρουσιάζει τις συσχετίσεις κατά Pearson αφού από την παράγραφο 4.1.2.1. φαίνεται ότι τα δεδομένα προσαρμόζονται καλά στην κανονική κατανομή. Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%. Οι μεταβλητές οι οποίες φαίνεται να συσχετίζονται μεταξύ τους είναι η IR και η Al_2O_3, αφού η τιμή P είναι 0,0003<0,05, αλλά και οι Est2 με τη Al_2O_3 και την IR.

Για περαιτέρω μελέτη της συσχέτισης μεταξύ των μεταβλητών IR και η Al_2O_3 πραγματοποιείται γραμμική απλή παλινδρόμηση. Τα αποτελέσματα αυτής της παλινδρόμησης αποδεικνύουν ότι οι δύο μεταβλητές σχετίζονται μεταξύ τους σε επίπεδο εμπιστοσύνης 99% και το μοντέλο το οποίο περιγράφει καλύτερα τη σχέση μεταξύ τους είναι το ακόλουθο:

IR_2 = 1/(-0,139334 + 1,62526/Al2O3_2)

Το παραπάνω μοντέλο περιγράφει τη σχέση μεταξύ των μεταβλητών IR και Al_2O_3 κατά 27,8742 %.

__πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών__

Στην προσπάθεια προσδιορισμού ενός μοντέλου το οποίο θα συσχετίζει όλες τις μεταβλητές πραγματοποιήθηκε πολλαπλή παλινδρόμηση και το μοντέλο που προέκυψε ήταν το παρακάτω:

Est2MT1 = 1,68222 - 2,29699*Al2O3MT1 + 0,0108423*BLAINEMT1 - 0,662723*IRMT1 - 0,947734*LOIMT1 - 0,276071* $SiO_2{}^{MT1}$

Η p τιμή του μοντέλου είναι μικρότερη του 0,01 και κατά συνέπεια η συσχέτιση μεταξύ των μεταβλητών είναι σημαντική.
Το μοντέλο περιγράφει κατά 42,7258% την μεταβλητότητα των αντοχών τσιμέντου δεύτερης ημέρας. Στο συγκεκριμένο μοντέλο εμφανίζεται πολυσυγγραμικότητα λόγω της σχέσης που φαίνεται να υπάρχει μεταξύ των μεταβλητών SiO_2 – IR.

4.3.2.4. Αντοχές $7^{ης}$ ημέρας – μύλος1

__πολλαπλή παλινδρόμηση-ανιούσα επιλογή__

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την $7^{η}$ ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI), IR.** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

Με τη χρήση «forward selection» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές:
LOI, Al_2O_3 και IR.

Το τελικό μοντέλο που προκύπτει από τη διαδικασία είναι :
Est7MT1 = 67,422 - 4,16081*Al2O3MT1 - 0,779985*IRMT1

και δικαιολογείται από τον παρακάτω πίνακα

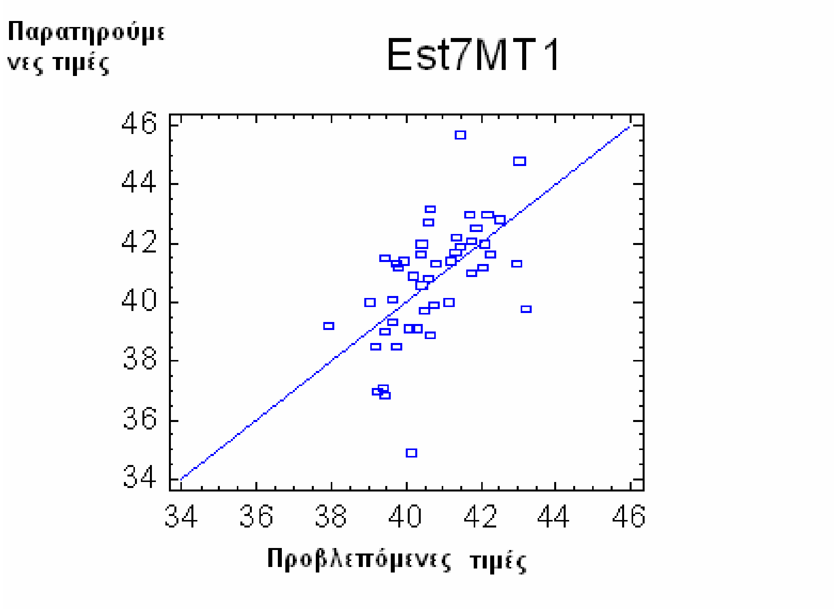
εξαρτώμενη μεταβλητή: Est7MT1

Πίνακας 5. 35 Πολλαπλή παλινδρόμηση για το μοντέλο Est7MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
CONSTANT	67,422	7,44241	9,05917	0,0000
Al2O3MT1	-4,16081	1,57779	-2,63712	0,0116
IRMT1	-0,779985	0,384416	-2,02901	0,0487

Όπως φαίνεται και παραπάνω τα P-values είναι μικρότερα του 0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης και δε θα έπρεπε να αφαιρεθεί άλλος συντελεστής.

Στο ακόλουθο διάγραμμα (Plot of Est7MT1), απεικονίζονται οι πραγματικές τιμές των αντοχών της έβδομης ημέρας σε σχέση με τις εκτιμώμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 68 Διάγραμμα παρατηρούμενων- προβλεπόμενων τιμών

Πίνακας 5. 36 Ανάλυση διασποράς για το μοντέλο Est7MT1

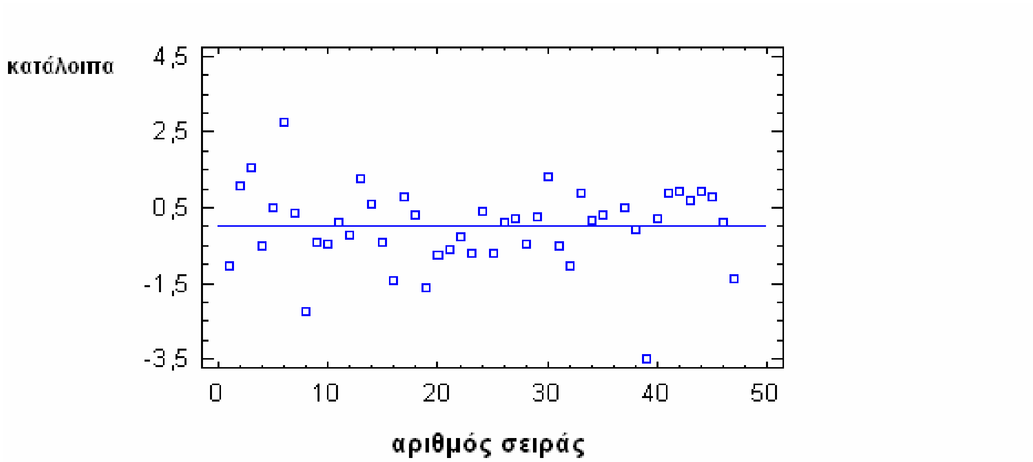
Source	άθροισμα τετραγώνων	β.ε.	$\overline{X^2}$	F-λόγος	P-τιμή
μοντέλο	64,4079	2	32,204	11,05	0,0001
κατάλοιπα	125,269	43	2,91324		
συνολικό (συσχ.)	189,677	45			

R^2 = 33,9566%
R^2 (προσαρμοσμένο στους β.ε.) = 30,8848 %
Τυπικό σφάλμα εκτίμησης. = 1,70682
Μέσο απόλυτο σφάλμα = 1,27334
Durbin-Watson = 1,73621 (P=0,1401)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,101407

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 33,9566% της μεταβλητότητας της αντοχής Est7MT1.

Η τιμή P-value του Durbin-Watson είναι 0,1401>0,05. Άρα δεν υπάρχει ένδειξη αυτοσυσχέτισης των κατάλοιπων.

Από την κατανομή μάλιστα των κατάλοιπων (residual plot), επιβεβαιώνεται ότι τα κατάλοιπα δεν ακολουθούν ένα συγκεκριμένο πρότυπο.

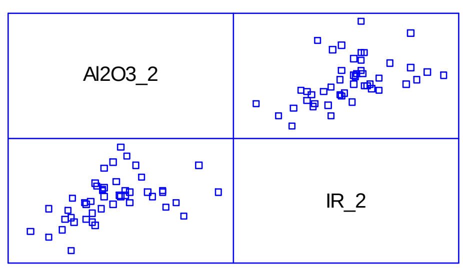


Διάγραμμα5. 69 Διάγραμμα κατάλοιπων για τη μεταβλητή Est7MT1

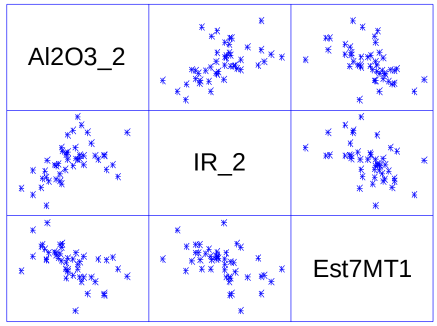
Η τιμή P-value του πίνακα ανάλυσης είναι 0,0001< 0,01 υπάρχει η ένδειξη στατιστικά σημαντικής συσχέτισης μεταξύ των συντελεστών του μοντέλου.

Συσχέτιση

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στα επόμενα γραφήματα



Διάγραμμα5.70 Διάγραμμα συσχετίσεων ανεξάρτητων μεταβλητών



Διάγραμμα5. 71 Διάγραμμα συσχετίσεων ανεξάρτητών και εξαρτημένης (Est7MT1)μεταβλητής

καθώς και στον πίνακα που ακολουθεί

Πίνακας 5. 37 Συσχετίσεις ανεξάρτητων –εξαρτημένης (Est7MT1)μεταβλητής

	Al2O3MT1	IRMT1	Est7MT1
Al2O3MT1		**0,5048** (46) **0,0003**	**-0,5257** (46) **0,0002**
IRMT1	**0,5048** (46) **0,0003**		**-0,4824** (46) **0,0007**
Est7MT1	**-0,5257** (46) **0,0002**	**-0,4824** (46) **0,0007**	

Συσχέτιση
(μέγεθος δείγματος)
P-τιμή

Ο παραπάνω πίνακας παρουσιάζει τις συσχετίσεις κατά Pearson αφού όπως έχει αναφερθεί και στην παράγραφο 4.1.2.2. τα δεδομένα προσαρμόζονται καλά στην κανονική κατανομή. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%. Οι μεταβλητές οι οποίες φαίνεται να συσχετίζονται μεταξύ τους είναι η IR και η Al_2O_3, αφού η τιμή P είναι 0,0003<0,05, αλλά και οι Est7 με τη Al_2O_3 και την IR.

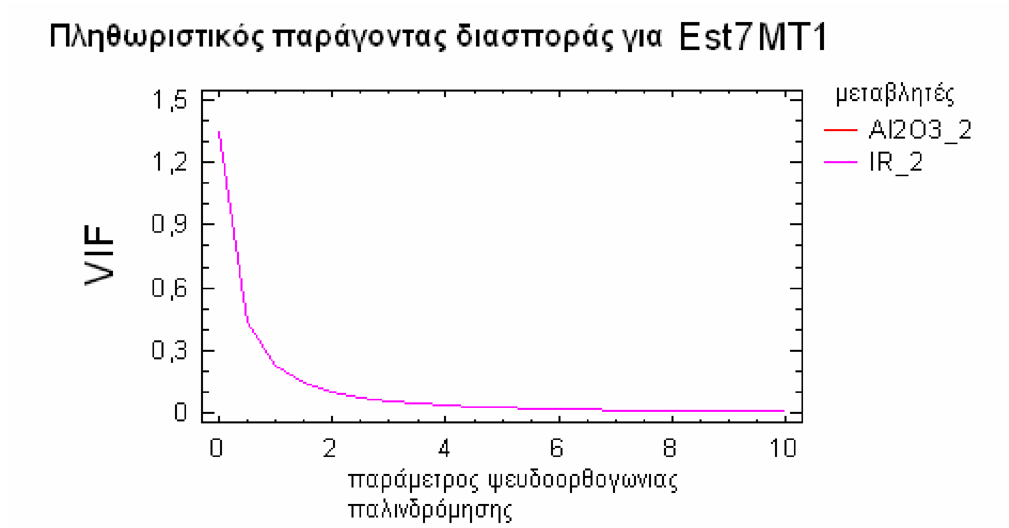
Ψευδο-ορθογώνια παλινδρόμηση *(Ridge regression)*

Το μοντέλο συσχέτισης των αντοχών 7 ημερών με τις ανεξάρτητες μεταβλητές παρουσιάζει ιδιαίτερο ενδιαφέρον για την παραγωγική διαδικασία του τσιμέντου και για το λόγο αυτό έχει ιδιαίτερη σημασία η όσο το δυνατό καλύτερη εκτίμησή του.
Προκειμένου να βελτιωθεί το ήδη προτεινόμενο μοντέλο πραγματοποιείται ridge regression.
Η διαδικασία αυτή είναι σχεδιασμένη για να παρέχει εκτιμήσεις των συντελεστών παλινδρόμησης όταν οι ανεξάρτητες μεταβλητές είναι ισχυρά συσχετισμένες.

Επιτρέποντας ένα μικρό ποσοστό μεροληψίας, η ακρίβεια των εκτιμητριών μπορεί να αυξηθεί σημαντικά.

Στη συγκεκριμένη περίπτωση οι μεταβλητές Al_2O_3 και IR εμφανίζουν θετική συσχέτιση μεταξύ τους. Χρησιμοποιείται λοιπόν η παλινδρόμηση ridge regression με σκοπό τη βελτίωση της ακρίβειας των συντελεστών.

Από το διάγραμμα που δείχνει το ύψος της μεταβολής των συντελεστών των μεταβλητών με την μεταβολή της παραμέτρου της παλινδρόμησης γίνεται η επιλογή της βέλτιστης παραμέτρου.



Διάγραμμα5. 72

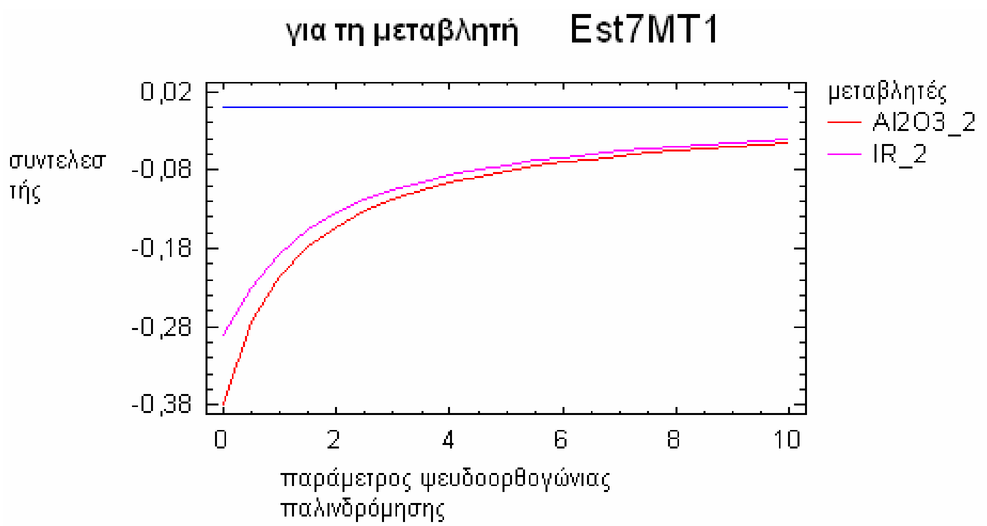
Στο συγκεκριμένο διάγραμμα εμφανίζεται μόνο μία γραμμή λόγω του ότι και για τις δύο μεταβλητές το ύψος της μεταβολής των συντελεστών είναι το ίδιο. Επιλέγεται η παράμετρος κατά την οποία το ύψος της μεταβολής δεν μεταβάλλεται έντονα κατά την αύξησή της, δηλαδή το σημείο στο διάγραμμα στο οποίο σταθεροποιείται η καμπύλη. Επίσης η παράμετρος πρέπει να είναι αυτή κατά την οποία δε θα δημιουργείται στο μοντέλο συσχέτιση στα κατάλοιπα.

Ύστερα από δοκιμές, επιλέγεται ως κατάλληλη παράμετρος η τιμή 3.

Τα αποτελέσματα της παλινδρόμησης με αυτήν την παράμετρο φαίνονται παρακάτω

```
Αποτελέσματα μοντέλου για παράμετρο ψευδοορθογώνιας παλινδρόμησης(ridge parameter)=3,0
--------------------------------------------------
                                          Πληθωριστικός
                                          παράγοντας
Παράμετρος                   εκτίμηση     διασποράς
--------------------------------------------------
Σταθερά                      49,295
Al2O3MT1                     -1,29763      0,0573433
IRMT1                        -0,28304      0,0573433
--------------------------------------------------
R2 = 11,3069 %
R2 (προσαρμοσμένο για β.ε.)= 7,18163 %
Τυπικό σφάλμα για εκτ. = 1,89208
Μέσο απόλυτο σφάλμα = 1,39011
Durbin-Watson statistic = 1,45125 (P=0,1281)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,240785
```

Οι συντελεστές των μεταβλητών και πώς αυτές μεταβάλλονται με την μεταβολή της παραμέτρου παλινδρόμησης φαίνονται στο παρακάτω διάγραμμα.



Διάγραμμα5. 73

Το μοντέλο το οποίο προτείνεται είναι το παρακάτω

Est7MT1 = 49,295 - 1,29763*Al2O3MT1 - 0,28304*IRMT1

Ο συντελεστής Durbin Watson ισούται με 1,45125 και με τιμή $p>0,05$. Κατά συνέπεια δεν υπάρχει η υπόνοια συσχετίσεων στα κατάλοιπα, κάτι που φαίνεται και από το διάγραμμα των κατάλοιπων όπως φαίνεται και στο παράρτημα Γ.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Από τη συσχέτιση όλων των μεταβλητών με τη μέθοδο της πολλαπλής παλινδρόμησης προκύπτει το παρακάτω μοντέλο

Est7MT1 = 39,3031 - 3,89863*Al2O3MT1 + 0,00397432*BLAINEMT1 - 0,80901*IRMT1 - 0,927097*LOIMT1 + 0,568193* $\mathbf{SiO_2}^{\mathbf{MT1}}$

το οποίο περιγράφει τη μεταβλητότητα των αντοχών τσιμέντου κατά την $7^{η}$ ημέρα σε ποσοστό 37,7461%. Δεδομένου ότι η τιμή p του μοντέλου είναι μικρότερη του 0,01 προκύπτει ότι υπάρχει σημαντική συσχέτιση μεταξύ των μεταβλητών.
Η όποια πολυσυγγραμικότητα οφείλεται στη συσχέτιση μεταξύ των μεταβλητών IR και SiO_2. Η απλοποίηση του μοντέλου απαιτεί τη μελέτη των τιμών p κάθε μεταβλητής. Η μελέτη αυτή οδηγεί στην εξαίρεση ορισμένων μεταβλητών κατά τρόπο ο οποίος οδηγεί στο μοντέλο που προέκυψε από την ανιούσα επιλογή (forward selection) μελέτη.

4.3.2.5. Αντοχές 28ης ημέρας – μύλος 1

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την 7η ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI), IR.** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: **Al_2O_3**

Και το μοντέλο που προκύπτει από τη διαδικασία είναι:
Est28MT1 = 76,8445 - 4,44702*Al2O3MT1

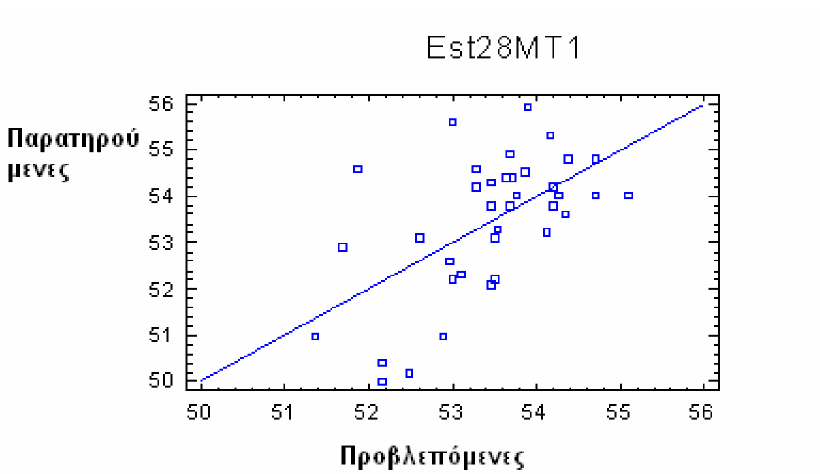
Το οποίο δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 38 Ανάλυση πολλαπλής παλινδρόμησης για εξαρτημένη μεταβλητή Est28MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
CONSTANT	76,8445	5,53945	13,8722	0,0000
Al2O3MT1	-4,44702	1,05161	-4,22876	0,0002

Όπως φαίνεται και παραπάνω τα P-values είναι μικρότερα του 0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης και δε θα έπρεπε να αφαιρεθεί άλλος συντελεστής.

Στο ακόλουθο διάγραμμα (Plot of Est28MT1), απεικονίζονται οι πραγματικές τιμές των αντοχών της 28ης ημέρας σε σχέση με τις εκτιμώμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 74 Διάγραμμα παρατηρούμενων- προβλεπόμενων μεταβλητών

από την ανάλυση διασποράς φαίνεται ότι

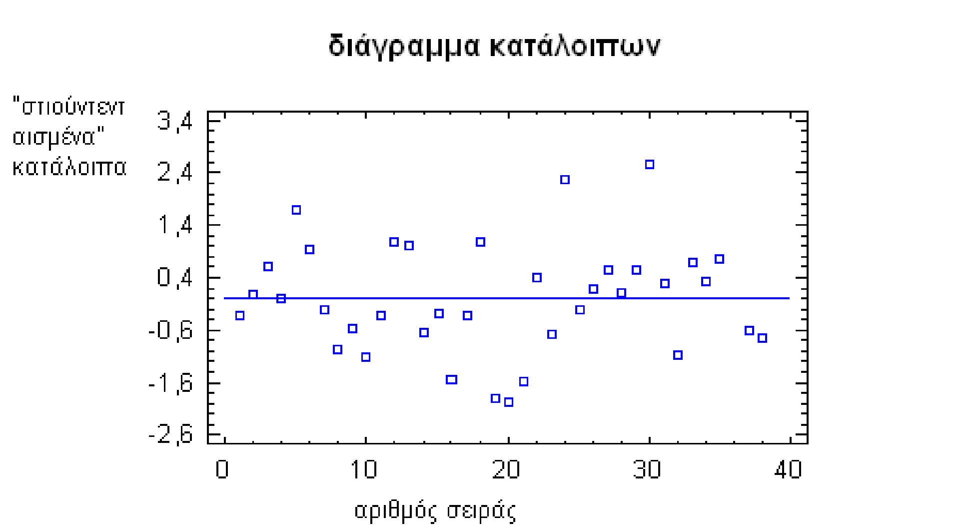
Πίνακας 5. 39 Ανάλυση διασποράς για το μοντέλο προσδιορισμού της μεταβλητής Est28MT1

Source	άθροισμα τετραγώνων	β.ε.	μ.τ. τετραγώνων	F-λόγος	P-τιμή
μοντέλο	27,1147	1	27,1147	17,88	0,0002
κατάλοιπα	53,0697	35	1,51628		
συνολικό (Συσχ.)	80,1843	36			

R^2 = 33,8154 percent
R^2 (προσαρμοσμένο στους β.ε.) = 31,9244 percent
Τυπικό σφάλμα για εκτίμηση. = 1,23137
Μέσο απόλυτο σφάλμα = 0,963892
Durbin-Watson = 1,58421 (P=0,0776)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,19834

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 33,8154% της μεταβλητότητας της αντοχής Est28MT1.

Παρακάτω φαίνεται και το διάγραμμα κατανομής των κατάλοιπων.



*Διάγραμμα5. 75 Διάγραμμα κατάλοιπων για την **Est28MT1***

Προκειμένου να μελετηθεί σε βάθος η συσχέτιση των αντοχών των 28 ημερών με τις φυσικοχημικές και χημικές ιδιότητες πραγματοποιείται η δημιουργία μοντέλων Απλής Γραμμικής Παλινδρόμησης για τα παρακάτω ζεύγη μεταβλητών.

- Est28MT1-BlaineMT1

Από σύγκριση διαφόρων μοντέλων προκύπτει ότι αυτό το οποίο περιγράφει πιο καλά τη σχέση μεταξύ των δύο μεταβλητών είναι αυτό της διπλής αντιστροφής ($\frac{1}{1+\frac{1}{x}}$) το οποίο ερμηνεύει το συγκεκριμένο μοντέλο κατά 0,72% έναντι 0,62% που ερμηνεύει το γραμμικό μοντέλο.

σύγκριση εναλλακτικών μοντέλων

Model	Correlation	R-Squared
διπλή αντιστροφή	0,0851	0,72%
αντίστροφο-Y	-0,0832	0,69%
καμπύλη μορφής S	-0,0829	0,69%
πολλαπλασιαστικό	0,0820	0,67%
Εκθετικό	0,0810	0,66%
αντίστροφο-X	-0,0808	0,65%
Square root-Y	0,0799	0,64%
Λογαριθμικό-X	0,0798	0,64%
Square root-X	0,0793	0,63%
Γραμμικό	0,0788	0,62%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

το μοντέλο που προκύπτει είναι:

Est28MT1 = 1/(0,0124935 + 29,8138/BLAINEMT1)

Και η ανάλυση παρουσιάζεται παρακάτω

Source	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	7,47008E-8	1	7,47008E-8	0,26	0,6165
κατάλοιπα	0,0000102405	35	2,92587E-7		
συνολικά (συσχ.)	0,0000103152	36			

συντελεστής συσχέτισης = 0,0850987
R^2 = 0,724179 %
R^2 (προσαρμοσμένο στους β.ε) = -2,11227 %
Τυπικό σφάλμα για εκτίμηση = 0,000540913
Μέσο τυπικό σφάλμα = 0,000422486
Durbin-Watson = 0,909885 (P=0,0001)
Αυτοσυσχέτιση κατάλοιπων= 0,543514

Η τιμή p του μοντέλου είναι μεγαλύτερη από ο,1. Μπορεί να θεωρηθεί λοιπόν ότι δεν υπάρχει στατιστικά σημαντική σχέση μεταξύ των μεταβλητών.

- Est28MT1-IR

Από σύγκριση διαφόρων μοντέλων προκύπτει ότι αυτό το οποίο περιγράφει πιο καλά τη σχέση μεταξύ των δύο μεταβλητών είναι το πολλαπλασιαστικό το οποίο ερμηνεύει το συγκεκριμένο μοντέλο κατά 10,09% έναντι 9,94% που ερμηνεύει το γραμμικό μοντέλο.

σύγκριση εναλλακτικών μοντέλων

Μοντέλο	συσχέτιση	R^2
Πολλαπλασιαστικό	-0,3177	10,09%
Λογαριθμικό-X	-0,3166	10,02%
αντίστροφο-Y	0,3165	10,02%
τετραγωνική ρίζα-X	-0,3164	10,01%
Διπλή αντιστροφή	-0,3163	10,00%
Εκθετικό	-0,3160	9,98%
Τετραγωνική ρίζα-Y	-0,3156	9,96%
Γραμμικό	-0,3152	9,94%
Καμπύλη μορφής S	0,3151	9,93%
Αντίστροφο-X	0,3137	9,84%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

το μοντέλο που προκύπτει είναι:

Est28MT1 = 60,0819*IRMT1^-0,065843

Ή

ln(Est28MT1) = 4,09571 - 0,065843*ln(IRMT1)

ανάλυση διασποράς

Πηγή	άθροισμα τετραγώνων	β.ε.	μ.τ. τετραγώνων	F-λόγος	P-τιμή
μοντέλο	0,0029004	1	0,0029004	3,93	0,0553
Κατάλοιπα	0,0258337	35	0,000738107		
Συνολικά (Συσχ.)	0,0287341	36			

Συντελεστής συσχέτισης = -0,317709
R^2 = 10,0939 %
R^2 (προσαρμοσμένο για τους β.ε.) = 7,52518 %
Τυπικό σφάλμα για εκτ = 0,0271681
Μ.τ. για απόλυτο τυπικό σφάλμα = 0,0202406
Durbin-Watson = 1,05967 (P=0,0007)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,462245

Η τιμή p του μοντέλου είναι μικρότερη από 0,1. Μπορεί να θεωρηθεί λοιπόν ότι υπάρχει στατιστικά σημαντική σχέση μεταξύ των μεταβλητών σε επίπεδο εμπιστοσύνης 90%. Ο συντελεστής συσχέτισης όμως είναι ίσος με -0,317709, γεγονός που αποδεικνύει ότι οι δύο μεταβλητές δεν έχουν μεγάλη συσχέτιση.

- Est28MT1-LOIMT1

Από σύγκριση διαφόρων μοντέλων προκύπτει ότι αυτό το οποίο περιγράφει πιο καλά τη σχέση μεταξύ των δύο μεταβλητών είναι αυτό της διπλής αντιστροφής ($\frac{1}{1+\frac{1}{x}}$) το οποίο ερμηνεύει το συγκεκριμένο μοντέλο κατά 5,20% έναντι 4,65% που ερμηνεύει το γραμμικό μοντέλο.

Σύγκριση εναλλακτικών μοντέλων

Μοντέλο	συσχέτιση	R^2
Διπλή αντιστροφή	-0,2281	5,20%
Καμπύλη μορφής S	0,2278	5,19%
Αντίστροφο-X	0,2273	5,17%
Πολλαπλασιαστικό	-0,2229	4,97%
Λογαριθμικό-X	-0,2225	4,95%
Τετραγωνική ρίζα-X	-0,2194	4,81%
Αντίστροφο-Y	0,2163	4,68%
Εκθετικό	-0,2161	4,67%
Τετραγωνική ρίζα-Y	-0,2159	4,66%
Γραμμικό	-0,2157	4,65%
Λογιστικό	<no fit>	
Λογαριθμικό probit		

το μοντέλο που προκύπτει είναι :

Est28MT1 = 1/(0,0202178 - 0,00745945/LOIMT1)

Ανάλυση διασποράς

	άθροισμα τετραγώνων		μέση τιμή τετραγώνων	F-λόγος	P-τιμή
μοντέλο	5,36822E-7	1	5,36822E-7	1,92	0,1745
Κατάλοιπα	0,00000977841	35	2,79383E-7		
σύνολο (Συσχ.)	0,0000103152	36			

Συντελεστής συσχέτισης = -0,228126
R^{2+} = 5,20417 percent
R^2 (προσαρμοσμένο στους β.ε.) = 2,49571 percent
Τυπικό σφάλμα εκτίμησης. = 0,000528567
Μέση τιμή απόλυτου σφάλματος = 0,000400428
Durbin-Watson = 1,00546 (P=0,0004)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,495405

Η τιμή p του μοντέλου που προκύπτει είναι ίση με 0,1745 > 0,1. Κατά συνέπεια δεν υπάρχει σημαντική σχέση μεταξύ των μεταβλητών.

- Est 28Mt1-SiO_2

Από σύγκριση διαφόρων μοντέλων προκύπτει ότι αυτό το οποίο περιγράφει πιο καλά τη σχέση μεταξύ των δύο μεταβλητών είναι αυτό της διπλής αντιστροφής, το οποίο ερμηνεύει το συγκεκριμένο μοντέλο κατά 3,61% έναντι 3,38% που ερμηνεύει το γραμμικό μοντέλο.

