

# PCCAS Asphalt Rubber Binder Round Robin Phase II

September 2015

# Samples

	% Wt. of AR Binder					
	SAMPLE A		SAMPLE B		SAMPLE C	
Asphalt <sup>a</sup>	PG 70-10	76	PG 64-16	77	PG 64-22	80
Extender Oil <sup>b</sup>	Supplier A	2	Supplier A	2	Supplier A	2
CRM Scrap Tire <sup>c</sup>	Supplier A	17	Supplier A	15.75	Supplier B	13.5
CRM High Nat <sup>c</sup>	Supplier A	5	Supplier A	5.25	Supplier B	4.4
Binder/Rubber <sup>d</sup>	Ratio	78/22	Ratio	70/21	Ratio	82/18
<sup>a</sup> asphalt from 3 different suppliers						
<sup>b</sup> Extender oil from same supplier for the three samples						
<sup>c</sup> CRM source from two suppliers						
<sup>d</sup> Each sample (A,B,C)field produced by a different supplier in California						
The three materials were field produced by different suppliers, all according to Caltrans						
Section 39-3.02 for Asphalt Rubber Binder for Rubber Hot Mix Asphalt.						

# Current Specifications

Test Performed	45 Minute Rx Time			Specification	
	SAMPLE A	SAMPLE B	SAMPLE C		
Cone Penetration, 77F, dmm, (D217)	N/A	57	32	25-70	
Resilience at 77F, %, (D5329)	N/A	32	50	18 min.	
Softening Point, degF (D6)	N/A	146	158	125-165	
Viscosity, Haake at 375F, cP, (LP-11)	N/A	2900	2200	1500-4000	

# Protocol

- Written procedures were given out
- An excel spread sheet was provided for entering data
- All samples were tested in triplicate
- Model and software was asked about each equipment
- Notes section was added
- Samples are all field samples, which were mixed together then poured up

# Observations

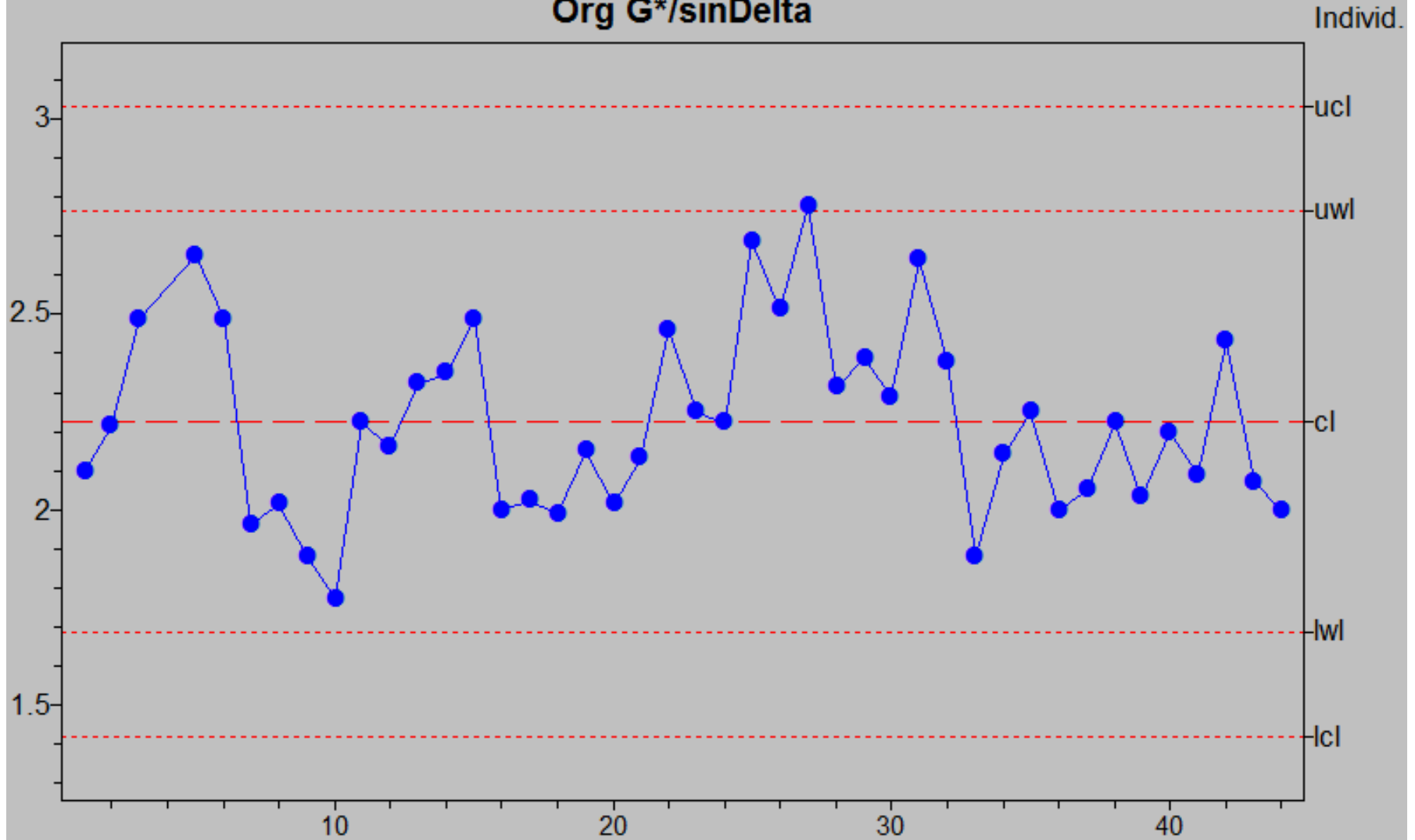
- DSR looks more reproducible as the binder ages
- AASHTO reproducibility were placed on the graphs and show that most of the data would fall within published ranges.
- ASTM was used for Elastic Recovery and results don't look very good, maybe method needs to be modified for better results
- BBR m value don't look bad
- BBR stiffness does not look good but the numbers are very low, maybe the reproducibility is not as good when the numbers are low. Most of the studies looked at so far have number ranging from 100 to 280.

# Data

- Northwest Analytical is the software package used
- Some of the data was considered to be outliers and marked in the program as such
- The Mass Change is included but should not be used as many people did not remove the data. I don't have the raw data so I am not sure if the sample came out of the bottles during the RTFO or they just did not do it
- There are some other methods to get mass change and PAV testing, which are not included in this initial report.
- The material did separate slightly during the PAV

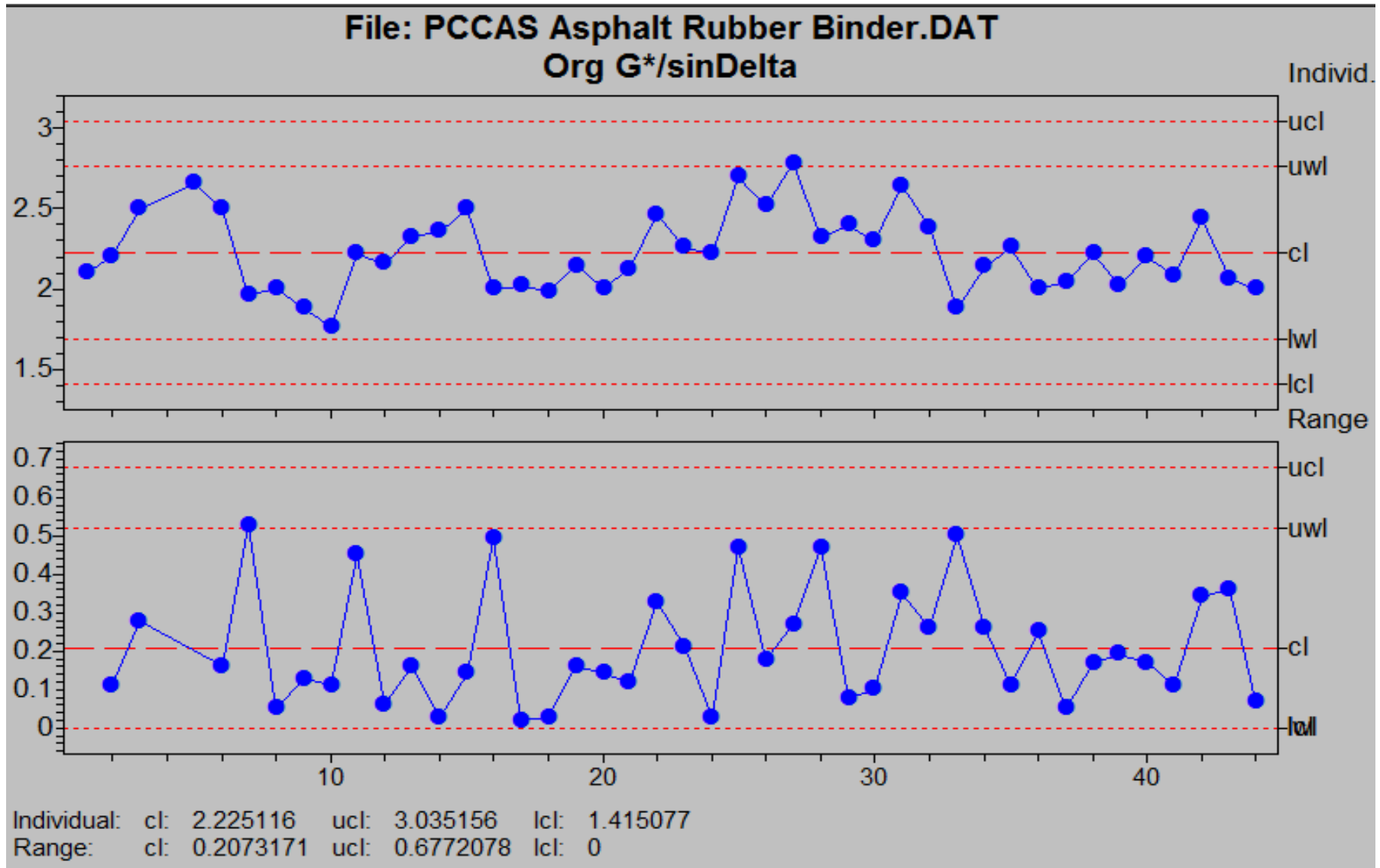
# Sample A Org. G\*/sinDelta

File: PCCAS Asphalt Rubber Binder.DAT  
Org G\*/sinDelta



Individual: cl: 2.225116 ucl: 3.035156 lcl: 1.415077

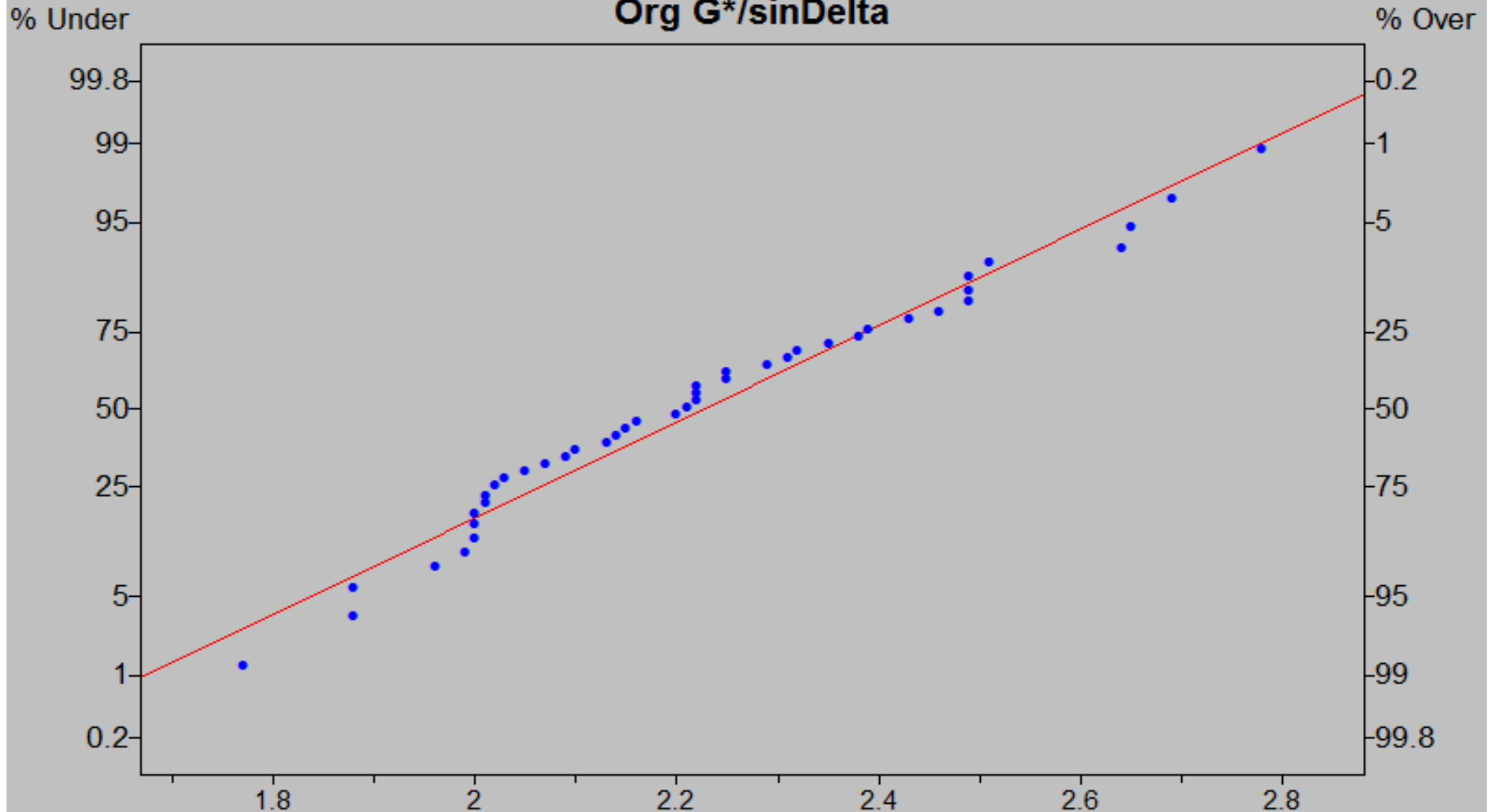
# Sample A ORG. $G^*/\sin\Delta$





# Sample A ORG. $G^*/\sin\Delta$

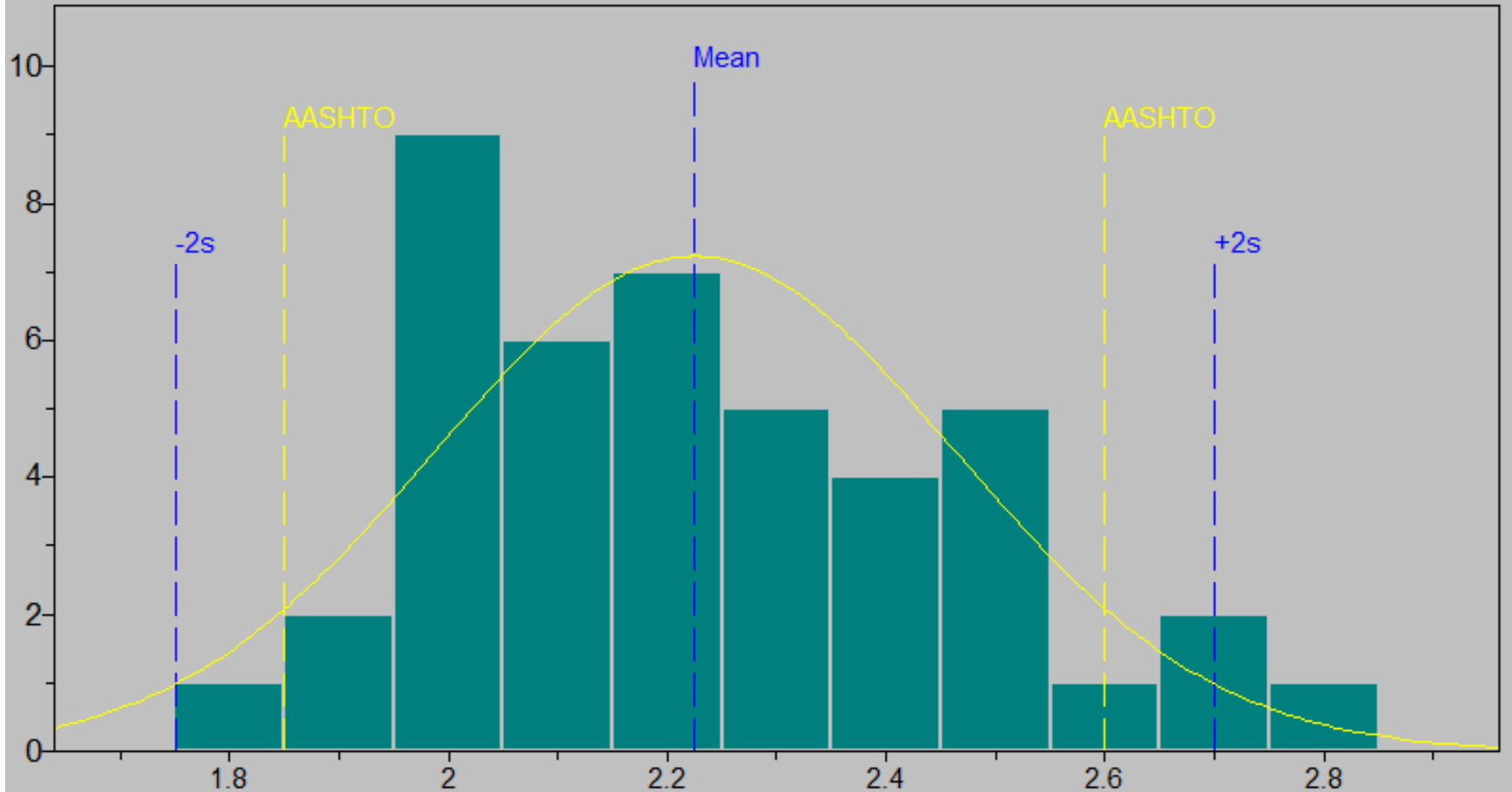
File: PCCAS Asphalt Rubber Binder.DAT  
Org  $G^*/\sin\Delta$



Sample size:	43	Mean :	2.2251	Std. Dev.:	0.23731	Upper 3 Sigma:	2.937	Above Est. % Outside:	None
Target :	None	LSL :	None	USL :	None	Lower 3 Sigma:	1.5132	Below Est. % Outside:	None

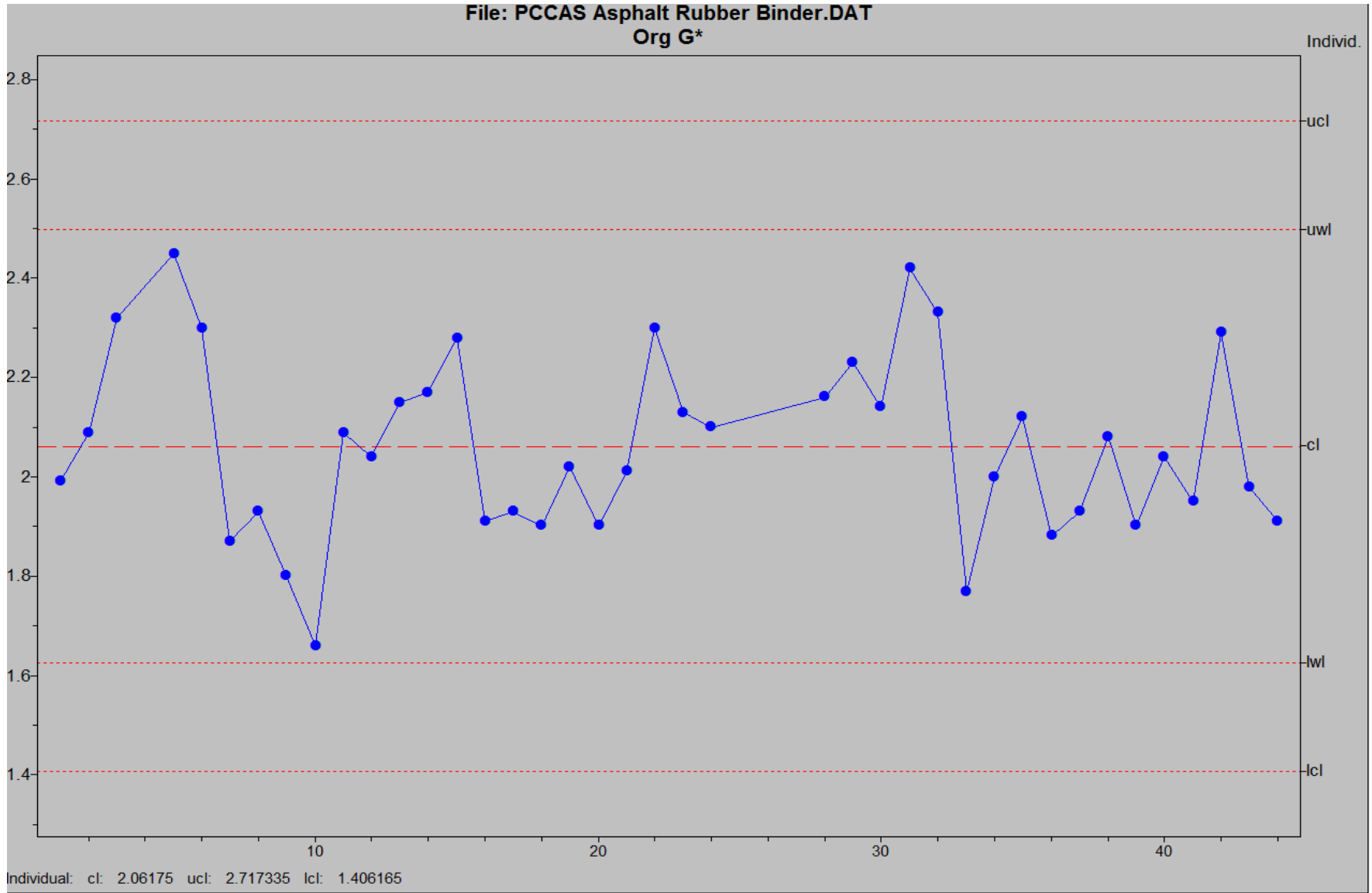
# Sample A Org. $G^*/\sin\Delta$

File: PCCAS Asphalt Rubber Binder.DAT  
Org  $G^*/\sin\Delta$

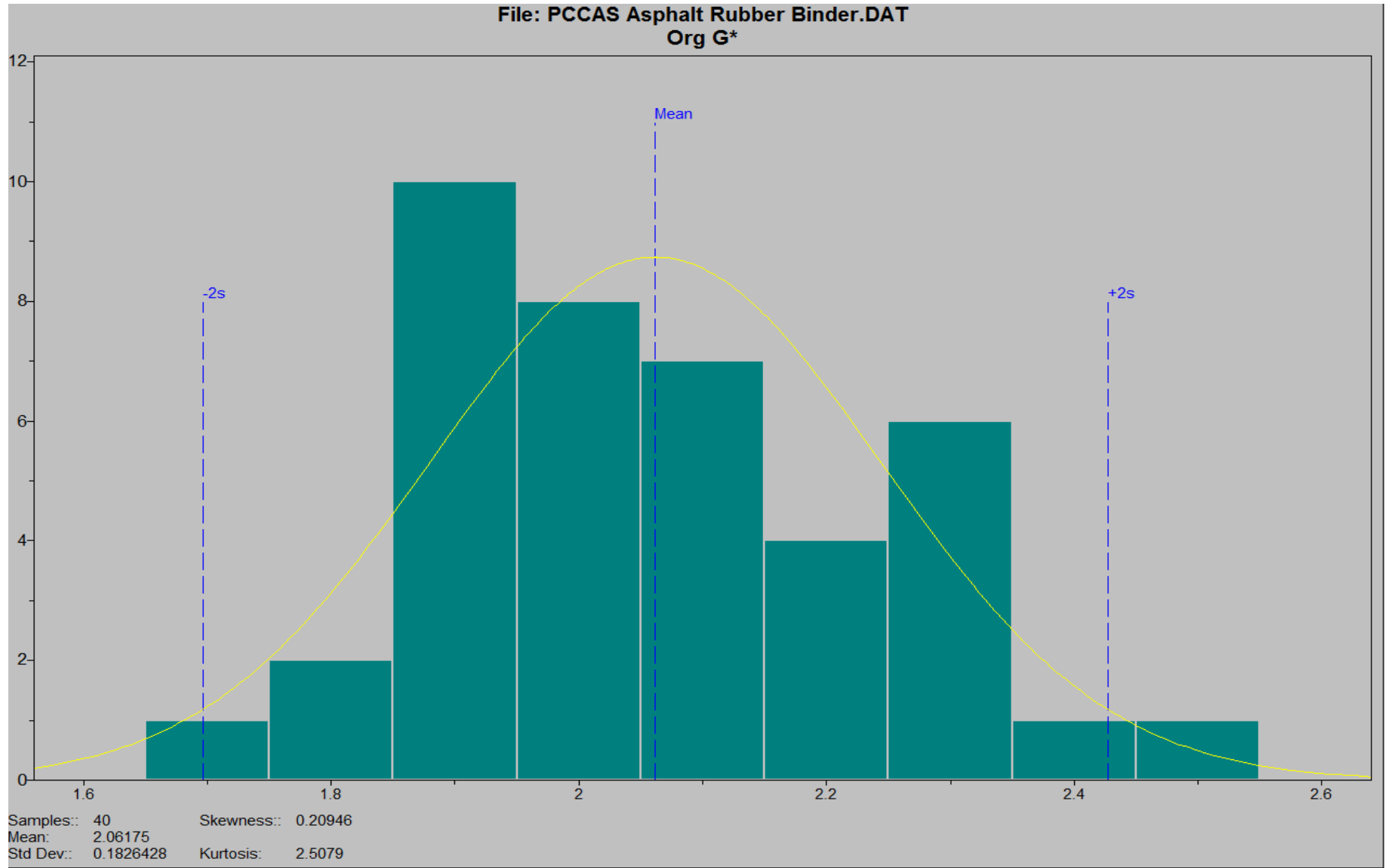


Samples:: 43  
Mean: 2.225116  
Std Dev:: 0.23731  
Skewness:: 0.42859  
Kurtosis: 2.5238