Σύγκριση εναλλακτικών μοντέλων

Μοντέλο	Correlation	R-Squared
Διπλή αντιστροφή	-0,1900	3,61%
Καμπύλη της μορφής S	0,1892	3,58%
Αντίστροφο-X	0,1883	3,54%
Πολλαπλασιαστικό	-0,1870	3,50%
Λογαριθμικό-X	-0,1861	3,46%
Αντίστροφο-Y	0,1855	3,44%
Τετραγωνική ρίζα-X	-0,1850	3,42%
Εκθετικό	-0,1847	3,41%
Τετραγωνική ρίζα-Y	-0,1843	3,40%
Γραμμικό	-0,1838	3,38%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

το μοντέλο που προκύπτει είναι :

Est28MT1 = 1/(0,024461 - 0,127405/ SiO_2 ^{MT1})

Ανάλυση Διασποράς

	άθροισμα τετραγώνων	β.ε.	μ.τ. τετραγώνων	F-λόγος	P-τιμή
Model	3,72541E-7	1	3,72541E-7	1,31	0,2599
Residual	0,00000994269	35	2,84077E-7		
Total (Corr.)	0,0000103152	36			

Συντελεστής συσχέτισης = -0,190041
R^2 = 3,61157 %
R^2(προσαρμοσμένο στους β.ε.) = 0,85761 %
Τυπικό σφάλμα της εκτίμησης. = 0,000532989
Μέση τιμή απόλυτου σφάλματος = 0,000406575
Durbin-Watson = 0,960935 (P=0,0002)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,516358

Η τιμή p που προκύπτει είναι ίση με 0,2599>0,1. Άρα δεν υπάρχει σημαντική σχέση μεταξύ των μεταβλητών.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η έρευνα για συσχέτιση όλων των μεταβλητών οι οποίες ενδέχεται να επηρεάσουν τις αντοχές του τσιμέντου 28 ημερών επέφερε το εξής μοντέλο:

Est28MT1 = 46,3135 - 6,21512*Al2O3MT1 + 0,000163824*BLAINEMT1 - 0,545235*IRMT1 + 1,02692*LOIMT1 + 1,67148* SiO_2 ^{MT1}

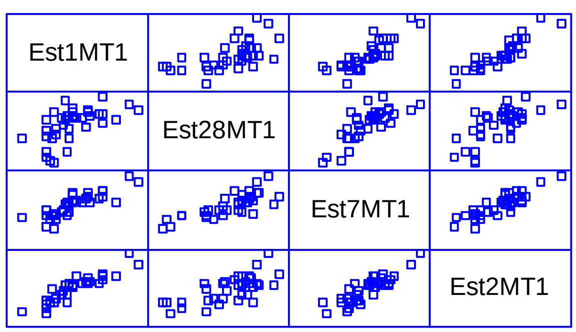
το παραπάνω μοντέλο περιγράφει τη συσχέτιση μεταξύ των μεταβλητών κατά 42,8408% ενώ η τιμή p του μοντέλου είναι μικρότερη του 0,01 γεγονός το οποίο αποδεικνύει την ύπαρξη σχέσης μεταξύ των μεταβλητών.

Οι συσχετίσεις μεταξύ των ανεξάρτητων μεταβλητών επικεντρώνονται στα ζέυγη μεταβλητών LOI – Al_2O_3 και SiO_2 και IR. Η προσπάθεια απλοποίησης του μοντέλου επιβάλει τη μελέτη των τιμών p κάθε μεταβλητής. Μία τέτοια μελέτη οδηγεί στο μοντέλο το οποίο προκύπτει και από την πολλαπλή παλινδρόμηση με τη μέθοδο ανιούσας επιλογής(forward selection).

4.3.2.6. Συσχέτιση μεταξύ των αντοχών τσιμέντου 1^{ης} ημέρας, 2 ημερών, 7 ημερών και 28 ημερών. – μύλος 1

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο από την 1^{η} έως και την 28^{η} ημέρα σχετίζονται μεταξύ τους.

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στο επόμενο γράφημα:



Διάγραμμα5. 76 Συσχετίσεις μεταξύ των αντοχών διαφόρων ημερών

Πίνακας 5. 40 Συσχετίσεις μηχανικών ιδιοτήτων τσιμέντου ΙΙ 42,5 για το μύλο 1

	Est1MT1	Est28MT1	Est7MT1	Est2MT1
Est1MT1		**0,5907** (37) **0,0001**	**0,8334** (37) **0,0000**	**0,9024** (37) **0,0000**
Est28MT1	**0,5907** (37) **0,0001**		**0,7790** (37) **0,0000**	**0,6894** (37) **0,0000**
Est7MT1	**0,8334** (37) **0,0000**	**0,7790** (37) **0,0000**		**0,8734** (37) **0,0000**
Est2MT1	**0,9024** (37) **0,0000**	**0,6894** (37) **0,0000**	**0,8734** (37) **0,0000**	

Ο παραπάνω πίνακας (5.40) παρουσιάζει τις συσχετίσεις κατά Pearson,δεδομένου ότι τα δεδομένα έχουν καλή προσαρμογή στην κανονική κατανομή. Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%.
Όπως φαίνεται από τον πίνακα όλες οι μεταβλητές παρουσιάζουν σημαντικές συσχετίσεις μεταξύ τους.

4.3.2.7. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 28 ημερών – μύλος 1

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 28 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει στις 7 ημέρες. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 7 και 28 ημέρες.
Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est28MT1 = 28,6938 + 0,606125*Est7MT1

Και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 41 Απλή παλινδρόμηση - Est28MT1 με Est7MT1

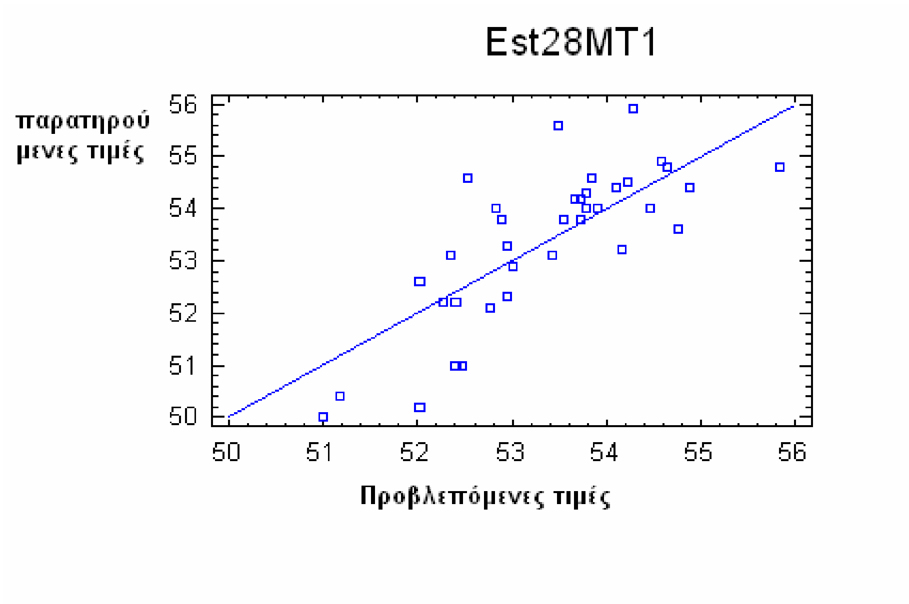
Ανάλυση παλινδρόμησης – γραμμικό μοντέλο: Y = a + b*X

εξαρτώμενη μεταβλητή: Est28MT1
ανεξάρτητη μεταβλητή: Est7MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	28,6938	3,36945	8,51587	0,0000
Κλίση	0,606125	0,0824577	7,35075	0,0000

Όπως φαίνεται και από τις τιμές των p αυτές είναι 0<0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.

Στο ακόλουθο διάγραμμα (5.77), απεικονίζονται οι πραγματικές τιμές των αντοχών της 28ης ημέρας σε σχέση με τις εκτιμώμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 77 Διάγραμμα παρατηρούμενων- προβλεπόμενων μεταβλητών

από την ανάλυση της διασποράς παρατηρείται ότι

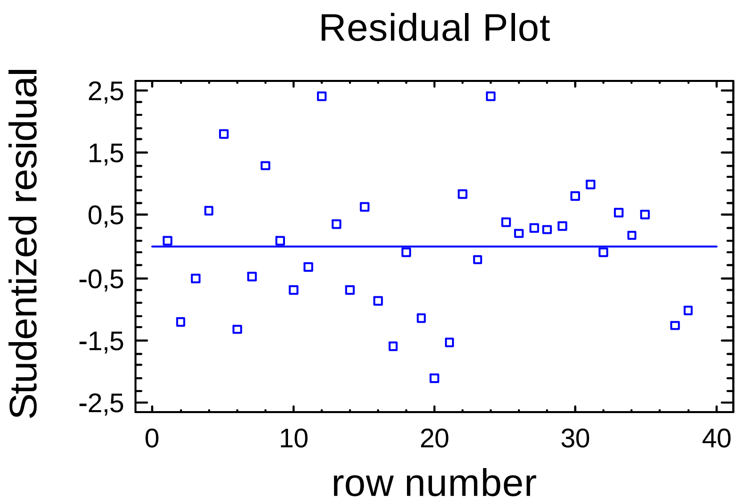
Πίνακας 5. 42Ανάλυση Διασποράς για το μοντέλο προσδιορισμού της μεταβλητής Est28MT1

Source	άθροισμα τετραγώνων	β.ε.	μ.τ τετραγώνων	F-λόγος	P-τιμή
μοντέλο	48,663	1	48,663	54,03	0,0000
Κατάλοιπα	31,5213	35	0,900609		
Τελικό (Συσχ.)	80,1843	36			

Συντελεστής συσχέτισης = 0,779031
R^2 = 60,6889 percent
R^2 (προσαρμοσμένους στους β.ε) = 59,5658 percent
Τυπικό σφάλμα της εκτίμησης. = 0,949004
Μέση τιμή απόλυτου σφάλματος = 0,736398
Durbin-Watson statistic = 1,64211 (P=0,1145)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,164512

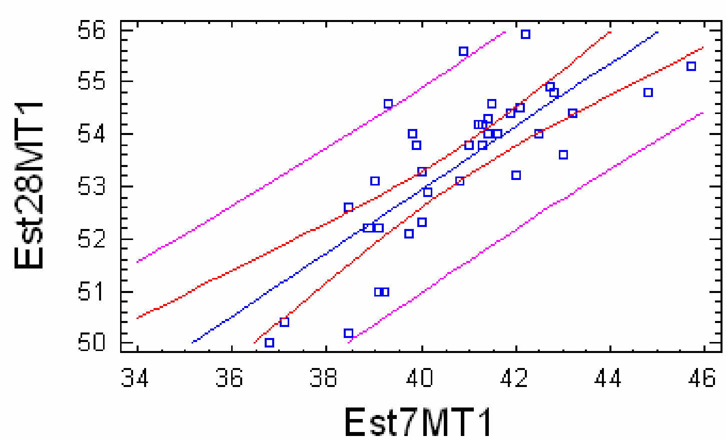
Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 60,6889% της μεταβλητότητας της αντοχής Est28MT1.

Παρακάτω φαίνεται και το διάγραμμα κατανομής των κατάλοιπων.



Διάγραμμα5. 78 Διάγραμμα κατάλοιπων

ενώ η σχέση μεταξύ της μεταβλητής Est28 και της μεταβλητής Est7 φαίνεται από το παρακάτω διάγραμμα.



Διάγραμμα5. 79Διάγραμμα προσαρμοσμένου μοντέλου

Με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 43 Ανάλυση Διασποράς με τη χρήση lack-of-fit

Source	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	48,663	1	48,663	54,03	0,0000
κατάλοιπα	31,5213	35	0,900609		
Lack-of-Fit	27,2963	30	0,909877	1,08	0,5237
Pure Error	4,225	5	0,845		
Total (Corr.)	80,1843	36			

με p τιμή ίση με 0,5237>0,10. Άρα το μοντέλο παρουσιάζεται ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές.

Συγκρίνοντας με άλλα μοντέλα αυτό που φαίνεται ακόμα πιο ιδανικό είναι το double reciprocal, το οποίο περιγράφει τη μεταβολή της μεταβλητής Est28 κατά 63,48%.

Σύγκριση εναλλακτικών μοντέλων

Μοντέλο	Συσχέτιση	R^2
διπλή αντιστροφή	0,7968	63,48%
καμπύλη της μορφής S	-0,7966	63,46%
Αντίστροφος-X	-0,7963	63,41%
Πολλαπλασιαστικό μοντέλο	0,7882	62,12%
Λογαριθμικό-X	0,7881	62,12%
Τετραγωνική ρίζα-X	0,7837	61,42%
Γραμμικό μοντέλο	0,7790	60,69%
Τετραγωνική ρίζα-Y	0,7789	60,68%
Εκθετικό μοντέλο	0,7788	60,65%
Αντίστροφο-Y	-0,7784	60,59%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

4.3.2.8. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 2 ημερών – μύλος 1

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 28 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει στις 7 ημέρες. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 7 και 28 ημέρες.
Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est7MT1 = 13,5594 + 1,02878*Est2MT1

Και δικαιολογείται από τον παρακάτω πίνακα

***Πίνακας 5. 44 Ανάλυση γραμμικού μοντέλου απλής παλινδρόμησης* Est7MT1 vs. Est2MT1**

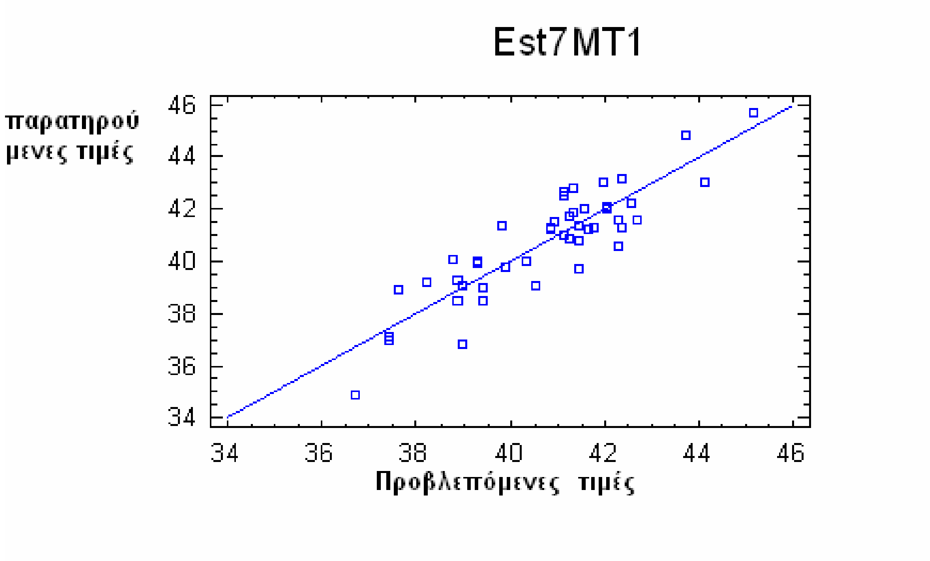
Ανάλυση Παλινδρόμησης – Γραμμικό μοντέλο: Y = a + b*X

Εξαρτώμενη μεταβλητή: Est7MT1
Ανεξάρτητη μεταβλητή: Est2MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	13,5594	2,1717	6,24367	0,0000
Κλίση	1,02878	0,0820488	12,5387	0,0000

όπως δικαιολογείται από τις τιμές p αυτές είναι μικρότερες του 0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.

Στο ακόλουθο διάγραμμα (Plot of Est28MT1), απεικονίζονται οι πραγματικές τιμές των αντοχών της 7ης ημέρας σε σχέση με τις εκτιμώμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 80 Διάγραμμα παρατηρούμενων- προβλεπόμενων μεταβλητών

Η ανάλυση της διασποράς παρουσιάζει ότι

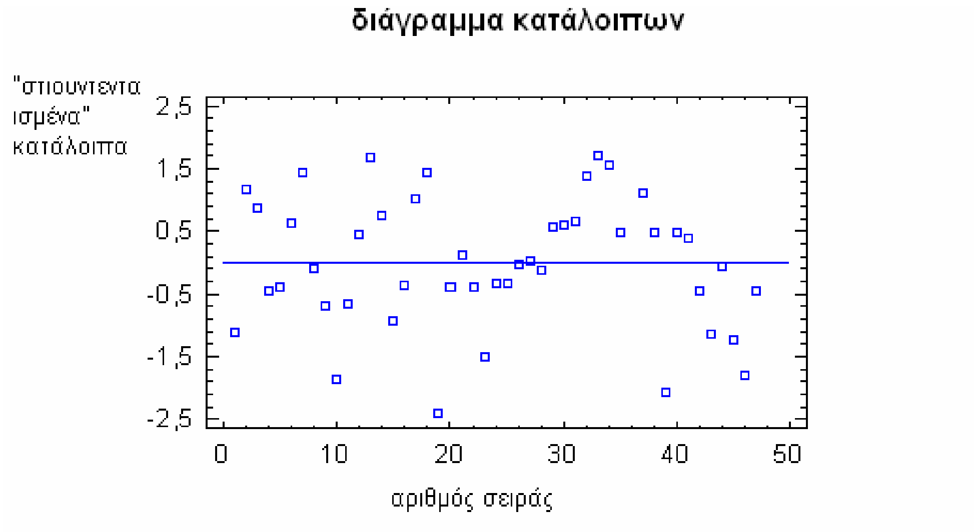
Πίνακας 5. 45Ανάλυση διασποράς για το μοντέλο συσχέτισης Est7MT1 με Est2MT1

	άθροισμα τετραγώνων	β.ε.	Mean Square	F-λόγος	P-τιμή
μοντέλο	148,201	1	148,201	157,22	0,0000
κατάλοιπα	41,4764	44	0,942645		
Συνολικά (Συσχ.)	189,677	45			

Συντελεστής συσχέτισης = 0,88393
R^2 = 78,1332 percent
R^2 (προσαρμοσμένο στους βε) = 77,6362 percent
Τυπικό σφάλμα των εκτιμήσεων = 0,970899
Μέσο απόλυτο σφάλμα = 0,780959
Durbin-Watson = 1,37407 (P=0,0116)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,297084

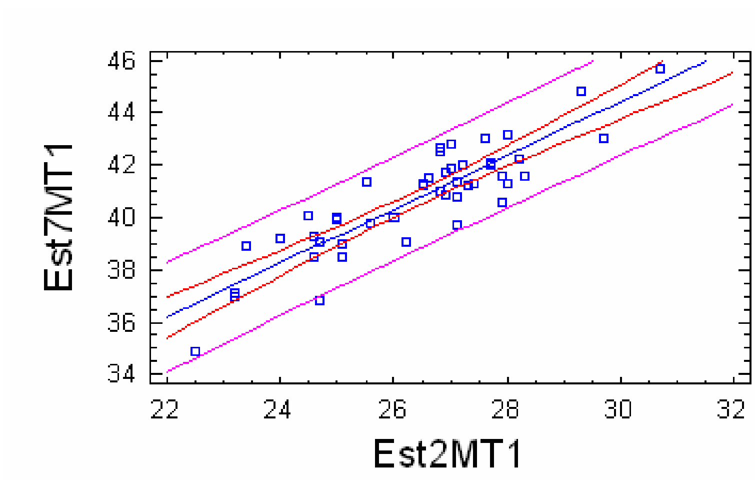
Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 78,1332% τη μεταβλητότητα της αντοχής Est7MT1.

Παρακάτω φαίνεται και το διάγραμμα κατανομής των κατάλοιπων.



Διάγραμμα5. 81Διάγραμμα κατάλοιπων

η σχέση μεταξύ των αντοχών της 7ης ημέρας και της 28ης ημέρας παρουσιάζονται στο παρακάτω διάγραμμα.



Διάγραμμα5. 82διάγραμμα προσαρμοσμένου μοντέλου

με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 46 Εξέταση προσαρμογής μοντέλου που συσχετίζει την 7η με την 28η ημέρα

	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	148,201	1	148,201	157,22	0,0000
κατάλοιπα	41,4764	44	0,942645		
Lack-of-Fit	32,1231	29	1,10769	1,78	0,1209
Pure Error	9,35333	15	0,623556		
συνολικό (Συσχ.)	189,677	45			

με p τιμή ίση με 0,1209>0,10. Άρα το μοντέλο παρουσιάζεται ικανοποιητικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές.

Συγκρίνοντας με άλλα μοντέλα αυτό που φαίνεται ακόμα πιο ιδανικό είναι το S-curve, το οποίο περιγράφει τη μεταβολή της μεταβλητής Est28 κατά 78,56%.

Σύγκριση εναλλακτικών μοντέλων

Μοντέλο	Συσχέτιση	R^2
καμπύλη της μορφής S	-0,8863	78,56%
Αντίστροφος-X	-0,8861	78,51%
Λογαριθμικό-X	0,8857	78,44%
Διπλή αντιστροφή	0,8851	78,34%
Τετραγωνική ρίζα-X	0,8850	78,32%
Πολλαπλασιαστικό μοντέλο	0,8846	78,24%
Γραμμικό μοντέλο	0,8839	78,13%
Τετραγωνική ρίζα-Y	0,8828	77,94%
Εκθετικό μοντέλο	0,8813	77,68%
Αντίστροφο-Y	-0,8772	76,95%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

4.3.2.9.Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 2 ημερών και τσιμέντου 1 ημέρας – μύλος 1

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 2 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει κατά την 1η ημέρα. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 2 και 1 ημέρες.
Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est2 και ανεξάρτητη την Est1.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est2MT1 = 12,0673 + 0,973593*Est1MT1

Και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 47 Ανάλυση παλινδρόμησης για συσχέτιση μεταξύ Est2MT1 και Est1MT1

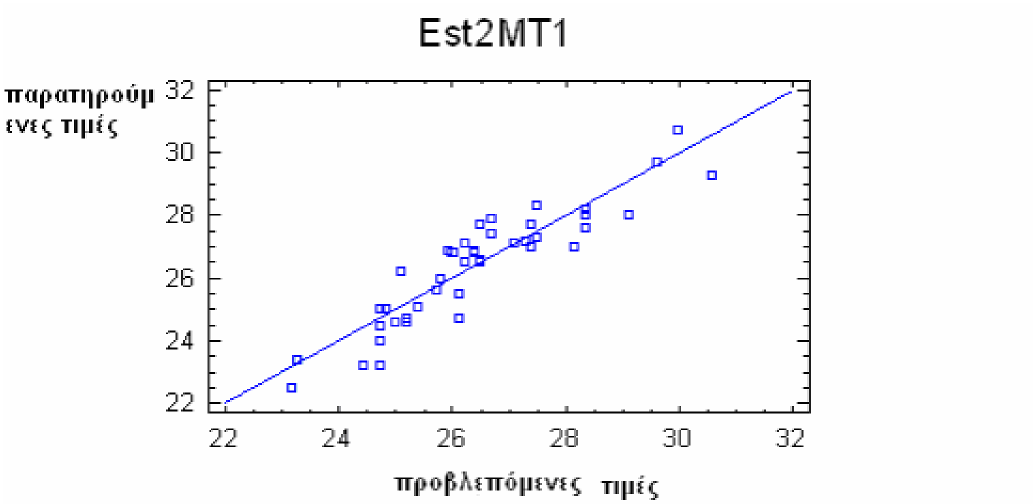
Ανάλυση παλινδρόμησης-γραμμικό μοντέλο: Y = a + b*X

εξαρτώμενη μεταβλητή: Est2MT1
ανεξάρτητη μεταβλητή: Est1MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	12,0673	1,01159	11,9291	0,0000
Κλίση	0,973593	0,0682494	14,2652	0,0000

Όπως φαίνεται και από τις τιμές των p αυτές είναι 0<0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.

Στο ακόλουθο διάγραμμα (Plot of Est2MT1), απεικονίζονται οι πραγματικές τιμές των αντοχών της 2ης ημέρας σε σχέση με τις εκτιμώμενες από το παραπάνω μοντέλο.



Διάγραμμα5. 83 Διάγραμμα παρατηρούμενων- προβλεπόμενων μεταβλητών

Από την ανάλυση της διασποράς παρατηρείται ότι

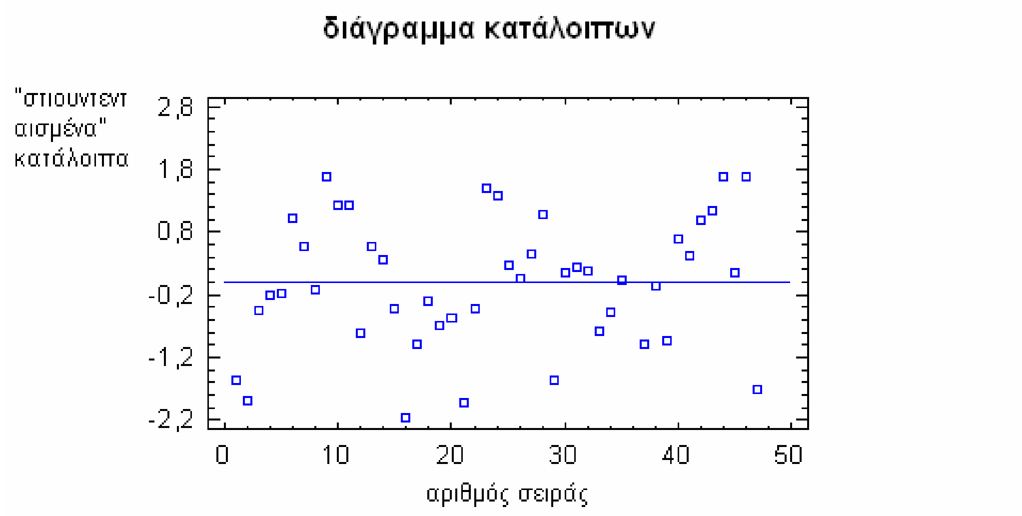
Πίνακας 5. 48 Ανάλυση διασποράς για το μοντέλο προσδιορισμού της μεταβλητής Est2MT1

Source	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγο	P-τιμή
μοντέλο	115,131	1	115,131	203,50	0,0000
κατάλοιπα	24,8936	44	0,565763		
συνολικά (Συσχ.)	140,025	45			

συντελεστής συσχέτισης = 0,906763
R^2 = 82,222 %
R^2 (προσαρμοσμένο στους β.ε..) = 81,818 %
Τυπικό σφάλμα εκτίμησης. = 0,752172
Μέσο απόλυτο σφάλμα = 0,60131
Durbin-Watson = 1,32218 (P=0,0068)
Lag 1 αυτοσυσχέτιση κατάλοιπων = 0,283894

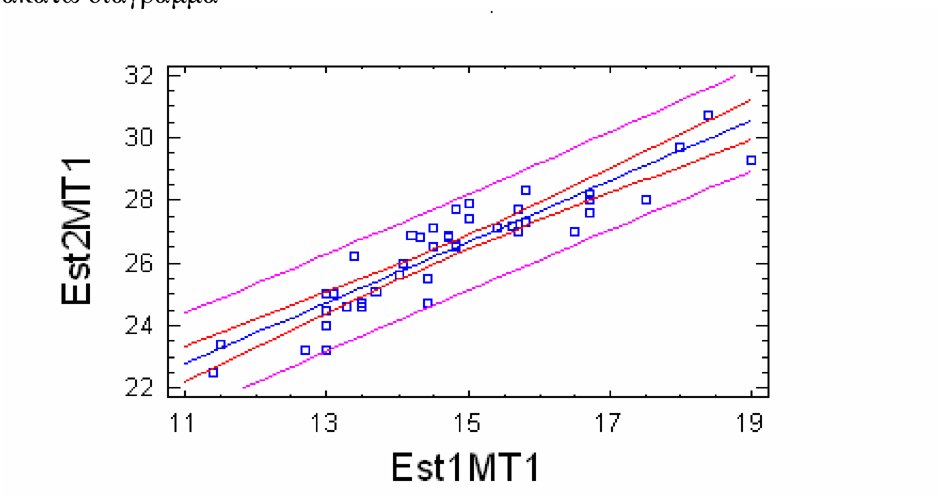
Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 82,222% τη μεταβλητότητα της αντοχής Est2MT1.

Παρακάτω φαίνεται και το διάγραμμα κατανομής των κατάλοιπων



Διάγραμμα5. 84 Διάγραμμα κατάλοιπων

ενώ η σχέση μεταξύ της μεταβλητής Est28 και της μεταβλητής Est7 φαίνεται από το παρακάτω διάγραμμα



Διάγραμμα5. 85διάγραμμα κατάλληλου μοντέλου για τις μεταβλητές Est2MT1 καιEst1MT1

με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 49Ανάλυση διασποράς για το μοντέλο συσχέτισης των μεταβλητών Est2MT-Est1MT1

	άθροισμα τετραγώνων	β.ε.	μέση τιμή τετρ.	F-λόγος	P-τιμή
μοντέλο	115,131	1	115,131	203,50	0,0000
κατάλοιπα	24,8936	44	0,565763		
Lack-of-Fit	20,5694	26	0,791131	3,29	0,0056
Pure Error	4,32417	18	0,240231		
σύνολο (Συσχ.)	140,025	45			

με p τιμή ίση με 0,0056<0,01. Άρα το μοντέλο δεν παρουσιάζεται αρκετά ικανοποιητικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Συγκεκριμένα υπάρχει η πιθανότητα να μην παρουσιάζει την ακριβή σχέση κατά 99%.

Μελετώντας πιο μοντέλο είναι το πλέον ιδανικό για τις δύο μεταβλητές, αυτό που παρουσιάζεται ως το πλέον ικανοποιητικό είναι το Αντίστροφο-x

Σύγκριση εναλλακτικών μοντέλων

Μοντέλο	Συσχέτιση	R^2
Αντίστροφο-X	-0,9186	84,38%
Καμπύλης μορφής S	-0,9184	84,34%
Διπλή αντιστροφή	0,9165	83,99%
Λογαριθμικό-X	0,9157	83,85%
Πολλαπλασιαστικό	0,9125	83,27%
Τετραγωνική ρίζα-X	0,9119	83,16%
Γραμμικό	0,9068	82,22%
Τετραγωνική ρίζα-Y	0,9040	81,72%
Εκθετικό	0,9008	81,14%
Αντίστροφο-Y	-0,8933	79,79%
Λογιστικό	<no fit>	
Λογαριθμικό probit		<no fit>

Αντίστροφο-x model

Το μοντέλο που προκύπτει από την ανάλυση είναι

Est2MT1 = 41,209 - 215,444/Est1MT1

Και ερμηνεύεται από τον παρακάτω πίνακα

Πίνακας 5. 50 ανάλυση μοντέλου συσχέτισης Est2MT1-Est1MT1/Αντίστροφο-X μοντέλο

Y = a + b/X

εξαρτώμενη μεταβλητή: Est2MT1
ανεξάρτητη μεταβλητή: Est1MT1

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	41,209	0,965385	42,6867	0,0000
Κλίση	-215,444	13,9731	-15,4184	0,0000

Όπως φαίνεται και από τις τιμές των p αυτές είναι 0<0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.
Από την ανάλυση της διασποράς προκύπτει ότι

***Πίνακας 5. 51Ανάλυση Διασποράς* μοντέλου συσχέτισης Est2MT1-Est1MT1/Αντίστροφο-X**

	άθροισμα τετραγώνων	β.ε.	Μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	118,156	1	118,156	237,73	0,0000
κατάλοιπα	21,8689	44	0,497021		
Total (Corr.)	140,025	45			

Συντελεστής συσχέτισης = -0,918597 Τυπικό σφάλμα εκτίμησης = 0,704997
R^2= 84,3821 percent

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 84,3821% τη μεταβλητότητα της αντοχής Est2MT1.