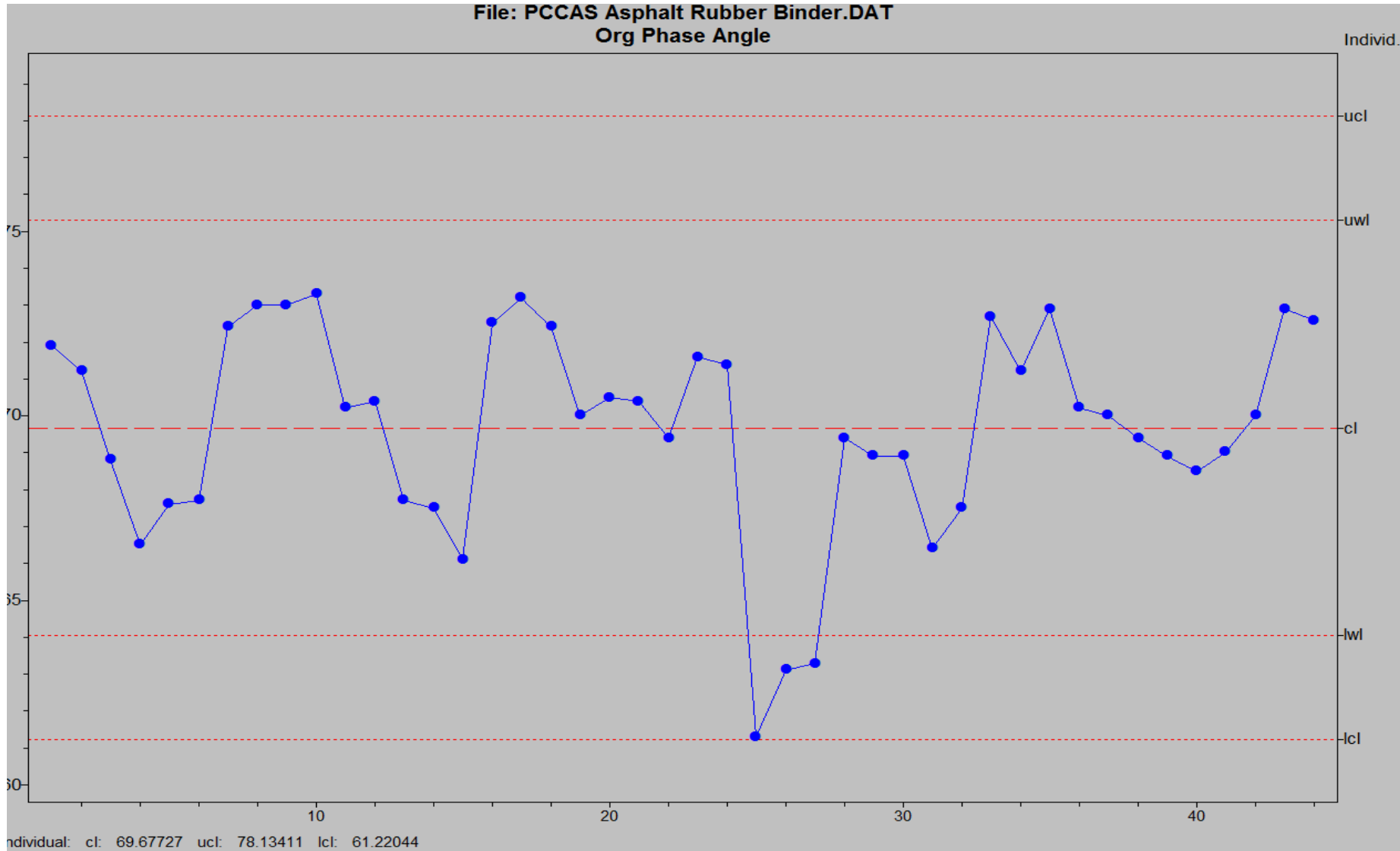
# Sample A Org. G\*



# Sample A Org. G\*

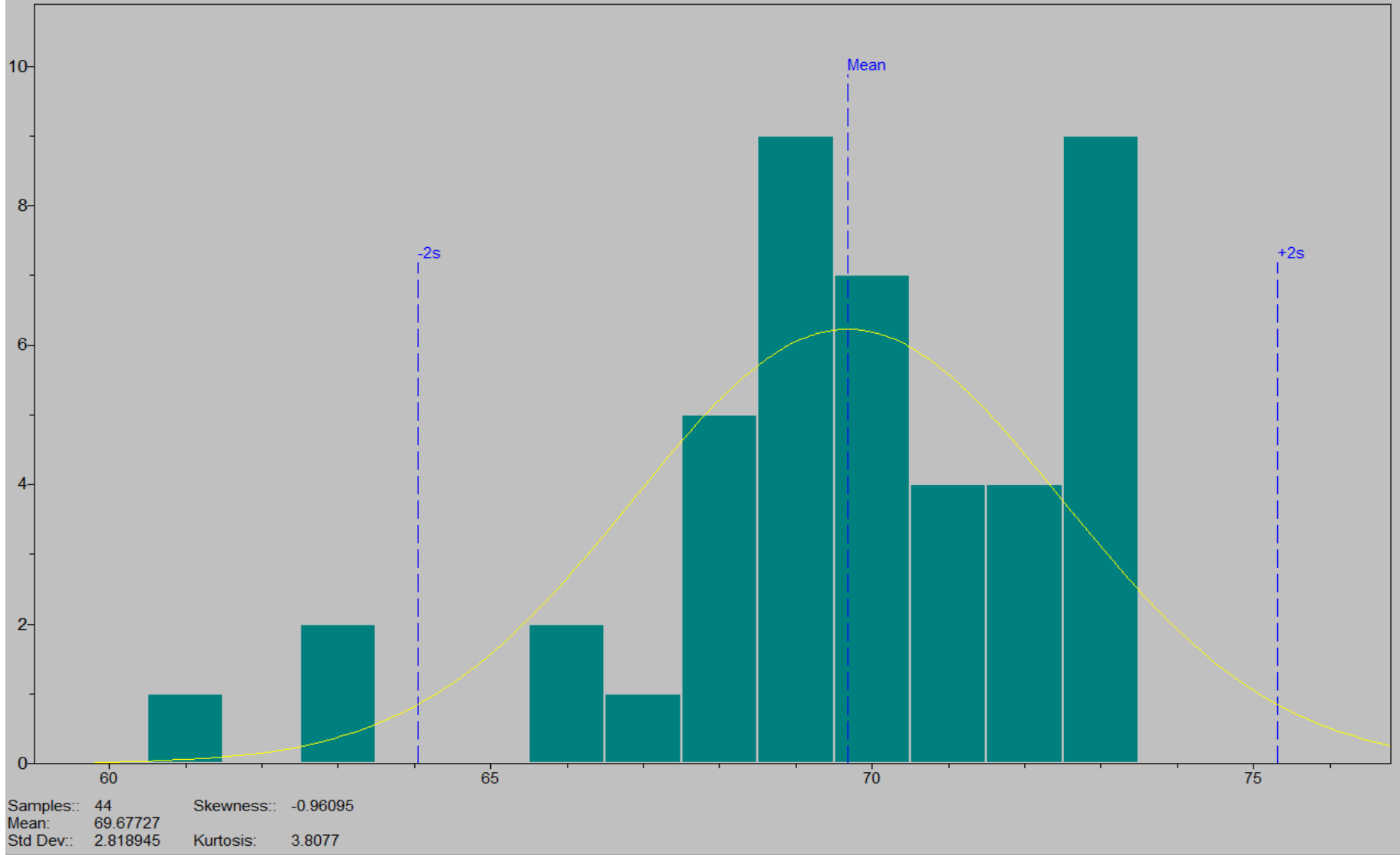


# Sample A Org. Phase Angle



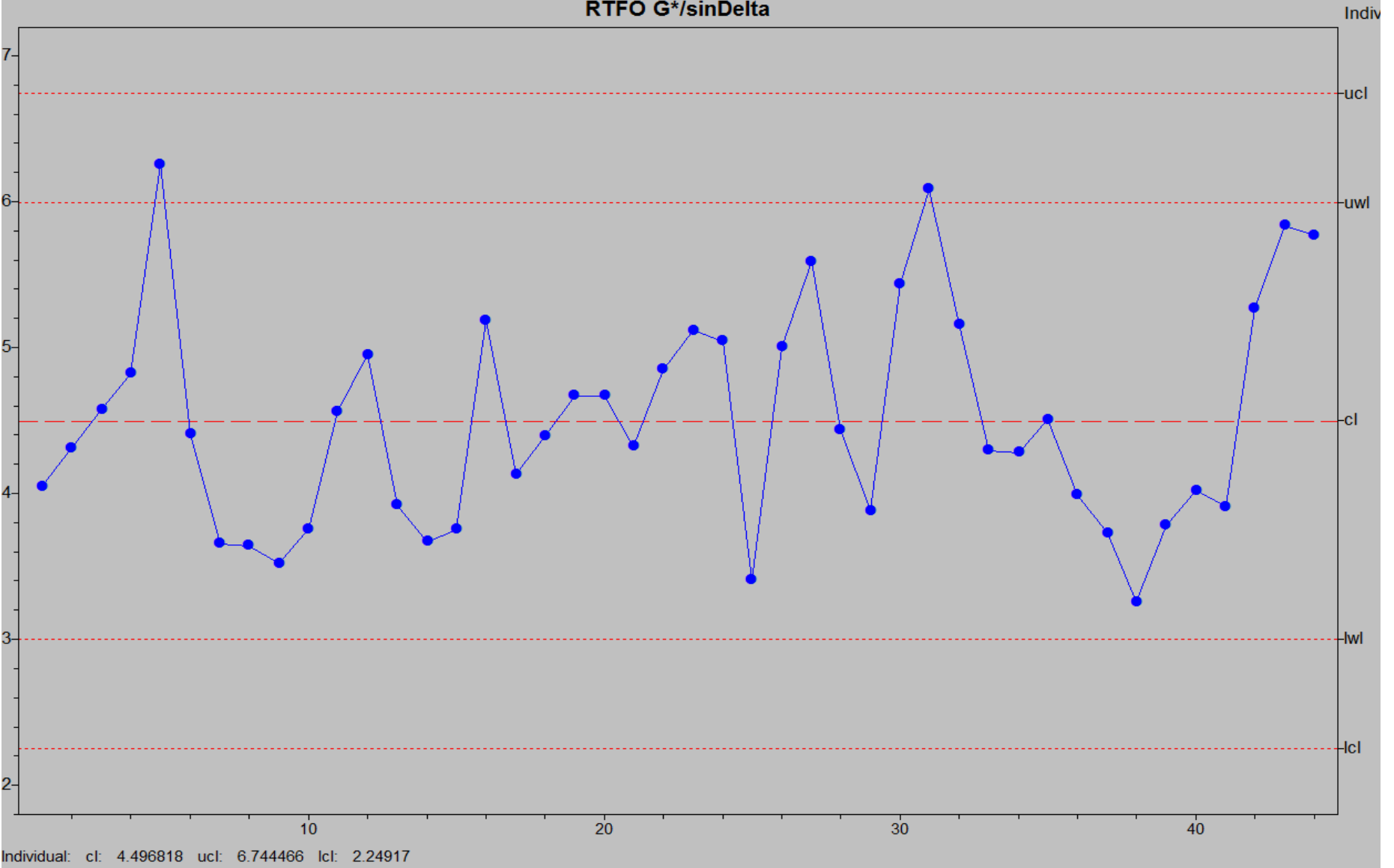
# Sample A Org. Phase Angle

File: PCCAS Asphalt Rubber Binder.DAT  
Org Phase Angle



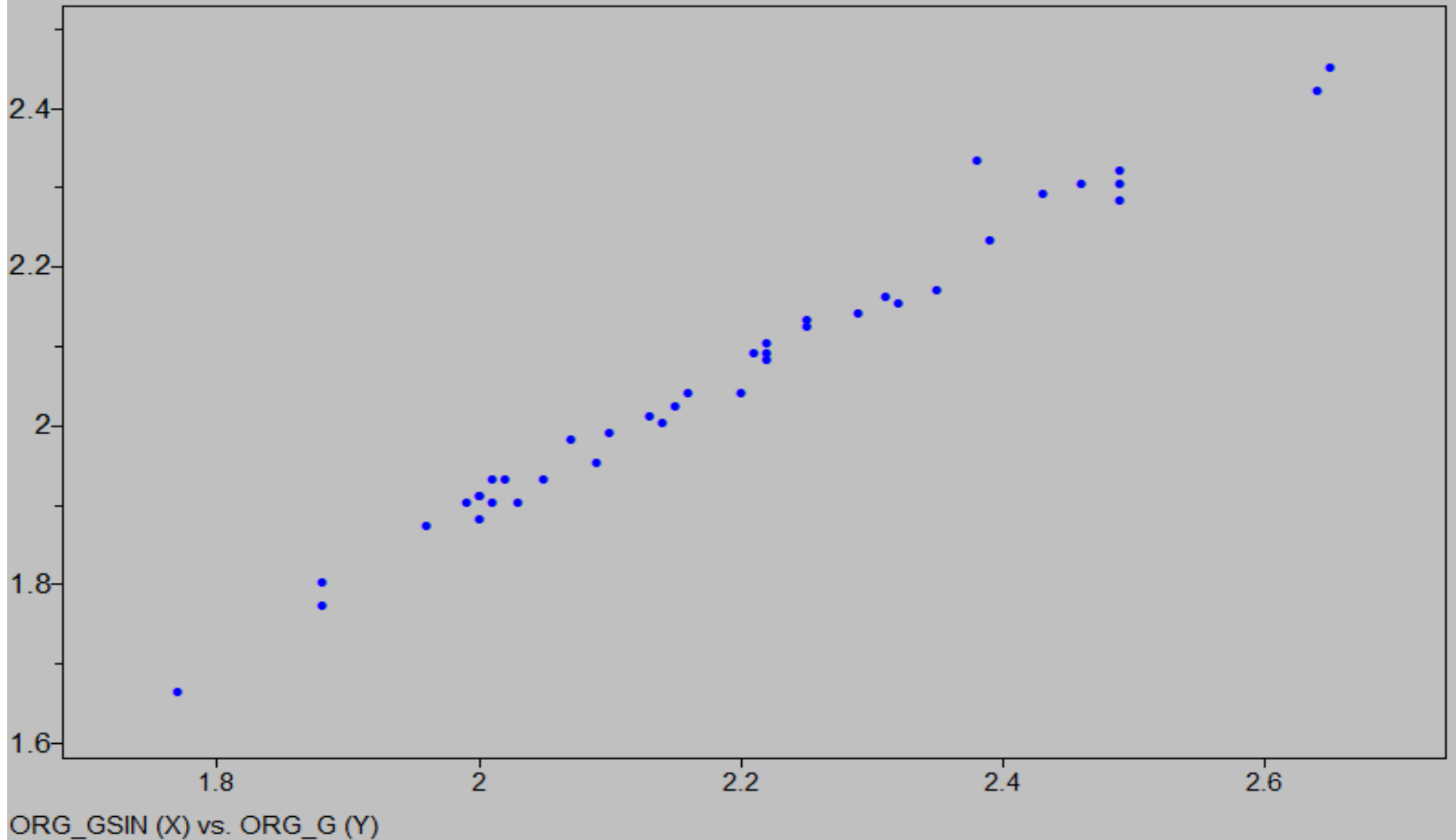
# Sample A RTFO $G^*/\sin\Delta$

File: PCCAS Asphalt Rubber Binder.DAT  
RTFO  $G^*/\sin\Delta$



# Sample A ORG. $G^*/\sin\Delta$ vs $G^*$

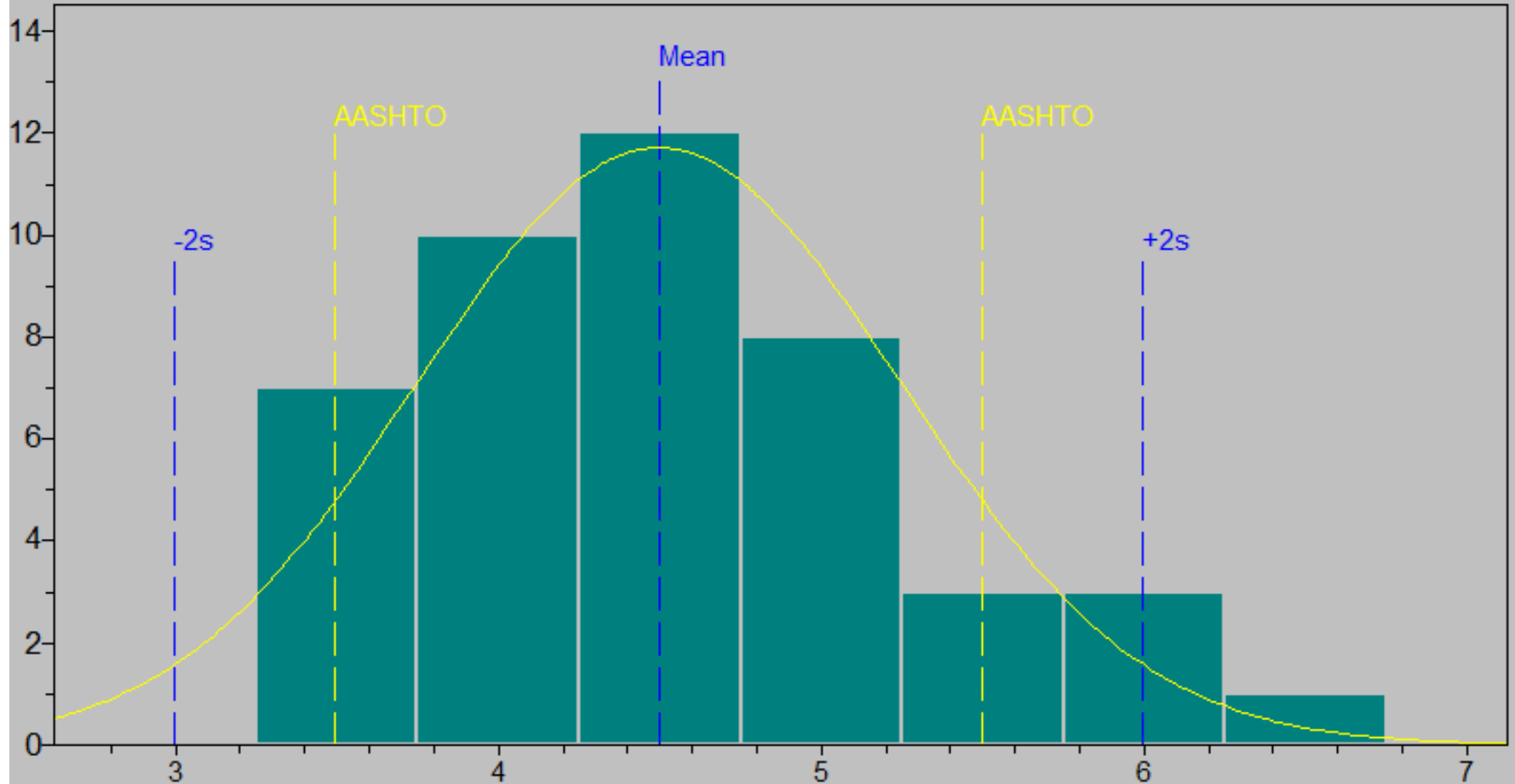
File: PCCAS Asphalt Rubber Binder.DAT





# Sample A RTFO $G^*/\sin\Delta$

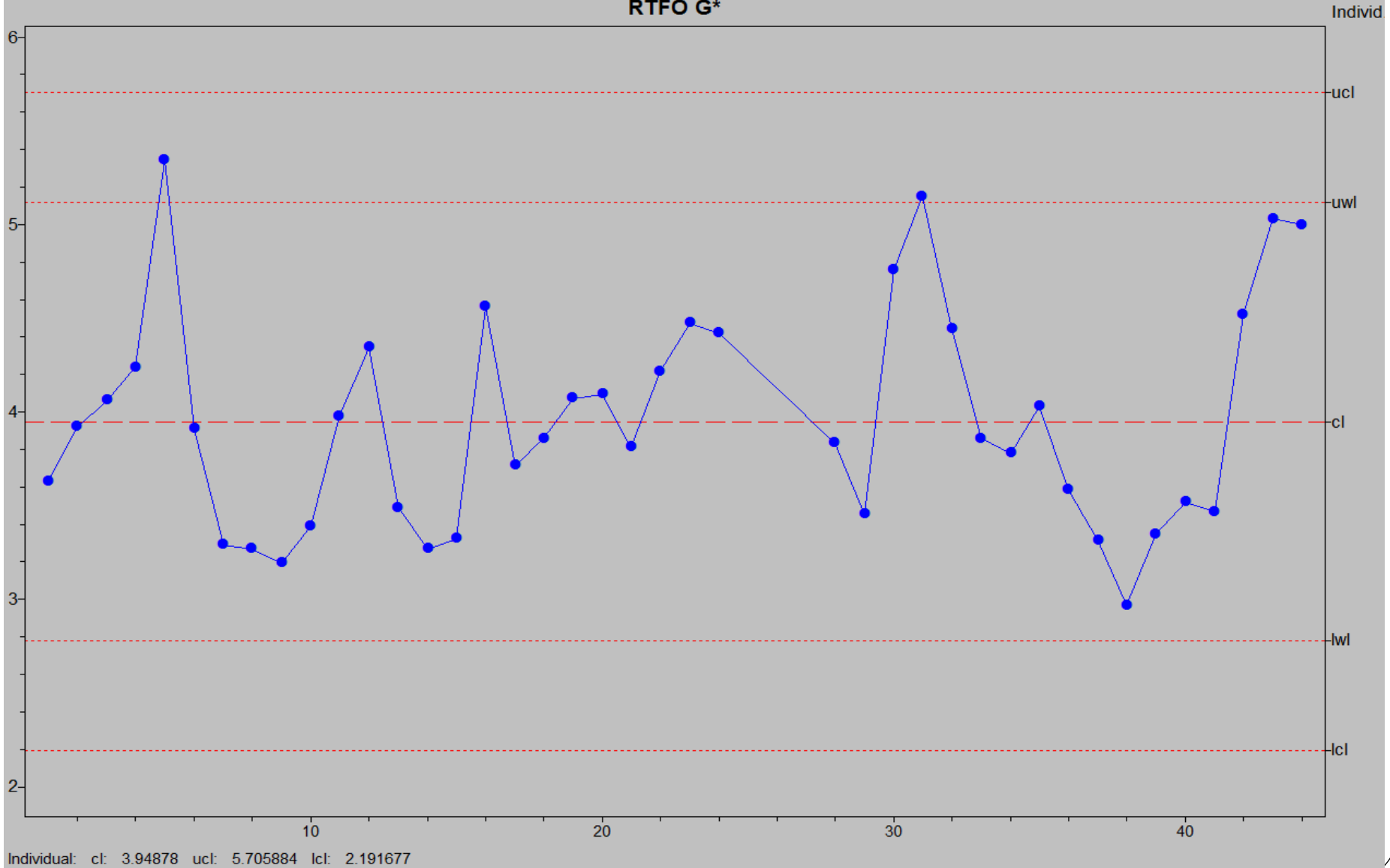
File: PCCAS Asphalt Rubber Binder.DAT  
RTFO  $G^*/\sin\Delta$



Samples:: 44      Skewness:: 0.51504  
Mean: 4.496818  
Std Dev:: 0.7492159      Kurtosis: 2.4997

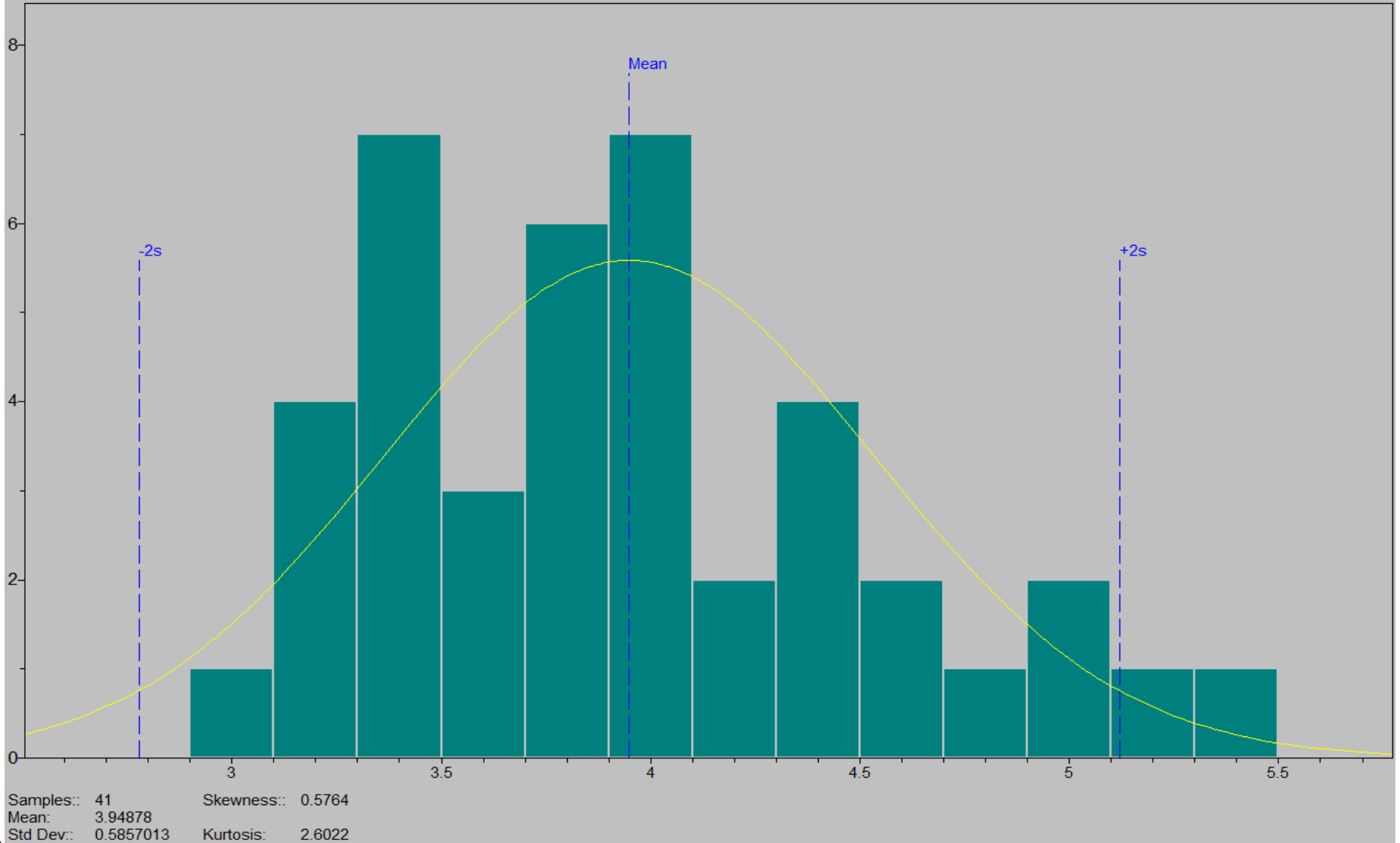
# Sample A RTFO G\*

File: PCCAS Asphalt Rubber Binder.DAT  
RTFO G\*



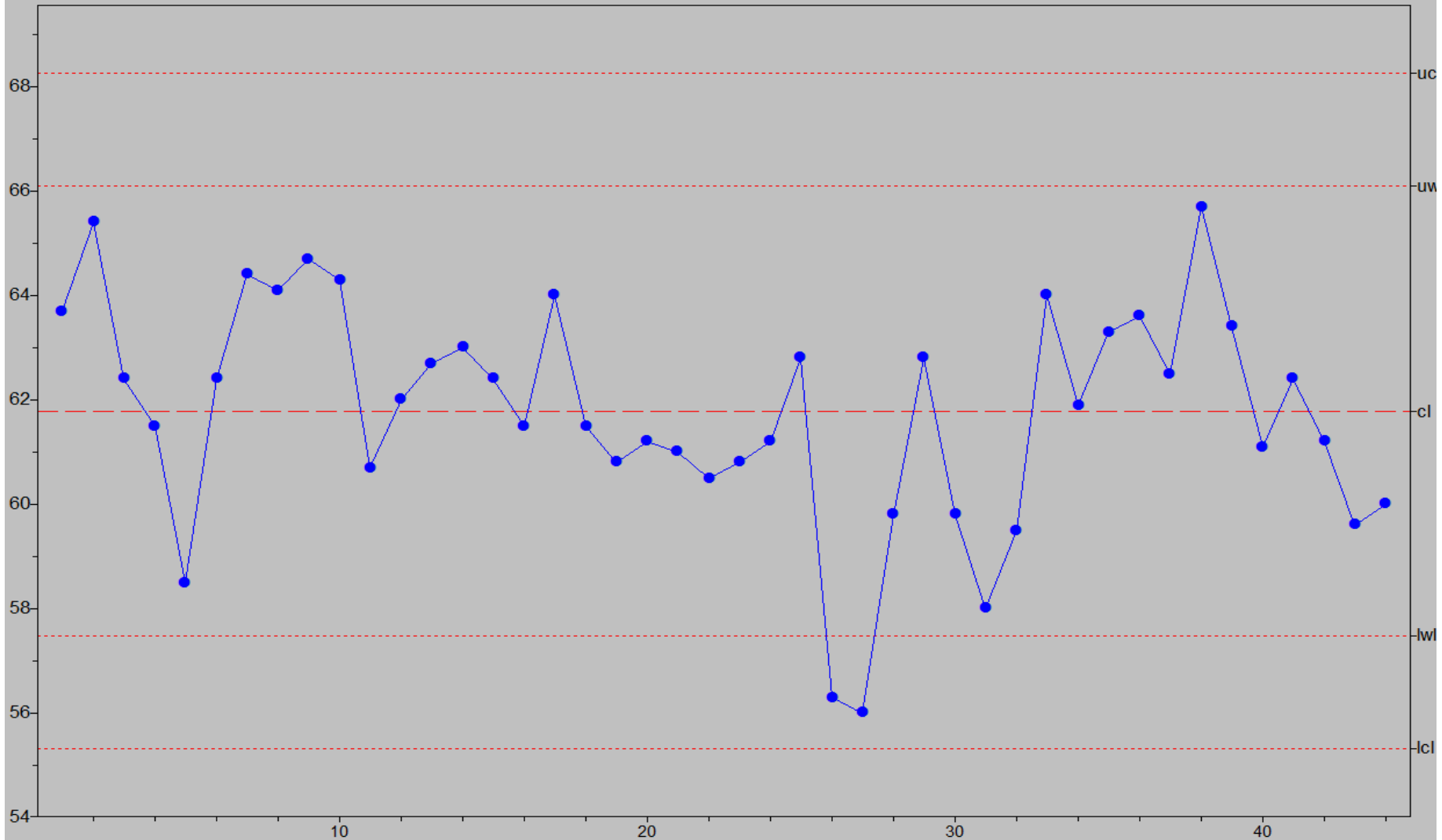
# Sample A RTFO G\*

File: PCCAS Asphalt Rubber Binder.DAT  
RTFO G\*



# Sample A RTFO Phase Angle

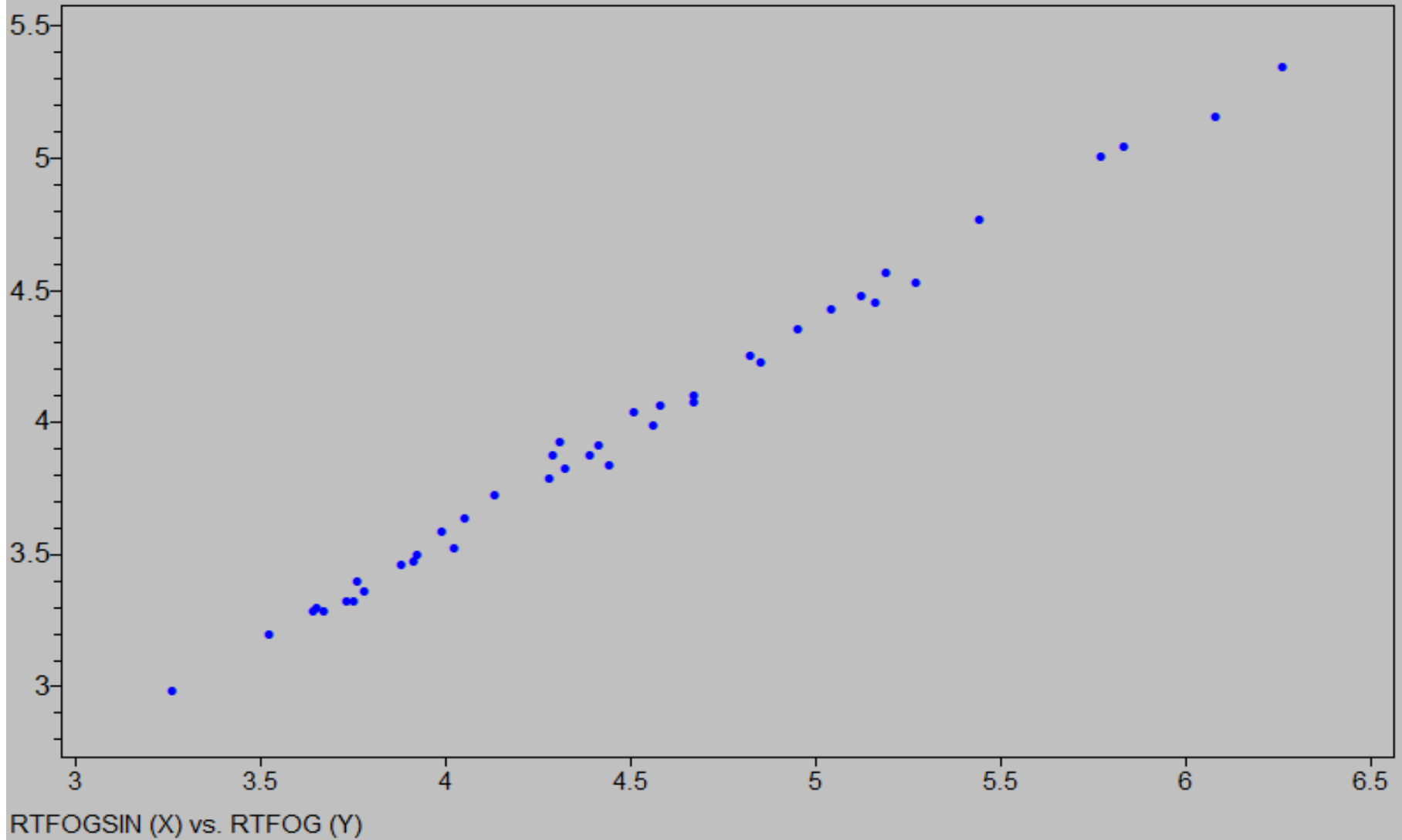
File: PCCAS Asphalt Rubber Binder.DAT  
RTFO Phase Angle



Individual: cl: 61.78182 ucl: 68.25834 lcl: 55.3053

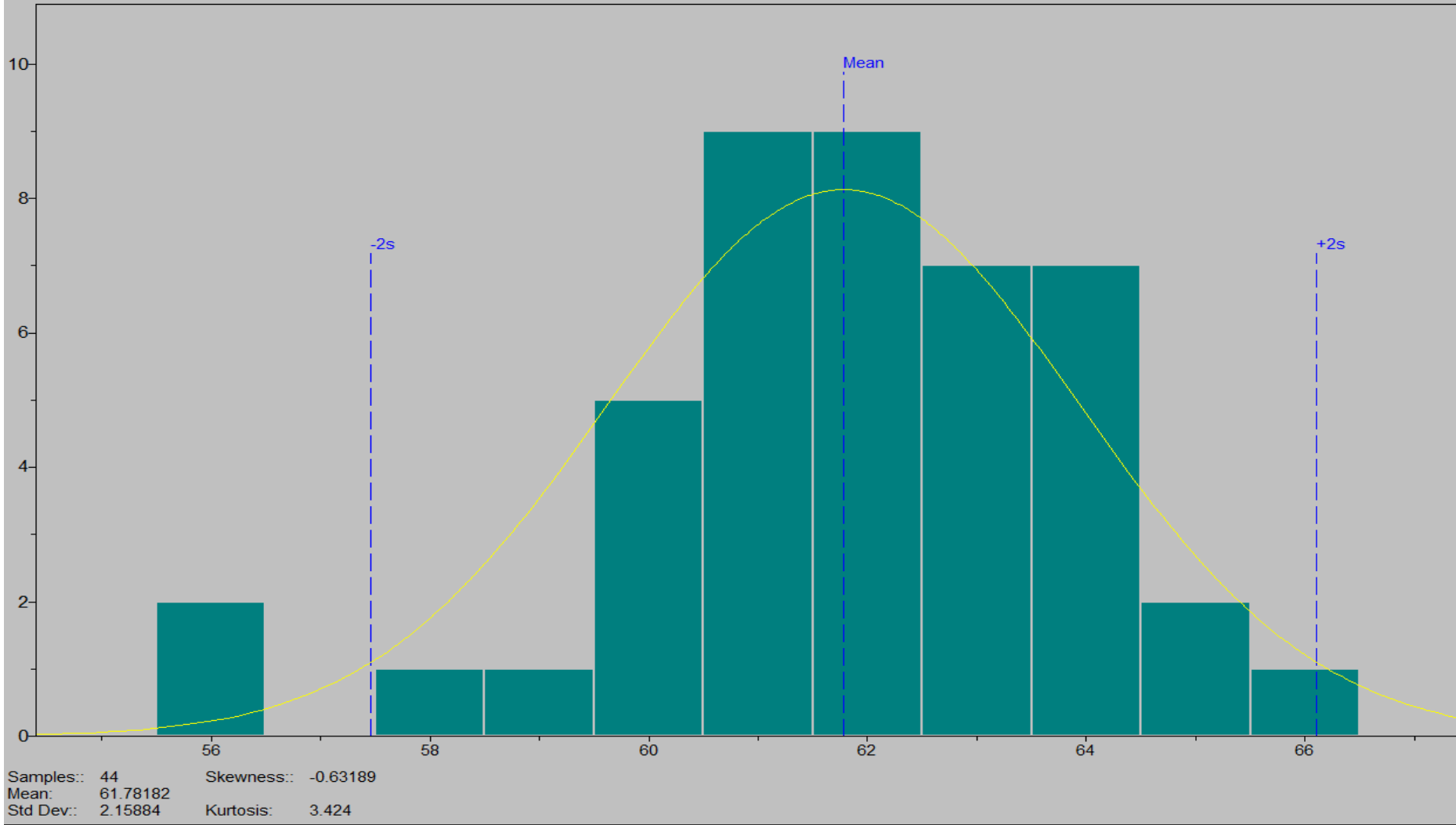
# Sample A RTFO $G^*/\sin\Delta$ vs $G^*$