Με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 52 Ανάλυση διασποράς για εξέταση καλής προσαρμογής μοντέλου

	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	118,156	1	118,156	237,73	0,0000
κατάλοιπα	21,8689	44	0,497021		
Lack-of-Fit	17,5448	26	0,674798	2,81	0,0134
Pure Error	4,32417	18	0,240231		
σύνολο (συσχ.)	140,025	45			

με p τιμή ίση με $0{,}01<0{,}0134<0{,}05$. Όπως φαίνεται το μοντέλο αστοχεί να περιγράψει ικανοποιητικά τη σχέση μεταξύ των μεταβλητών Est2 και Est1 σε επίπεδο εμπιστοσύνης 95%.

<u>Μύλος 4</u>

4.3.2.10. Συσχέτιση ανεξάρτητων μεταβλητών – μύλος 4

Αντίστοιχα με την ανάλυση που έγινε και στον μύλο 1, προτού πραγματοποιηθεί η ανάλυση των αντοχών και η μελέτη συσχέτισης με τις ιδιότητες του τσιμέντου, πραγματοποιείται μελέτη συσχέτισης μεταξύ των χημικών και φυσικών ιδιοτήτων του. Οι ιδιότητες αυτές θα αποτελέσουν τις ανεξάρτητες μεταβλητές στο προτεινόμενο μοντέλο για τον προσδιορισμό των αντοχών.

Πιο συγκεκριμένα μελετάται η συσχέτιση μεταξύ των μεταβλητών **Al_2O_3, SiO_2, Blaine, Loss Of Ignition(LOI), IR.**

Από τη μελέτη προέκυψαν τα παρακάτω αποτελέσματα που παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Pearson, γιατί όλα τα δεδομένα έχουν καλή προσαρμογή στην κανονική κατανομή, όπως φαίνεται από τον πίνακα 4.2).

Πίνακας 5. 53 Συσχετίσεις ανεξάρτητων- εξαρτημένων μεταβλητών

	AMT4l2O3	BLAINEMT4	IR MT4	LOIMT4
AMT4l2O3		-0,1336	0,5087	0,0997
		(48)	(48)	(48)
		0,3653	0,0002	0,5003
BLAINEMT4	-0,1336		0,0429	0,3471
	(48)		(48)	(48)
	0,3653		0,7723	0,0156
IR MT4		0,5087		0,0429
0,4337				
	(48)	(48)		(48)
	0,0002	0,7723		0,0021
LOIMT4	0,0997	0,3471	0,4337	
	(48)	(48)	(48)	
	0,5003	0,0156	0,0021	
SIO_2 ^{MT4}	0,4603	-0,0922	0,8121	0,0049
	(48)	(48)	(48)	(48)
	0,0010	0,5331	0,0000	0,9736

	SIO_2 ^{MT4}
AMT4l2O3	0,4603
	(48)
	0,0010
BLAINEMT4	-0,0922
	(48)
	0,5331
IR MT4	0,8121
	(48)
	0,0000
LOIMT4	0,0049
	(48)
	0,9736
SIO_2 ^{MT4}	

Όπως φαίνεται από τον παραπάνω πίνακα υπάρχει συσχέτιση μεταξύ των μεταβλητών :

AMT4l2O3 and IR MT4

AMT4l2O3 and SIO_2 ^{MT4}

BLAINEMT4 and LOIMT4

IR MT4 and LOIMT4

IR MT4 and SIO_2 ^{MT4}

4.3.2.11. Αντοχές πρώτης ημέρας – μύλος 4

Κατά αντιστοιχία με τη μελέτη που έγινε για το μύλο 1 πραγματοποιήθηκε μελέτη για τον τρόπο με τον οποίο συνδέονται οι ιδιότητες με τις αντοχές τσιμέντου που παράγεται από τον μύλο 4. Συνοπτικά τα αποτελέσματα παρουσιάζονται παρακάτω.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-εισόδου: 4, προκρίνονται οι ακόλουθες μεταβλητές:
LOI και Al2O3.
Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2

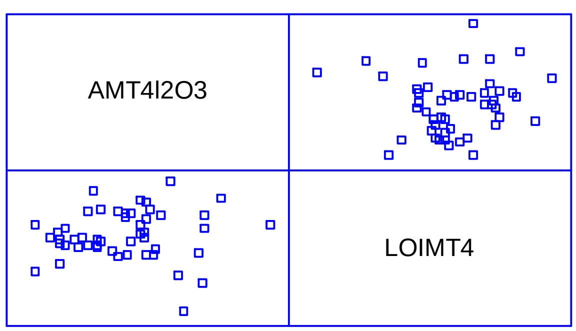
Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 54 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est1MT4

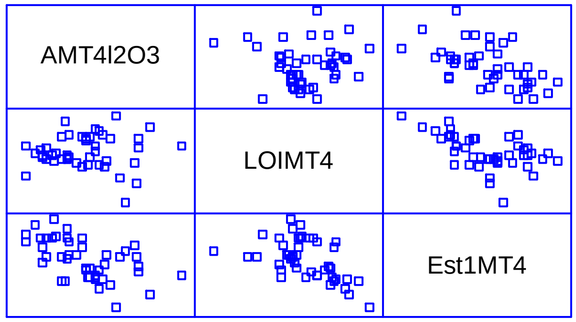
	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est1MT4 = 38,2197 - 3,99913*AMT4l2O3 -0,990476*LOIMT4
R^2	56,9393 %
$\overline{R^2}$	54,7863 %
P τιμή του Durbin-Watson	0,0687
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση
Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στα επόμενα γραφήματα



Διάγραμμα5. 86 Συσχετίσεις μεταξύ των μεταβλητώνAl_2O_3MT4 και LOIMT4



Διάγραμμα5. 87Συσχετίσεις μεταξύ ανεξάρτητων και εξαρτημένης (Est1MT4)μεταβλητής

καθώς και στον πίνακα που ακολουθεί

Πίνακας 5. 55 Συσχετίσεις ανεξάρτητων- εξαρτημένης (Est1MT4)μεταβλητών

	Est1MT4	AMT4l2O3	LOIMT4
Est1MT4		**-0,5541** (45) **0,0001**	**-0,5239** (45) **0,0002**
AMT4l2O3	**-0,5541** (45) **0,0001**		0,0401 (45) 0,7936
LOIMT4	**-0,5239** (45) **0,0002**	0,0401 (45) 0,7936	

Συσχέτιση
(Μέγεθος δείγματος)
P-τιμή

Ο παραπάνω πίνακας παρουσιάζει τις συσχετίσεις κατά Pearson αφού τα δεδομένα προσαρμόζονται ικανοποιητικά στην κανονική κατανομή, όπως έχει αποδειχθεί και στην παράγραφο 4.12.1.Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%. Από τον πίνακα φαίνεται ότι δεν υπάρχει έντονη συσχέτιση μεταξύ των μεταβλητών LOI και Al_2O_3. Αντίθετα, υπάρχει έντονη συσχέτιση μεταξύ των αντοχών της πρώτης ημέρας και των μεταβλητών αυτών.

πολλαπλή παλινδρόμηση-όλες οι μεταβλητές

Προσδιορίζεται ένα γραμμικό μοντέλο συσχέτισης όλων των μεταβλητών οι οποίες δύναται να επηρεάσουν τις αντοχές του τσιμέντου και μελετάται το ποσοστό σημαντικότητας κάθε μεταβλητής στο μοντέλο.

Πίνακας 5. 56 πολλαπλή παλινδρόμηση-όλες οι μεταβλητές- Est1MT4

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est1MT4 = 13,7422 - 3,86692*AMT4l2O3 +0,00234256*BLAINEMT4 -0,351936*IR MT4 - 0,817075*LOIMT4 + 0,679244* SIO_2 MT4
R^2	60,8918%
$\overline{R^2}$	55,746 %
P τιμή του Durbin-Watson	0,0945
Συσχετισμένες μεταβλητές	-

Το μοντέλο παρουσιάζει πολυσυγγραμικότητα, η οποία οφείλεται στη συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών. Πιο συγκεκριμένα, συσχέτιση εμφανίζουν τα ζεύγη των μεταβλητών LOI-IR(αρνητική συσχέτιση), SiO_2 – IR (αρνητική συσχέτιση) και SiO_2-LOI (θετική συσχέτιση).
Στην προσπάθεια απλοποίησης του μοντέλου είναι καλό να τονισθεί ότι υπάρχουν μεταβλητές οι οποίες έχουν τιμή p> 0,1. Αυτές οι μεταβλητές θα μπορούσαν να εξαιρεθούν από το μοντέλο. Η εξαίρεση αυτή θα οδηγούσε στο μοντέλο που προκύπτει από τη ανιούσα επιλογή. (βλ. 4.1.1)

4.3.2.12. Αντοχές 2ης ημέρας – μύλος 4

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την 2η ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI), IR.** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-εισόδου: 4, προκρίνονται οι ακόλουθες μεταβλητές:
Al_2O_3 και LOI

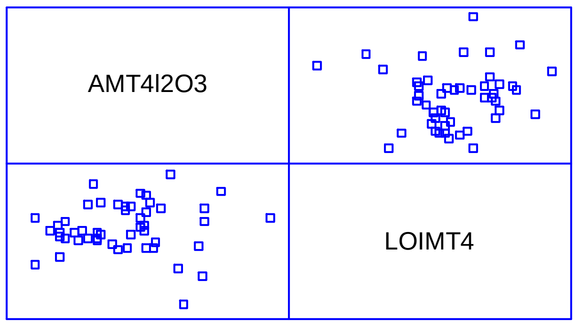
Πίνακας 5. 57 Βηματική παλινδρόμηση- ανιούσα επιλογή-Est2MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est2MT4 = 53,2607 - 4,60501*AMT4l2O3 - 1,12208*LOIMT4
R^2	54,4751 %
$\overline{R^2}$	52,1405 %
P τιμή του Durbin-Watson	0,3350
Συσχετισμένες μεταβλητές	-

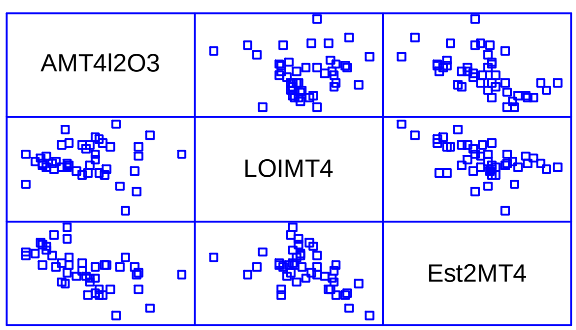
Οι τιμές P κάθε μεταβλητής είναι μικρότερα του 0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης και δε θα έπρεπε να αφαιρεθεί άλλος συντελεστής.
Η τιμή P-value του Durbin-Watson είναι 0,3350<0,05. Οπότε δεν υπάρχει ένδειξη αυτοσυσχέτισης των κατάλοιπων. Από το παρακάτω διάγραμμα μάλιστα των κατάλοιπων μπορεί να διαπιστωθεί ότι αυτά δεν ακολουθούν κάποιο μοτίβο.

Συσχέτιση

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στα επόμενα γραφήματα



Διάγραμμα5. 88 Συσχετίσεις μεταξύ των ανεξάρτητων μεταβλητών



Διάγραμμα5. 89 Συσχετίσεις μεταξύ ανεξάρτητων και εξαρτημένης μεταβλητής

καθώς και στον πίνακα που ακολουθεί

Πίνακας 5. 58 Συσχετίσεις ανεξάρτητων-εξαρτημένης μεταβλητής

	AMT4l2O3	LOIMT4	Est2MT4
AMT4l2O3		0,0401 (44) 0,7958	**-0,5582** (44) **0,0001**
LOIMT4	0,0401 (44) 0,7958		**-0,4933** (44) **0,0007**
Est2MT4	**-0,5582** (44) **0,0001**	**-0,4933** (44) **0,0007**	

Συσχέτιση
(Μέγεθος δείγματος)
P-τιμή

Ο παραπάνω πίνακας παρουσιάζει τις συσχετίσεις κατά Pearson δεδομένου ότι τα δεδομένα προσαρμόζονται ικανοποιητικά στην κανονική κατανομή (βλ. Παράγραφο 4.12.1).Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%. Οι μεταβλητές οι οποίες φαίνεται να συσχετίζονται μεταξύ τους είναι η Est2 και η Al_2O_3, αφού η τιμή P είναι 0,0001<0,05, αλλά και οι Est2 με τη LOI αφού οι τιμές είναι 0,0007.

πολλαπλή παλινδρόμηση-όλες οι μεταβλητές

Λαμβάνοντας υπόψη όλες τις μεταβλητές, η πολλαπλή παλινδρόμηση δίνει τα παρακάτω αποτελέσματα

Πίνακας 5. 59 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est2MT4

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est2MT4 = 31,7392 - 4,97889*AMT4l2O3 - 0,000753625*BLAINEMT4 - 0,506593*IR MT4 - 0,727142*LOIMT4 + 1,24997* SIO_2 ^{MT4}
R^2	59,2145 %
$\overline{R^2}$	53,703 %
P τιμή του Durbin-Watson	0,2742
Συσχετισμένες μεταβλητές	-

Η πολυσυγγραμικότητα του μοντέλου οφείλεται στη συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών.

Για την απλοποίηση του μοντέλου θα πρέπει να παρατηρηθούν οι αξίες p κάθε μεταβλητής. Από αυτές φαίνεται ότι κάποιες μεταβλητές θα έπρεπε να εξαιρεθούν, εάν ήταν επιθυμητή η χρήση του απλούστερου μοντέλου. Με την εξαίρεση των μεταβλητών αυτών προκύπτει το μοντέλο που προέκυψε με τη χρήση forward selection.

4.3.2.13. Αντοχές 7ης ημέρας – μύλος 4

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-εισόδου: 4, δεν προκρίνεται καμία μεταβλητή:

Πίνακας 5. 60 βηματική παλινδρόμηση-ανιούσα επιλογή-Est7MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est7MT4 = 40,207
R^2	33,9566 %
$\overline{R^2}$	30,8848 %
P τιμή του Durbin-Watson	0,1401
Συσχετισμένες μεταβλητές	-

Η τιμή P-value του Durbin-Watson είναι 0,1401>0,05. Άρα δεν υπάρχει ένδειξη αυτοσυσχέτισης των κατάλοιπων.

πολλαπλή παλινδρόμηση-όλες οι μεταβλητές

Η μελέτη πολλαπλής παλινδρόμησης χωρίς την εξαίρεση καμίας μεταβλητής παρουσιάζει το παρακάτω μοντέλο

Πίνακας 5. 61 πολλαπλή παλινδρόμηση-όλες οι μεταβλητές-Est7MT4

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est7MT4 = 45,0267 - 4,54338*AMT4l2O3 + 0,00199912*BLAINEMT4 + 0,554794*IR MT4 - 0,0609844*LOIMT4 + 0,302376* SIO_2 ^{MT4}
R^2	9,83305 %
$\overline{R^2}$	0,0 %
P τιμή του Durbin-Watson	0,3918
Συσχετισμένες μεταβλητές	-

Το παραπάνω μοντέλο περιγράφει τον τρόπο μεταβολής της μεταβλητής Est7 κατά 9,83305% μόνο. Η τιμή p του μοντέλου είναι παραπάνω από 0,1 γεγονός το οποίο φανερώνει ότι δεν υπάρχει σημαντική συσχέτιση μεταξύ των μεταβλητών. Παρατηρώντας μάλιστα τις τιμές p κάθε μεταβλητής διαπιστώνεται ότι καμία από αυτές, εκτός της Al_2O_3 δεν πληροί τις προϋποθέσεις για να ενταχθεί στο μοντέλο υπολογισμού των αντοχών 7ης ημέρας.

4.3.2.14. Αντοχές 28ης ημέρας – μύλος 4

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-εισόδου: 4, προκρίνονται οι ακόλουθες μεταβλητές: **Al_2O_3**

Πίνακας 5. 62 βηματική παλινδρόμηση- ανιούσα επιλογή-Est28MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est28MT4 = 103,315 - 0,0119256*BLAINEMT4
R^2	12,7558 %
$\overline{R}^2$	10,1121 %
P τιμή του Durbin-Watson	0,2699
Συσχετισμένες μεταβλητές	-

Προκειμένου να μελετηθεί σε βάθος η συσχέτιση των αντοχών των 28 ημερών με τις φυσικοχημικές και χημικές ιδιότητες πραγματοποιείται η δημιουργία μοντέλων Απλής Γραμμικής Παλινδρόμησης για τα παρακάτω ζεύγη μεταβλητών.

- Est28MT1-Al_2O_3
- Est28MT1-IR
- Est28MT1-LOIMT1
- Est 28Mt1-SiO_2

Για κάθε ζεύγος μεταβλητών πραγματοποιήθηκε σύγκριση των διαφόρων μοντέλων για εύρεση του μοντέλου που περιγράφει καλύτερα τη συσχέτισή τους. Τα αποτελέσματα παρουσιάζονται στον παρακάτω πίνακα.

Πίνακας 5. 63 εναλλακτικά μοντέλα προσδιορισμού της μεταβλητής Est28MT1

	Est28MT1-Al_2O_3	*Est28MT1-IR*	*Est28MT1-LOIMT1*	*Est 28Mt1-SiO_2*
Μοντέλο Εξίσωση	reciprocal-X Est2MT4 = 2,36546 + 112,236/AMT4l2O3	Reciprocal-Y Est2MT4 = 1/(0,0350691 + 0,000992032*IR MT4)	Reciprocal-Y Est2MT4 = 1/(0,0309406 + 0,00195932*LOIMT4)	Double reciprocal Est2MT4 = 1/(0,0481454 - 0,170507/ $SIO_2{}^{MT4}$)
Ποσοστό συσχέτισης	32,28%	13,31%	26,31%	0,70%

πολλαπλή παλινδρόμηση-όλες οι μεταβλητές

Η παραγωγική διαδικασία απαιτεί τη γνώση κάθε παραμέτρου η οποία επηρεάζει έστω και κατά το ελάχιστο τις απαιτούμενες ιδιότητες. Για το λόγο αυτό, με τη γραμμική παλινδρόμηση γίνεται προσπάθεια εντοπισμού ενός μοντέλου το οποίο θα περιλαμβάνει όλες τις μεταβλητές. Το μοντέλο που προκύπτει από την ανάλυση είναι το παρακάτω

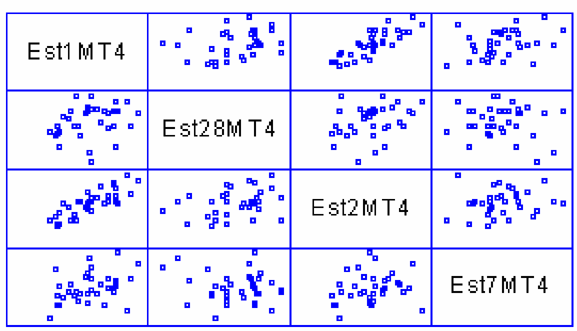
Est28MT4 = 121,658 + 0,746605*AMT4l2O3 - 0,0119392*BLAINEMT4 - 0,276651*IR MT4 - 0,281288*LOIMT4 - 0,873203* SIO_2^{MT4}

Το μοντέλο αυτό περιγράφει κατά 24,1043% τη μεταβλητότητα των αντοχών κατά την 28η ημέρα. Δεδομένου όμως ότι η τιμή p του μοντέλου είναι μεγαλύτερη από 0,1 επιβεβαιώνεται ότι δεν υπάρχει σημαντική συσχέτιση των ανεξάρτητων μεταβλητών με την εξαρτημένη μεταβλητή. Η πολυσυγγραμικότητα του μοντέλου οφείλεται στη συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών και πιο συγκεκριμένα των ζευγών BLAINE- LOI , SiO_2- LOI, SiO_2 – IR, LOI- IR. Πολλές από τις μεταβλητές μπορούν να εξαιρεθούν από το μοντέλο , ώστε να γίνει αυτό απλούστερο και να πάρει τη μορφή του μοντέλου που προτείνεται με τη μέθοδο forward selection.

4.3.2.15. Συσχέτιση μεταξύ των αντοχών τσιμέντου 1ης ημέρας, 2 ημερών, 7 ημερών και 28 ημερών. – μύλος 4

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο από την 1η έως και την 28η ημέρα σχετίζονται μεταξύ τους.

Η συσχέτιση μεταξύ των μεταβλητών παρουσιάζεται στο επόμενο γράφημα:



Διάγραμμα5. 90Συσχετίσεις μεταξύ των μεταβλητών

Καθώς και στον πίνακα όπου φαίνονται οι συσχετίσεις κατά Spearman

Πίνακας 5. 64 Συσχετίσεις αντοχών τσιμέντου ΙΙ 42,5 για το μύλο 4

	Est1MT4	Est28MT4	Est2MT4	Est7MT4
Est1MT4		**0,3482**	**0,8254**	**0,3986**
		(35)	(35)	(35)
		0,0423	**0,0000**	**0,0201**
Est28MT4	**0,3482**		0,3212	-0,0354
	(35)		(35)	(35)
	0,0423		0,0611	0,8366
Est2MT4	**0,8254**	0,3212		0,2870
	(35)	(35)		(35)
	0,0000	0,0611		0,0942
Est7MT4	**0,3986**	-0,0354	0,2870	
	(35)	(35)	(35)	(μέγεθος δείγματος)
	0,0201	0,8366	0,0942	P-τιμή

Ο παραπάνω πίνακας παρουσιάζει τις συσχετίσεις κατά Spearman.Οι σταθερές συσχέτισης κυμαίνονται από -1 έως +1 και μετράνε τη γραμμική συνάφεια μεταξύ των μεταβλητών. Στην παρένθεση φαίνεται το μέγεθος του δείγματος ενώ στον πίνακα επίσης καταγράφεται και η τιμή του P,με την οποία ελέγχεται η σημαντικότητα των εκτιμώμενων συσχετίσεων. Οι τιμές του P οι οποίες είναι κάτω από 0,05 παρουσιάζουν συσχετίσεις σε σημαντικότητα 95%.

Όπως φαίνεται από τον πίνακα οι μεταβλητές οι οποίες παρουσιάζουν σημαντικές συσχετίσεις μεταξύ τους είναι αυτές που εκφράζουν τις αντοχές $1^{ης}$ – $2^{ης}$ ημέρας, $1^{ης}$- $7^{ης}$ ημέρας και $1^{ης}$- $28^{ης}$ ημέρας . Οι αντοχές $2^{ης}$ ημέρας δε φαίνεται να συσχετίζονται με αυτές της $7^{ης}$. Το ίδιο ισχύει και τις αντοχές μεταξύ των αντοχών $2^{ης}$- $28^{ης}$ ημέρας , όπως και γι αυτές μεταξύ $7^{ης}$-$28^{ης}$ ημέρας.

Για αναλυτικότερη προσέγγιση των συσχετίσεων μεταξύ των παραπάνω ζευγών μεταβλητών πραγματοποιείται απλή παλινδρόμηση:

5.3.2.16. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 28 ημερών – μύλος 4

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 28 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει στις 7 ημέρες. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 7 και 28 ημέρες.
Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est28MT4 = 55,8427 - 0,0825909*Est7MT4

Και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 65 Ανάλυση απλής παλινδρόμησης **Est28MT1 vs. Est7MT1**

Ανάλυση παλινδρόμησης – γραμμικό μοντέλο: Y = a + b*X

εξαπτόμενη μεταβλητή: Est28MT4
Ανεξάρτητη μεταβλητή: Est7MT4

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	55,8427	4,28065	13,0454	0,0000
Κλίση	-0,0825909	0,106765	-0,77358	0,4447

Όπως φαίνεται και από τις τιμές των p αυτές είναι 0,4447>0,05. Άρα δεν υπάρχει μεγάλη συσχέτιση μεταξύ των μεταβλητών.

Με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές ή αν απαιτείται κάποιο περισσότερο πολύπλοκο μοντέλο. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 66Ανάλυση διασποράς για την προσαρμογή μοντέλου που δείχνει τη σχέση μεταξύ Est28MT4-Est7MT4

	άθροισμα τετραγώνων	β.ε.	μέσος τετραγώνων	F-λόγος	P-τιμή
μοντέλο	2,11358E-7	1	2,11358E-7	0,68	0,4170
Κατάλοιπα	0,0000103245	33	3,12863E-7		
Lack-of-Fit	0,00000889619	27	3,29488E-7	1,38	0,3648
Pure Error	0,0000014283	6	2,38049E-7		
σύνολο (Συσχ.)	0,0000105358	34			

με p τιμή ίση με 0,3648>0,10. Άρα το μοντέλο παρουσιάζεται ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές.

Συγκρίνοντας με άλλα μοντέλα αυτό που φαίνεται ακόμα πιο ιδανικό είναι το reciprocal y, το οποίο περιγράφει τη μεταβολή της μεταβλητής Est28 κατά 2,01%, ποσοστό το οποίο και πάλι δεν αποτελεί σημαντικό για τον προσδιορισμό της συσχέτισης μεταξύ των μεταβλητών.

Σύγκριση με εναλλακτικά μοντέλα

Μοντέλο	Συσχέτιση	R^2
Διπλή αντιστροφή	0,7968	63,48%
Καμπύλη μορφής S	-0,7966	63,46%
Αντίστροφο-X	-0,7963	63,41%
Πολλαπλασιαστικό	0,7882	62,12%
Λογαριθμικό-X	0,7881	62,12%
Τετραγωνική ρίζα-X	0,7837	61,42%
Γραμμικό	0,7790	60,69%
Τετραγωνική ρίζα-Y	0,7789	60,68%
Εκθετική	0,7788	60,65%
Αντίστροφο-Y	-0,7784	60,59%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

4.3.2.17. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 2 ημερών – μύλος 4

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 28 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει στις 7 ημέρες. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 7 και 28 ημέρες.

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.

Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est7MT4 = 35,1867 + 0,201282*Est2MT4

Και δικαιολογείται από τον παρακάτω πίνακα

Απλή παλινδρόμηση - Est7MT1 vs. Est2MT1

Πίνακας 5. 67 Ανάλυση γραμμικής παλινδρόμησης Est7MT4-Est2MT4

Γραμμική παλινδρόμηση- γραμμικό μοντέλο: Y = a + b*X

εξαπτόμενη μεταβλητή: Est7MT4
ανεξάρτητη μεταβλητή: Est2MT4

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	35,1867	6,65183	5,28977	0,0000
κλίση	0,201282	0,267312	0,752986	0,4560

όπως δικαιολογείται από τις τιμές p αυτές είναι μεγαλύτερες του 0,05. Άρα οι συντελεστές δεν είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.

με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι
Analysis of Variance with Lack-of-Fit

Πίνακας 5. 68 Ανάλυση διασποράς για την προσαρμογή γραμμικού μοντέλου Est7MT4-Est2MT4

	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	3,12052	1	3,12052	0,57	0,4560
Κατάλοιπα	214,643	39	5,50368		
Lack-of-Fit	115,429	26	4,43959	0,58	0,8838
Pure Error	99,2142	13	7,63186		
σύνολο (Συσχ.)	217,764	40			

με p τιμή ίση με 0,8838>0,10. Άρα το μοντέλο παρουσιάζεται ικανοποιητικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές.

Συγκρίνοντας με άλλα μοντέλα αυτό που φαίνεται ακόμα πιο ιδανικό είναι το Double reciprocal, το οποίο περιγράφει τη μεταβολή της μεταβλητής Est28 κατά 1,66%.

Σύγκριση με εναλλακτικά μοντέλα

Μοντέλο	Συσχέτιση	R^2
Διπλή αντιστροφή	0,1288	1,66%
Καμπύλη της μορφής S	-0,1288	1,66%
αντίστροφος-X	-0,1286	1,65%
πολλαπλασιαστικό	0,1245	1,55%
λογαριθμικό-X	0,1244	1,55%
Τετραγωνική ρίζα-X	0,1221	1,49%
Εκθετικό	0,1198	1,43%
Τετραγωνική ρίζα-Y	0,1197	1,43%
Γραμμικό	0,1197	1,43%
Αντίστροφο-Y	-0,1197	1,43%
Λογιστικό	<no fit>	
Λογαριθμικό probit	<no fit>	

4.3.2.18. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 2 ημερών και τσιμέντου 1 ημέρας – μύλος 4

Εξετάζεται κατά πόσο οι αντοχές που αναπτύσσει το τσιμέντο στις 2 ημέρες σχετίζονται με τις αντοχές που αυτό αναπτύσσει κατά την 1η ημέρα. Για να διερευνηθεί κατά πόσο υπάρχει γραμμική σχέση και αν μπορεί να αναπτυχθεί κάποιο μαθηματικό μοντέλο που να ερμηνεύει αυτήν τη σχέση, μελετάται η συμπεριφορά το μέσου δείγματος τσιμέντου κατά τις 2 και 1 ημέρες.
Πραγματοποιείται απλή παλινδρόμηση μεταξύ των δύο μεταβλητών με εξαρτώμενη μεταβλητή την Est2 και ανεξάρτητη την Est1.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est2MT4 = 11,1752 + 1,01394*Est1MT4

Και δικαιολογείται από τον παρακάτω πίνακα

Πίνακας 5. 69 Ανάλυση γραμμικής απλής παλινδρόμησης για το μοντέλο συσχέτισης Est2MT4-Est1MT4

Ανάλυση παλινδρόμησης-γραμμικό μοντέλο: Y = a + b*X

εξαπτόμενη μεταβλητή: Est2MT4
ανεξάρτητη μεταβλητή: Est1MT4

Παράμετρος	εκτίμηση	τυπικό σφάλμα	T Statistic	τιμή p
Intercept	11,1752	1,19192	9,37579	0,0000
Slope	1,01394	0,0882392	11,4908	0,0000

Όπως φαίνεται και από τις τιμές των p αυτές είναι 0<0,05. Άρα οι συντελεστές είναι σημαντικοί για το μοντέλο γραμμικής παλινδρόμησης.

Από την ανάλυση της διασποράς παρατηρείται ότι

Πίνακας 5. 70Ανάλυση διασποράς για προτεινόμενο μοντέλο συσχέτισης Est2MT4-Est1MT4

Πηγή	άθροισμα τετραγώνων	β.ε.	μ.τ.τετραγώνων	F-λόγος	P-τιμή
μοντέλο	59,2219	1	59,2219	132,04	0,0000
κατάλοιπα	18,3893	41	0,448519		
Συνολικά (Συσχ.)	77,6112	42			

Συντελεστής συσχέτισης = 0,873532
R^2 = 76,3059 percent
R^2 (προσαρμοσμένο στους β.ε.) = 75,728 percent
Τυπικό σφάλμα εκτ. = 0,669715
Μέσο απόλυτο σφάλμα = 0,560176
Durbin-Watson = 1,85744 (P=0,2854)
Αυτοσυσχέτιση κατάλοιπων = 0,0424245

Όπως φαίνεται από το R^2 το μοντέλο όπως περιγράφεται ερμηνεύει κατά 75,3059% τη μεταβλητότητα της αντοχής Est2MT1.

Με τη χρήση του lack of fit test, εξετάζουμε κατά πόσο το παραπάνω προτεινόμενο μοντέλο είναι ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές. Από την ανάλυση της εξέτασης αυτής προκύπτει ότι

Πίνακας 5. 71 Ανάλυση διασποράς για προσαρμογή γραμμικού μοντέλου συσχέτισης Est2MT4-Est1MT4

	άθροισμα τετραγώνων	β.ε.	τετράγωνο μέσων	F-λόγος	P-τιμή
μοντέλο	59,2219	1	59,2219	132,04	0,0000
κατάλοιπα	18,3893	41	0,448519		
Lack-of-Fit	11,9593	26	0,459972	1,07	0,4562
Pure Error	6,43	15	0,428667		
σύνολο (συσχ.)	77,6112	42			

με p τιμή ίση με 0,4562>0,01. Άρα το μοντέλο παρουσιάζεται ιδανικό για την περιγραφή της σχέσης που συνδέει τις δύο μεταβλητές.