File: PCCAS Asphalt Rubber Binder.DAT



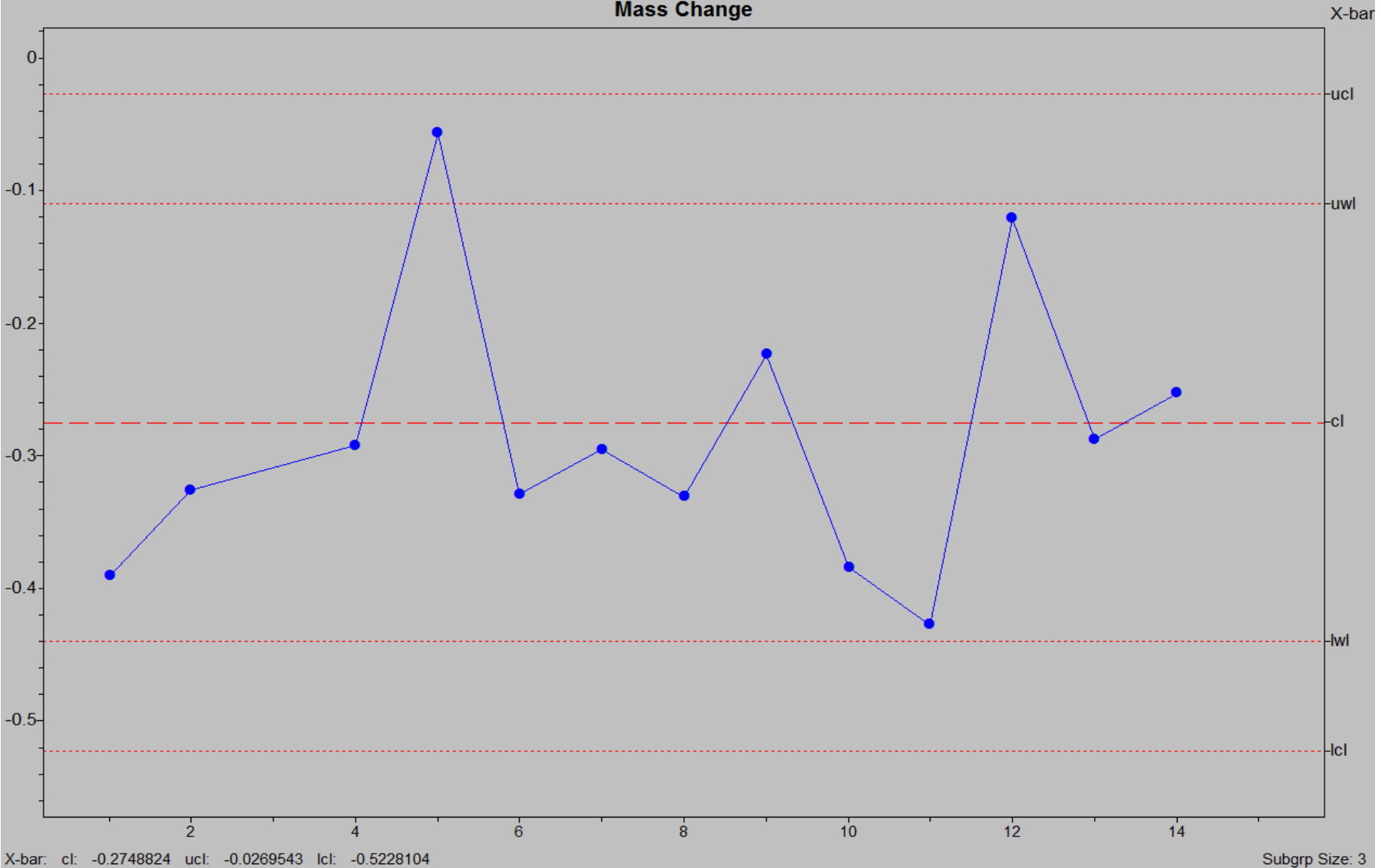
# Sample A RTFO Phase Angle

File: PCCAS Asphalt Rubber Binder.DAT  
RTFO Phase Angle



# Sample A Mass Change

File: PCCAS Asphalt Rubber Binder.DAT  
Mass Change

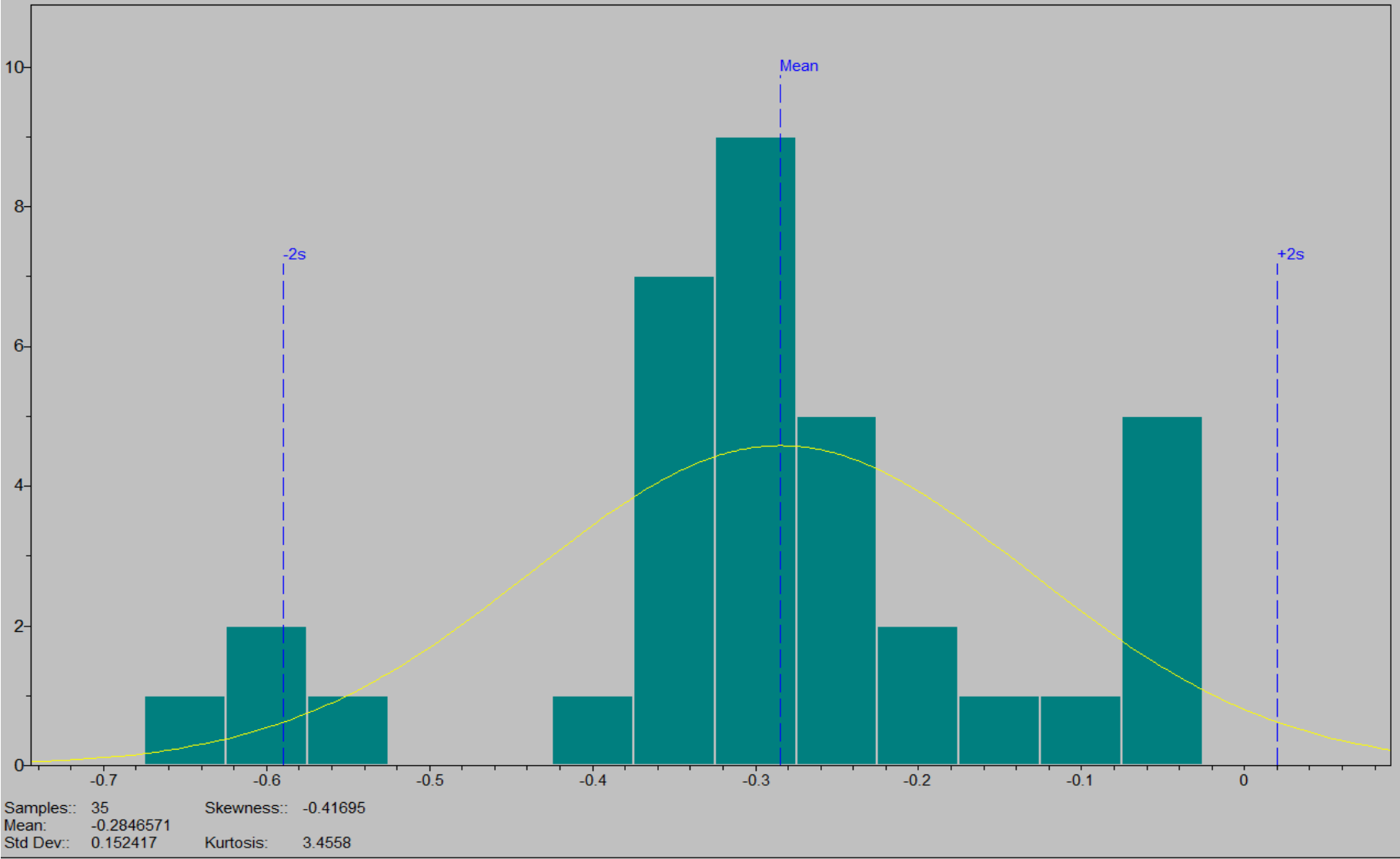


X-bar: cl: -0.2748824 ucl: -0.0269543 lcl: -0.5228104

Subgrp Size: 3

# Sample A Mass Change

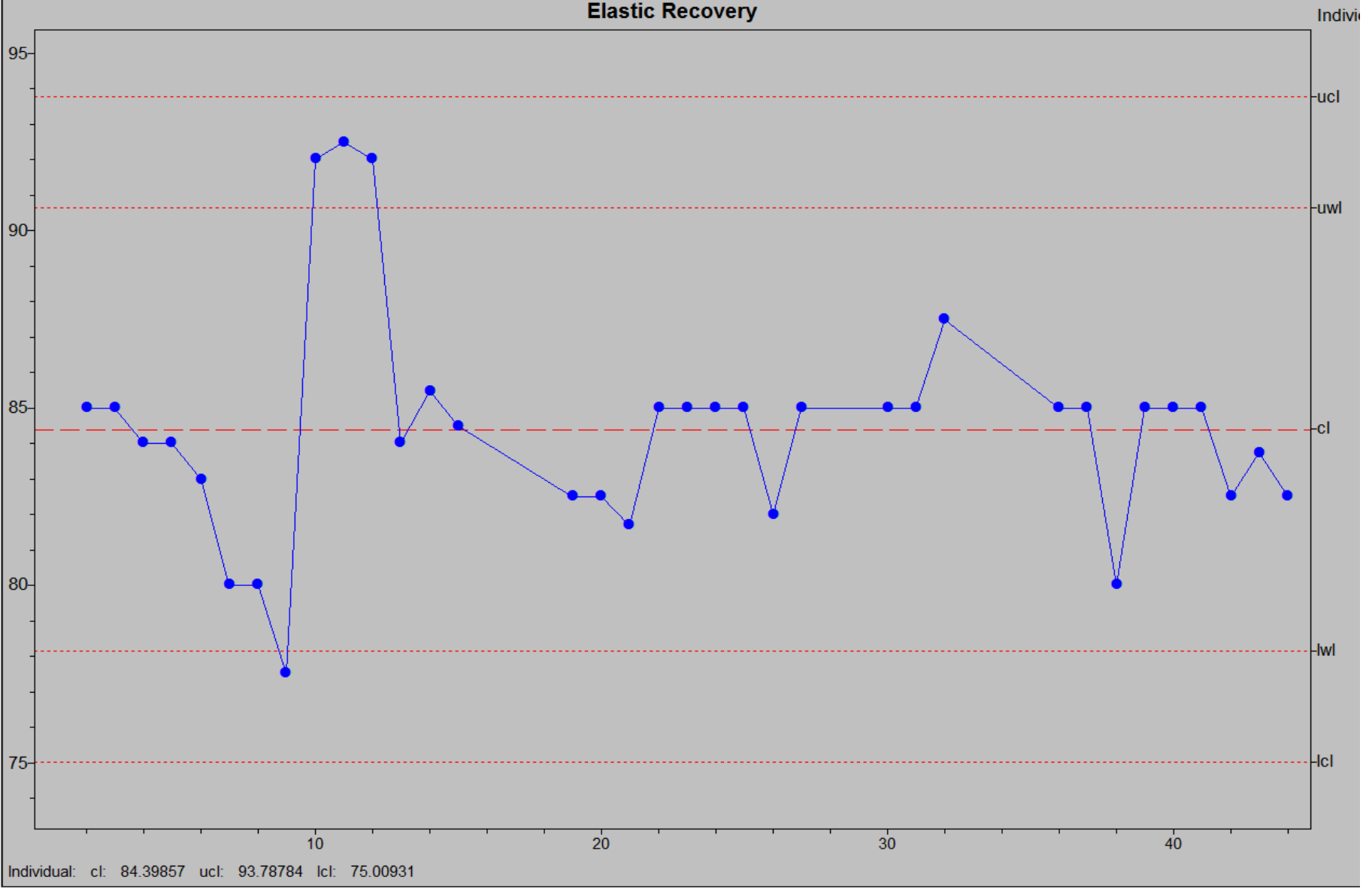
File: PCCAS Asphalt Rubber Binder.DAT  
Mass Change





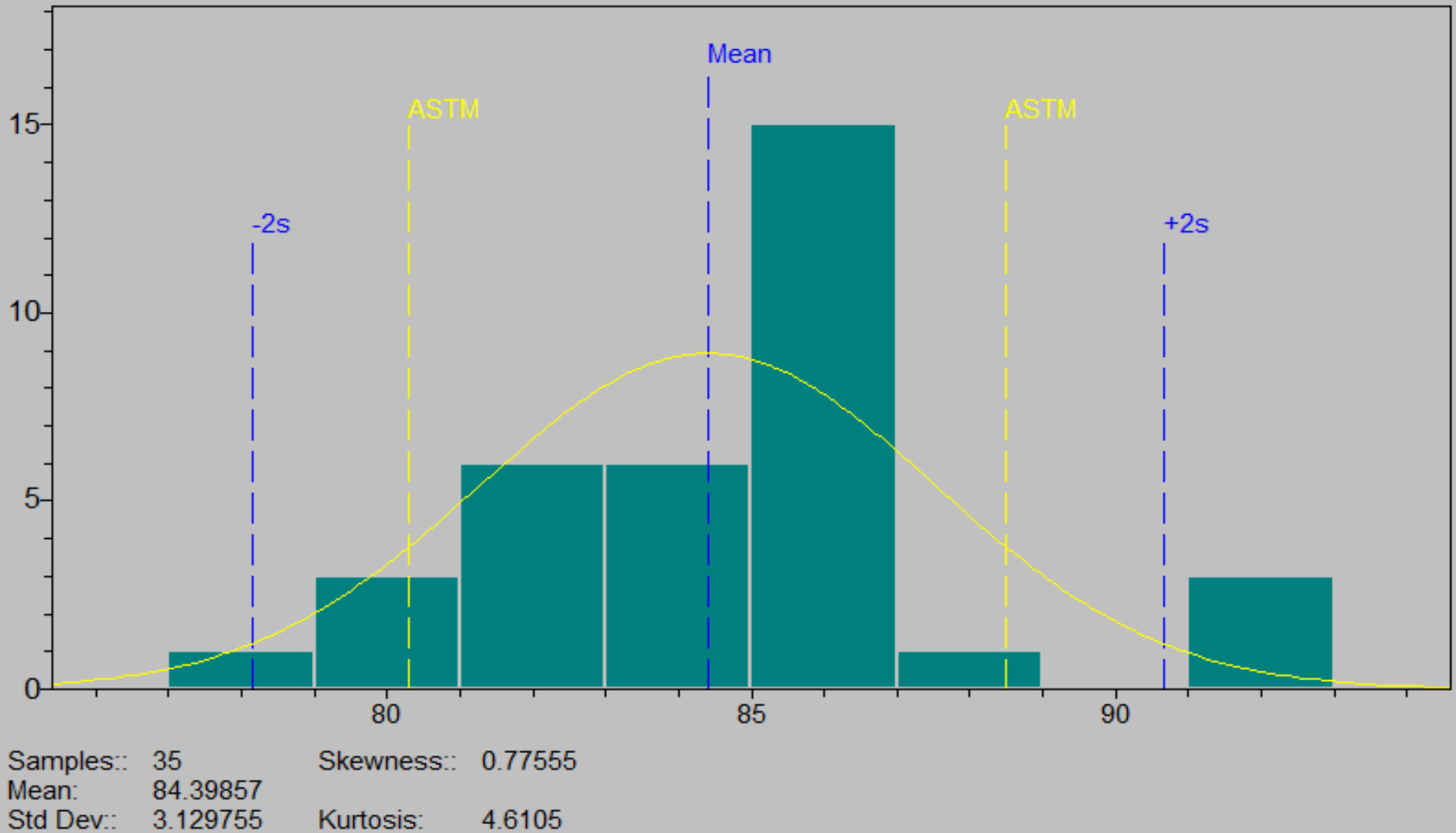
# Sample A Elastic Recovery

File: PCCAS Asphalt Rubber Binder.DAT  
Elastic Recovery



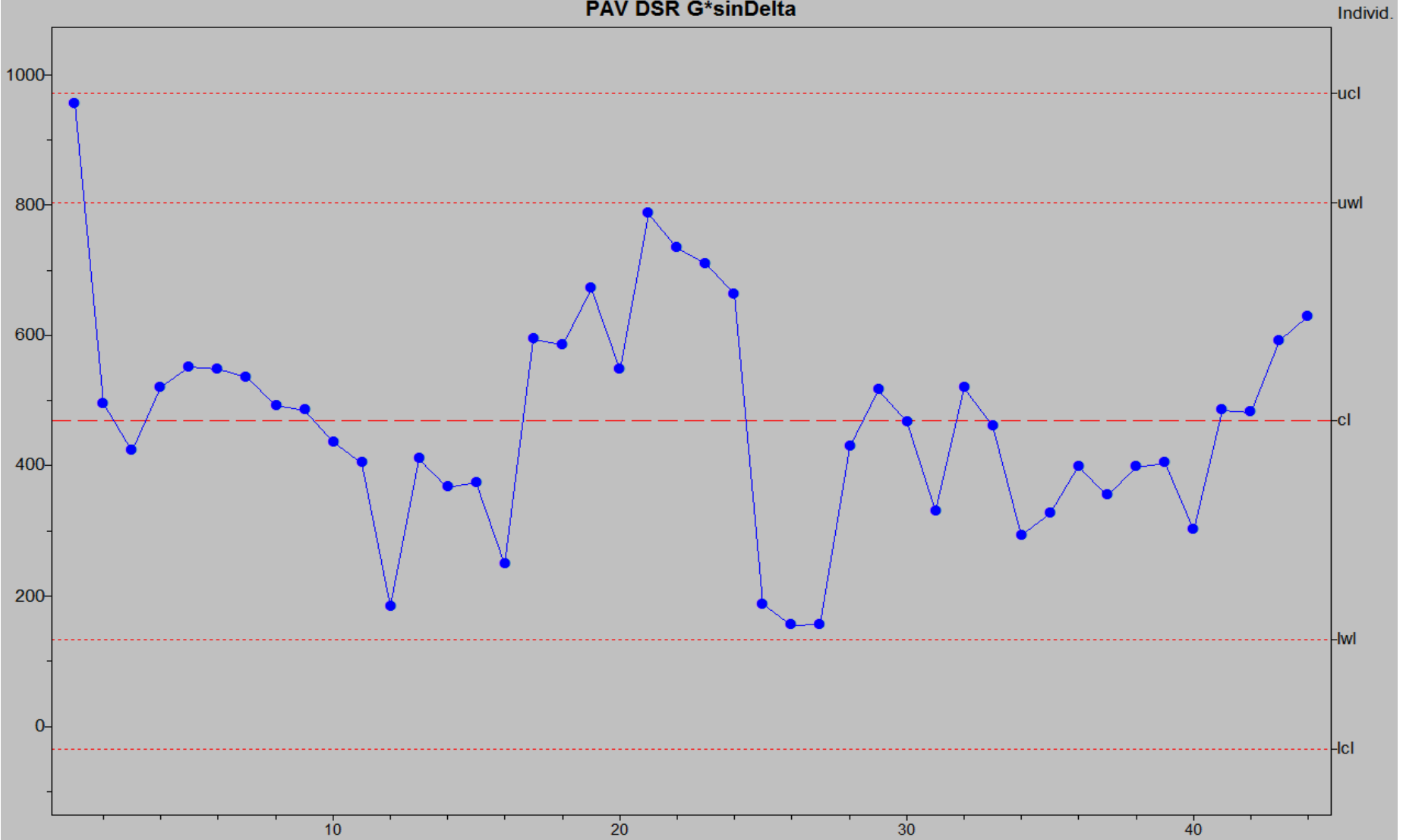
# Sample A Elastic Recovery

File: PCCAS Asphalt Rubber Binder.DAT  
Elastic Recovery



# Sample A PAV DSR G\* $\sin\Delta$

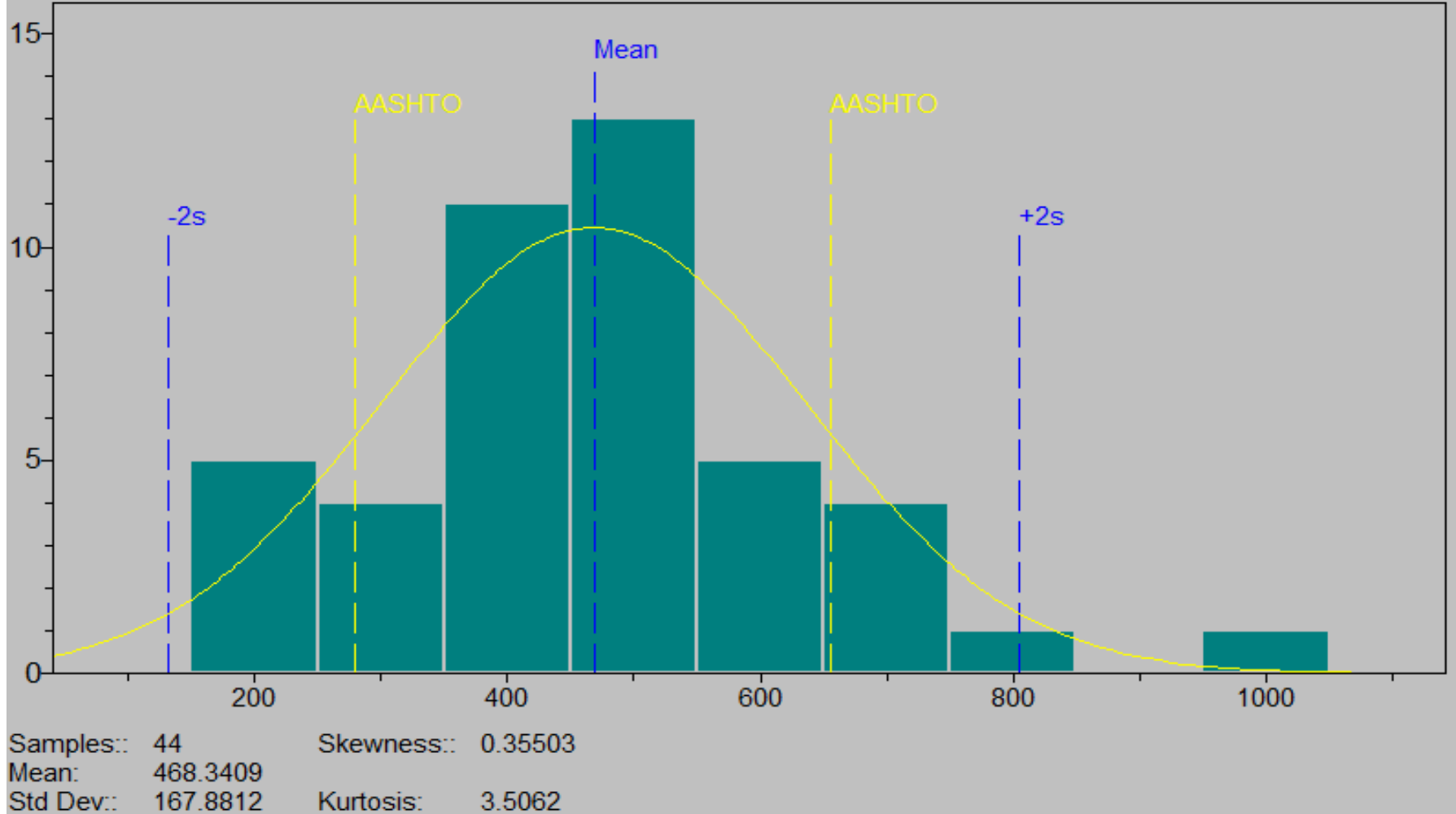
File: PCCAS Asphalt Rubber Binder.DAT  
PAV DSR G\* $\sin\Delta$



Individual: cl: 468.3409 ucl: 971.9844 lcl: -35.30263

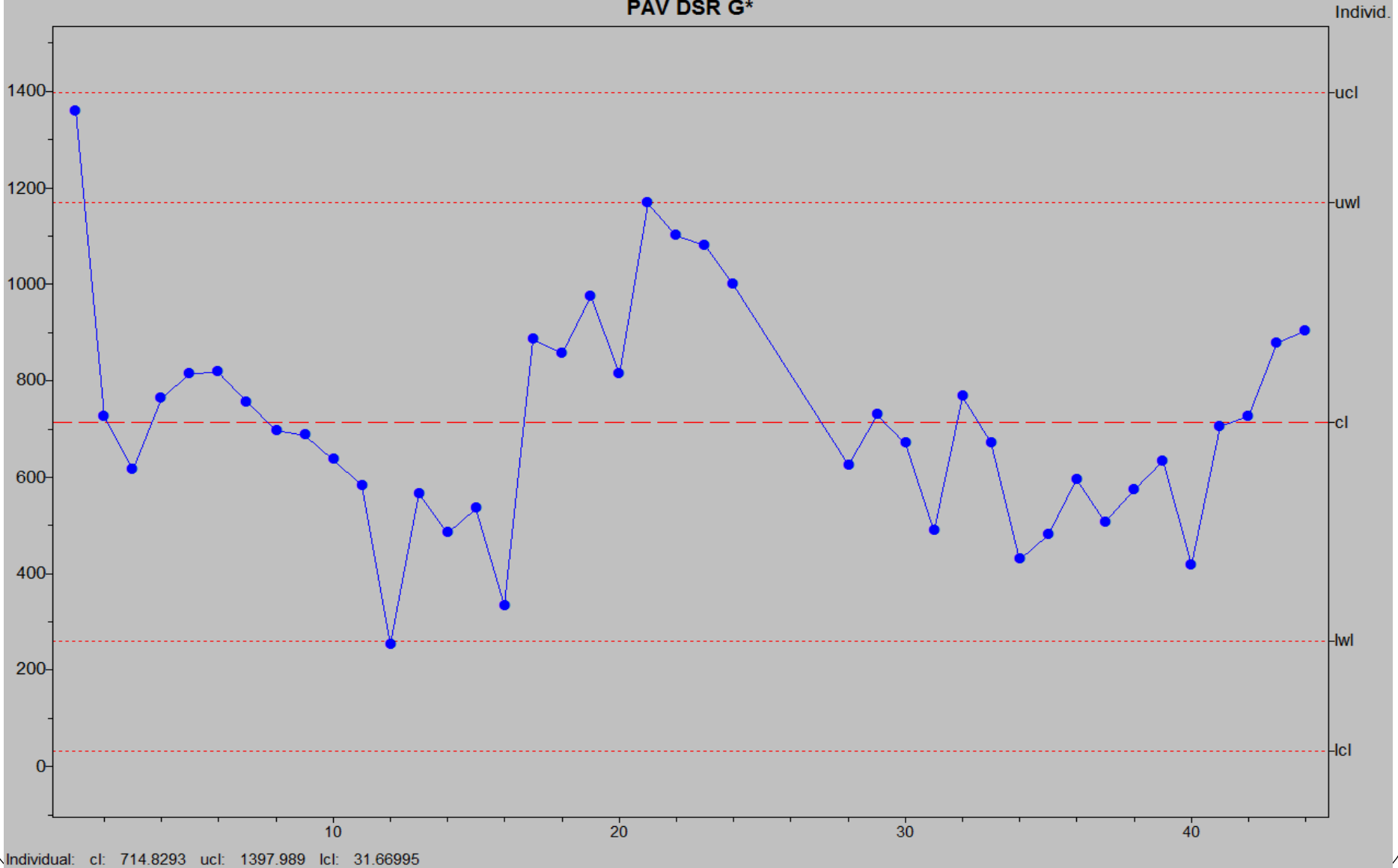
# Sample A PAV $G^*\sin\Delta$

File: PCCAS Asphalt Rubber Binder.DAT  
PAV DSR  $G^*\sin\Delta$



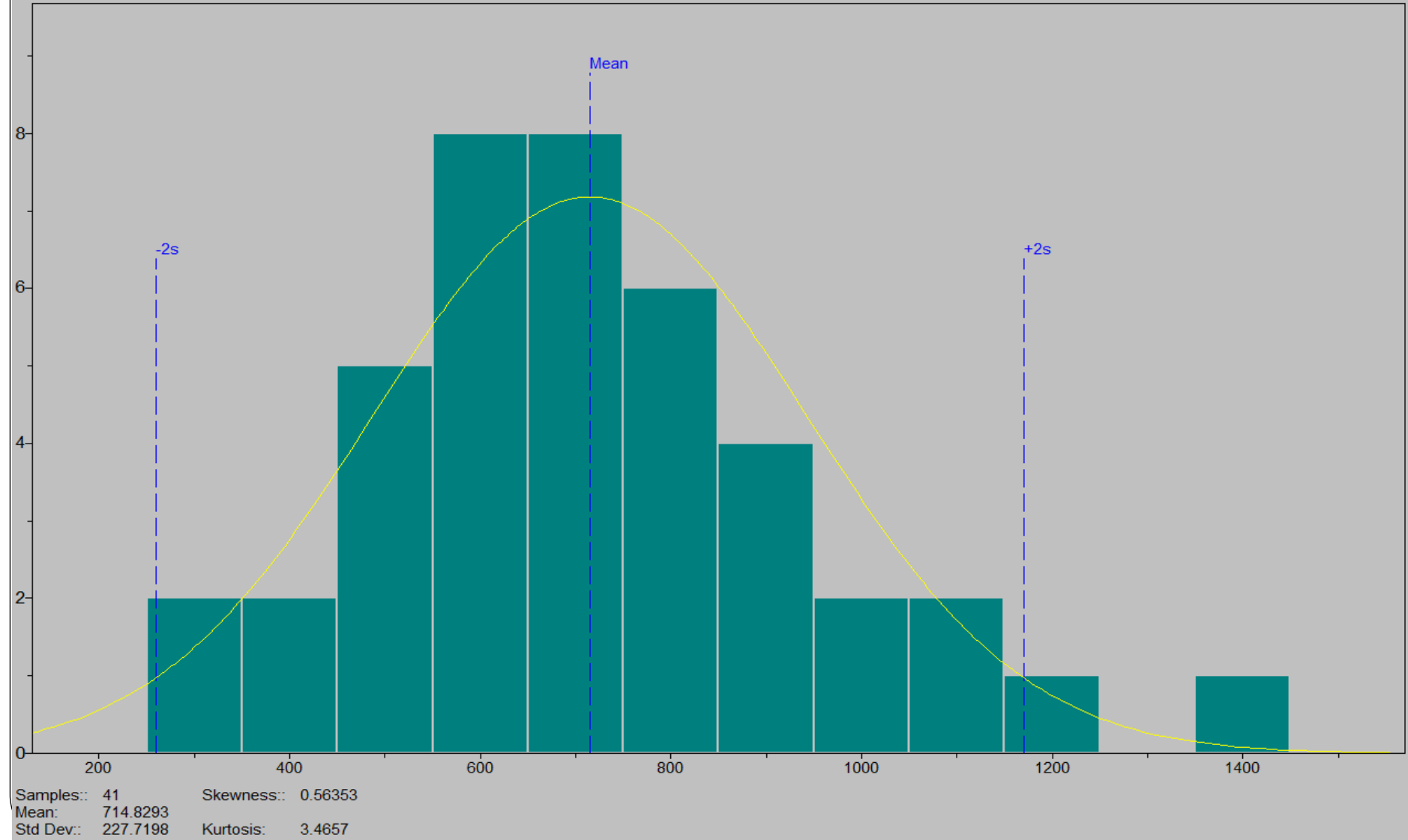
# Sample A PAV DSR G\*

File: PCCAS Asphalt Rubber Binder.DAT  
PAV DSR G\*



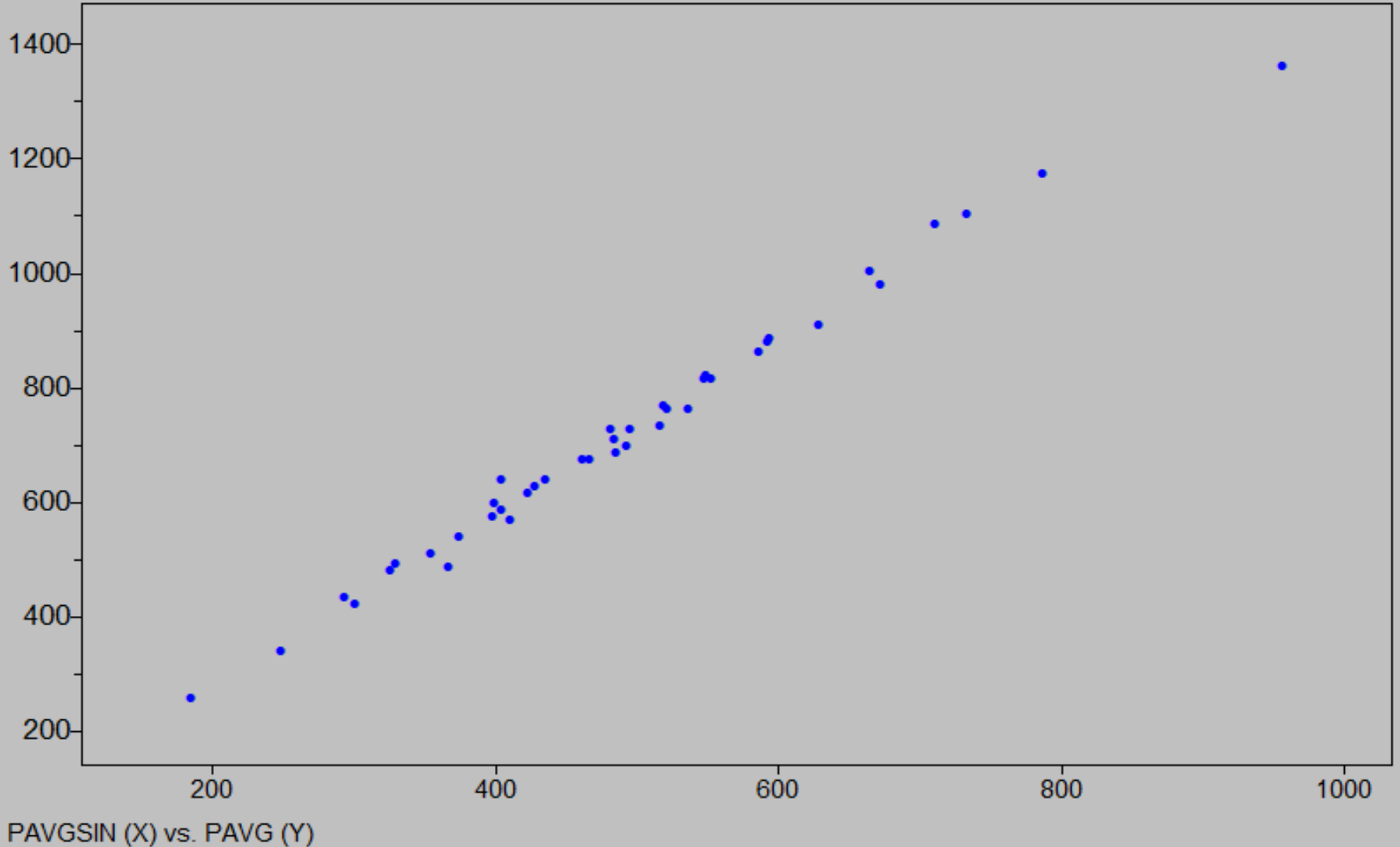
# Sample A PAV DSR G\*

File: PCCAS Asphalt Rubber Binder.DAT  
PAV DSR G\*

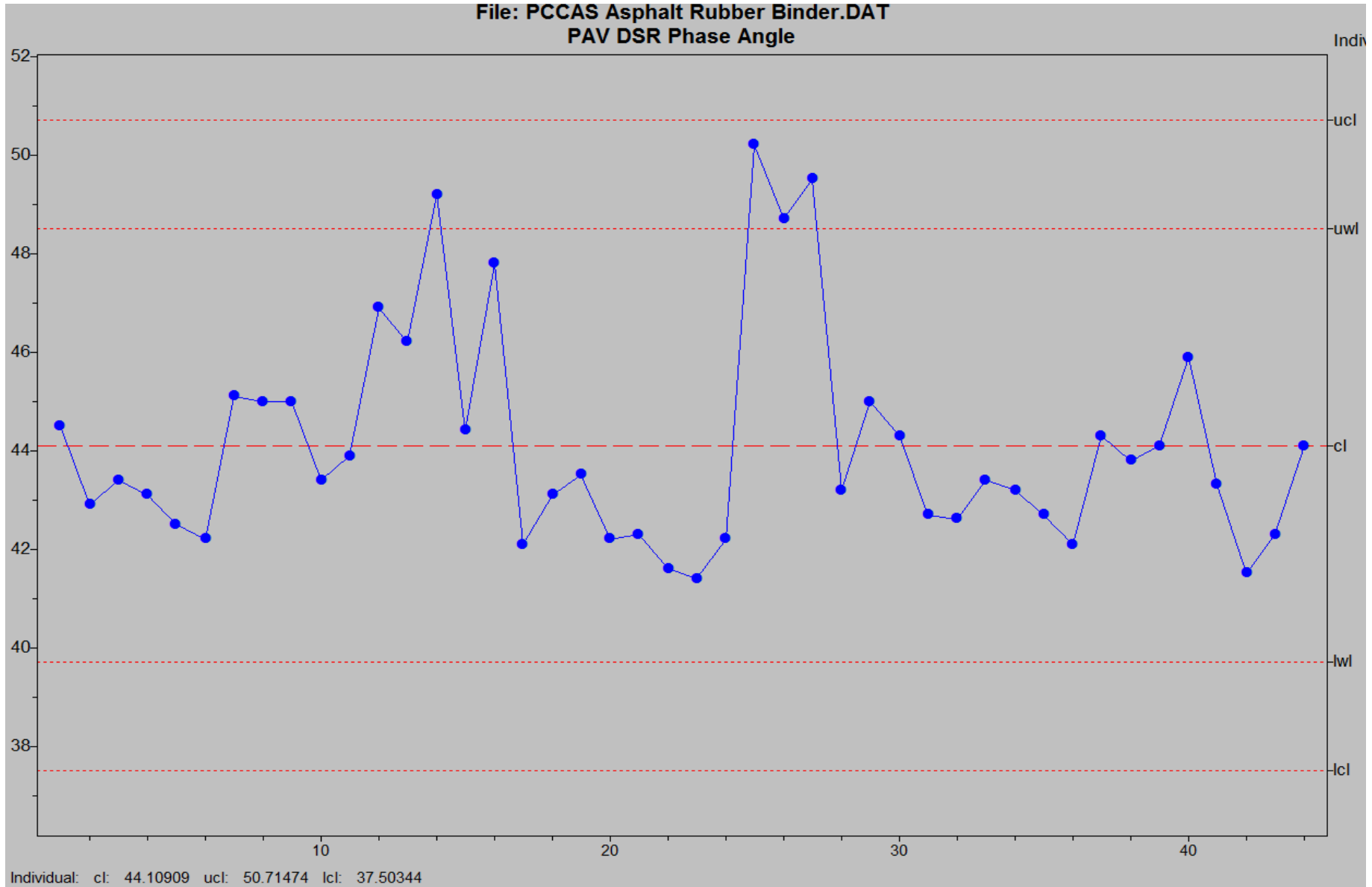


# Sample A PAV DSR $G^*\sin\Delta$ vs $G^*$

File: PCCAS Asphalt Rubber Binder.DAT



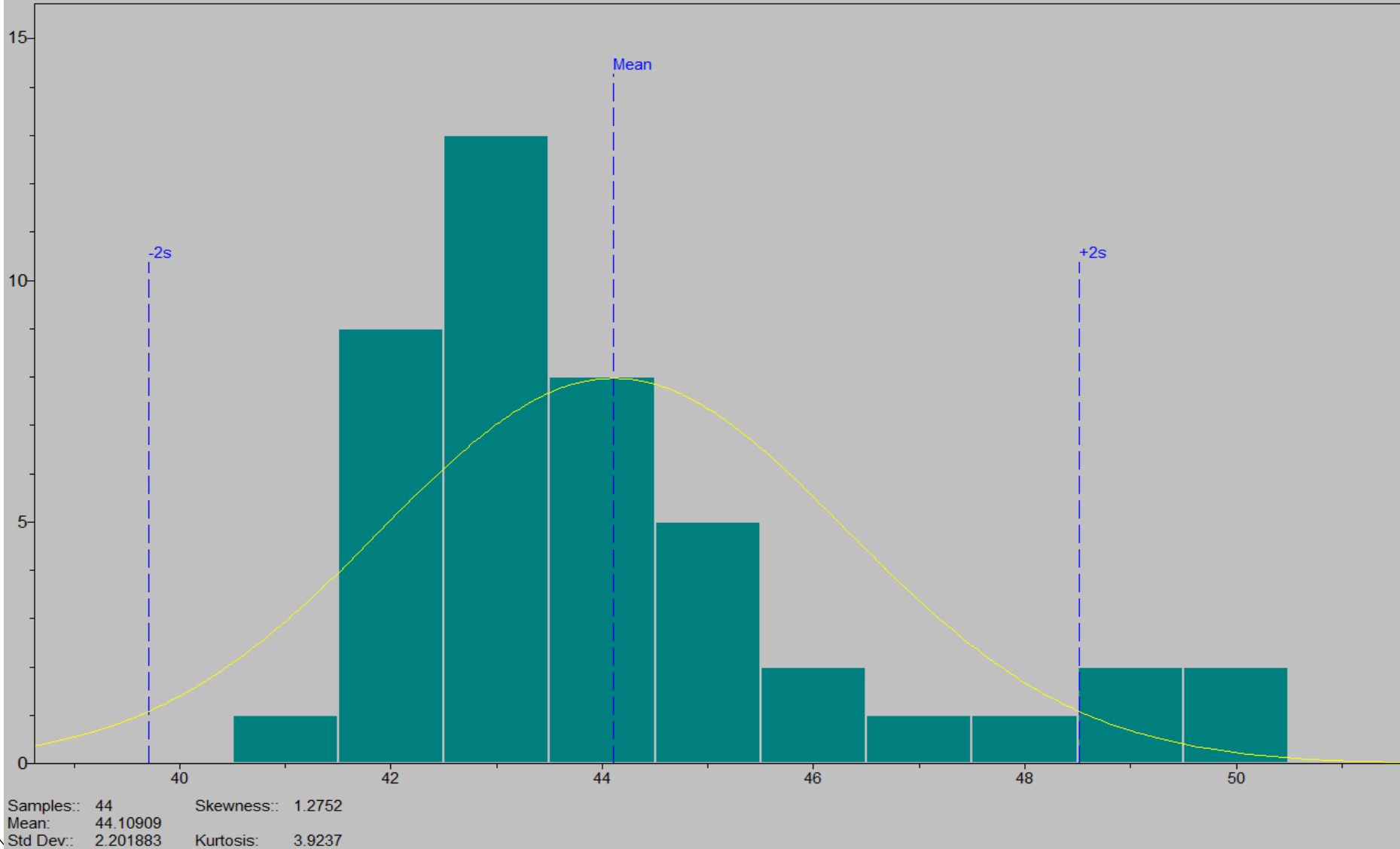
# Sample A PAV DSR Phase Angle



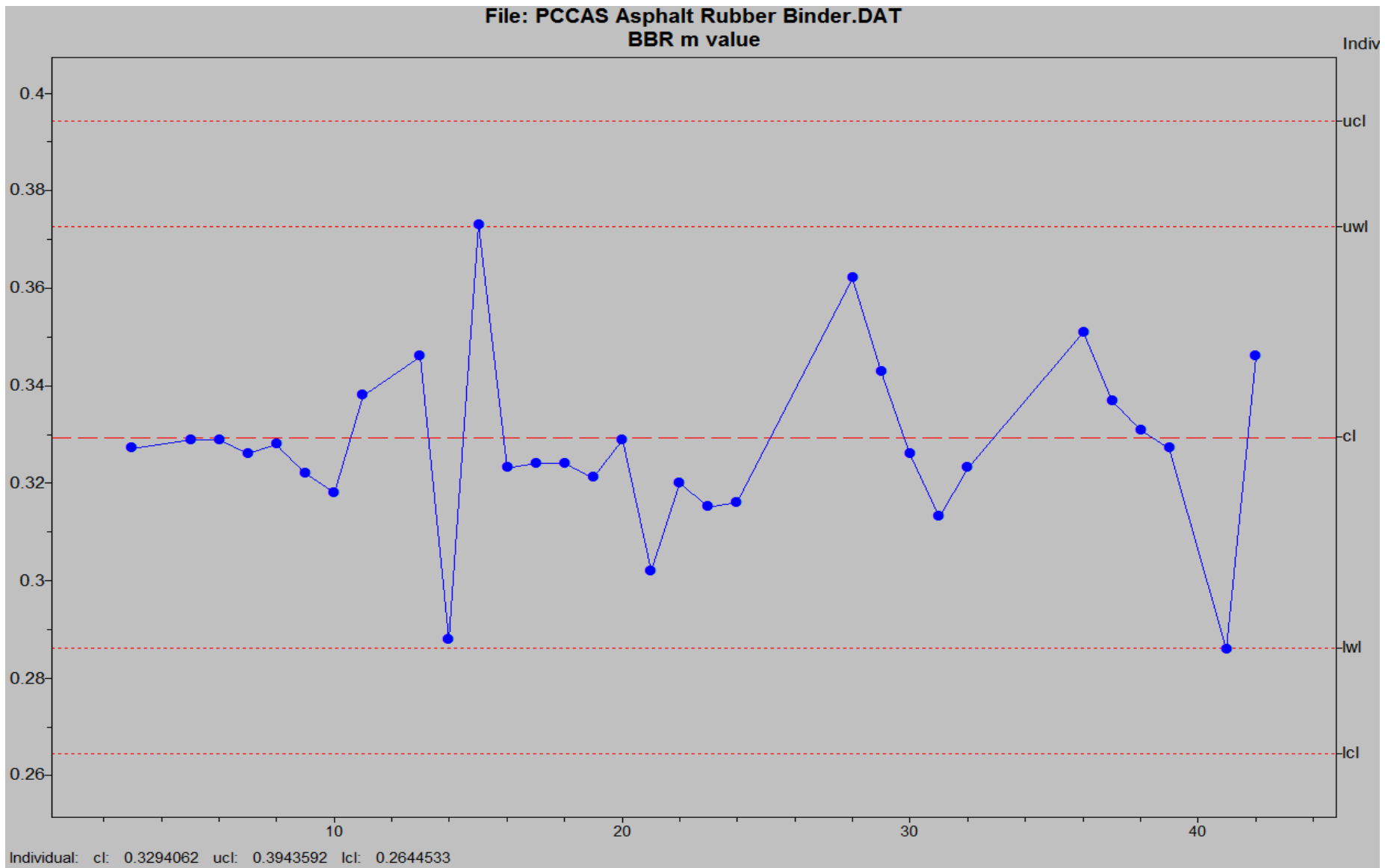


# Sample A PAV DSR Phase Angle

File: PCCAS Asphalt Rubber Binder.DAT  
PAV DSR Phase Angle

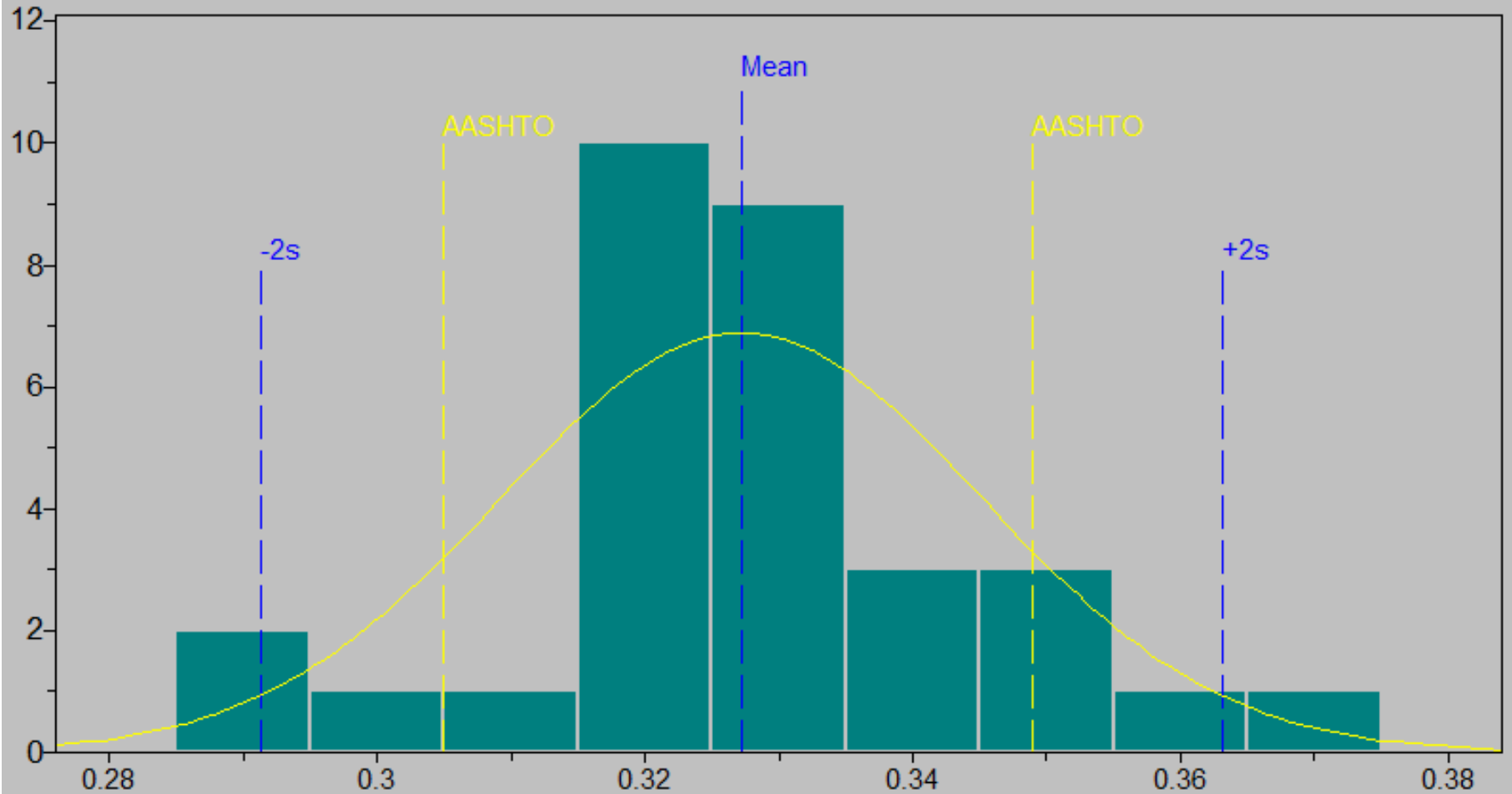


# Sample A BBR m value



# Sample A BBR m value

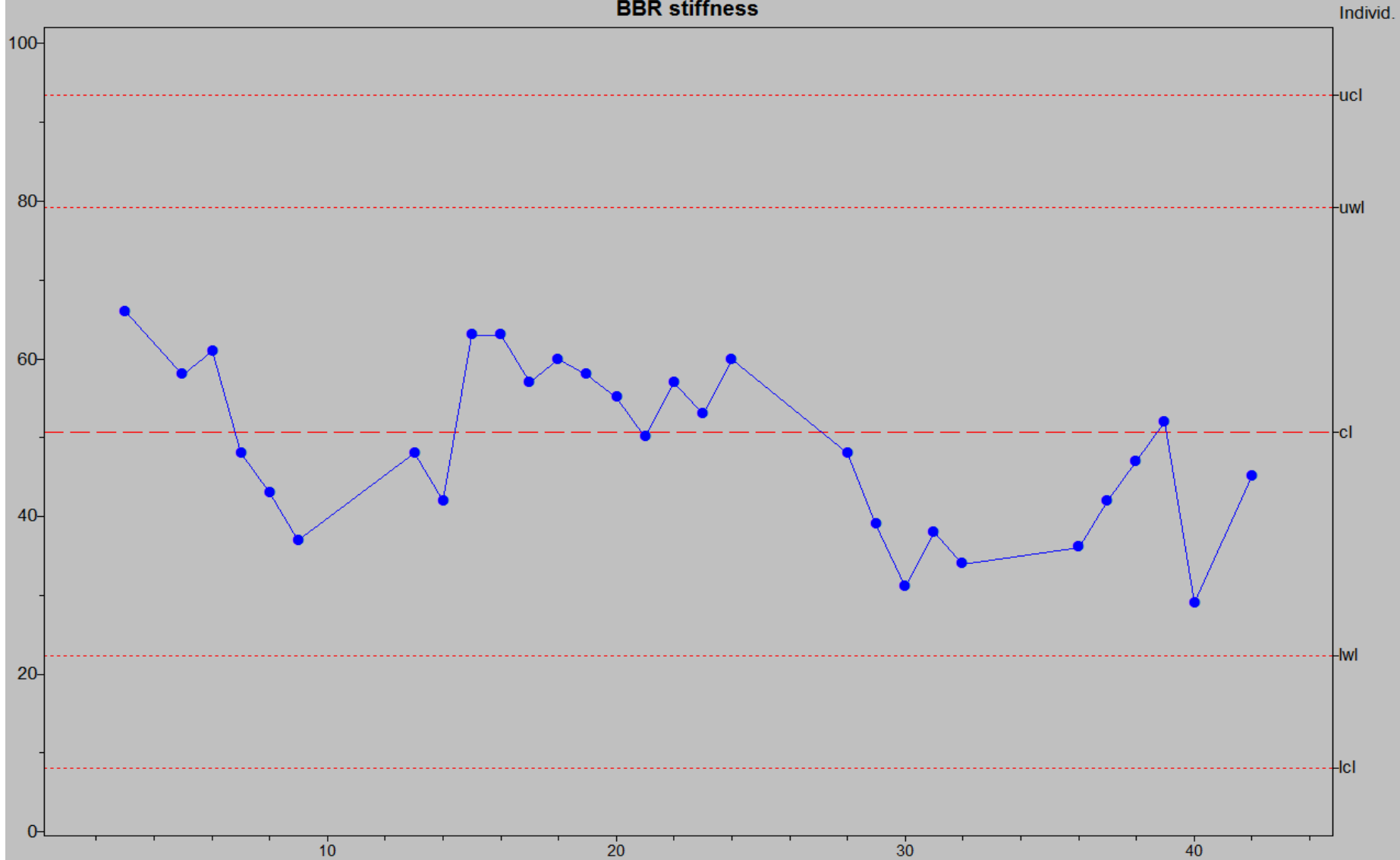
File: PCCAS Asphalt Rubber Binder.DAT  
BBR m value