Συγκρίνοντας και με άλλα μοντέλα αυτό το οποίο περιγράφει πιο καλά τη σχέση μεταξύ των δύο μεταβλητών είναι το Double reciprocal.

Σύγκριση εναλλακτικών μοντέλων

μοντέλο	συσχέτιση	R^2
διπλή αντιστροφή	0,8855	78,41%
καμπύλη μορφής S	-0,8819	77,77%
πολλαπλασιαστικό	0,8797	77,38%
αντίστροφο-X	-0,8770	76,91%
λογαριθμικό-X	0,8764	76,81%
αντίστροφο-Y	-0,8758	76,70%
εκθετικό	0,8753	76,61%
τετραγωνική ρίζα-X	0,8752	76,60%
τετραγωνική ρίζα-Y	0,8746	76,49%
γραμμικό	0,8735	76,31%
λογιστικό	<no fit>	
λογαριθμικό probit	<no fit>	

4.3.3. Ποιότητα τσιμέντου OPC

4.3.3.1. Συσχέτιση ανεξάρτητων μεταβλητών

Πριν από κάθε στατιστική ανάλυση και προσπάθεια προσδιορισμού της γραμμικής συσχέτισης μεταξύ των αντοχών και των ιδιοτήτων ή των αντοχών και της σύστασης είναι απαραίτητο να μελετηθεί η σχέση μεταξύ των ανεξάρτητων μεταβλητών.

Ως προς τις ιδιότητες του τσιμέντου:

Μελετήθηκε η συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών **Al_2O_3, SiO_2, Blaine, Loss Of Ignition(LOI).**
Από τη μελέτη προέκυψαν τα παρακάτω αποτελέσματα που παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Spearman).

Πίνακας 5. 72 Συσχέτιση ανεξάρτητων μεταβλητών

	Al2O3MT3	BlaineMT3	LOIMT3	SiO2MT3
Al2O3MT3		0,0638 (66) 0,6071	-0,1083 (66) 0,3826	**0,4036** (66) **0,0011**
BlaineMT3	0,0638 (66) 0,6071		0,1043 (66) 0,4004	-0,0768 (66) 0,5356
LOIMT3	-0,1083 (66) 0,3826	0,1043 (66) 0,4004		0,0055 (66) 0,9646
SiO2MT3	**0,4036** (66) **0,0011**	-0,0768 (66) 0,5356	0,0055 (66) 0,9646	

Όπως φαίνεται από τον παραπάνω πίνακα υπάρχει συσχέτιση μεταξύ των μεταβλητών :
Al2O3MT3 and SiO2MT3

Από εκτενέστερη μελέτη της συσχέτισης των δύο αυτών μεταβλητών προέκυψε ότι το κατάλληλο μοντέλο που προσδιορίζει αυτή τη συσχέτιση είναι το γραμμικό και πιο συγκεκριμένα το προτεινόμενο μοντέλο είναι το ακόλουθο
Al2O3_3 = -0,273568 + 0,244569*SiO2_3
Η σταθερά συσχέτισης είναι ίση με 0,4901 που σημαίνει ότι δεν είναι ιδιαίτερα έντονη η συσχέτιση ενώ το μοντέλο ερμηνεύει τη συσχέτιση αυτή κατά 22,83333%.

Ως προς τα σύνθεση του τσιμέντου:

Μελετήθηκε η συσχέτιση μεταξύ των μεταβλητών: **ποσοστό κλίνκερ (Clk), γύψου(Gyp) και λεπτότητα (Blaine) .** Τα αποτελέσματα παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Pearson).

Πίνακας 5. 73 Συσχέτιση ανεξάρτητων μεταβλητών σύνθεσης τσιμέντου OPC

	CLMT3	BlaineMT3	GYP_3
CLK_3		0,1481 (66) 0,2352	**-1,0000** (66) **0,0000**
BlaineMT3	0,1481 (66) 0,2352		-0,1481 (66) 0,2352
GYPMT3	**-1,0000** (66) **0,0000**	-0,1481 (66) 0,2352	

Όπως φαίνεται και από τον παραπάνω πίνακα η μεταβλητή Gyp και η μεταβλητή Clk έχουν απόλυτη γραμμική συσχέτιση (αρνητική).
Περαιτέρω μελέτη της σχέσης μεταξύ των δύο μεταβλητών αποδεικνύει ότι το μοντέλο το οποίο ερμηνεύει τη σχέση των δύο μεταβλητών είναι το γραμμικό. Το μοντέλο το οποίο προτείνεται είναι το παρακάτω
CLK_3 = 100,0 - 1,0*GYP_3
Το οποίο ερμηνεύει κατά 100% τη σχέση μεταξύ των μεταβλητών.

5.3.3.2. Αντοχές πρώτης ημέρας – μύλος 3

Συσχέτιση αντοχών- ιδιοτήτων

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την πρώτη ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI).** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Από την ανάλυση και αντίστοιχα με τη μελέτη του τσιμέντου τύπου ΙΙ 42,5 προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 74 Πολλαπλή παλινδρόμηση (όλες οι μεταβλητές) για Est1MT3

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est1MT3 = 44,1397 - 0,661762*Al2O3MT3 + 0,002985*BlaineMT3 - 0,797173*LOIMT3 - 1,59767*SiO2MT3
R^2	14,9212%
$\overline{R^2}$	9,24927 %
P τιμή του Durbin-Watson	0
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 75 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est1MT3

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	`Est1MT3 = 53,8431 - 1,73483*SiO2MT3`
R^2	11,7982%
$\overline{R^2}$	10,3982 %
P τιμή του Durbin-Watson	0
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση αντοχών- σύνθεσης

Εξετάζεται πώς ερμηνεύεται η μεταβολή των αντοχών του τσιμέντου σε σχέση με τη σύνθεση αυτού. Πιο συγκεκριμένα εξετάζεται η μεταβολή του τσιμέντου ανάλογα με το ποσοστό κλίνκερ (Clk), γύψου(Gyp) και τη λεπτότητα(Blaine) αυτού.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 76 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est1MT3-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	`Est1MT3 = 16,5879 - 0,120695*CLKMT3 + 0,00355834*BlaineMT3`
R^2	4,51256%
$\overline{R^2}$	1,57448 %
P τιμή του Durbin-Watson	0,0001
Συσχετισμένες μεταβλητές	-

Η μεταβλητή **Gyp** δεν εμφανίζεται στο μοντέλο διότι έχει γραμμική συσχέτιση με τη μεταβλητή **Clk**
Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των

κατάλοιπων(παράρτημα Γ)παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσα επιλογή και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-εισόδου: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 77 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est1MT3-σύνθεση

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est1MT3 = 18,0265
$\mathbf{R^2}$	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0002
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την πρώτη ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την πρώτη ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

5.3.3.3. Αντοχές 2ης ημέρας – μύλος 3

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 78 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est2MT3-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est2MT3 = 71,0307 - 3,62439*Al2O3MT3 + 0,00291448*BlaineMT3 -0,516118*LOIMT3 - 1,6752*SiO2MT3
$\mathbf{R^2}$	28,0979%
$\overline{R^2}$	23,2232 %
P τιμή του Durbin-Watson	0,0034
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-forward selection

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2, Al_2O_3

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 79 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est2MT3-ιδιότητες

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est2MT3 = 81,2166 - 3,29373*Al2O3MT3 - 1,7559*SiO2MT3
R^2	26,1999%
$\overline{R^2}$	23,7802%
P τιμή του Durbin-Watson	0,0032
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 80 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est2MT3-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est2MT3 = 41,5619 - 0,237812*CLKMT3 + 0,00287281*BlaineMT3
R^2	2,27545 %
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0054
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων (παράρτημα) παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 81 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est2MT3-σύνθεση

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est2MT3 = 29,191
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0110
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά τη δεύτερη ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά τη δεύτερη ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

5.3.3.4. Αντοχές 7ης ημέρας- μύλος 3

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 82 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est7MT3-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est7MT3 = 90,8807 - 2,90638*Al2O3MT3 + 0,00237135*BlaineMT3 - 0,831902*LOIMT3 - 1,97108*SiO2MT3
R^2	18,2503%
$\overline{R^2}$	12,411 %
P τιμή του Durbin-Watson	0,0002
Συσχετισμένες μεταβλητές	Al_2O_3-SiO_3(p=-0,5011)

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 83 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est7MT3- ιδιότητες

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est7MT3 = 99,3417 - 2,67811*SiO2MT3
R^2	14,4355%
$\overline{R^2}$	12,9852%
P τιμή του Durbin-Watson	0,0001
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 84 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est7MT3-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est7MT3 = 103,579 - 0,747787*CLKMT3 + 0,00340307*BlaineMT3
R^2	3,06634 %
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0003
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων(παράρτημα) παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

πολλαπλή παλινδρόμηση-forward selection

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 85 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est7MT3-σύνθεση

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est7MT3 = 43,9922
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0024
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την $7^η$ ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την $7^η$ ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

5.3.3.5. Αντοχές $28^{ης}$ ημέρας- μύλος 3

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 86 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est28MT3-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est28MT3 = 53,9409 + 1,79985*Al2O3MT3 + 0,00318596*BlaineMT3 - 0,46652*LOIMT3 - 0,552152*SiO2MT3
R^2	4,1122%
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0462
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσα επιλογή και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προτείνεται καμία μεταβλητή.

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 87 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est28MT3-ιδιότητες

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est28MT3 = 62,3109
R^2	0%
$\overline{R^2}$	0%
P τιμή του Durbin-Watson	0,1707
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο. Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την $28^η$ ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την 28η ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 88 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές-Est28MT3-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est28MT3 = -38,4727 + 0,970306*CLKMT3 + 0,00192984*BlaineMT3
R^2	3,77706 %
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0460
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 89 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est28MT3-σύνθεση

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est28MT3 = 62,1959
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0536
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την $28^η$ ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την $28^η$ ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

5.3.3.6. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 28 ημερών – μύλος 3

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est7 και Est28 με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est28MT3 = 42,1483 + 0,460497*Est7MT3

Με
R^2 = 18,4906 %
R^2 (προσαρμοσμένο σε β.ε.) = 16,7564 %

4.3.3.7. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 2 ημερών – μύλος 3

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est7 και Est2 με εξαρτώμενη μεταβλητή την Est7 και ανεξάρτητη την Est2.
Το μοντέλο που προκύπτει από την ανάλυση είναι

Est7MT3 = 17,2843 + 0,913628*Est2MT3

Με
R^2 = 58,3068 %
R^2 (προσαρμοσμένο για β.ε.) = 57,6343 %

5.3.3.8. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 2 ημερών και τσιμέντου 1 ημέρας – μύλος 3

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est2 και Est1 με εξαρτώμενη μεταβλητή την Est2 και ανεξάρτητη την Est1.
Το μοντέλο που προκύπτει από την ανάλυση είναι

Est2MT3 = 14,2238 + 0,829585*Est1MT3

Με
R^2 = 51,8046 %
R^2(προσαρμοσμένο για β.ε.) = 51,0631 %

Μύλος 4

4.3.3.9. Συσχέτιση ανεξάρτητων μεταβλητών – μύλος 4

Αντίστοιχα με τη μελέτη της συσχέτισης των ανεξάρτητων μεταβλητών που πραγματοποιήθηκε για το μύλο 3, πραγματοποιήθηκε και για ο μύλο 4.

Ως προς τις ιδιότητες του τσιμέντου:

Μελετήθηκε η συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών **Al_2O_3, SiO_2, Blaine, Loss Of Ignition(LOI).**
Από τη μελέτη προέκυψαν τα παρακάτω αποτελέσματα που παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Pearson).

Πίνακας 5. 90 Συσχέτιση μεταβλητών ιδιοτήτων

	Al2O3_4	Blaine_4	LOI_4	sio2_4
Al2O3_4		-0,1213 (44) 0,4329	-0,0690 (44) 0,6562	0,1020 (44) 0,5101
Blaine_4	-0,1213 (44) 0,4329		**0,3086** (44) **0,0416**	**0,3933** (44) **0,0083**
LOI_4	-0,0690 (44) 0,6562	**0,3086** (44) **0,0416**		0,1856 (44) 0,2277
sio2_4	0,1020 (44) 0,5101	**0,3933** (44) **0,0083**	0,1856 (44) 0,2277	

Όπως φαίνεται από τον παραπάνω πίνακα υπάρχει συσχέτιση μεταξύ των μεταβλητών :
Blaine_4 and LOI_4
Blaine_4 and sio2_4

Από εκτενέστερη μελέτη της συσχέτισης κάθε ζεύγους των δύο αυτών μεταβλητών προέκυψαν τα ακόλουθα:

Blaine_4 and LOI_4

το κατάλληλο μοντέλο που προσδιορίζει αυτή τη συσχέτιση είναι το γραμμικό και πιο συγκεκριμένα το προτεινόμενο μοντέλο είναι το ακόλουθο
Blaine_4 = 3538,85 + 127,214*LOI_4

Η σταθερά συσχέτισης είναι ίση με 0,308573 που σημαίνει ότι δεν είναι ιδιαίτερα έντονη η συσχέτιση ενώ το μοντέλο ερμηνεύει τη συσχέτιση αυτή κατά 7,36746%.

Blaine_4 and sio2_4

Το κατάλληλο μοντέλο που προσδιορίζει αυτή τη συσχέτιση είναι το Reciprocal-Y και πιο συγκεκριμένα το προτεινόμενο μοντέλο είναι το ακόλουθο:

Blaine_4 = 1/(0,00044524 - 0,00000845191*sio2_4)

Η σταθερά συσχέτισης ισούται με -0,396465 που σημαίνει ότι η συσχέτιση μεταξύ των δύο μεταβλητών δεν είναι ιδιαίτερα έντονη. Το μοντέλο ερμηνεύει αυτή τη συσχέτιση κατά 13,7118%.

Ως προς τα σύνθεση του τσιμέντου:

Μελετήθηκε η συσχέτιση μεταξύ των μεταβλητών: **ποσοστό κλίνκερ (Clk), γύψου(Gyp) και λεπτότητα (Blaine) .** Τα αποτελέσματα παρουσιάζονται στον παρακάτω πίνακα (συσχετίσεις κατά Pearson).

Πίνακας 5. 91 Συσχέτιση μεταβλητών σύνθεσης

	CLK_3	Blaine_3	GYP_3
CLK_3		0,1481 (66) 0,2352	**-1,0000** (66) **0,0000**
Blaine_3	0,1481 (66) 0,2352		-0,1481 (66) 0,2352
GYP_3	**-1,0000** (66) **0,0000**	-0,1481 (66) 0,2352	

Όπως φαίνεται και από τον παραπάνω πίνακα η μεταβλητή Gyp και η μεταβλητή Clk έχουν απόλυτη γραμμική συσχέτιση (αρνητική).
Περαιτέρω μελέτη της σχέσης μεταξύ των δύο μεταβλητών αποδεικνύει ότι το μοντέλο το οποίο ερμηνεύει τη σχέση των δύο μεταβλητών είναι το γραμμικό. Το μοντέλο το οποίο προτείνεται είναι το παρακάτω
CLK_4 = 100,0 - 1,0*GYP_4

Το οποίο ερμηνεύει κατά 100% τη σχέση μεταξύ των μεταβλητών

4.3.3.10. Αντοχές πρώτης ημέρας – μύλος 4

Συσχέτιση αντοχών- ιδιοτήτων

Εξετάζεται πώς ερμηνεύεται η μεταβλητή αντοχών του τσιμέντου κατά την πρώτη ημέρα σε σχέση με τις μεταβλητές **Al_2O_3, SiO_2, Blaine, Loss Of Ignition (LOI).** Πιο συγκεκριμένα εξετάζεται ποια είναι η σχέση των αντοχών του τσιμέντου με τη χημική σύσταση αυτού.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Από την ανάλυση και αντίστοιχα με τη μελέτη του τσιμέντου τύπου II 42,5 προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 92 Πολλαπλή παλινδρόμηση-όλες οι μεταβλητές-Est1MT4-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est1_4 = 41,9881 + 0,171539*Al2O3_4 - 0,00258124*Blaine_4 + 0,997516*LOI_4 - 0,86516*sio2_4
R^2	7,29584%
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0010
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσα επιλογή» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 93 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est1MT4- ιδιότητες

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est1_4 = 16,614
R^2	0,0%
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0059
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.
Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την πρώτη ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την πρώτη ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

Συσχέτιση αντοχών- σύνθεσης

Εξετάζεται πώς ερμηνεύεται η μεταβολή των αντοχών του τσιμέντου σε σχέση με τη σύνθεση αυτού. Πιο συγκεκριμένα εξετάζεται η μεταβολή του τσιμέντου ανάλογα με το ποσοστό κλίνκερ (Clk), γύψου(Gyp) και τη λεπτότητα(Blaine) αυτού.

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 94 Πολλαπλή παλινδρόμηση- όλες οι μεταβλητές- Est1MT4- σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est1_4 = -46,5083 + 0,75*CLK_4 - 0,00248938*Blaine_4
R^2	4,7709%
$\overline{R^2}$	0,341637 %
P τιμή του Durbin-Watson	0,0013
Συσχετισμένες μεταβλητές	-

Δεδομένου ότι η μεταβλητή Gyp σχετίζεται γραμμικά απόλυτα με τη μεταβλητή Clk η πρώτη δε συμπεριλαμβάνεται στο προτεινόμενο μοντέλο. Η τιμή p του Durbin-Watson είναι μικρότερη του 0,5 και κατά συνέπεια υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσα επιλογή» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 95 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est1MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est1_4 = 16,6696
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0006
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την πρώτη ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την πρώτη ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

4.3.3.11. Αντοχές 2ης ημέρας – μύλος 4

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 96 Πολλαπλή Παλινδρόμηση-όλες οι μεταβλητές- Est2MT4-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est2_4 = 40,8838 + 0,140413*Al2O3_4 + 0,00104062*Blaine_4 - 0,0375825*LOI_4 - 0,857598*sio2_4
R^2	2,23625%
$\overline{R^2}$	0,0 %
P τιμή του Durbin-Watson	0,0204
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

4.2.1.2. πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση ανιούσας επιλογής και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2, Al_2O_3

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 97 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est2MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est2_4 = 27,6535
$\mathbf{R^2}$	0,0%
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0661
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 98Πολλαπλή παλινδρόμηση-όλες οι μεταβλητές- Est2MT4-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est2_4 = 0,507005 + 0,245614*CLK_4 + 0,000952027*Blaine_4
$\mathbf{R^2}$	0,475555 %
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0082
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

4.1.1.2. πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσα επιλογή» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 99 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est2MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est2_4 = 27,7261
$\mathbf{R^2}$	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0099
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά τη δεύτερη ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά τη δεύτερη ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

4.3.3.12. Αντοχές 7ης ημέρας

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 100Πολλαπλή παλινδρόμηση- όλες οι μεταβλητές-Est7MT4-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est7_4 = 43,4854 + 1,42281*Al2O3_4 + 0,00553258*Blaine_4 - 2,91636*LOI_4 - 1,19267*sio2_4
$\mathbf{R^2}$	12,1944%
$\overline{R^2}$	2,15947 %
P τιμή του Durbin-Watson	0,002
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσα επιλογή» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, προκρίνονται οι ακόλουθες μεταβλητές: SiO_2

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 101 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est7MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est7_4 = 42,52
R^2	0,0%
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0008
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 102Πολλαπλή παλινδρόμηση- όλες οι μεταβλητές-Est7MT4-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est7_4 = 94,9098 - 0,580835*CLK_4 + 0,00100749*Blaine_4
R^2	1,14168 %
$\overline{R^2}$	0,0%
P τιμή του Durbin-Watson	0,0001
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων(παράρτημα) παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο πρότυπο

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 103 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est7MT4-σύνθεση

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est7_4 = 42,5837
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,0002
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την 7η ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την 7η ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

4.3.3.13. Αντοχές 28ης ημέρας – μύλος 4

Συσχέτιση αντοχών- ιδιοτήτων

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 104Πολλαπλή παλινδρόμηση- όλες οι μεταβλητές- Est28MT4-ιδιότητες

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	Est28_4 = 113,664 + 7,75457*Al2O3_4 - 0,00225153*Blaine_4 - 3,47307*LOI_4 - 3,69425*sio2_4
R^2	32,6096%
$\overline{R^2}$	21,3778%
P τιμή του Durbin-Watson	0,1692
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων (παράρτημα) παρατηρείται ότι αυτά ακολουθούν κάποιο πρότυπο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προτείνεται καμία μεταβλητή.

Από την ανάλυση προκύπτει ο ακόλουθος πίνακας

Πίνακας 5. 105 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est28MT4-ιδιότητες

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	Est28_4 = 61,2966
R^2	0%
$\overline{R^2}$	0%
P τιμή του Durbin-Watson	0,2259
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο μοτίβο. Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την

28η ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την 28η ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

Συσχέτιση αντοχών- σύνθεσης

πολλαπλή παλινδρόμηση- συσχέτιση όλων των μεταβλητών

Η ανάλυση είχε τα εξής αποτελέσματα τα οποία παρουσιάζονται στον παρακάτω πίνακα

Πίνακας 5. 106Πολλαπλή παλινδρόμηση-όλες οι μεταβλητές- Est28MT4-σύνθεση

	Όλες οι μεταβλητές
Προτεινόμενο μοντέλο	`Est28_4 = 326,238 - 2,2631*CLK_4 - 0,0126088*Blaine_4`
R^2	15,3388 %
$\overline{R^2}$	9,2916%
P τιμή του Durbin-Watson	0,4344
Συσχετισμένες μεταβλητές	-

Επειδή η τιμή p του Durbin- Watson είναι μικρότερη του 0,5 υπάρχει η πιθανότητα συσχετισμού των κατάλοιπων. Από το διάγραμμα γραφικής αναπαράστασης των κατάλοιπων (παράρτημα) παρατηρείται ότι αυτά δεν ακολουθούν κάποιο συγκεκριμένο πρότυπο.

πολλαπλή παλινδρόμηση-ανιούσα επιλογή

Με τη χρήση «ανιούσας επιλογής» και ακολουθώντας τη βηματική παλινδρόμηση και με τιμή F-to-enter: 4, δεν προκρίνεται καμία μεταβλητή

Το μοντέλο που προκύπτει φαίνεται στον παρακάτω πίνακα

Πίνακας 5. 107 Βηματική Παλινδρόμηση-Ανιούσα επιλογή-Est28MT4

	Ανιούσα επιλογή
Προτεινόμενο μοντέλο	`Est28_4 = 61,2355`
R^2	0 %
$\overline{R^2}$	0 %
P τιμή του Durbin-Watson	0,4247
Συσχετισμένες μεταβλητές	-

Το γεγονός ότι η τιμή του R^2 είναι ίση με μηδέν δεν αποδεικνύει ότι οι αντοχές κατά την 28η ημέρα είναι σταθερές. Είναι φανερό ότι οι αντοχές κατά την 28η ημέρα επηρεάζονται περισσότερο από άλλες μεταβλητές και όχι από αυτές που έχουν προταθεί.

4.3.3.14. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 28 ημερών – μύλος 4

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est7 και Est28 με εξαρτώμενη μεταβλητή την Est28 και ανεξάρτητη την Est7.
Το μοντέλο που προκύπτει από την ανάλυση είναι :

Est28_4 = 16,4107 + 1,06399*Est7_4

Με
R^2 = 24,0316 %
R^2 (προσαρμοσμένο για β.ε.) = 21,412 %

4.3.3.15. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 7 ημερών και τσιμέντου 2 ημερών – μύλος 4

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est7 και Est2 με εξαρτώμενη μεταβλητή την Est7 και ανεξάρτητη την Est2.
Το μοντέλο που προκύπτει από την ανάλυση είναι

Est7_4 = 16,3461 + 0,946969*Est2_4

Με
R^2 = 51,7057 %
R^2 (προσαρμοσμένο στους β.ε..) = 50,5278 %

5.3.3.16. Μοντέλο συσχέτισης μεταξύ των αντοχών τσιμέντου 2 ημερών και τσιμέντου 1 ημέρας – μύλος 4

Πραγματοποιείται απλή παλινδρόμηση μεταξύ των μεταβλητών Est2 και Est1 με εξαρτώμενη μεταβλητή την Est2 και ανεξάρτητη την Est1.
Το μοντέλο που προκύπτει από την ανάλυση είναι

Est2_4 = 13,4367 + 0,857215*Est1_4

Με
R^2 = 60,3604 %
R^2 (προσαρμοσμένο στους β.ε.) = 59,4595 %

4.3.4. Συμπεράσματα

Από τα μοντέλα εκτίμησης των αντοχών σε θλίψη, διαφαίνονται και οι μεταβλητές οι οποίες επηρεάζουν σε μεγάλο βαθμό τις μηχανικές ιδιότητες του τσιμέντου.
Για την εξακρίβωση της σημαντικότητας αυτών των μεταβλητών πραγματοποιήθηκε μελέτη της συσχέτισης κάθε μίας από τις μεταβλητές που εκφράζουν τις αντοχές σε διάφορες μέρες με όλες τις υπόλοιπες αντοχές. Τα αποτελέσματα των παραπάνω

μελετών σε συνδυασμό με τις επιπλέον συσχετίσεις ανέδειξαν τις παρακάτω μεταβλητές ως τις πλέον σημαντικές για τη πρόβλεψη των μηχανικών αντοχών.

Πίνακας 5. 108 Οι πλέον σημαντικές μεταβλητές για την πρόβλεψη μηχανικων αντοχών αναφορικά με το τσιμέντο τύπου CEM II 42,5

CEM II 42,5					
		$1^{η}$ ημέρα	**$2^{η}$ ημέρα**	**$7^{η}$ ημέρα**	**$28^{η}$ ημέρα**
MT1	Από τα μοντέλα παλινδρόμησης	IR, Blaine, LOI	Al_2O_3, IR	Al_2O_3, IR	Al_2O_3
	Από συσχέτιση (Παράρτημα Γ)	IR, LOI, SiO2, Al2O3	IR, LOI,SiO2, Al2O3	-	Al2O3
MT4	Από τα μοντέλα παλινδρόμησης	Al_2O_3, LOI	Al_2O_3, LOI	-	Blaine
	Από συσχέτιση (Παράρτημα Γ)	IR, Al_2O_3, LOI	IR, Al_2O_3, LOI	IR, LOI, Al_2O_3	-

Πίνακας 5. 109 Οι πλέον σημαντικές μεταβλητές για την πρόβλεψη μηχανικων αντοχών αναφορικά με το τσιμέντο τύπου OPC

OPC					
		$1^{η}$ ημέρα	**$2^{η}$ ημέρα**	**$7^{η}$ ημέρα**	**$28^{η}$ ημέρα**
MT3	Από τα μοντέλα παλινδρόμησης	SiO2	Al_2O_3, SiO2	SiO2	-
	Από συσχέτιση (Παράρτημα Γ)	SiO2	SiO2, Al2O3	SiO2, Al2O3	-
MT4	Από τα μοντέλα παλινδρόμησης	-	-	-	-
	Από συσχέτιση (Παράρτημα Γ)	-	-	-	-

Σε ότι αφορά στη σύνθεση του τσιμέντου τύπου OPC, οι αντοχές αυτού δε φαίνεται να έχουν ιδιαίτερη συσχέτιση με τη σύνθεση και πιο συγκεκριμένα με το ποσοστό κλίνκερ και γύψου.
Όπως μπορεί εύκολα κανείς να διαπιστώσει από τους παραπάνω πίνακες πολλές μεταβλητές παρά το γεγονός ότι βρίσκονται σε συσχέτιση με τις μεταβλητές οι οποίες εκφράζουν αντοχές (Est) εντούτοις δεν εντάσσονται σε κάποιο μοντέλο παλινδρόμησης. Κάτι τέτοιο είναι απόλυτα ερμηνεύσιμο.

Δύο μεταβλητές οι οποίες συσχετίζονται μεταξύ τους δεν είναι απαραίτητο ότι η μία αποτελεί την αιτία της άλλης. Επίσης,ο στατιστικός προσδιορισμός ότι δύο μεταβλητές σχετίζονται μεταξύ τους δε σημαίνει απαραίτητα ότι συσχετίζονται με ευθύ και εξηγήσιμο τρόπο. Είναι δυνατό οι μεταβλητές αυτές απλά να μεταβάλλονται κατά τον ίδιο ή ακριβώς αντίθετο τρόπο λόγω κάποιας εξωτερικής αιτίας, η οποία τις επηρεάζει το ίδιο ή αντιθέτως[8] Οι μεταβλητές οι οποίες εντάσσονται στα μοντέλα είναι αυτές για τις οποίες τα δεδομένα εμφανίζουν καλή προσαρμοστικότητα. Οι μεταβλητές δηλαδή οι οποίες παρουσιάζονται σημαντικές για το μοντέλο είναι αυτές με τις οποίες δημιουργείται μία εξίσωση παλινδρόμησης στην οποία προσαρμόζονται πολύ καλά τα δεδομένα. Η συσχέτιση της ανεξάρτητης με τις εξαρτώμενες μεταβλητές φαίνεται από τους πίνακες συσχέτισης.

Παρατηρείται, από την παραπάνω ανάλυση ότι κάποια μοντέλα στα οποία χρησιμοποιούνται όλες οι μεταβλητές προσδιορίζουν καλύτερα τη μεταβλητότητα της εξαρτημένης μεταβλητής από τα αντίστοιχα μοντέλα τα οποία προκύπτουν από τη βηματική παλινδρόμηση. (R^2). Αυτή η παρατήρηση θα ήταν λάθος αν οδηγούσε στο συμπέρασμα ότι τα πρώτα μοντέλα μπορούν καλύτερα να προβλέψουν την ανεξάρτητη μεταβλητή. Αντίθετα, σε αυτά τα μοντέλα η ελευθερία διακύμανσης των μεταβλητών είναι τόσο μικρή, ώστε να είναι αρκετά δύσκολο να προβλεφθεί η όποια διακύμανση των νέων τιμών. [3]

Κατά τη μελέτη της γραμμικής παλινδρόμησης και για την ερμηνεία των αντοχών του τσιμέντου τύπου CEM II 42,5 δε μελετάται η σύνθεση αυτού. Αυτό γίνεται διότι ο τύπος αυτού του τσιμέντου αποτελείται από κλίνκερ, γύψο, ποζολάνη και ασβεστόλιθο, τα οποία είναι συστατικά τα οποία αλληλοεξαρτώνται μεταξύ τους. Το κλίνκερ περιλαμβάνει ένα ποσοστό ασβεστολίθου και η ποσότητά του είναι άμεσα συναπτόμενη με την ποσότητα του γύψου και της ποζολάνης.

Αποτελέσματα των πολλαπλών παλινδρομήσεων

Ποιότητα τσιμέντου CEM II 42,5- μύλος 1
Παρουσιάζεται απόλυτη γραμμική συσχέτιση μεταξύ των μεταβλητών Est28, Est7και Est2. Κάτι τέτοιο δίνει τη δυνατότητα στη βιομηχανία γνωρίζοντας τις αντοχές του τσιμέντου 2 ημερών να προσδιορίζει τις αντοχές που αυτό θα αποκτήσει σε διάστημα 28 ημερών.

Κατά το μοντέλο πρόβλεψης 1ης ημέρας φαίνεται πως δεν υπάρχει έντονη συσχέτιση μεταξύ της μεταβλητής Blaine και της εξαρτημένης Est1. Παρόλαυτά, η μεταβλητή Blaine θεωρείται σημαντική για το μοντέλο. Η αντίφαση αυτή οφείλεται στο γεγονός ότι αυτή η ανεξάρτητη μεταβλητή αν και δεν έχει έντονη συσχέτιση με την εξαρτημένη δεν παρουσιάζει καμία συσχέτιση με τις άλλες μεταβλητές. Η εισαγωγή της λοιπόν στο μοντέλο δεν δημιουργεί κανένα πρόβλημα πολυσυγγραμικότητας.