Samples:: 31      Skewness:: 0.10172  
Mean: 0.3271935  
Std Dev:: 0.01795814      Kurtosis: 4.0605

# Sample A BBR stiffness

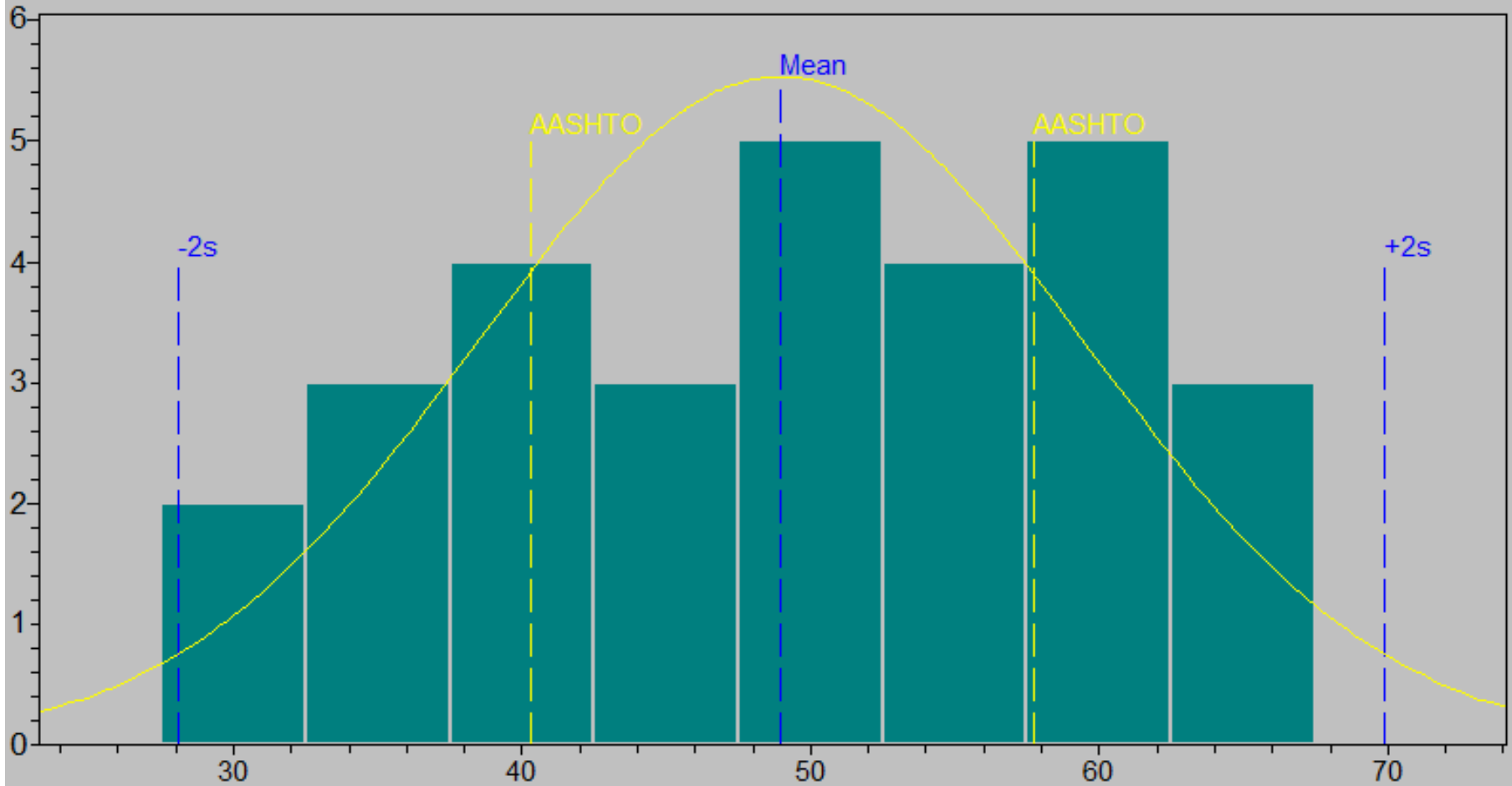
File: PCCAS Asphalt Rubber Binder.DAT  
BBR stiffness



Individual: cl: 50.76667 ucl: 93.48963 lcl: 8.043702

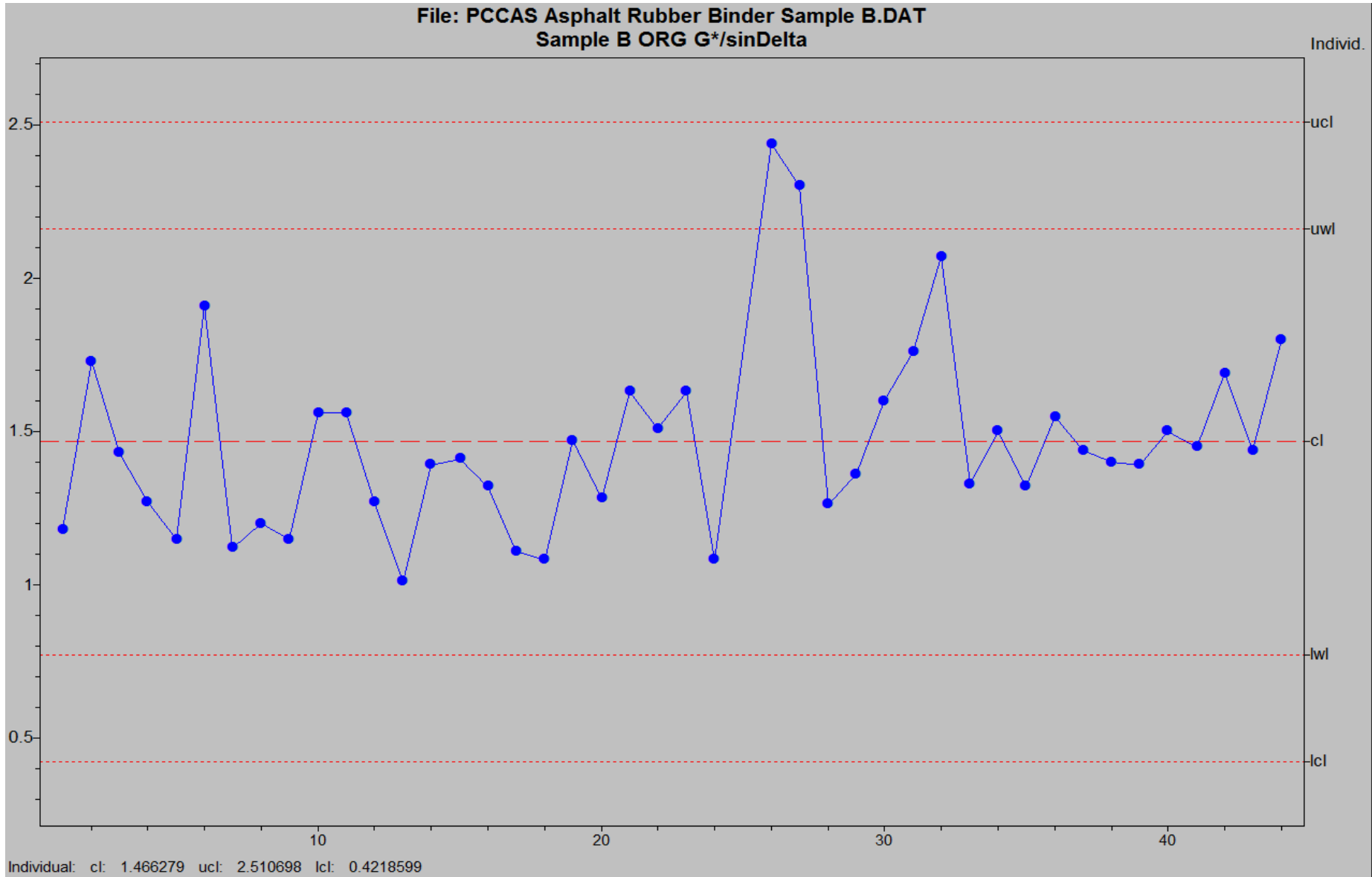
# Sample A BBR stiffness

File: PCCAS Asphalt Rubber Binder.DAT  
BBR stiffness



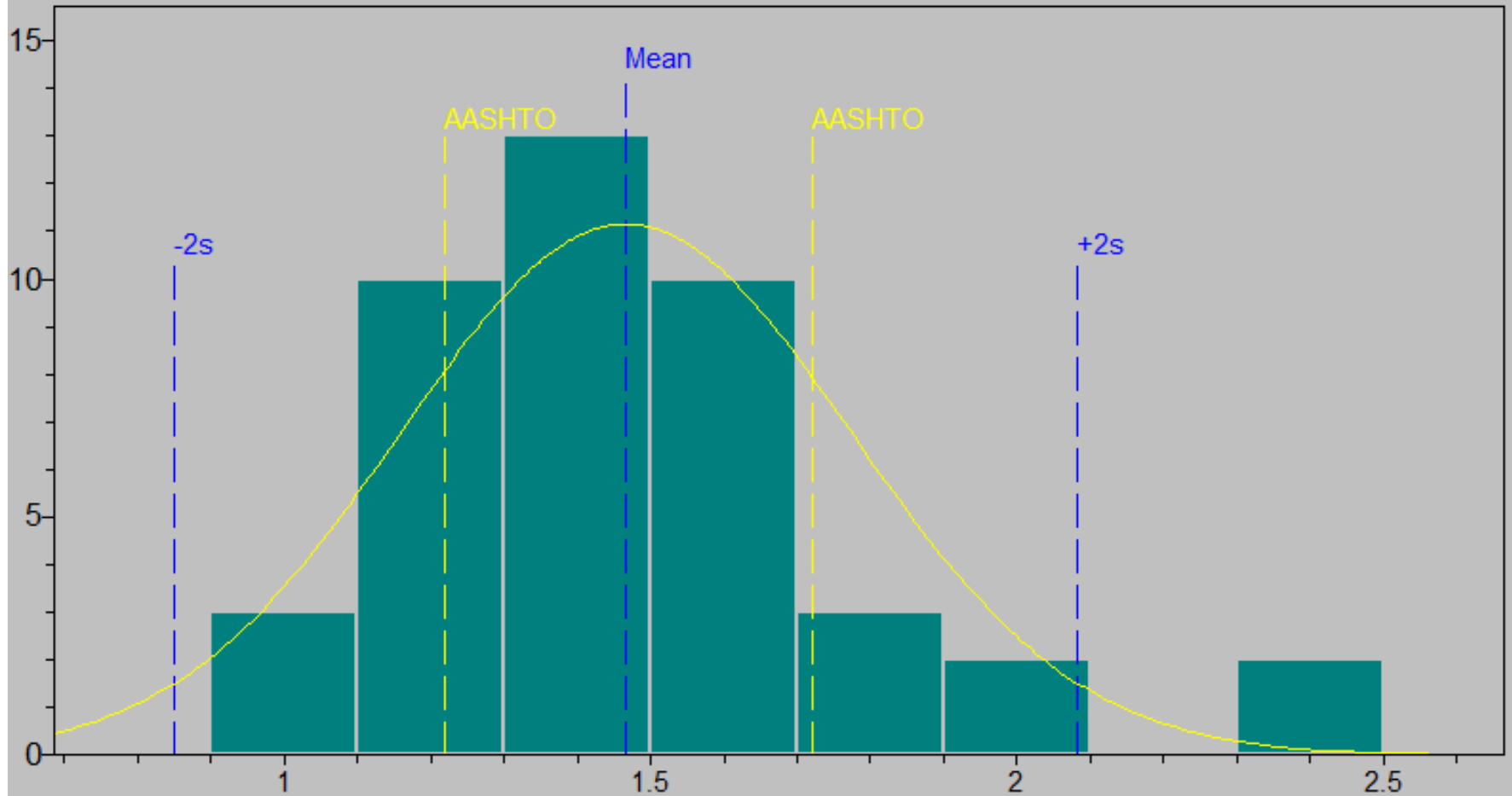
Samples:: 29      Skewness:: -0.20825  
Mean: 48.96552  
Std Dev:: 10.45221      Kurtosis: 1.9472

# Sample B ORG $G^*/\sin\Delta$



# Sample B ORG $G^*/\sin\Delta$

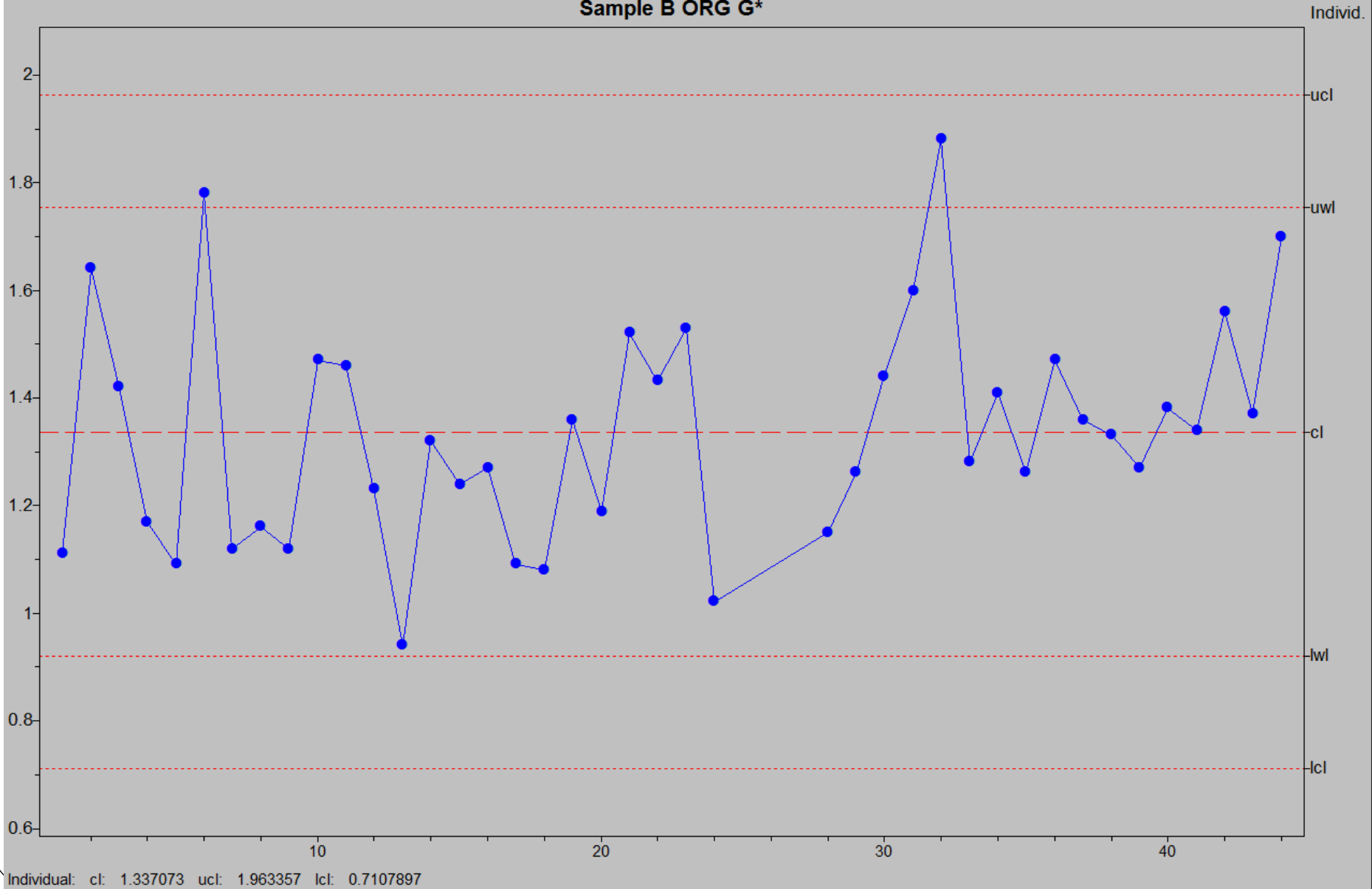
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B ORG  $G^*/\sin\Delta$



Samples:: 43      Skewness:: 1.2162  
Mean: 1.466279  
Std Dev:: 0.3077416      Kurtosis: 4.7303

# Sample B ORG G\*

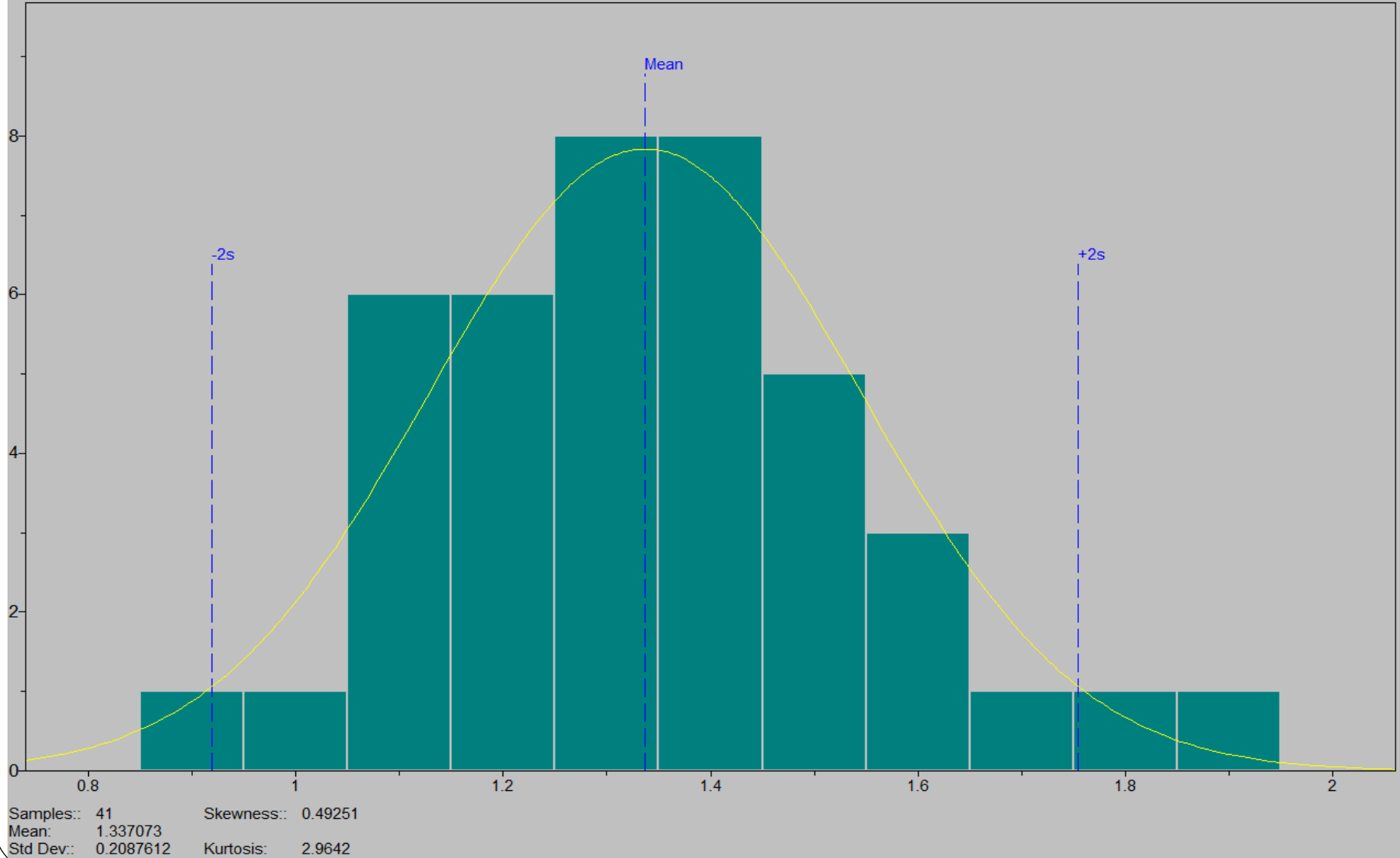
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B ORG G\*