Η μοναδική μεταβλητή η οποία φαίνεται να εισάγεται στο μοντέλο πρόβλεψης των αντοχών στις 28 ημέρες είναι η Al_2O_3. Το αποτέλεσμα αυτό φαίνεται αρχικά να είναι αντίθετα με τη βιβλιογραφία,[4],[5] σύμφωνα με την οποία οι αντοχές εξαρτώνται άμεσα και από το ποσοστό SiO_2 καθώς και από τη λεπτότητα του τσιμέντου η οποία μετράται και από το Blaine. Τα αποτελέσματα αυτά μπορούν να ερμηνευθούν από το γεγονός ότι κάποιες ανεξάρτητες μεταβλητές συσχετίζονται μεταξύ τους με αποτέλεσμα να επηρεάζουν με τον ίδιο τρόπο την ανεξάρτητη μεταβλητή. Το μοντέλο το οποίο προτείνεται, είναι αυτό στο οποίο προσαρμόζονται καλύτερα τα δεδομένα και κατά τη μελέτη αφαιρούνται πολλές φορές μεταβλητές οι οποίες συσχετίζονται με την εξαρτημένη αλλά ο τρόπος με τον οποίο την επηρεάζουν καλύπτεται με την παρουσία άλλων μεταβλητών.

Ποιότητα τσιμέντου CEM II 42,5- μύλος 4

Για το μύλο αυτό δεν παρουσιάζεται συσχέτιση μεταξύ των μεταβλητών οι οποίες αντιπροσωπεύουν τις αντοχές. Κάτι τέτοιο δικαιολογείται από το γεγονός ότι ο μύλος 4 διαφέρει από τον 1 ως προς την τεχνολογία. Σε αντίθεση με το μύλο 1, ο μύλος 4 είναι ένας κάθετος μύλος ο οποίος χρησιμοποιεί μια νέα τεχνολογία για την παραγωγή τσιμέντου. Κάτι τέτοιο αποδεικνύει τη σημασία των λειτουργικών παραμέτρων, οι οποίες δεν προσδιορίζονται από τα μοντέλα, στην ερμηνεία και πρόβλεψη των αντοχών.

Ποιότητα τσιμέντου OPC- μύλος 3

Παρουσιάζεται συσχέτιση μεταξύ των μεταβλητών Est7 και Est2 , ενώ οι μεταβλητές Est7 και Est28 δε φαίνεται να συσχετίζονται. Κάτι τέτοιο ερμηνεύεται απόλυτα από τη χρήση βελτιωτικών. Κατά την παραγωγή τσιμέντου τύπου OPC πραγματοποιείται η χρήση βελτιωτικών τα οποία επιδρούν μετά τις 7 πρώτες ημέρες της παραγωγής. Η χρήση αυτών έχει σκοπό τη βελτίωση των μηχανικών αντοχών. Κατά συνέπεια οι αντοχές κατά τη διάρκεια των 28 ημερών μπορούν να προσδιορισθούν σε ικανοποιητικό βαθμό μόνο με το συνυπολογισμό της επίδρασης αυτών των βελτιωτικών.

Από τη γραμμική παλινδρόμηση καθώς και από τους πίνακες συσχέτισης (βλ. Παράρτημα Γ) δε φαίνεται να υπάρχει έντονη εξάρτηση των μηχανικών ιδιοτήτων από τη σύνθεση του τσιμέντου. Φυσικά, η σύνθεση σίγουρα είναι βασικό στοιχείο αλλά υπάρχουν άλλοι παράγοντες οι οποίοι είναι καθοριστικοί για τις αντοχές και οι οποίοι μπορούν να μεταβάλλουν τον τρόπο με τον οποίο μπορεί η σύνθεση να επηρεάσει τις τελικές αντοχές του τσιμέντου.

Ποιότητα τσιμέντου OPC- μύλος 4

Ισχύουν τα ίδια με το μύλο 3 για την παραγωγή OPC αλλά και τα ίδια με τον μύλο 4 για τα τεχνικά χαρακτηριστικά του μύλου.

4.4. Σύγκριση δύο πληθυσμών

4.4.1. Σκοπός της μελέτης

Από τη μελέτη των φυσικών, χημικών και μηχανικών ιδιοτήτων των δειγμάτων τσιμέντου προέκυψαν διαφορετικά συμπεράσματα για κάθε ένα μύλο. Δεδομένου ότι κάθε μύλος έχει διαφορετικά τεχνικά χαρακτηριστικά, τα οποία και επηρεάζουν το τελικό προϊόν τα αποτελέσματα αυτά αιτιολογούνται πλήρως. Για την εύρεση του μεγέθους της διαφοράς στα αποτελέσματα για τους δύο μύλους εφαρμόσθηκε η μέθοδος σύγκρισης δύο πληθυσμών. Η σύγκριση έγινε σε κάθε προς μελέτη ιδιότητα. Πιο συγκεκριμένα πραγματοποιήθηκε σύγκριση στο ποσοστό Al_2O_3 , SiO_2 , απώλεια πύρωσης (LOI), στη λεπτότητα (Blaine), στο αδιάλυτο υπόλειμμα (IR) και στις αντοχές $1^{ης}$, $2^{ης}$, $7^{ης}$ και $28^{ης}$ ημέρας. Για το τσιμέντο ποιότητας OPC πραγματοποιείται σύγκριση και των πληθυσμών για τη σύνθεση, δηλαδή για το ποσοστό κλίνκερ και γύψου.

4.4.2. Σύγκριση αποτελεσμάτων για τους δύο μύλους – ποιότητα τσιμέντου CEM II 42,5

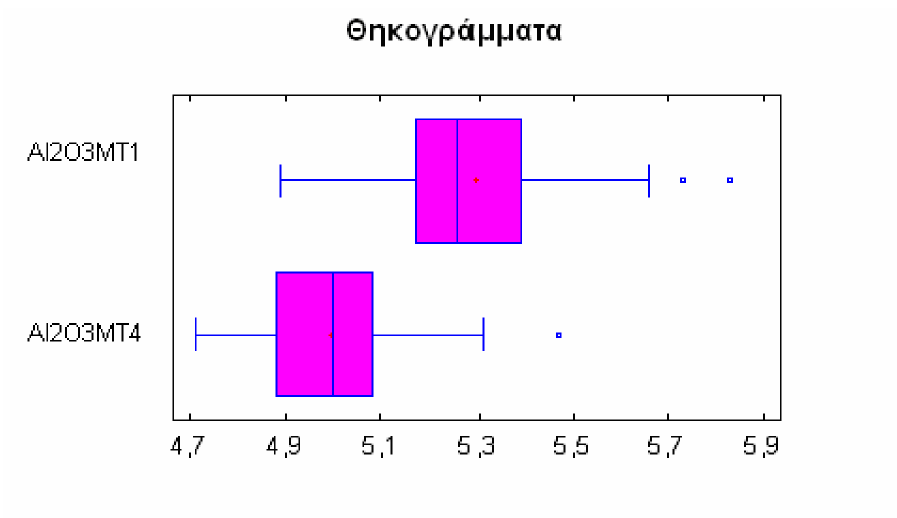
4.4.2.1 Σύγκριση ποσοστού Al_2O_3

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

Πίνακας 5. 110 Σύγκριση ποσοστού Al_2O_3 για μύλο 1 και μύλο 4

	Al2O3_2	AMT4l2O3
περιπτώσεις	47	49
μέσος όρος	5,29447	4,99735
Διασπορά	0,0405122	0,0281949
Τυπική απόκλιση	0,201276	0,167913
Μικρότερο	4,89	4,71
Μέγιστο	5,83	5,47
εύρος	0,94	0,76
τυπική ασυμμετρία	1,48054	1,27492
τυπική κύρτωση	0,328911	0,0629493

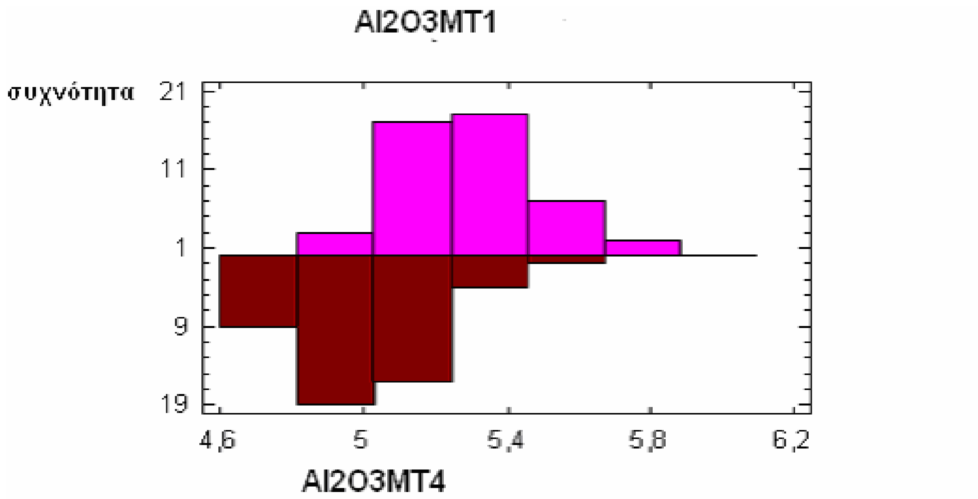
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



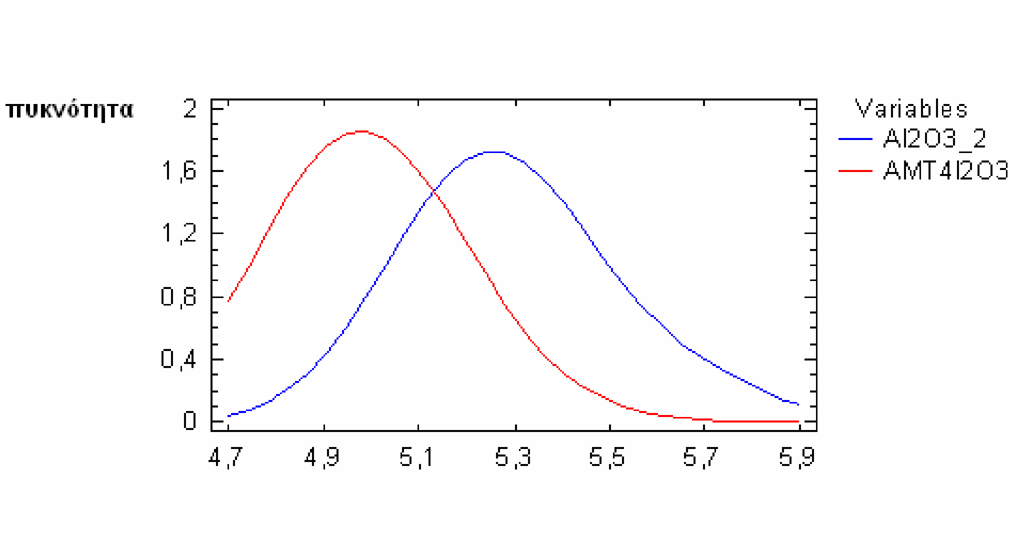
Διάγραμμα5. 91 Θηκογράμματα της μεταβλητής Al_2O_3 για κάθε μύλο και τσιμέντο τύπου II 42,5

Από τα παραπάνω θηκογράμματα πραγματοποιείται σύγκριση στην κεντρική τάση, τη διασπορά και την ασυμμετρία στις κατανομές των δεδομένων των δύο μεταβλητών.

Τα ιστογράμματα παρέχουν μία ακριβέστερη εικόνα για τη συχνότητα των διάφορων τιμών των μεταβλητών αυτών.



Διάγραμμα5. 92 Ιστογράμματα της μεταβλητής Al_2O_3 για κάθε μύλο και τσιμέντο τύπου II 42,5



Διάγραμμα5. 93 Χάραξη πυκνότητας (density trace) *των δύο δειγμάτων και τσιμέντο τύπου II 42,5*

Μελετάται αν η υπόθεση ότι η διασπορά των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι σωστή.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

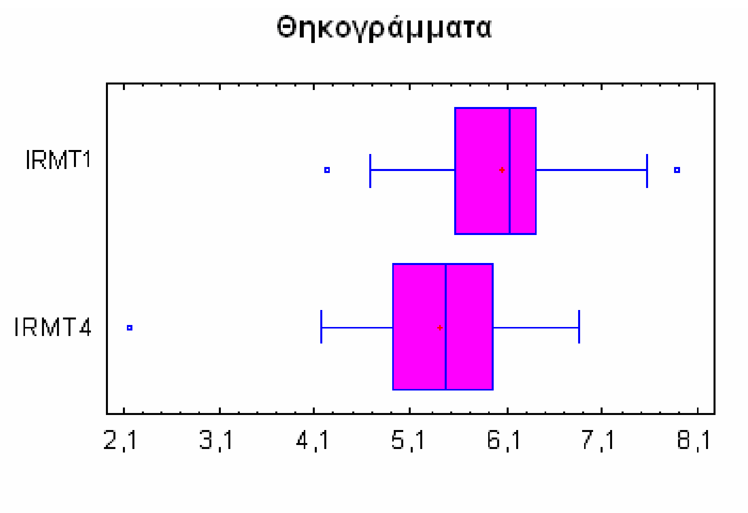
4.4.2.2. Σύγκριση αδιάλυτου υπολείμματος

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

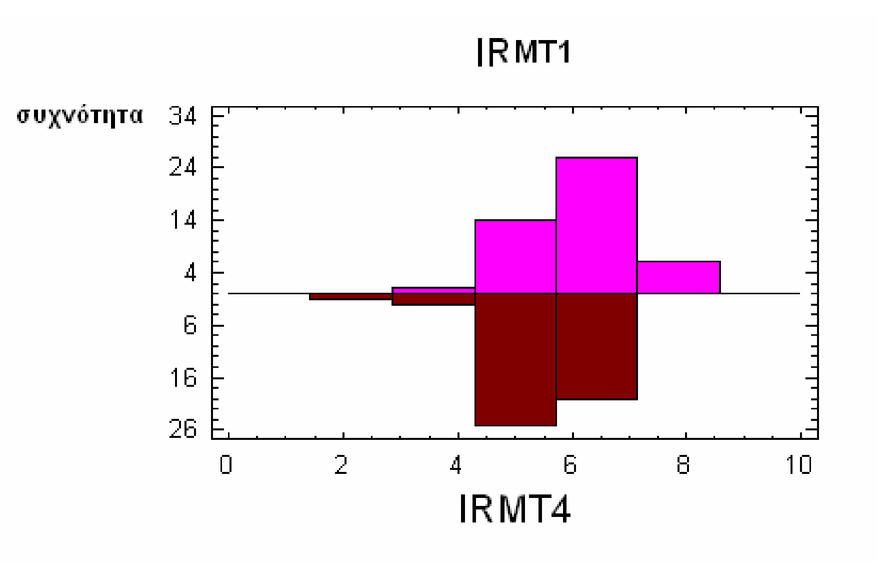
Πίνακας 5. 111 Σύγκριση ποσοστού IR για μύλο1 και μύλο 4

	IR_2	IRMT4
περιπτώσεις	47	48
Μέσος όρος	6,04468	5,38812
Διασπορά	0,576382	0,684092
Τυπική απόκλιση	0,759198	0,827099
Μικρότερη τιμή	4,22	2,16
Μέγιστη τιμή	7,89	6,85
Εύρος	3,67	4,69
Τυπική ασυμμετρία	0,440299	-3,42009
Τυπική κύρτωση	0,373963	4,97428

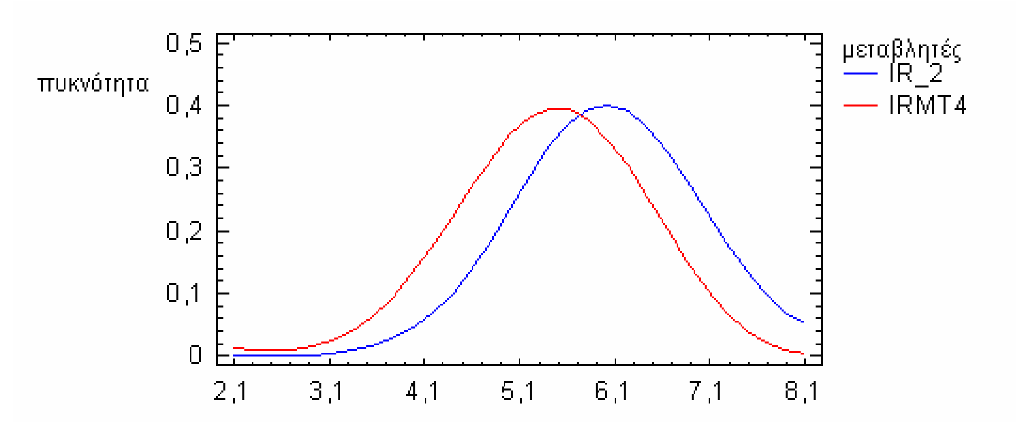
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 94 Θηκογράμματα της μεταβλητής IR για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



Διάγραμμα5. 95 Ιστογράμματα της μεταβλητής IR για κάθε μύλο



Διάγραμμα5. 96 διάγραμμα πυκνότητας IR από κάθε μύλο και τσιμέντο τύπου II 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι σωστή.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

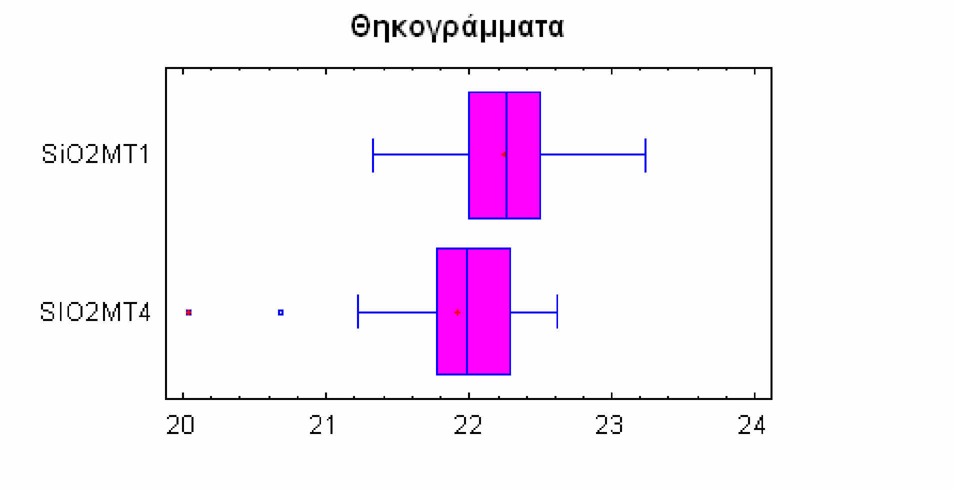
4.4.2.3. Σύγκριση ποσοστού SiO_2

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα.

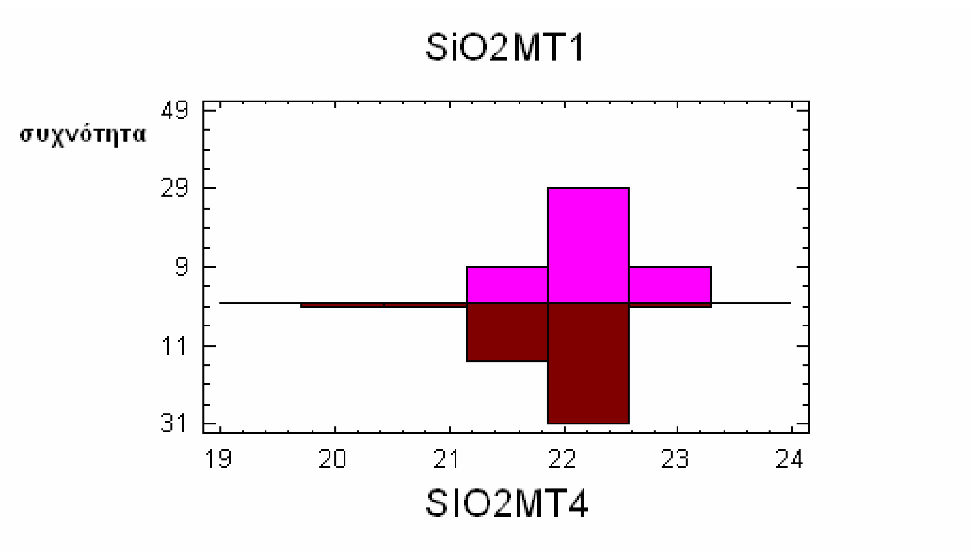
Πίνακας 5. 112 Σύγκριση ποσοστού SiO_2 για μύλο 1 και μύλο 4

	SiO_2 ^{MT1}	SIO_2 ^{MT4}
περιπτώσεις	47	49
Μέσος όρος	22,2479	21,9122
Διασπορά	0,160952	0,235714
Τυπική απόκλιση	0,401188	0,485503
Μικρότερη τιμή	21,32	20,04
Μέγιστη τιμή	23,24	22,61
Εύρος	1,92	2,57
Τυπική ασυμμετρία	0,338989	-4,29694
Τυπική κύρτωση	-0,0933634	5,34637

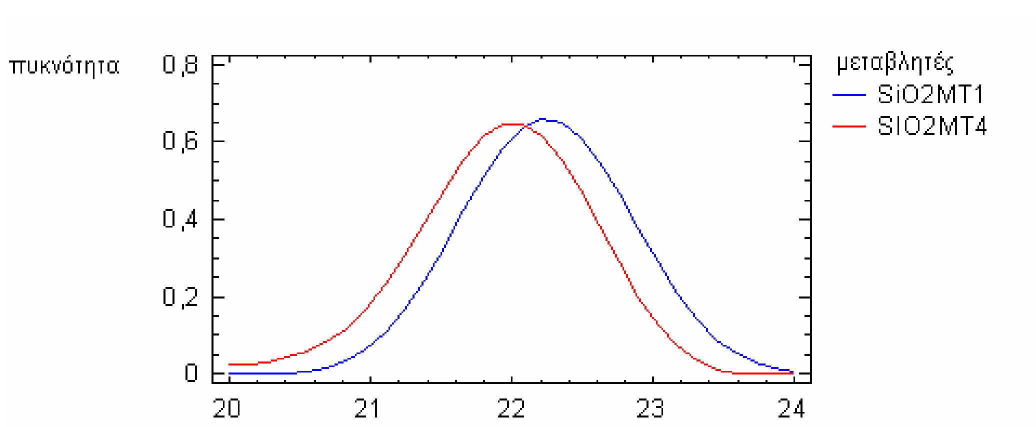
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 97 Θηκογράμματα της μεταβλητής SiO_2 για κάθε μύλο και τσιμέντο τύπου II 42,5



Διάγραμμα5. 98 Ιστογράμματα της μεταβλητής SiO_2 για κάθε μύλο



Διάγραμμα5. 99 διάγραμμα πυκνότηταςSiO_2 από κάθε μύλο και τσιμέντο τύπου II 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι σωστή.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

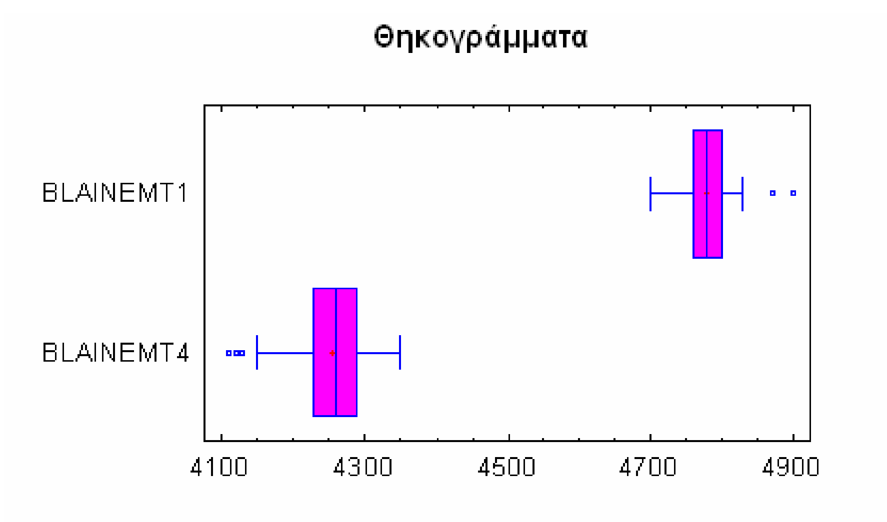
4.4.2.4. Σύγκριση των τιμών λεπτότητας (Blaine)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

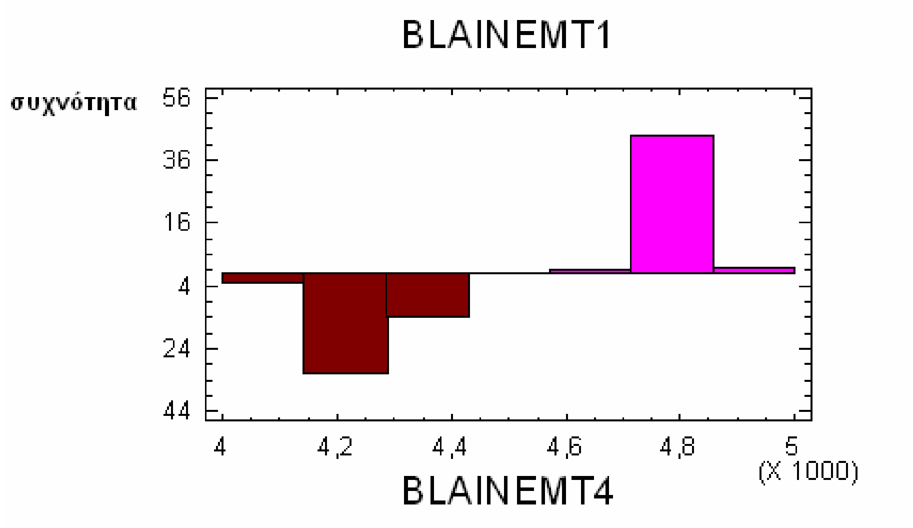
Πίνακας 5. 113 Σύγκριση ποσοστού Blaine για μύλο 1 και μύλο 4

	BLAINEMT1	BLAINEMT4
περιπτώσεις	47	49
μέσος όρος	4778,81	4255,1
Διασπορά	1245,85	2875,51
Τυπική απόκλιση	35,2967	53,6238
Μικρότερη τιμή	4700,0	4110,0
Μέγιστη τιμή	4900,0	4350,0
Εύρος	200,0	240,0
Τυπική ασυμμετρία	2,55893	-2,64714
Τυπική κύρτωση	3,70393	1,35442

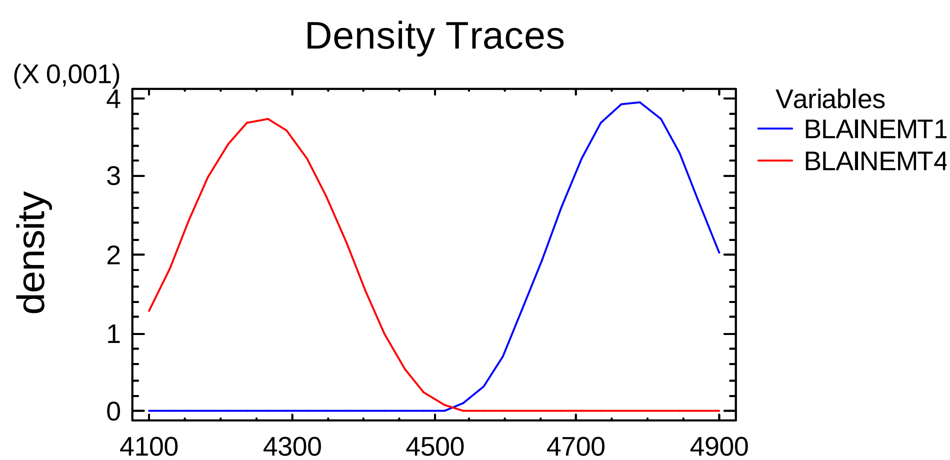
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 100 Θηκογράμματα της μεταβλητής Blaine για κάθε μύλο και τσιμέντο τύπου II 42,5



*Διάγραμμα5. 101 Ιστογράμματα της μεταβλητής **Blaine** για κάθε μύλο και τσιμέντο τύπου II 42,5*



*Διάγραμμα5. 102 διάγραμμα πυκνότητας **Blaine** από κάθε μύλο και τσιμέντο τύπου II 42,5*

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι λανθασμένη. Σε επίπεδο εμπιστοσύνης 95% η τυπική απόκλιση των δύο πληθυσμών είναι διαφορετική.

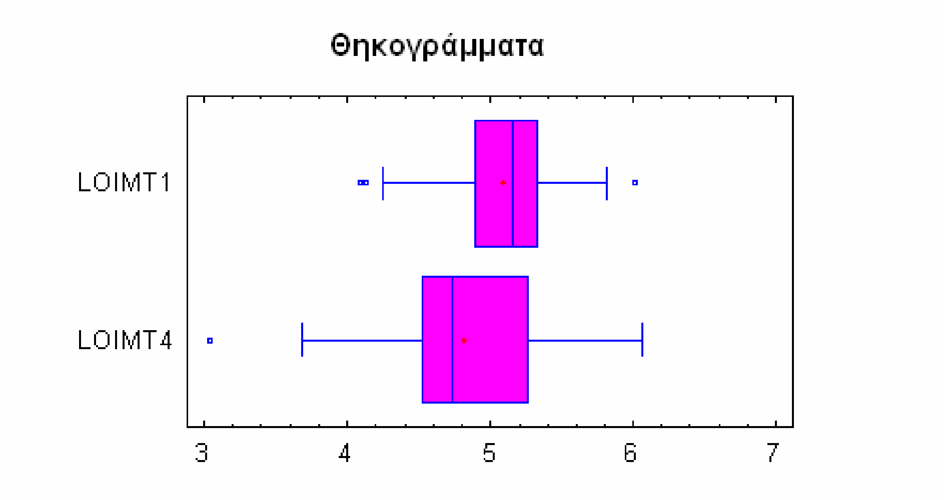
4.4.2.5. Σύγκριση των τιμών απώλειας πύρωσης (LOI)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

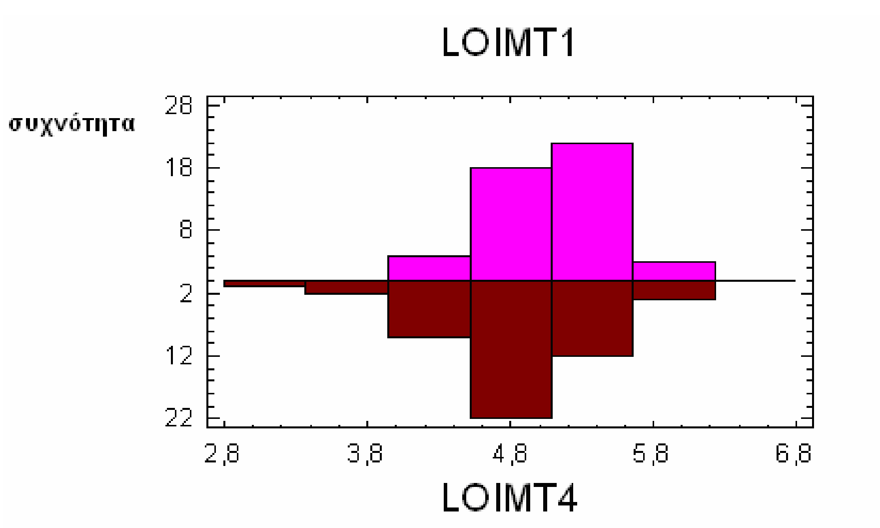
Πίνακας 5. 114 Σύγκριση ποσοστού* LOI *για μύλο 1 και μύλο 4

	LOIMT1	LOIMT4
περιπτώσεις	47	49
μέσος όρος	5,09128	4,81163
Διασπορά	0,151268	0,324147
Τυπική απόκλιση	0,388932	0,569339
Μικρότερη τιμή	4,1	3,04
Μέγιστη τιμή	6,01	6,07
εύρος	1,91	3,03
τυπική ασυμμετρία	-1,4963	-1,14022
τυπική κύρτωση	1,60564	1,49041

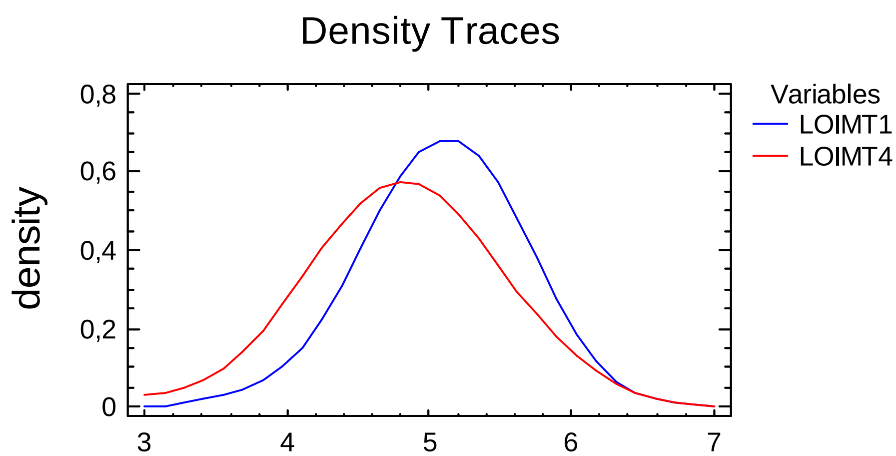
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 103 Θηκογράμματα της μεταβλητής LOI για κάθε μύλο και τσιμέντο τύπου II 42,5



Διάγραμμα5. 104 Ιστογράμματα της μεταβλητής LOI για κάθε μύλο και τσιμέντο τύπου II 42,5



Διάγραμμα5. 105 διάγραμμα πυκνότητας LOI από κάθε μύλο και τσιμέντο τύπου II 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι λανθασμένη. Σε επίπεδο εμπιστοσύνης 95% η τυπική απόκλιση των δύο πληθυσμών είναι σημαντικά διαφορετική.

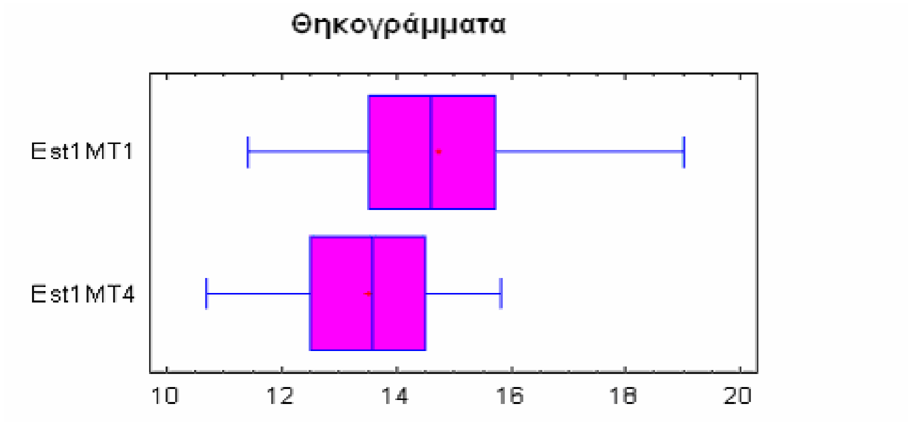
4.4.2.6. Σύγκριση των τιμών αντοχής τσιμέντου 1 ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

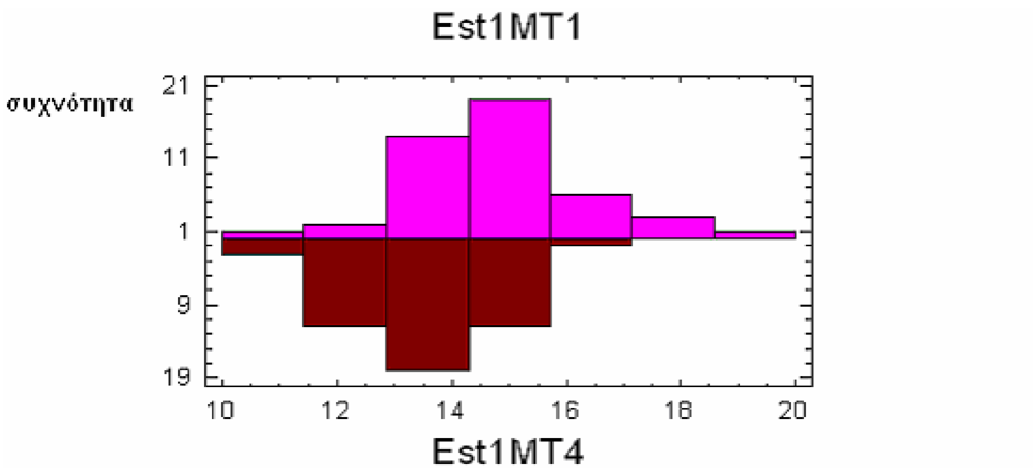
Πίνακας 5. 115 Σύγκριση τιμών αντοχής τσιμέντου για μύλο1 και μύλο 4

	Est1MT1	Est1MT4
περιπτώσεις	46	45
Μέσος όρος	14,7326	13,4822
Διακύμανση	2,69914	1,3674
Τυπική απόκλιση	1,6429	1,16936
Μικρότερη τιμή	11,4	10,7
Μέγιστη τιμή	19,0	15,8
εύρος	7,6	5,1
Τυπική ασυμμετρία	1,45266	-0,231335
Τυπική κύρτωση	0,634088	-0,782801

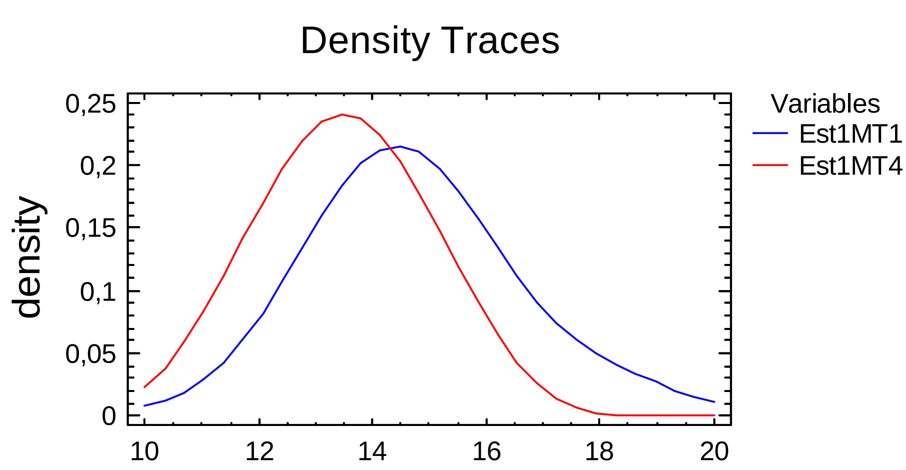
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 106 Θηκογράμματα της μεταβλητής Est1 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



Διάγραμμα5. 107 Ιστογράμματα της μεταβλητής Est1 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



Διάγραμμα5. 108 διάγραμμα πυκνότητας Est1 από κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

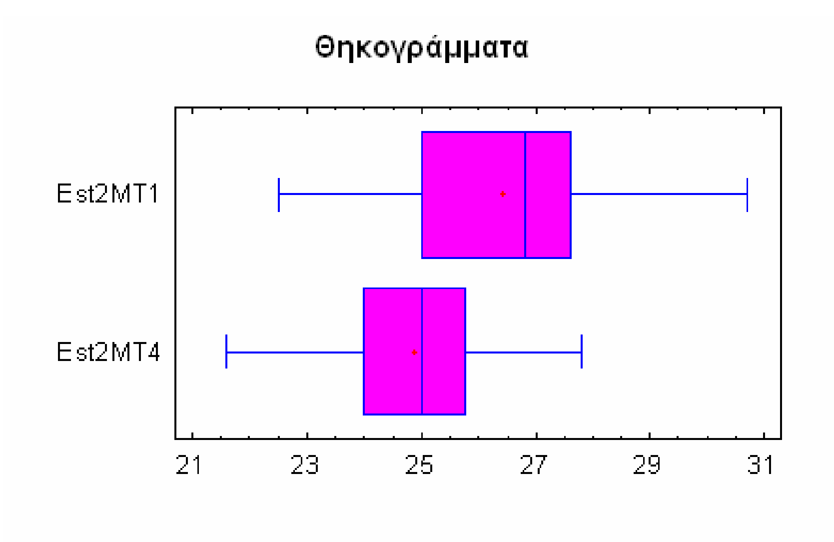
4.4.2.7. Σύγκριση των τιμών αντοχής τσιμέντου 2ης ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

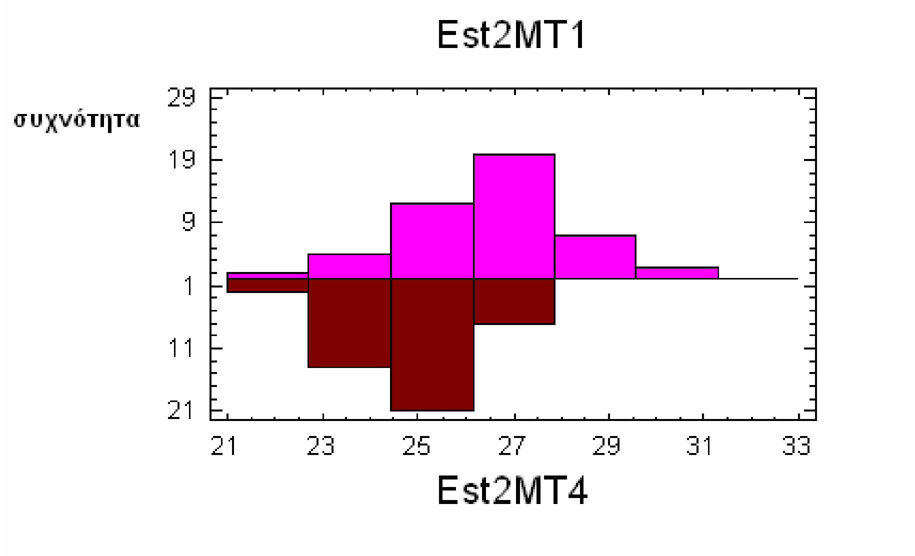
Πίνακας 5. 116 Σύγκριση τιμών αντοχής τσιμέντου 2ης ημέρας για μύλο1 και μύλο 4

	Est2MT1	Est2MT4
περιπτώσεις	46	44
μέσος όρος	26,4109	24,85
διακύμανση	3,11166	1,84209
τυπική απόκλιση	1,76399	1,35724
μικρότερη τιμή	22,5	21,6
μέγιστη τιμή	30,7	27,8
εύρος	8,2	6,2
τυπική ασυμμετρία	-0,375575	-0,293311
τυπική κύρτωση	-0,0491938	-0,0633007

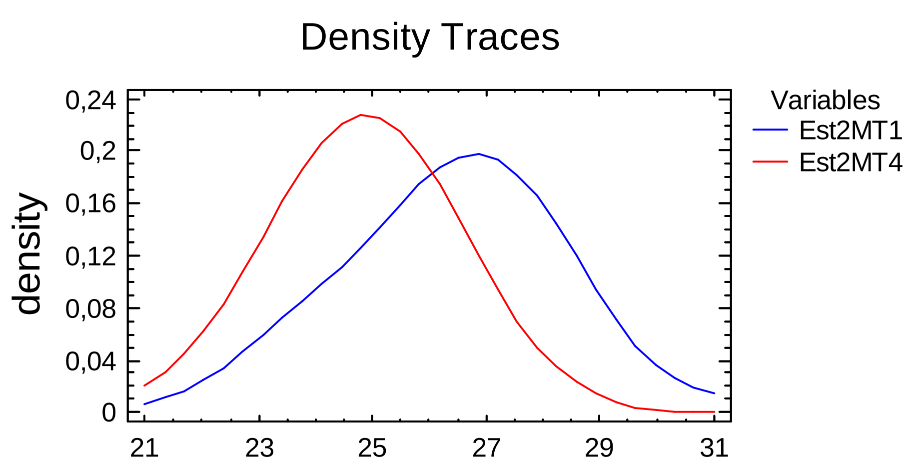
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 109 Θηκογράμματα της μεταβλητής Est2 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



*Διάγραμμα5. 110 Ιστογράμματα της μεταβλητής **Est2** για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5*



*Διάγραμμα5. 111 διάγραμμα πυκνότητας **Est2** από κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5*

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι

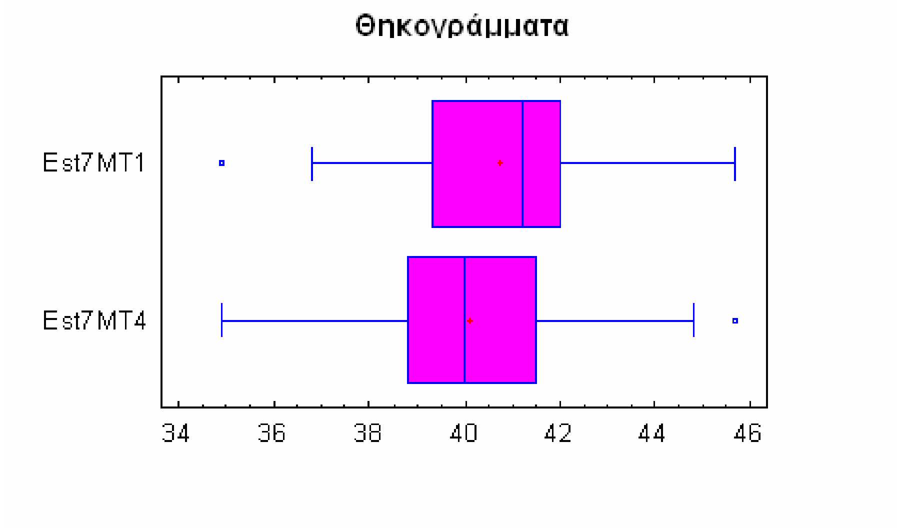
4.4.2.8. Σύγκριση των τιμών αντοχής τσιμέντου 7ης ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

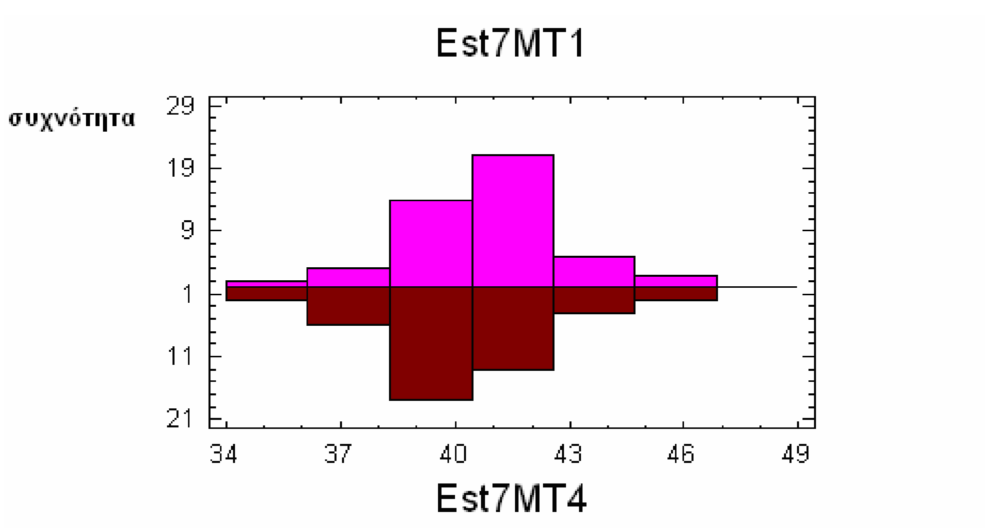
Πίνακας 5. 117 Σύγκριση τιμών αντοχής τσιμέντου 7^{ης} ημέρας για μύλο1 και μύλο 4

	Est7MT1	Est7MT4
περιπτώσεις	46	45
μέσος όρος	40,7304	40,1
διασπορά	4,21505	5,24682
τυπική απόκλιση	2,05306	2,29059
μικρότερη τιμή	34,9	34,9
μέγιστη τιμή	45,7	45,7
εύρος	10,8	10,8
τυπική ασυμμετρία	-1,07601	0,432137
τυπική κύρτωση	1,28179	0,0644646

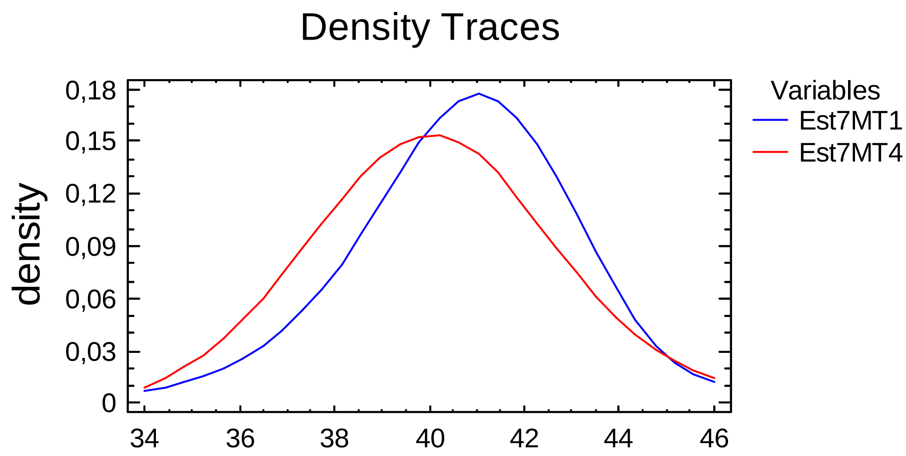
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 112 Θηκογράμματα της μεταβλητής Est7 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



Διάγραμμα5. 113 Ιστογράμματα της μεταβλητής Est7 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5



Διάγραμμα5. 114 διάγραμμα πυκνότητας Est7 από κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι η υπόθεση μπορεί να θεωρηθεί σωστή και ότι σε αυτό το ποσοστό εμπιστοσύνης οι μέσοι μπορούν να θεωρηθούν ίσοι.

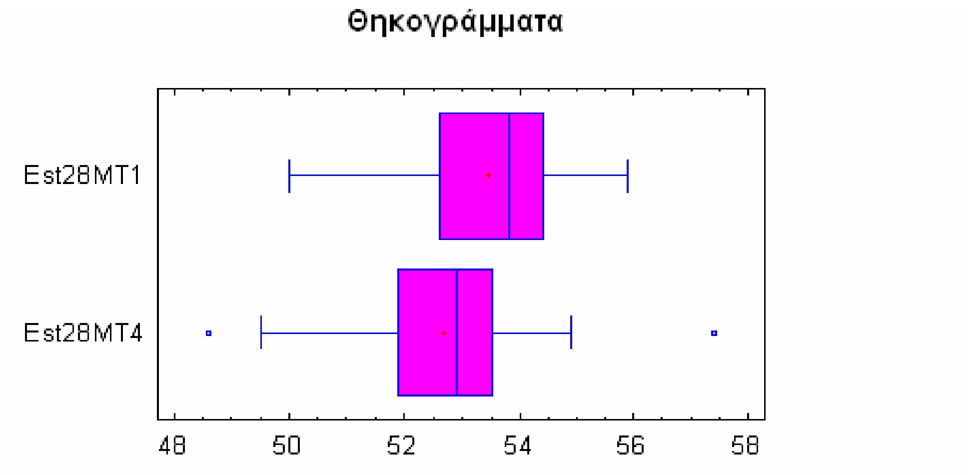
4.4.2.9. Σύγκριση των τιμών αντοχής τσιμέντου 28^{ης} ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

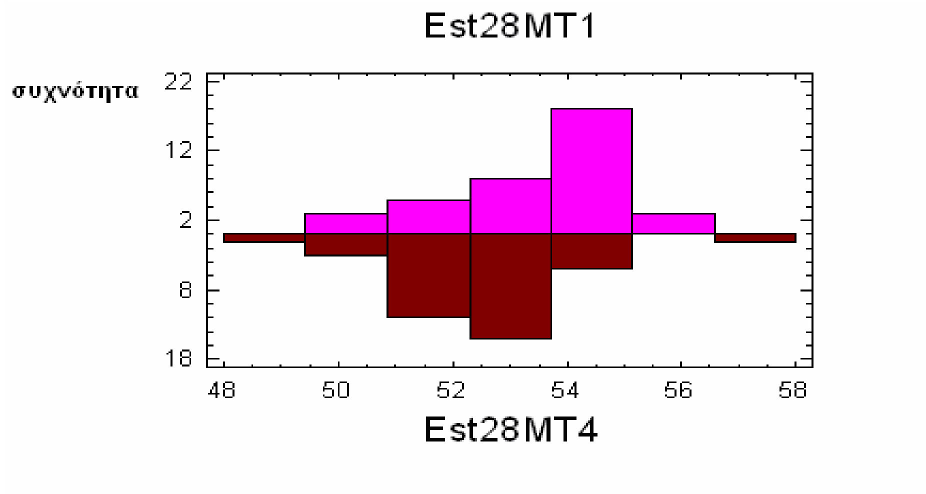
Πίνακας 5. 118 Σύγκριση τιμών αντοχής τσιμέντου 28^{ης} ημέρας για μύλο1 και μύλο 4

	Est28MT1	Est28MT4
περιπτώσεις	37	37
μέσος όρος	53,4351	52,6514
διασπορά	2,22734	2,78646
τυπική απόκλιση	1,49243	1,66927
μικρότερη τιμή	50,0	48,6
μέγιστη τιμή	55,9	57,4
εύρος	5,9	8,8
τυπική ασυμμετρία	-2,00193	0,0265021
τυπική κύρτωση	0,0912519	1,53087

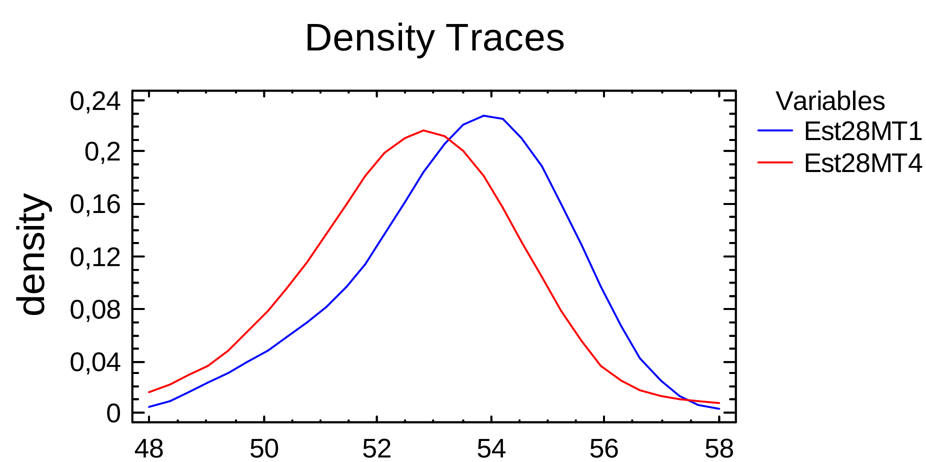
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 115 *Θηκογράμματα της μεταβλητήςEst28 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5*



Διάγραμμα5. 116 *Ιστογράμματα της μεταβλητής Est28 για κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5*



Διάγραμμα5. 117 διάγραμμα πυκνότητας Est28 από κάθε μύλο και τσιμέντο τύπου ΙΙ 42,5

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων έχουν σημαντικές διαφορές

4.4.3. Σύγκριση αποτελεσμάτων για τους δύο μύλους – ποιότητα τσιμέντου OPC

Ανάλογη επεξεργασία με τους δύο μύλους για το τσιμέντο τύπου II 42,5 πραγματοποιήθηκε και για το τσιμέντο τύπου OPC. Επειδή για το συγκεκριμένο τύπο τσιμέντου πραγματοποιείται ανάλυση και στη σύνθεση, γίνεται σύγκριση μεταξύ των μύλων και για τη σύνθεση του OPC.

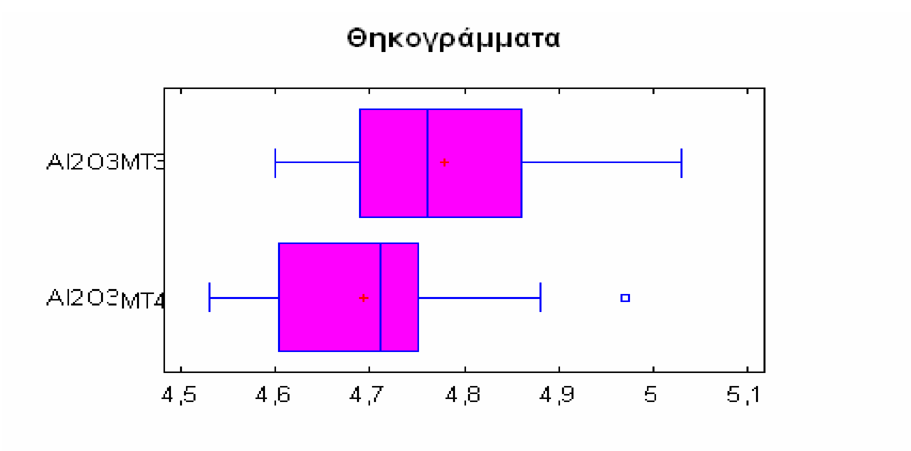
4.4.3.1 Σύγκριση ποσοστού Al_2O_3

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

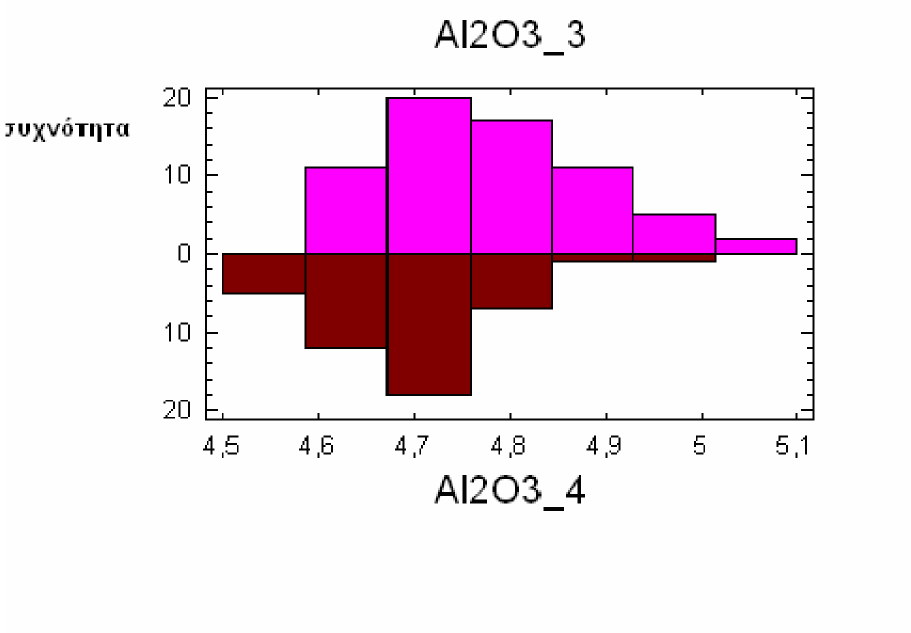
Πίνακας 5. 119 ***Σύγκριση ποσοστού Al_2O_3 για μύλο 3 και μύλο 4***

	Al2O3_3	Al2O3_4
περιπτώσεις	66	44
μέσος όρος	4,77712	4,69409
διασπορά	0,0118054	0,00925729
τυπική απόκλιση	0,108653	0,0962148
μικρότερη τιμή	4,6	4,53
μέγιστη τιμή	5,03	4,97
εύρος	0,43	0,44
τυπική ασυμμετρία	1,51044	1,09077
τυπική κύρτωση	-0,910087	0,415599

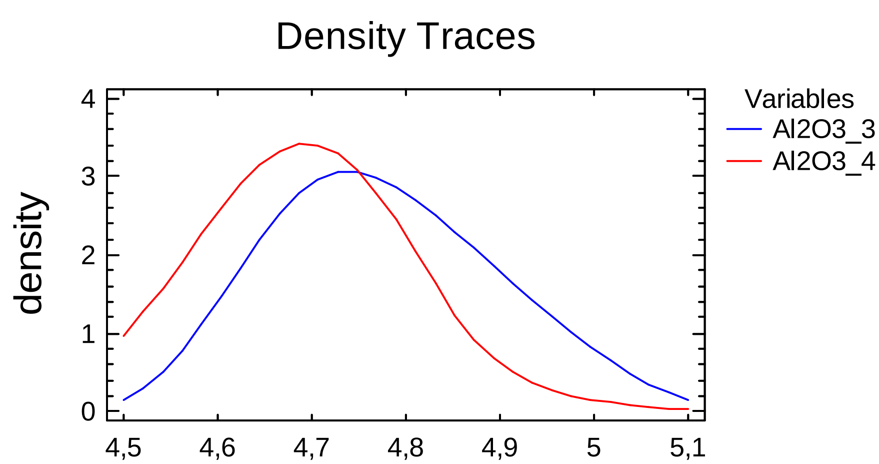
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 118 Θηκογράμματα της μεταβλητής Al_2O_3 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 119 Ιστογράμματα της μεταβλητής Al_2O_3 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 120 διάγραμμα πυκνότητας Al_2O_3 από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η διασπορά των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι σωστή.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

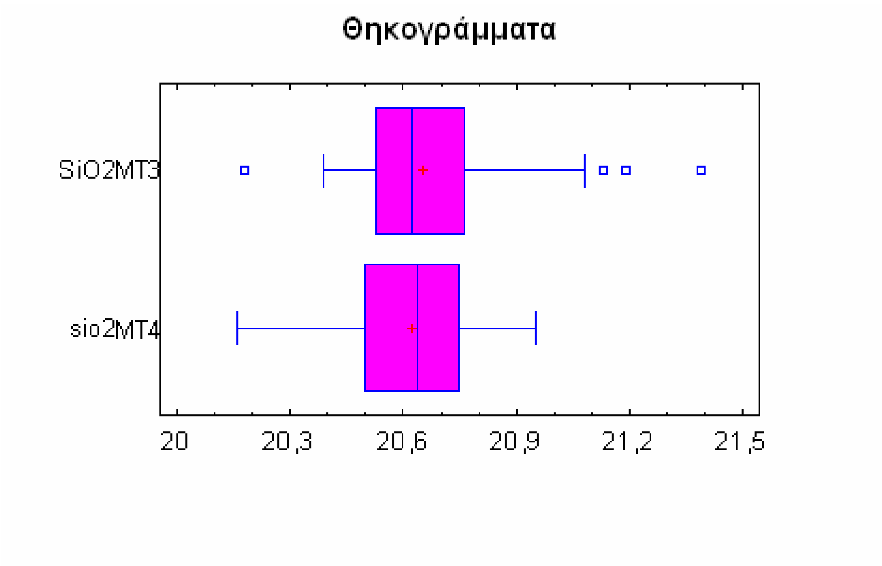
4.4.3.2. Σύγκριση ποσοστού SiO_2

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

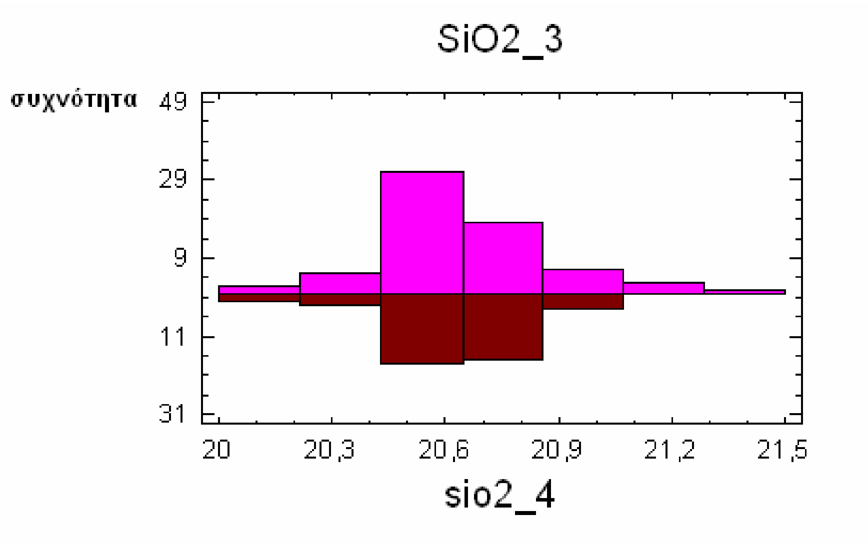
Πίνακας 5. 120 Σύγκριση ποσοστού SiO_2 για μύλο 3 και μύλο 4

	SiO2_3	sio2_4
περιπτώσεις	66	44
Μέσος όρος	20,6514	20,6209
Διασπορά	0,0474089	0,0315526
Τυπική απόκλιση	0,217736	0,177631
Μικρότερη τιμή	20,18	20,16
Μέγιστη τιμή	21,39	20,95
Εύρος	1,21	0,79
Τυπική ασυμμετρία	2,72936	-1,04715
Τυπική κύρτωση	2,73719	0,525681

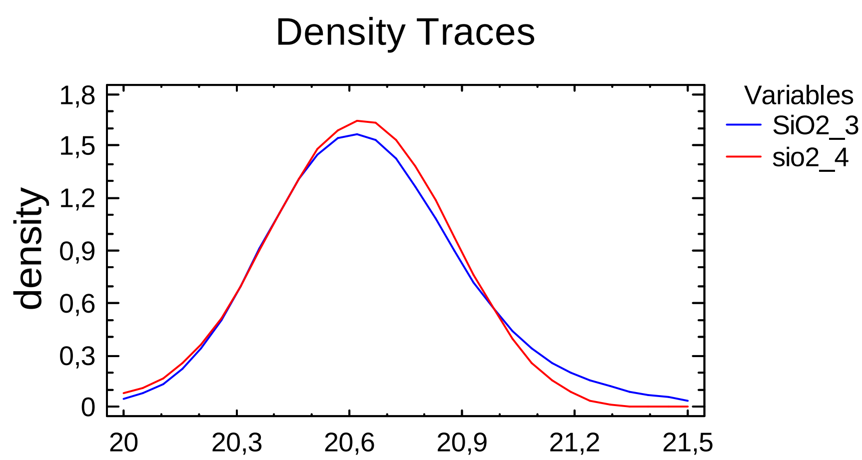
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 121 Θηκογράμματα της μεταβλητής SiO_2 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 122 Ιστογράμματα της μεταβλητής SiO_2 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 123 διάγραμμα πυκνότητας SiO_2 από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι σωστή.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων μπορούν να θεωρηθούν ίσοι.