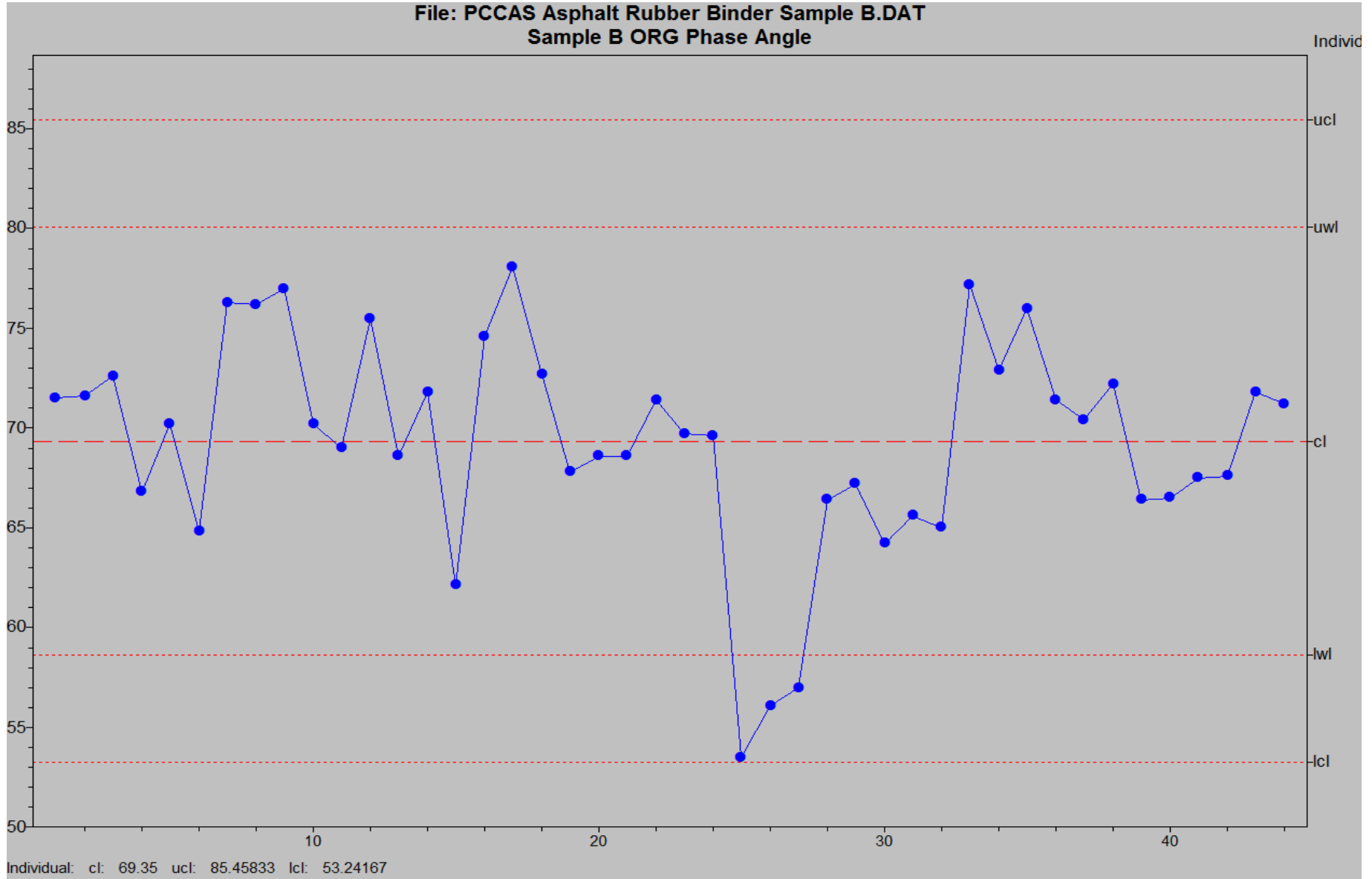
# Sample B ORG G\*

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B ORG G\*



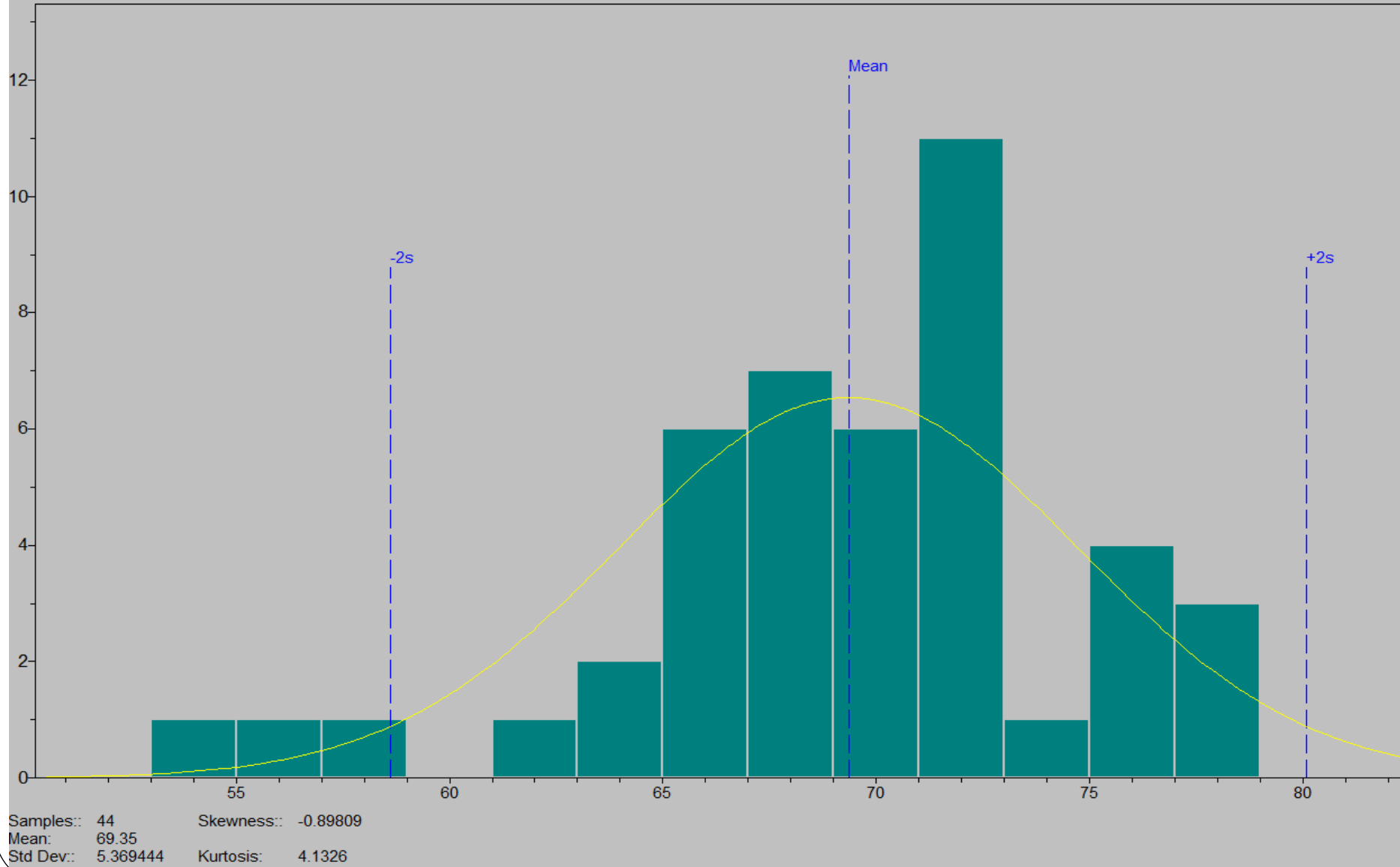
# Sample B ORG Phase Angle

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B ORG Phase Angle



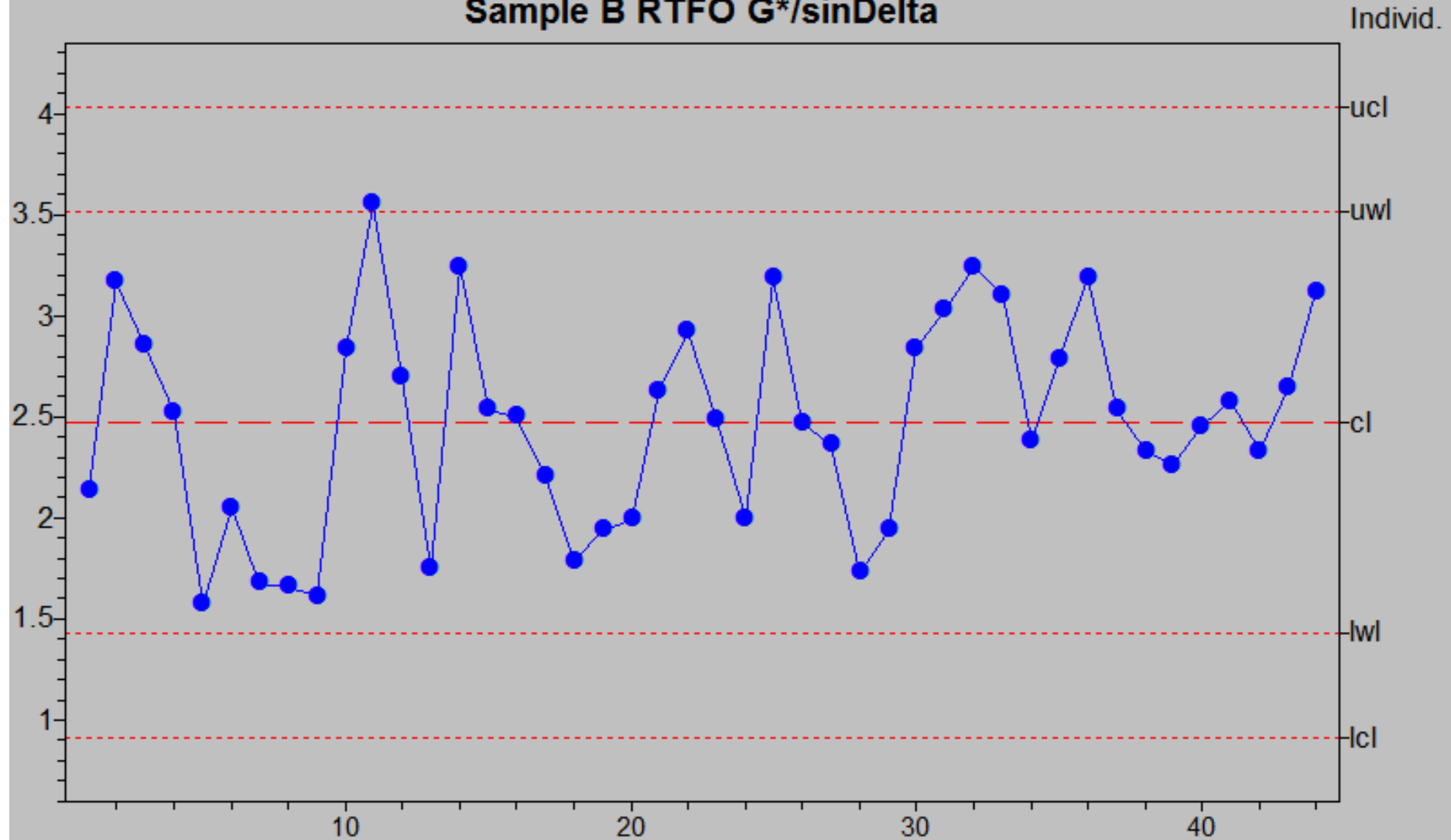
# Sample B ORG Phase Angle

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B ORG Phase Angle



# Sample B RTFO $G^*/\sin\Delta$

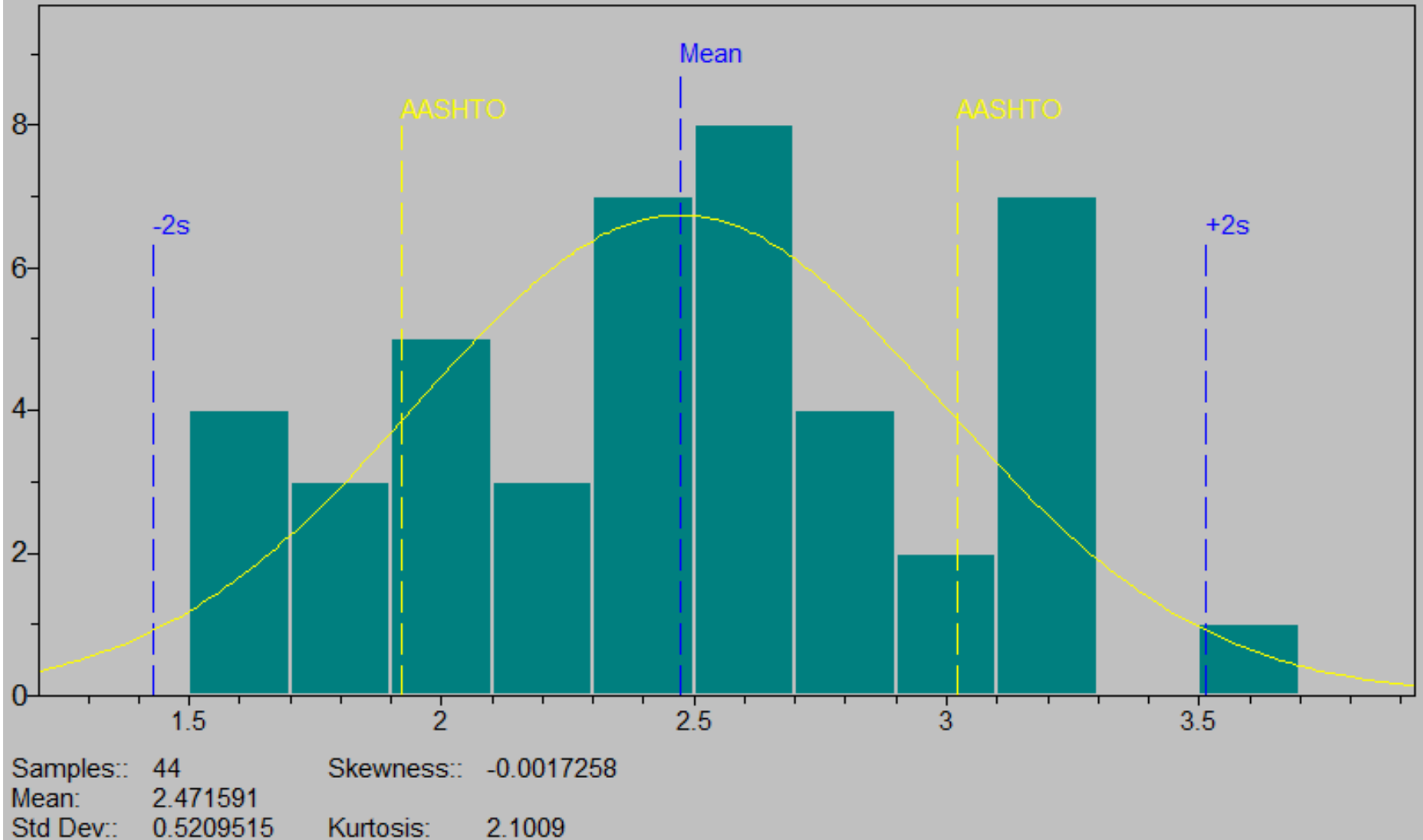
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO  $G^*/\sin\Delta$



Individual: cl: 2.471591 ucl: 4.034445 lcl: 0.9087365

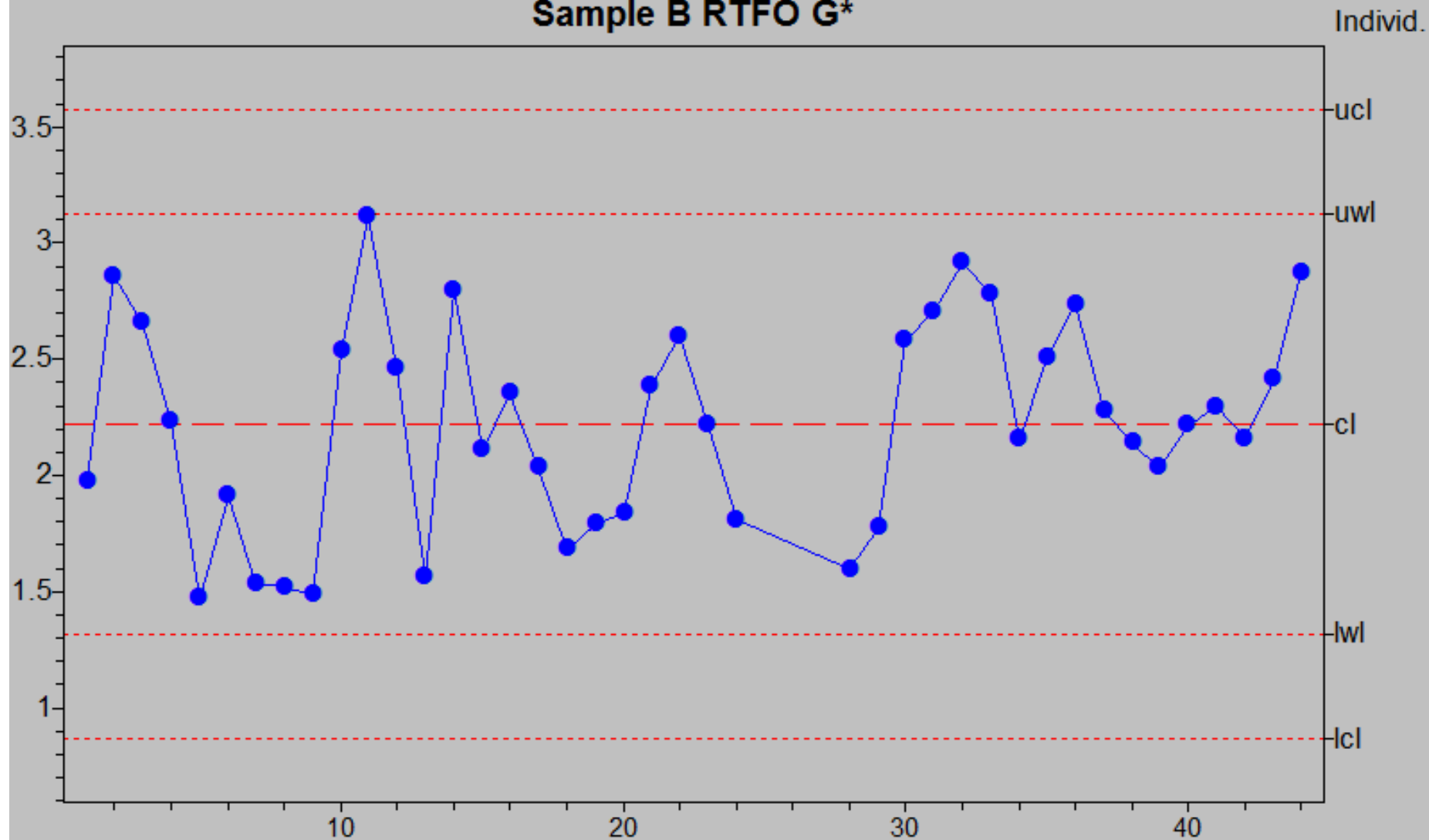
# Sample B RTFO $G^*/\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO  $G^*/\sin\Delta$



# Sample B RTFO G\*

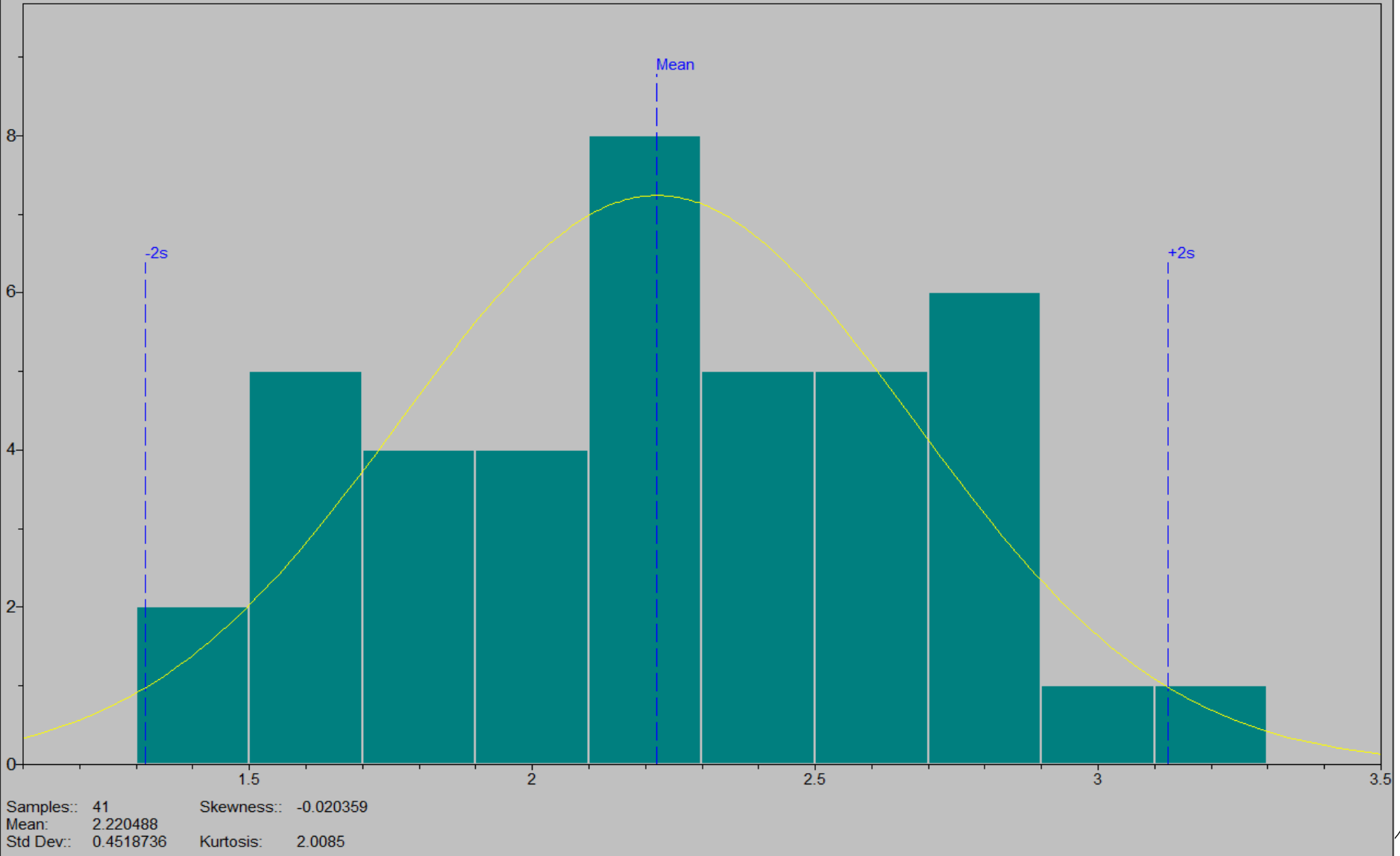
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO G\*