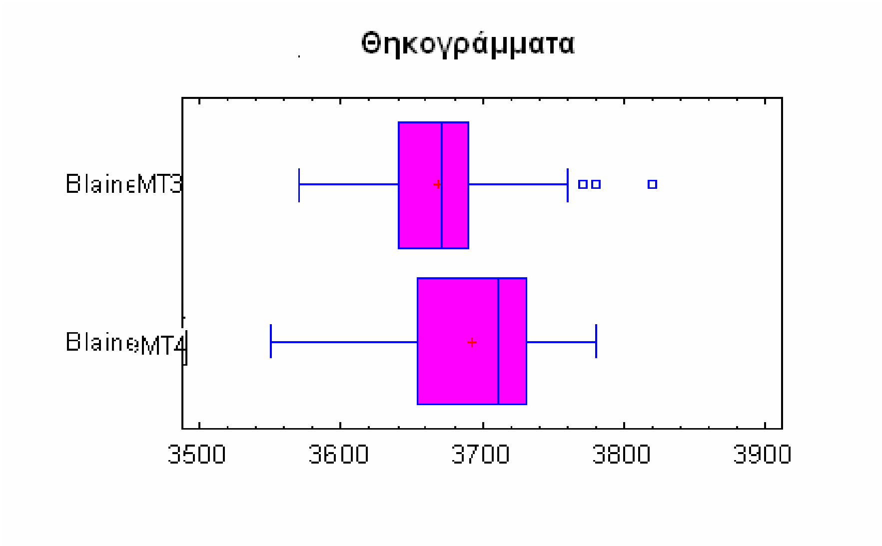
4.4.3.3. Σύγκριση των τιμών λεπτότητας (Blaine)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

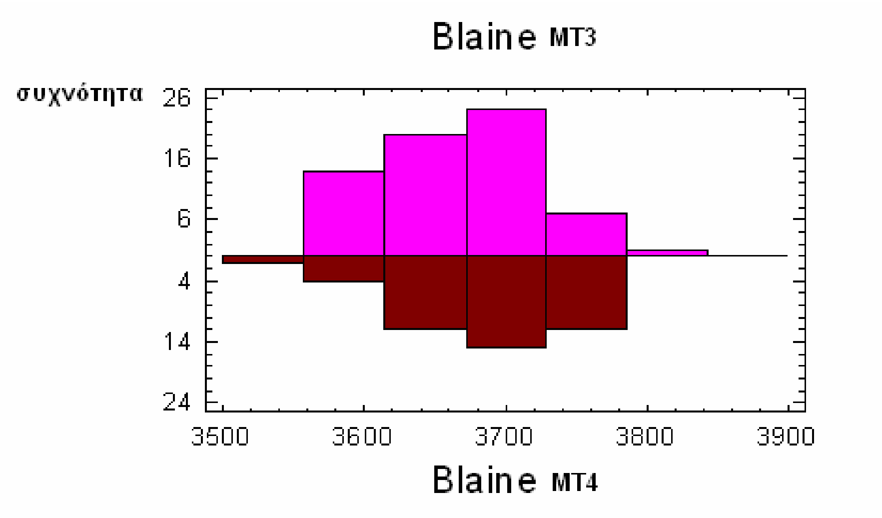
Πίνακας 5. 121 Σύγκριση ποσοστού Blaine για μύλο 3 και μύλο 4

	Blaine_3	Blaine_4
περιπτώσεις	66	44
μέσος όρος	3667,42	3691,36
Διασπορά	3151,72	2612,05
Τυπική απόκλιση	56,1402	51,1082
Μικρότερη τιμή	3570,0	3550,0
Μέγιστη τιμή	3820,0	3780,0
Εύρος	250,0	230,0
Τυπική ασυμμετρία	0,248365	-1,82542
Τυπική κύρτωση	0,0494155	0,0241074

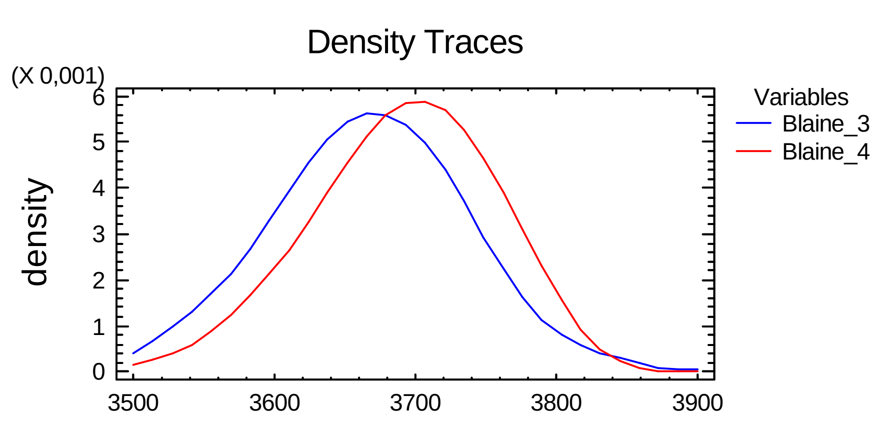
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 124 *Θηκογράμματα της μεταβλητής* ***Blaine*** *για κάθε μύλο και τσιμέντο τύπου* ***OPC***



Διάγραμμα5. 125 *Ιστογράμματα της μεταβλητής* ***Blaine*** *για κάθε μύλο και τσιμέντο τύπου* ***OPC***



Διάγραμμα5. 126 διάγραμμα πυκνότητας ***Blaine*** *από κάθε μύλο και τσιμέντο τύπου* ***OPC***

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η τυπική απόκλιση των δύο πληθυσμών είναι ίδια.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

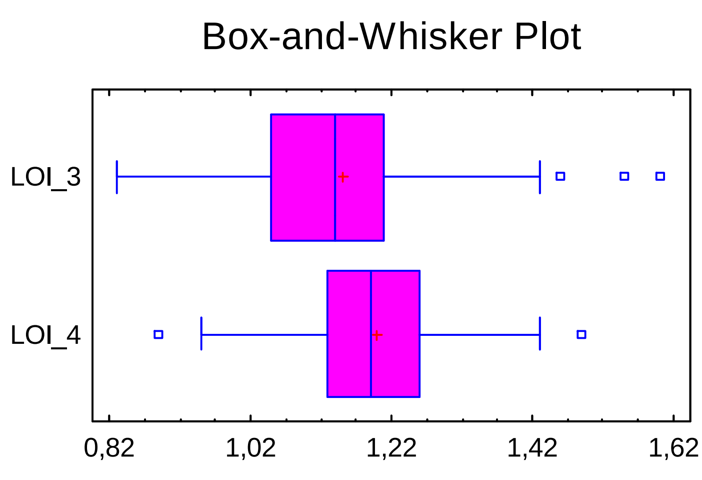
4.4.3.4. Σύγκριση των τιμών απώλειας πύρωσης (LOI)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

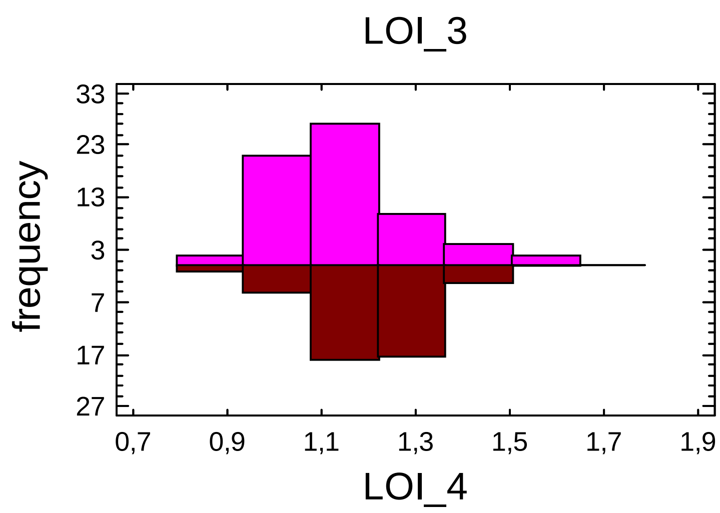
Πίνακας 5. 122 Σύγκριση ποσοστού LOI για μύλο3 και μύλο 4

	LOI_3	LOI_4
περιπτώσεις	66	44
μέσος όρος	1,14939	1,19886
διασπορά	0,0225935	0,0153684
τυπική απόκλιση	0,150311	0,12397
μικρότερη τιμή	0,83	0,89
μέγιστη τιμή	1,6	1,49
εύρος	0,77	0,6
τυπική ασυμμετρία	2,7588	-0,260205
τυπική κύρτωση	1,23789	0,407193

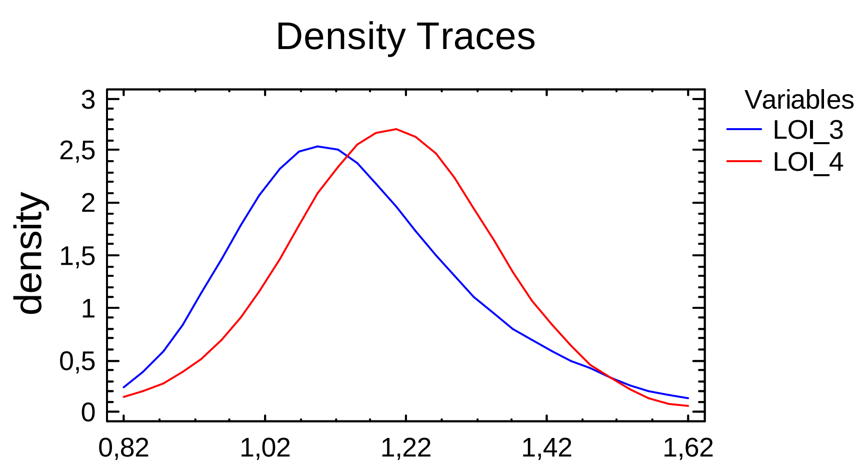
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 127 Θηκογράμματα της μεταβλητής LOI για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 128 Ιστογράμματα της μεταβλητής LOI για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 129 διάγραμμα πυκνότητας LOI από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% η υπόθεση είναι λανθασμένη. Σε επίπεδο εμπιστοσύνης 95% η τυπική απόκλιση των δύο πληθυσμών είναι σημαντικά διαφορετική.

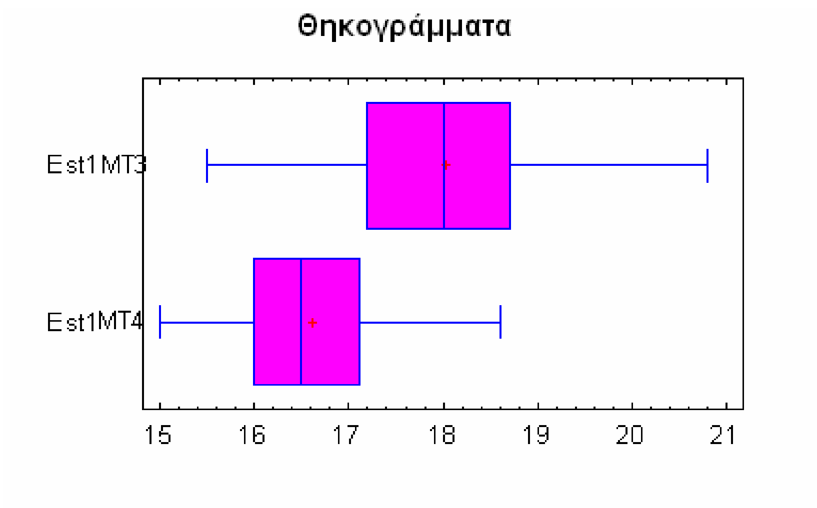
4.4.3.5. Σύγκριση των τιμών αντοχής τσιμέντου 1 ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

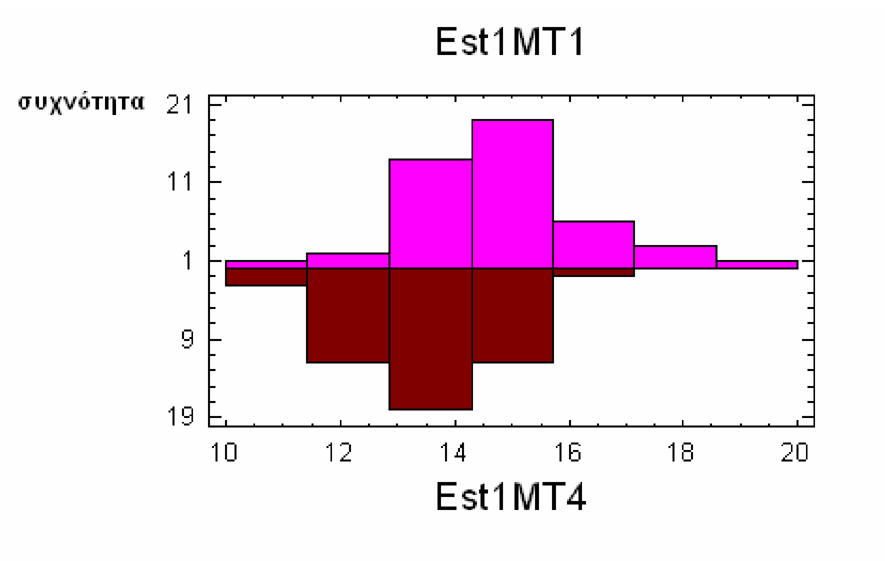
Πίνακας 5. 123 Σύγκριση τιμών αντοχής τσιμέντου 1ης ημέρας για μύλ3 και μύλο 4

	Est1_3	Est1_4
περιπτώσεις	65	43
μέσος όρος	18,0154	16,614
διασπορά	1,22757	0,74742
τυπική απόκλιση	1,10796	0,864534
ελάχιστη τιμή	15,5	15,0
μέγιστη τιμή	20,8	18,6
εύρος	5,3	3,6
τυπική ασυμμετρία	0,81769	0,971413
τυπική κύρτωση	0,0076236	-0,269562

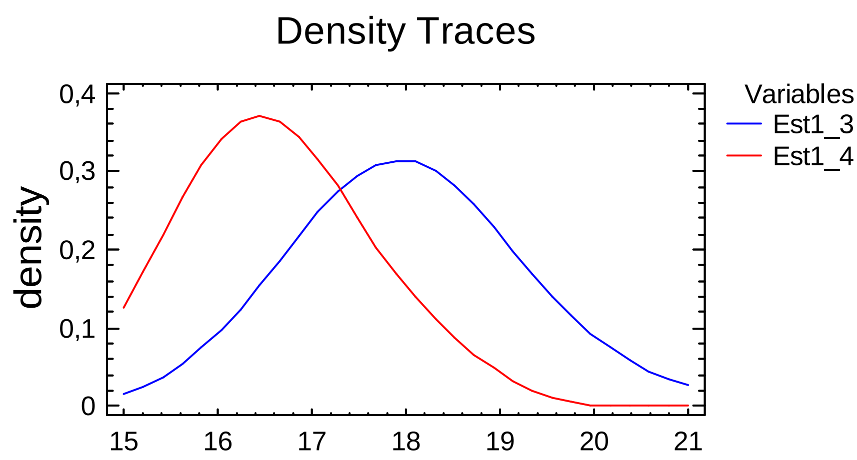
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 130 Θηκογράμματα της μεταβλητής Est1 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 131 Ιστογράμματα της μεταβλητής Est1 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 132 διάγραμμα πυκνότητας Est1 από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι.

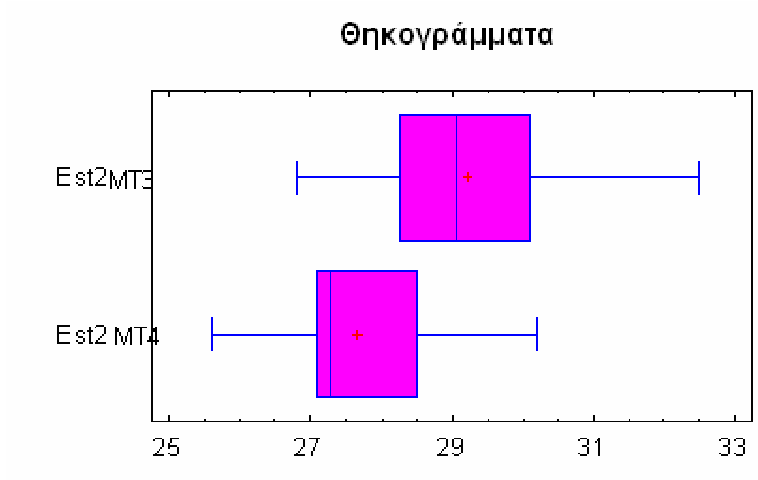
4.4.3.6. Σύγκριση των τιμών αντοχής τσιμέντου 2ης ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

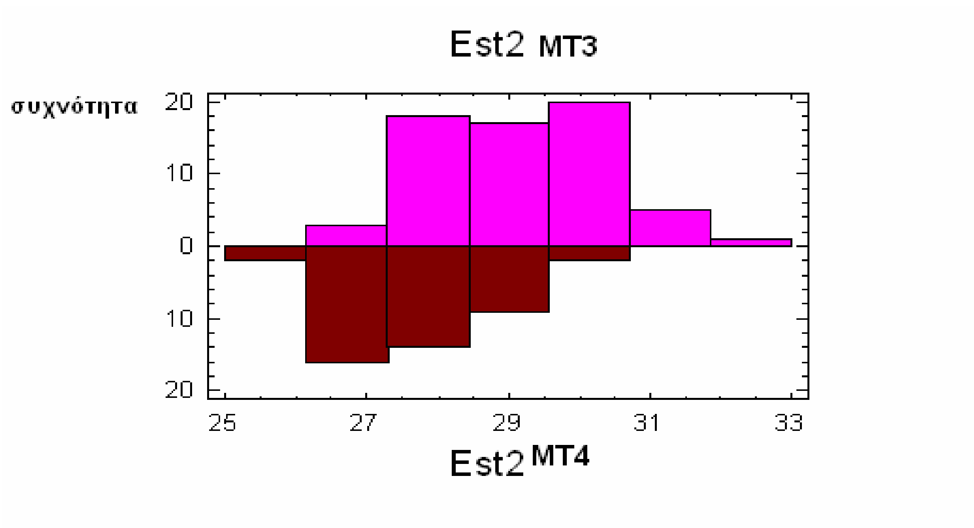
Πίνακας 5. 124 Σύγκριση τιμών αντοχής τσιμέντου 2ης ημέρας για μύλο3 και μύλο 4

	Est2_3	Est2_4
περιπτώσεις	64	43
μέσος όρος	29,2031	27,6535
διασπορά	1,57047	0,884928
τυπική απόκλιση	1,25318	0,940706
μικρότερη τιμή	26,8	25,6
μέγιστη τιμή	32,5	30,2
εύρος	5,7	4,6
τυπική ασυμμετρία	0,789736	1,74165
τυπική κύρτωση	-0,669312	0,750425

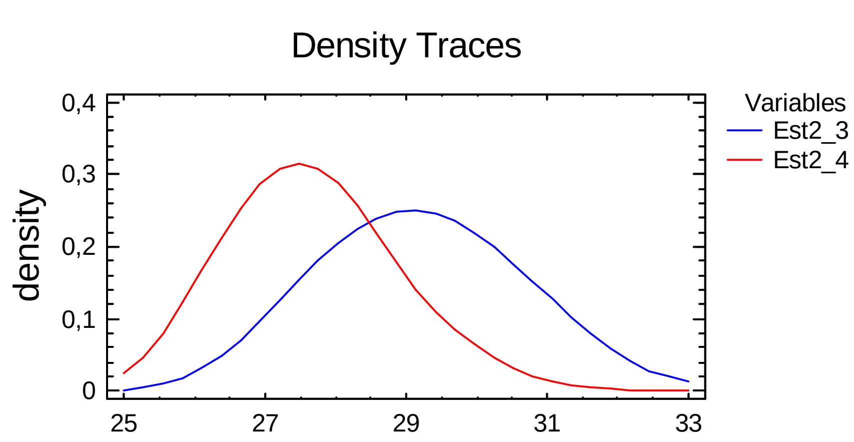
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 133 *Θηκογράμματα της μεταβλητής **Est2** για κάθε μύλο και τσιμέντο τύπου **OPC***



Διάγραμμα5. 134 *Ιστογράμματα της μεταβλητής **Est2** για κάθε μύλο και τσιμέντο τύπου **OPC***



*Διάγραμμα5. 135 διάγραμμα πυκνότητας **Est2** από κάθε μύλο και τσιμέντο τύπου **OPC***

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι οι μέσοι των δειγμάτων δεν μπορούν να θεωρηθούν ίσοι

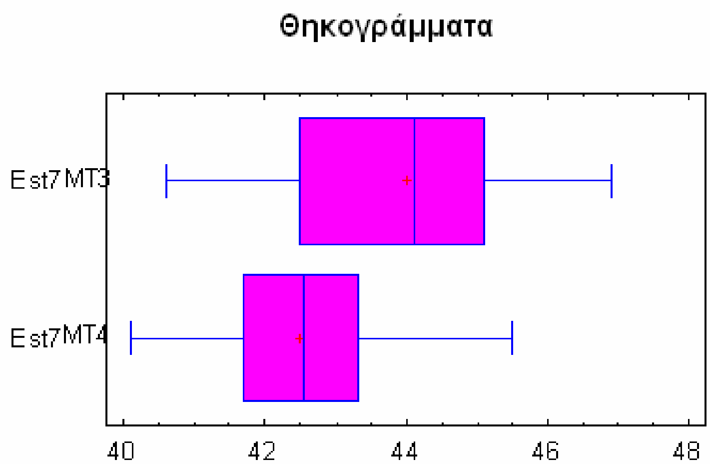
4.4.3.7. Σύγκριση των τιμών αντοχής τσιμέντου 7ης ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

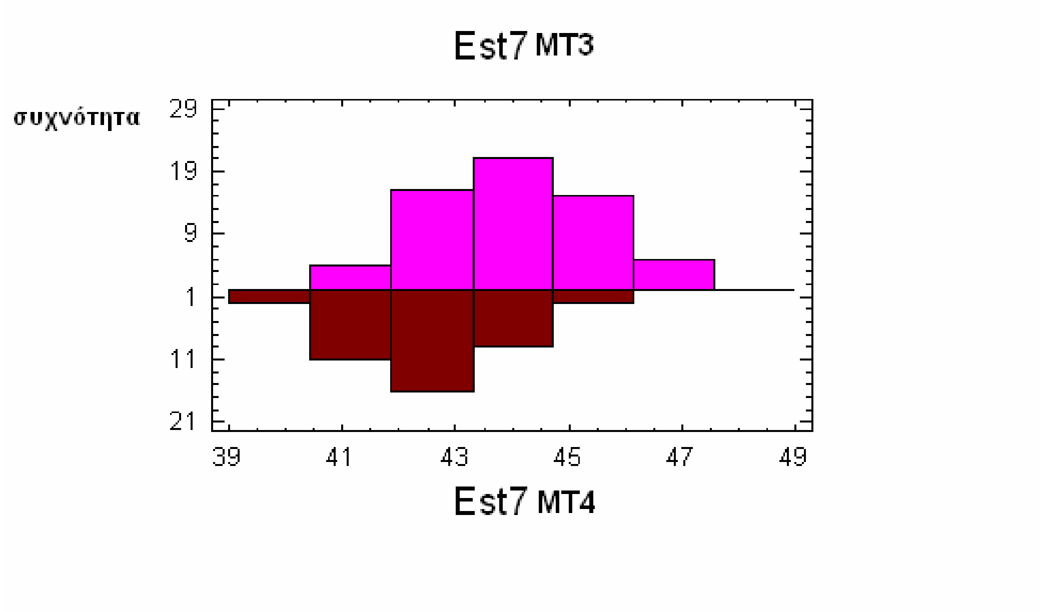
Πίνακας 5. 125 Σύγκριση τιμών αντοχής τσιμέντου 7ης ημέρας για μύλο3 και μύλο 4

	Est7_3	Est7_4
περιπτώσεις	61	40
μέσος όρος	43,9984	42,52
διασπορά	2,40916	1,60779
τυπική απόκλιση	1,55215	1,26799
μικρότερη τιμή	40,6	40,1
μέγιστη τιμή	46,9	45,5
εύρος	6,3	5,4
τυπική ασυμμετρία	-0,127274	0,677298
τυπική κύρτωση	-1,42973	-0,220099

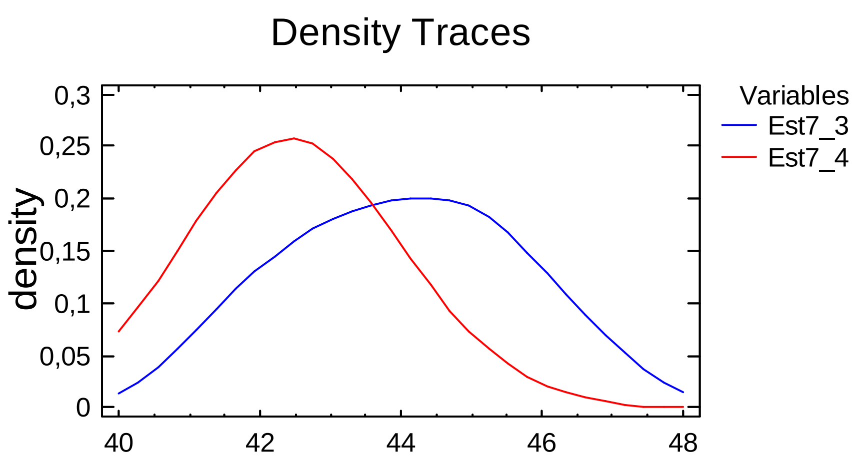
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 136 Θηκογράμματα της μεταβλητής Est7 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 137 Ιστογράμματα της μεταβλητής Est7 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 138 διάγραμμα πυκνότητας Est7 από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι η υπόθεση δεν μπορεί να θεωρηθεί σωστή και ότι σε αυτό το ποσοστό εμπιστοσύνης οι μέσοι δεν μπορούν να θεωρηθούν ίσοι.

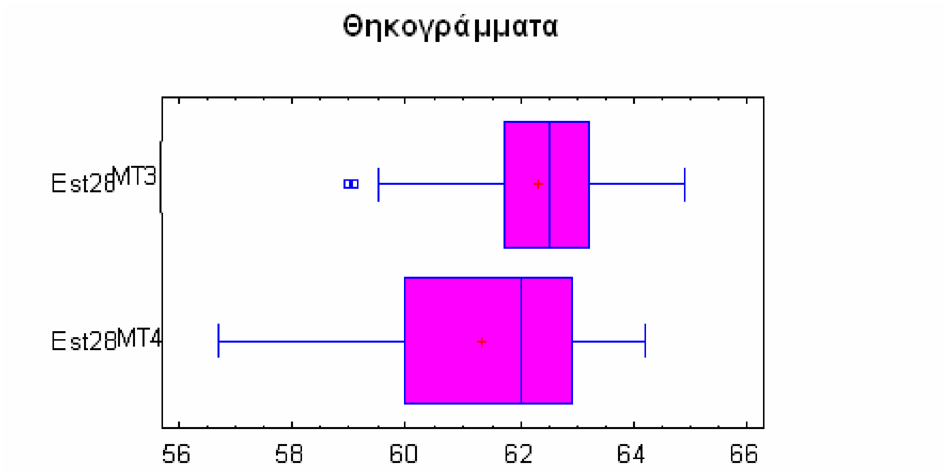
4.4.3.8. Σύγκριση των τιμών αντοχής τσιμέντου 28ης ημέρας

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

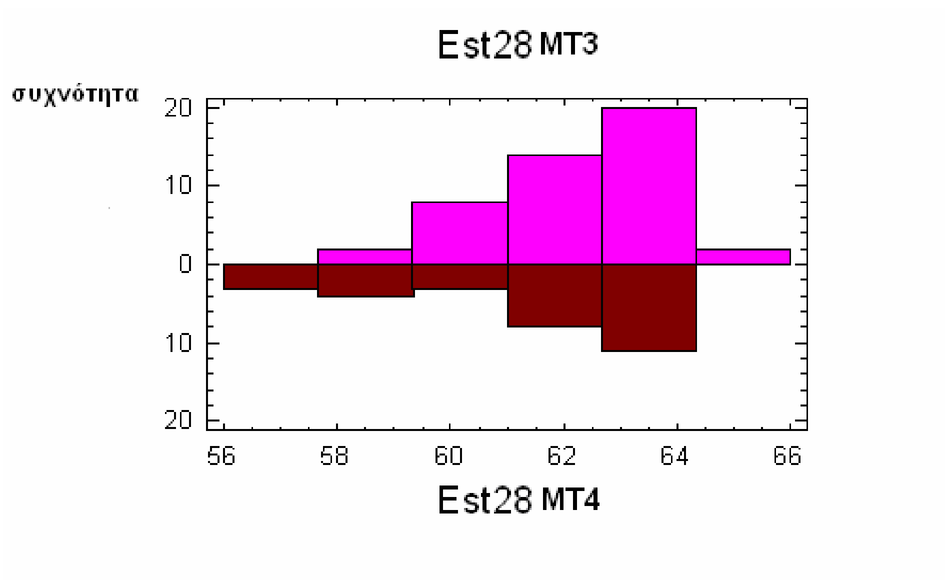
Πίνακας 5. 126 Σύγκριση τιμών αντοχής τσιμέντου 28ης ημέρας για μύλο3 και μύλο 4

	Est28_3	Est28_4
περιπτώσεις	46	29
μέσος όρος	62,3109	61,2966
διασπορά	1,96232	4,85749
τυπική απόκλιση	1,40083	2,20397
Μικρότερη τιμή	59,0	56,7
Μέγιστη τιμή	64,9	64,2
Εύρος	5,9	7,5
Τυπική ασυμμετρία	-1,97443	-1,67541
Τυπική κύρτωση	0,0215103	-0,727697

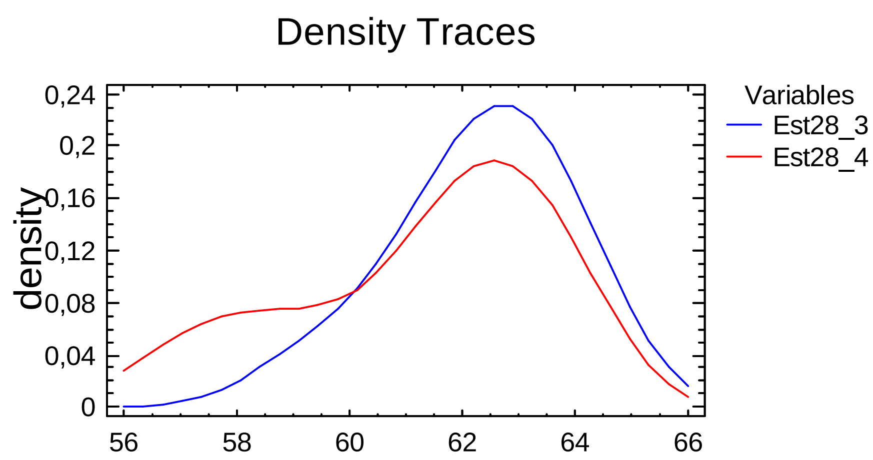
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 139 Θηκογράμματα της μεταβλητής Est28 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 140 Ιστογράμματα της μεταβλητής Est28 για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 141 διάγραμμα πυκνότητας Est28 από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.

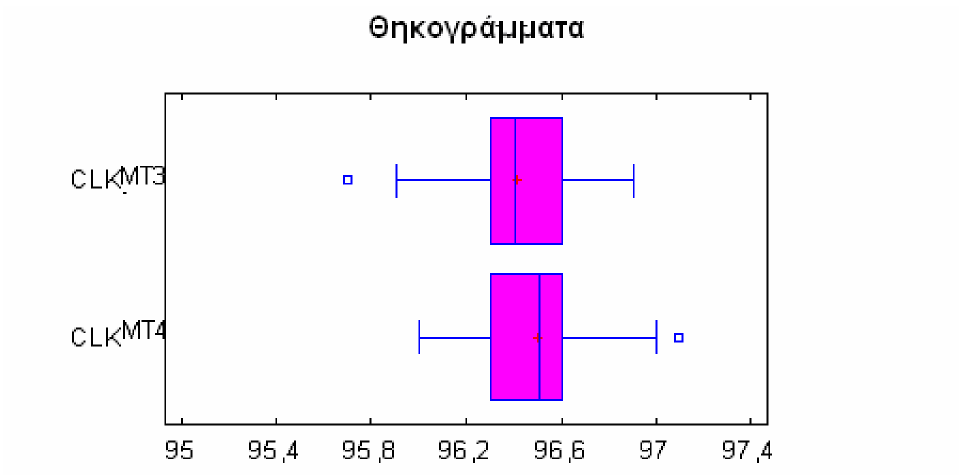
4.4.3.9. Σύγκριση ποσοστού κλίνκερ (Clk)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

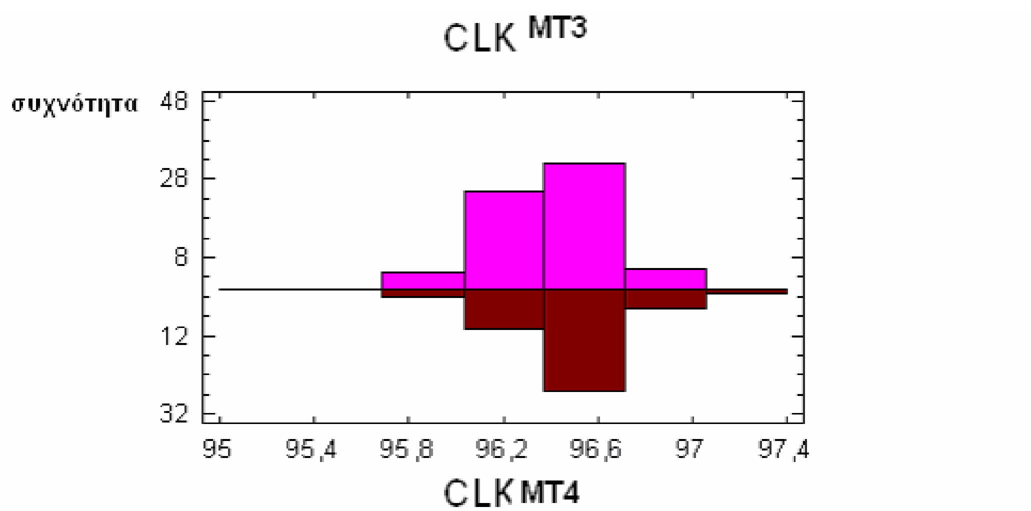
Πίνακας 5. 127 Σύγκριση ποσοστού Clk για μύλο 3 και μύλο 4

	CLK_3	CLK_4
περιπτώσεις	66	44
μέσος όρος	96,4106	96,4977
διασπορά	0,0631166	0,0532505
τυπική απόκλιση	0,25123	0,230761
μικρότερη τιμή	95,7	96,0
μέγιστη τιμή	96,9	97,1
εύρος	1,2	1,1
τυπική ασυμμετρία	-0,788508	0,432815
τυπική κύρτωση	0,0912864	0,704415

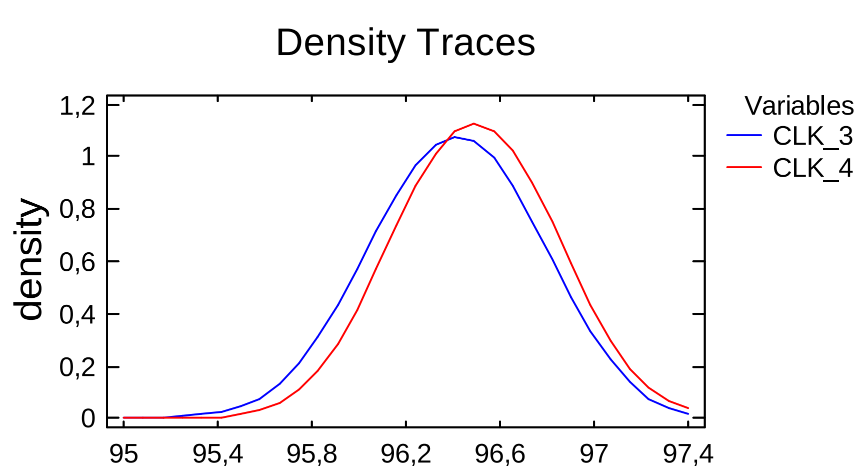
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 142 *Θηκογράμματα της μεταβλητής Clk για κάθε μύλο και τσιμέντο τύπου OPC*



Διάγραμμα5. 143 *Ιστογράμματα της μεταβλητής Clk για κάθε μύλο και τσιμέντο τύπου OPC*



Διάγραμμα5. 144 διάγραμμα πυκνότητας Clk από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι η υπόθεση δεν μπορεί να θεωρηθεί σωστή και ότι σε αυτό το ποσοστό εμπιστοσύνης οι μέσοι δεν μπορούν να θεωρηθούν ίσοι.

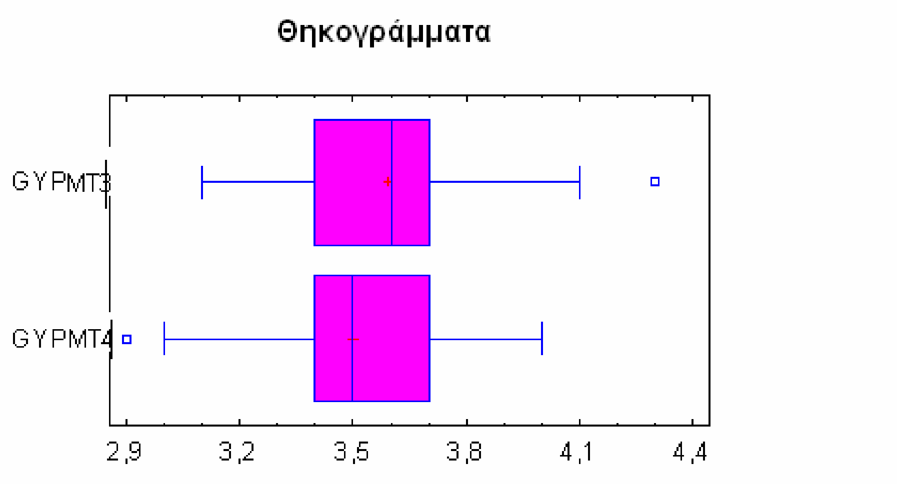
4.4.3.10. Σύγκριση ποσοστού γύψου (Gyp)

Συνοπτικά τα αποτελέσματα μελέτης της μεταβλητής για τους δύο διαφορετικούς μύλους παραγωγής φαίνονται στο παρακάτω πίνακα

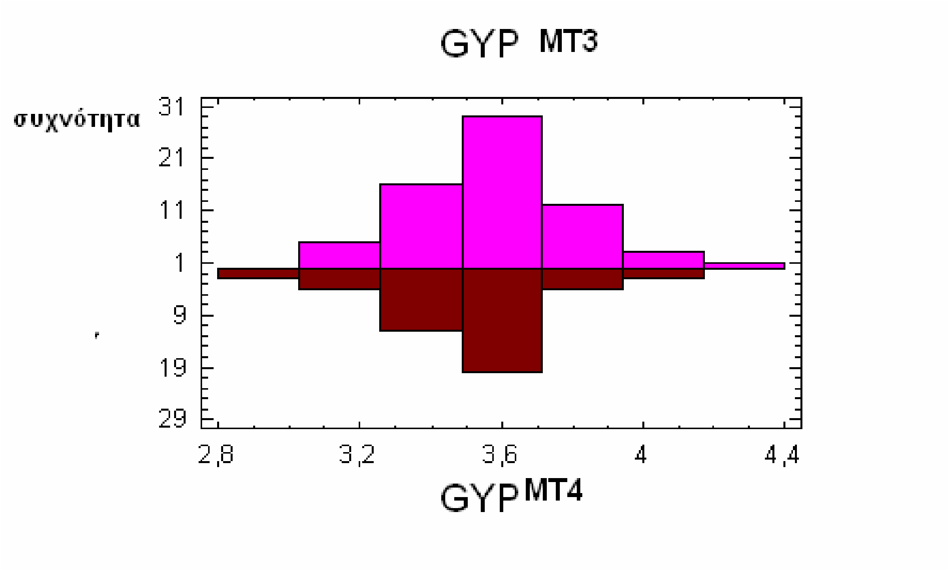
Πίνακας 5. 128 Σύγκριση ποσοστού Gyp για μύλο 3 και μύλο 4

	GYP_3	GYP_4
περιπτώσεις	66	44
μέσος όρος	3,58939	3,50227
διασπορά	0,0631166	0,0532505
τυπική απόκλιση	0,25123	0,230761
μικρότερη τιμή	3,1	2,9
μέγιστη τιμή	4,3	4,0
εύρος	1,2	1,1
τυπική ασυμμετρία	0,788508	-0,432815
τυπική κύρτωση	0,0912864	0,704415

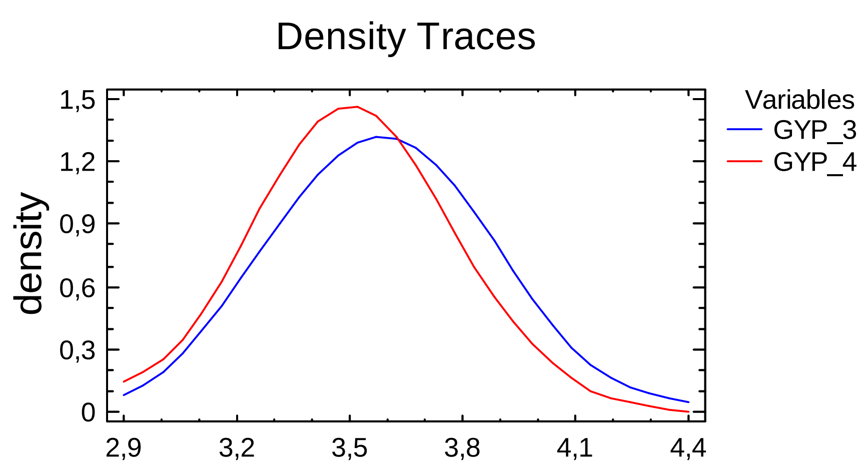
Ενώ οπτικά η διακύμανση των τιμών παρουσιάζεται στα γραφήματα που ακολουθούν



Διάγραμμα5. 145 Θηκογράμματα της μεταβλητής Gyp για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 146 Ιστογράμματα της μεταβλητής Gyp για κάθε μύλο και τσιμέντο τύπου OPC



Διάγραμμα5. 147 διάγραμμα πυκνότητας Gyp από κάθε μύλο και τσιμέντο τύπου OPC

Μελετάται αν η υπόθεση ότι η τυπική απόκλιση των δύο δειγμάτων είναι ίδια είναι σωστή. Με την πραγματοποίηση του f-test προκύπτει ότι σε επίπεδο εμπιστοσύνης 95% δεν υπάρχει σημαντική διαφορά στην τυπική απόκλιση των δύο πληθυσμών.
Με την υπόθεση αυτή πραγματοποιείται έλεγχος για το αν οι μέσοι των δειγμάτων είναι ίσοι. Σε επίπεδο εμπιστοσύνης 95% από τον έλεγχο (t-test) προκύπτει ότι η υπόθεση μπορεί να θεωρηθεί σωστή και ότι σε αυτό το ποσοστό εμπιστοσύνης οι μέσοι μπορούν να θεωρηθούν ίσοι.

4.4.4. Συμπεράσματα

Ποιότητα τσιμέντου CEM II 42,5

Όπως φαίνεται από την παραπάνω μελέτη, οι ιδιότητες στον μύλο 4 φαίνονται μειωμένες συγκριτικά με αυτές στο μύλο 1. Κάτι τέτοιο δικαιολογείται από το γεγονός ότι ο μύλος 4 είναι ουσιαστικά ένας μύλος κάθετος με εντελώς διαφορετική τεχνολογία από τους άλλους μύλους. Μάλιστα οι προδιαγραφές για πολλές από τις ιδιότητες τσιμέντου που παράγεται από αυτόν τον μύλο είναι πολύ χαμηλότερες, όπως για παράδειγμα η λεπτότητα (Blaine) από τις αντίστοιχες για τον μύλο1.

Ποιότητα τσιμέντου OPC

Τα συμπεράσματα είναι τα ίδια με αυτά που προκύπτουν από τη σύγκριση των μύλων 1 και 4 για τον τύπο τσιμέντου CEM II 42,5. Θα πρέπει να διευκρινισθεί ότι στο εργοστάσιο λειτουργούν 4 μύλοι παραγωγής εκ των οποίων οι 3 είναι οριζόντιοι ενώ ο 4^{ος} κάθετος.

Αυτό που ενδιαφέρει είναι το γεγονός ότι ο μύλος 4 παράγει τσιμέντο με λιγότερες αντοχές από αυτό που παράγει ο μύλος 3. Κάτι τέτοιο φαίνεται και από τη στατιστική ανάλυση των δεδομένων και από την ανάλυση ικανότητας αλλά και από τη σύγκριση των δύο μύλων. Σε συνδυασμό με τη γραμμική παλινδρόμηση και τις πληροφορίες που αντλούνται από αυτή είναι εύκολο να διευκρινισθεί, από ποιες ιδιότητες επηρεάζονται οι αντοχές του τσιμέντου. Παράλληλα μια κατηγοριοποίηση των τεχνικών παραμέτρων και η ένταξή τους στα μοντέλα παλινδρόμησης θα μπορέσουν ίσως να δείξουν μια ακριβέστερη εικόνα για τους παράγοντες που επηρεάζουν τις αντοχές του τσιμέντου. Παράλληλα, ένα τέτοιο μοντέλο το οποίο θα περιλαμβάνει όσο το δυνατό περισσότερους από τους παράγοντες που επιδρούν στις μηχανικές ιδιότητες θα είναι ικανό να προβλέψει τις αντοχές σε μεγάλα επίπεδα εμπιστοσύνης.

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Κεφάλαιο 5.
ΣΥΜΠΕΡΑΣΜΑΤΑ ΚΑΙ ΠΡΟΤΑΣΕΙΣ ΓΙΑ ΠΕΡΑΙΤΕΡΩ ΕΡΕΥΝΑ

Στην παραπάνω μελέτη χρησιμοποιήθηκαν στοιχεία από δύο βασικούς τύπους τσιμέντου. Οι δύο αυτοί τύποι τσιμέντου διαφέρουν μεταξύ τους ως προς τη ποζολάνη και τον ασβεστόλιθο, συστατικά τα οποία υπάρχουν στον τύπο τσιμέντου CEM II 42,5 αλλά όχι στον τύπο τσιμέντου OPC. (πίνακας 3.5) Επίσης, διαφέρουν ως προς τα βελτιωτικά τα οποία υπάρχουν στον τύπο τσιμέντου OPC αλλά όχι στον τύπο τσιμέντου CEM II 42,5. Από την μελέτη προκύπτει ότι :α) η επίδραση βελτιωτικών είναι καταλυτική, β) η ύπαρξη ποζολάνης δεν επηρεάζει σημαντικά τις τελικές μηχανικές ιδιότητες. Η επιλογή των δύο αυτών τύπων τσιμέντου έγινε διότι αποτελούν βασικούς τύπους, οι οποίοι διαφέρουν μεταξύ τους σε ορισμένα συστατικά. Με την επιλογή αυτών των τύπων τσιμέντου ο στόχος είναι να επικεντρωθεί η μελέτη σε ορισμένα στοιχεία της σύστασης και πραγματοποιείται μια πρώτη προσέγγιση για εύρεση των σημαντικότερων μεταβλητών οι οποίες επηρεάζουν τις τελικές μηχανικές ιδιότητες.

Τα ειδικά συμπεράσματα που αφορούν το τεχνικό μέρος έχουν αναφερθεί στο κεφάλαιο των αποτελεσμάτων. Στο κεφάλαιο των αποτελεσμάτων πραγματοποιείται ανάλυση και εξαγωγή συμπερασμάτων από κάθε μελέτη.

Η μελέτη απέδειξε ότι με τη χρήση εργαλείων της στατιστικής είναι δυνατό να πραγματοποιηθεί έλεγχος στην παραγωγική διαδικασία.

Πιο συγκεκριμένα, με τη χρήση της στατιστικής είναι δυνατό να εξακριβωθεί κατά πόσο τα πειραματικά αποτελέσματα ακολουθούν νόμους και αποδεδειγμένες θεωρίες. Στη συγκεκριμένη μελέτη, κατά την ανάλυση των δεδομένων αποδείχθηκε ότι αυτά ακολουθούν μοντέλα που προτάσσει η κινητική θεωρία. Παράλληλα, από τη συγκεκριμένη μελέτη έγινε κατανοητό ότι οι προς μελέτη ιδιότητες ακολουθούν κάποια συγκεκριμένη κατανομή, εν προκειμένω την κανονική, κάποιο συγκεκριμένο μοτίβο.

Επίσης, με τη χρήση εργαλείων της στατιστικής είναι δυνατό να ελεγχθεί η ικανότητα παραγωγής. Από τη μελέτη ανάλυσης της ικανότητας των προς εξέταση μεταβλητών είναι δυνατό να προσδιορισθεί το κατά πόσο αυτές οι μεταβλητές ακολουθούν τις προδιαγραφές της παραγωγής που έχουν τεθεί.

Η στατιστική επεξεργασία, με τη χρήση της γραμμικής παλινδρόμησης και της συσχέτισης μπορεί να καθορίσει τους σημαντικότερους παράγοντες από τους οποίους επηρεάζεται η παραγωγή. Στη συγκεκριμένη μελέτη πραγματοποιήθηκε έλεγχος της σχέσης μεταξύ των ανεξάρτητων μεταβλητών καθώς και έλεγχος της σχέσης μεταξύ των εξαρτημένων μεταβλητών. Δημιουργήθηκαν μάλιστα μοντέλα μεταξύ των προς εξέταση ιδιοτήτων με σκοπό την εύρεση μαθηματικής συσχέτισης μεταξύ τους. Από την ανάλυση προέκυψαν οι πλέον κρίσιμες μεταβλητές που επηρεάζουν τις μηχανικές ιδιότητες σε κάθε τύπο τσιμέντου καθώς και κάποιες μαθηματικές συναρτήσεις οι οποίες στοχεύουν στην ποσοτικοποίηση αυτής της επίδρασης.

Ο έλεγχος σημαντικότητας κάποιων εξωτερικών παραμέτρων για την παραγωγή μπορεί να πραγματοποιηθεί με τη σύγκριση δύο πληθυσμών. Με τη σύγκριση δύο δειγμάτων φαίνεται η διαφορά στις ιδιότητες που υπάρχει από την παραγωγή τσιμέντου από διαφορετικούς μύλους. Η συγκεκριμένη διαφορά ήταν αναμενόμενη και γνωστή στους υπεύθυνους παραγωγής. Η στατιστική όμως επεξεργασία παρέχει τη δυνατότητα να εξακριβωθεί και να καθορισθεί πλήρως αυτή η διαφορά.

Από την μελέτη προέκυψαν ισχυρές συσχετίσεις μεταξύ των ανεξάρτητων και των εξαρτημένων μεταβλητών (βλέπε κεφ.5). Με τη χρήση θεωρίας από τη χημεία και την κινητική είναι δυνατό αυτές οι συσχετίσεις να οδηγήσουν σε ακριβή μοντέλα κατά τα οποία θα είναι εφικτό :
Α) εφόσον είναι γνωστές οι αντοχές του τσιμέντου κατά τη δεύτερη μέρα να γίνεται ακριβής πρόβλεψη για τις αντοχές κατά την 28^{η} ημέρα.
Β) από τη σύσταση και τις φυσικοχημικές ιδιότητες του τσιμέντου να γίνεται ακριβής πρόβλεψη τόσο για τις αντοχές κατά τη 2^{η} όσο και κατά την 28^{η} ημέρα.

Ένα μοντέλο το οποίο θα είναι ικανό για τις παραπάνω προβλέψεις απαιτεί την παραμετροποίηση και τη μαθηματικοποίηση των τεχνικών χαρακτηριστικών. Παράλληλα, είναι απαραίτητο να ενταχθεί σε αυτό το μοντέλο ο τρόπος με τον οποίο επιδρούν στο τσιμέντο τα διάφορα βελτιωτικά. Οι παραπάνω απαιτήσεις είναι απαραίτητο να ικανοποιηθούν αφού όπως φάνηκε από τη μελέτη τόσο τα τεχνικά χαρακτηριστικά όσο και τα διάφορα βελτιωτικά επηρεάζουν σημαντικά τις τελικές μηχανικές ιδιότητες του τσιμέντου. Παράλληλα, είναι απαραίτητη η εύρεση ακριβούς μοντέλου το οποίο θα παρουσιάζει τη συσχέτιση μεταξύ των ανεξάρτητων μεταβλητών. Κατά τον τρόπο αυτό είναι δυνατό να μειωθεί με τον καλύτερο δυνατό τρόπο η πολυσυγγραμικότητα των προτεινόμενων μοντέλων και να παραχθεί κάποιο μοντέλο το οποίο θα προβλέπει σε μεγάλο βαθμό τις τελικές αντοχές.

Με τη δημιουργία ενός μοντέλου με το οποίο θα είναι δυνατό να γίνει ακριβής πρόβλεψη των τελικών μηχανικών ιδιοτήτων θα είναι πολύ πιο εύκολος ο έλεγχος της παραγωγής και της ανάλυσης ικανότητας. Ελέγχοντας όλες τις παραμέτρους οι οποίες καθορίζουν τις τελικές μηχανικές ιδιότητες να είναι εντός των προδιαγραφών, μειώνεται ο κίνδυνος να υπάρξουν αντοχές οι οποίες να είναι εκτός των προδιαγραφών.

Ο στατιστικός έλεγχος αποτελεί μία διαδικασία η οποία μπορεί να επισημάνει και να βελτιώσει την παραγωγή στο βαθμό όμως που χρησιμοποιούνται εργαλεία της στατιστικής, προσαρμοσμένα στις απαιτήσεις κάθε παραγωγικής διαδικασίας. Στόχο μάλιστα θα μπορούσε να αποτελέσει η χρήση ολοκληρωμένου ελέγχου διαδικασιών, ο οποίος πιθανώς να περιλαμβάνει αθροιστικούς χάρτες ελέγχου ή χάρτες ελέγχου στους οποίους θα φαίνονταν οι μεταβολές διαφόρων μεταβλητών. Σε συνδυασμό μάλιστα με διαγράμματα Pareto θα μπορούσε να δίνεται βάρος στις σημαντικότερες για την παραγωγική διαδικασία μεταβλητές.[1]

Φυσικά, η στατιστική επεξεργασία δεδομένων δεν αποτελεί τεχνική η οποία μπορεί να εφαρμοσθεί μόνο στην παραγωγική διαδικασία. Πολλές δημοσιεύσεις έχουν επισημάνει ότι η δύναμη των στατιστικών μεθόδων ελέγχου δεν έγκειται μόνο στις εφαρμογές των εργαλείων στατιστικής αλλά σε «εφαρμογές» οι οποίες φανερώνουν ένα στατιστικό τρόπο σκέψης.[2],[3] Η στατιστική σκέψη βασίζεται στη συνειδητοποίηση ότι όλο το βάρος θα πρέπει να δίνεται στις διαδικασίες, συμπεριλαμβανομένου και αυτές οι οποίες δεν αναφέρονται στην παραγωγή, ότι όλες οι διαδικασίες υπόκεινται σε μεταβολές και ότι με την κατανόηση και τον έλεγχο των αιτιών των όποιων μεταβολών βελτιώνεται το κέρδος. Με αυτόν τον τρόπο ο στατιστικός έλεγχος διεργασιών έχει ένα ευρύ φάσμα και μπορεί να χρησιμοποιηθεί σε ολόκληρο τον οργανισμό.[4] Τα εργαλεία της στατιστικής μπορούν να χρησιμοποιηθούν ευρέως σε όλους τους τομείς μίας εταιρίας , όπως για παράδειγμα σε έρευνες του τμήματος μάρκετινγκ, στο στρατηγικό σχεδιασμό και στο οικονομικό τμήμα. Στα παραπάνω τμήματα εκτός από γραμμικές παλινδρομήσεις είναι δυνατό να χρησιμοποιηθούν και τα εργαλεία του στατιστικού ελέγχου ποιότητας με σκοπό να εξακριβωθεί κατά πόσο οι πωλήσεις για παράδειγμα βρίσκονται κοντά στο στόχο της εταιρίας ή κατά πόσο τα έξοδα υπερβαίνουν τα επιτρεπτά όρια.

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Ελληνική – Αγγλική ορολογία

ανιούσα επιλογή	=	forward selection
ασυμμετρία	=	skewness
βηματική επιλογή	=	stepwise selection
διακύμανση	=	variability
εγγενής ή τυχαία διακύμανση	=	random or common cause variability
ειδική ή αξιοσημείωτη αιτία διακύμανσης	=	special or assignable cause variability
διασπορά	=	variance inflation factor
διάστημα εμπιστοσύνης	=	confidence intervals
εσφαλμένος συναγερμός	=	false alarm
ευσταθής διεργασία	=	stable process
ιδιότητες	=	attributes
κατώτατα/ανώτατα όρια ελέγχου	=	action limits
κεντρική γραμμή	=	central line
κεντρικό οριακό θεώρημα	=	Central Limit Theorem
κύρτωση	=	kurtosis
μεγάλης διάρκειας	=	long term
μεταβλητές	=	variables
μικρής διάρκειας	=	short term
όρια προδιαγραφών	=	specification limits
Παλινδρόμηση	=	Regression
ψευδοορθογώνια	=	Ridge Regression
πληθωριστικός παράγοντας διασποράς	=	variance inflation factor
στατιστικός έλεγχος διεργασιών	=	statistical process control (SPC)
στατιστικός έλεγχος ποιότητας	=	statistical quality control (SQC)
συσχέτιση	=	correlation
υποομάδες	=	subgroups
φύλλα δεδομένων	=	data sheets
χάρτες ελέγχου	=	control charts
αθροιστικό	=	cumulative
κινητού εύρους	=	moving range
μεμονωμένων τιμών	=	individual control chart

Αγγλική – Ελληνική ορολογία

action limits	=	κατώτατα/ανώτατα όρια ελέγχου
attributes	=	ιδιότητες
Central Limit Theorem	=	κεντρικό οριακό θεώρημα
central line	=	κεντρική γραμμή
confidence intervals	=	διάστημα εμπιστοσύνης
control charts	=	χάρτες ελέγχου
cumulative	=	αθροιστικό
individual control chart	=	μεμονωμένων τιμών
moving range	=	κινητού εύρους
correlation	=	συσχέτιση
data sheets	=	φύλλα δεδομένων
false alarm	=	εσφαλμένος συναγερμός
forward selection	=	ανιούσα επιλογή
kurtosis	=	κύρτωση
long term	=	μεγάλης διάρκειας
Regression	=	Παλινδρόμηση
Ridge Regression	=	ψευδοορθογώνια
short term	=	μικρής διάρκειας
skewness	=	ασυμμετρία
specification limits	=	όρια προδιαγραφών
stable process	=	ευσταθής διεργασία
statistical process control (SPC)	=	στατιστικός έλεγχος διεργασιών
statistical quality control (SQC)	=	στατιστικός έλεγχος ποιότητας
stepwise selection	=	βηματική επιλογή
subgroups	=	υποομάδες
variability	=	διακύμανση
random or common cause variability	=	εγγενής ή τυχαία διακύμανση
special or assignable cause variability	=	ειδική ή αξιοσημείωτη αιτία διακύμανσης
variables	=	μεταβλητές
variance inflation factor	=	διασπορά
variance inflation factor	=	πληθωριστικός παράγοντας διασποράς

Παράρτημα [1]

[1] Λόγω μεγάλου όγκου της εργασίας το παράρτημα επισυνάπτεται σε ηλεκτρονική μορφή