Individual: cl: 2.220488 ucl: 3.576109 lcl: 0.864867

# Sample B RTFO G\*

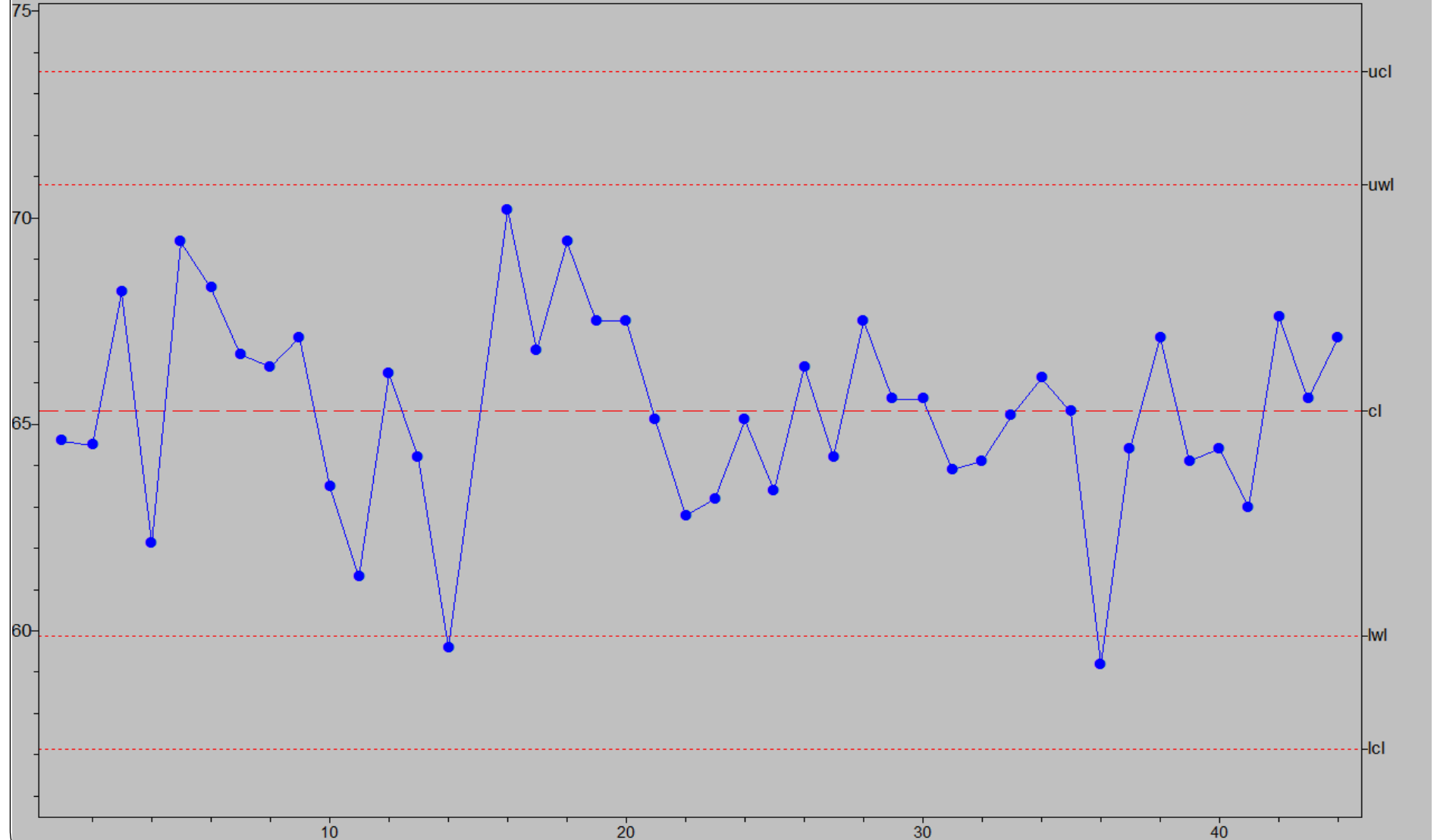
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO G\*



# Sample B RTFO Phase Angle

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO Phase Angle

Individ.

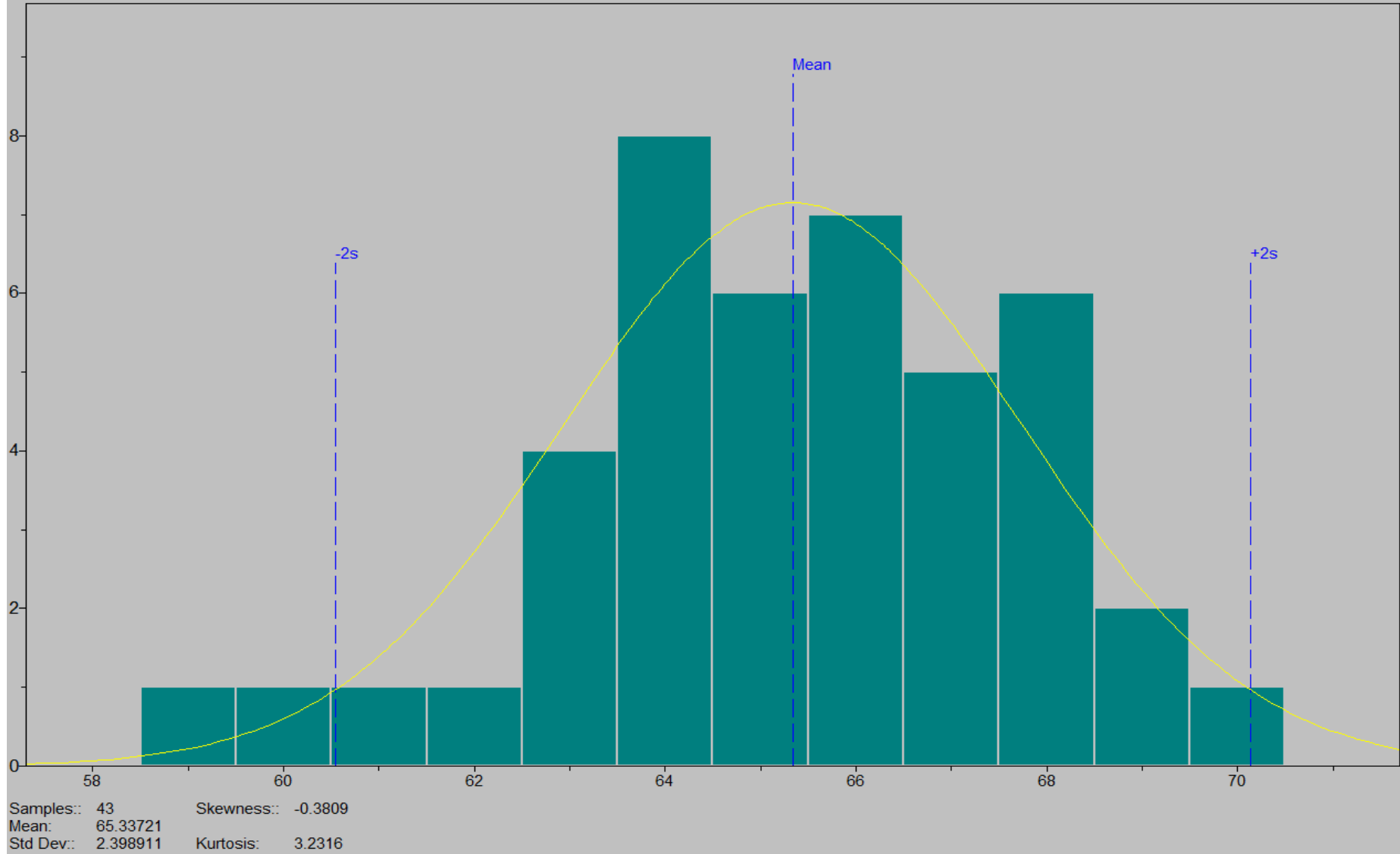


Individual: cl: 65.33721 ucl: 73.54605 lcl: 57.12837



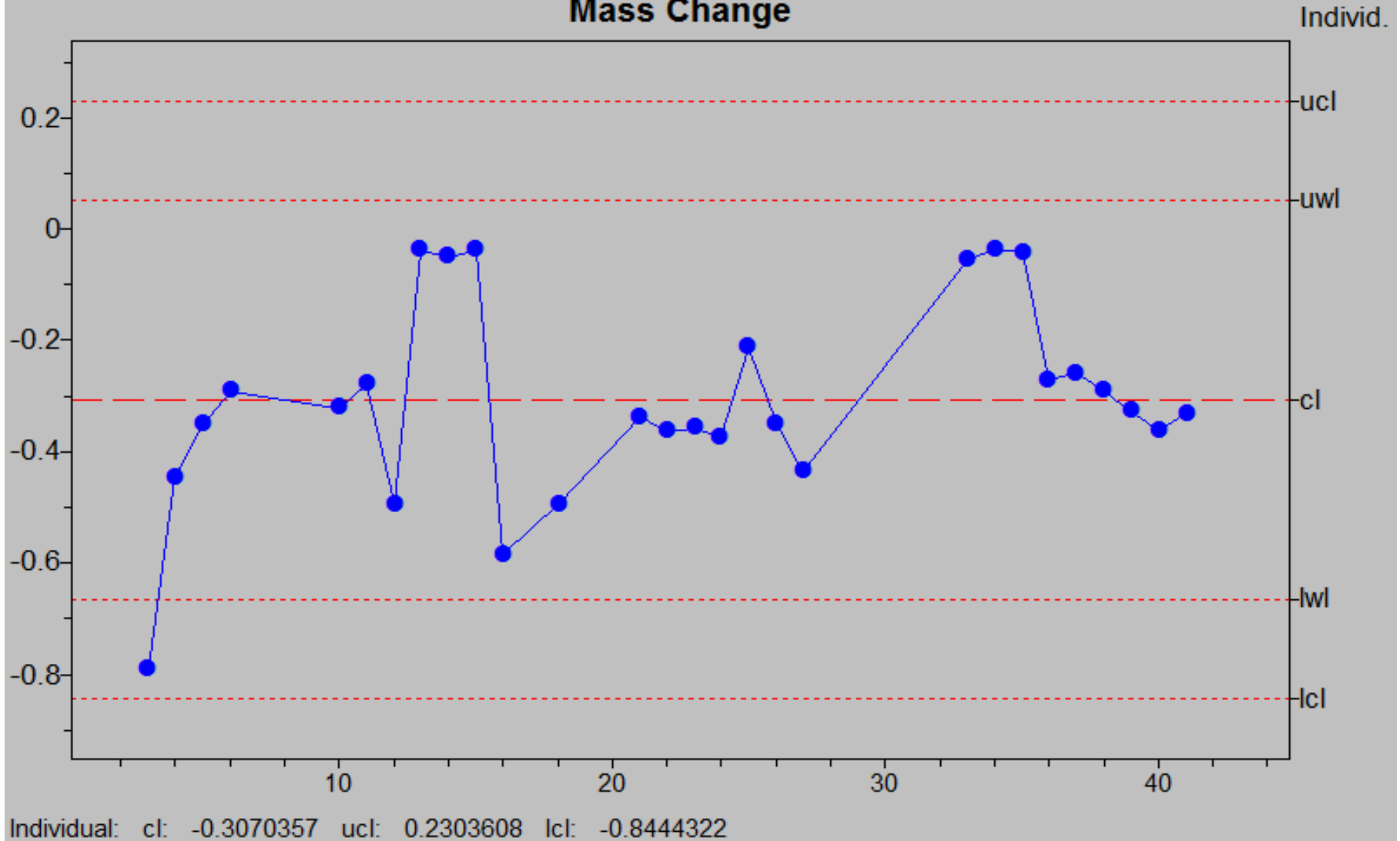
# Sample B RTFO Phase Angle

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B RTFO Phase Angle



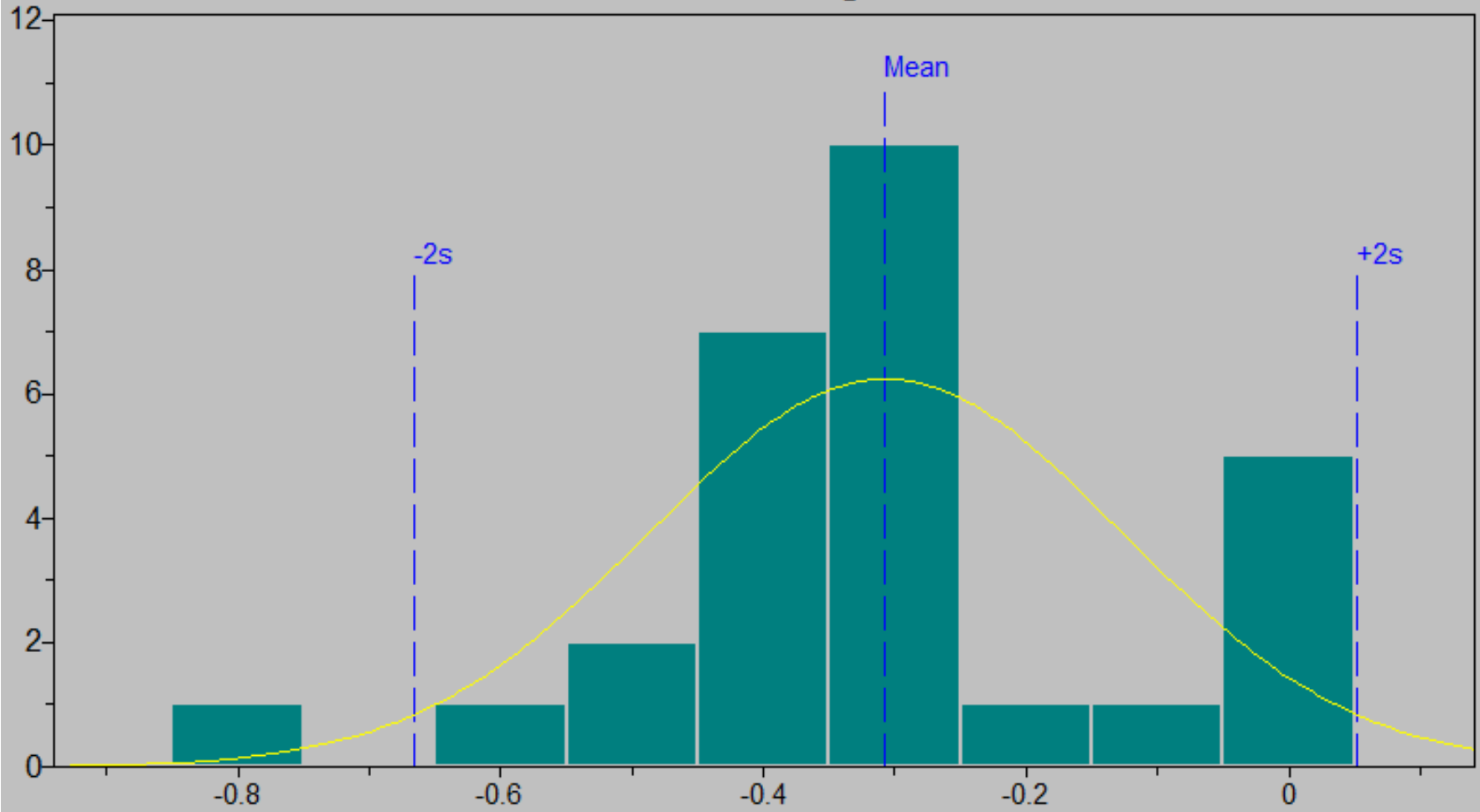
# Sample B Mass Change

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Mass Change



# Sample B Mass Change

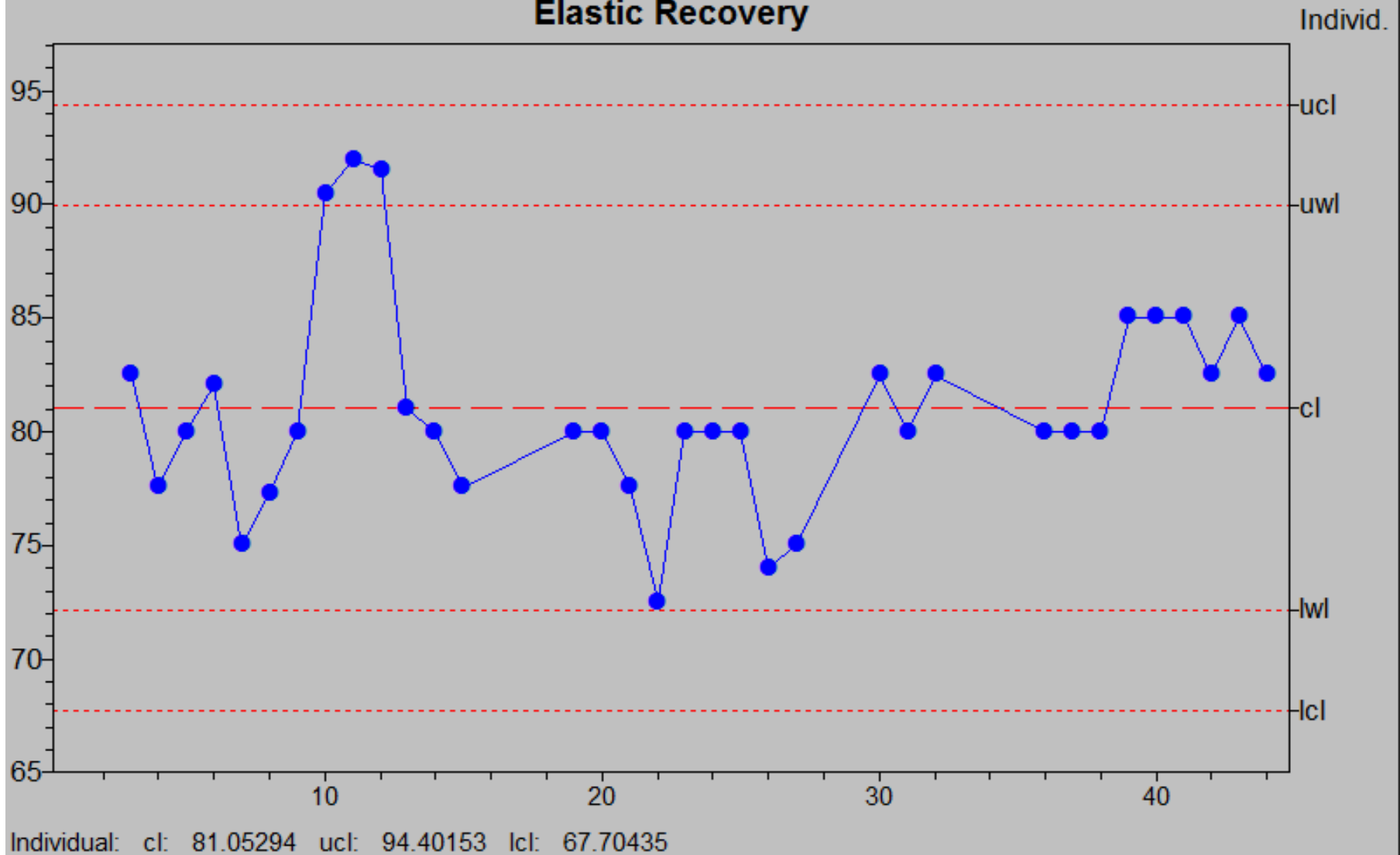
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Mass Change



Samples:: 28      Skewness:: -0.29096  
Mean: -0.3070357  
Std Dev:: 0.1791322      Kurtosis: 3.4813

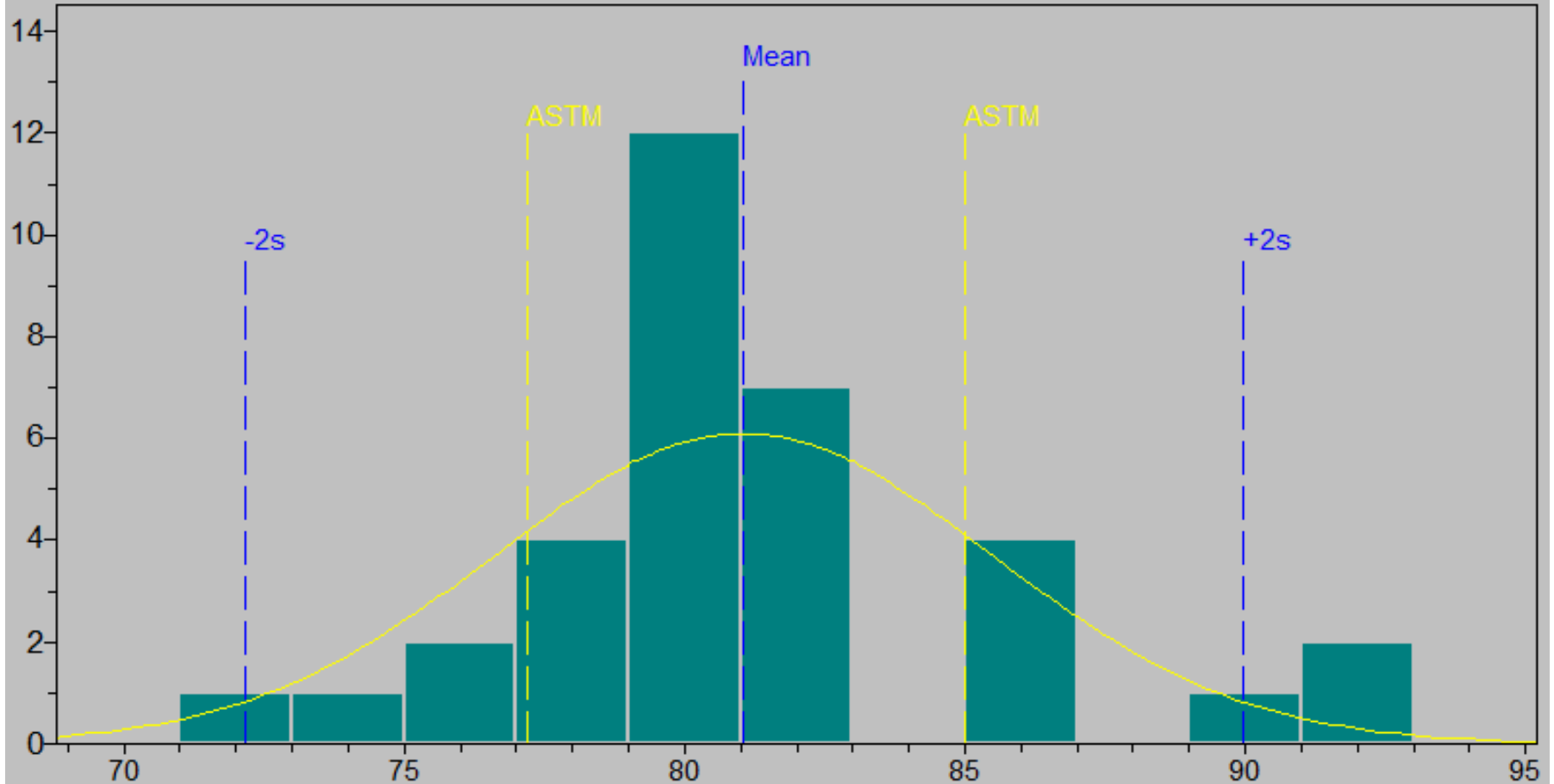
# Sample B Elastic Recovery

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Elastic Recovery



# Sample B Elastic Recovery

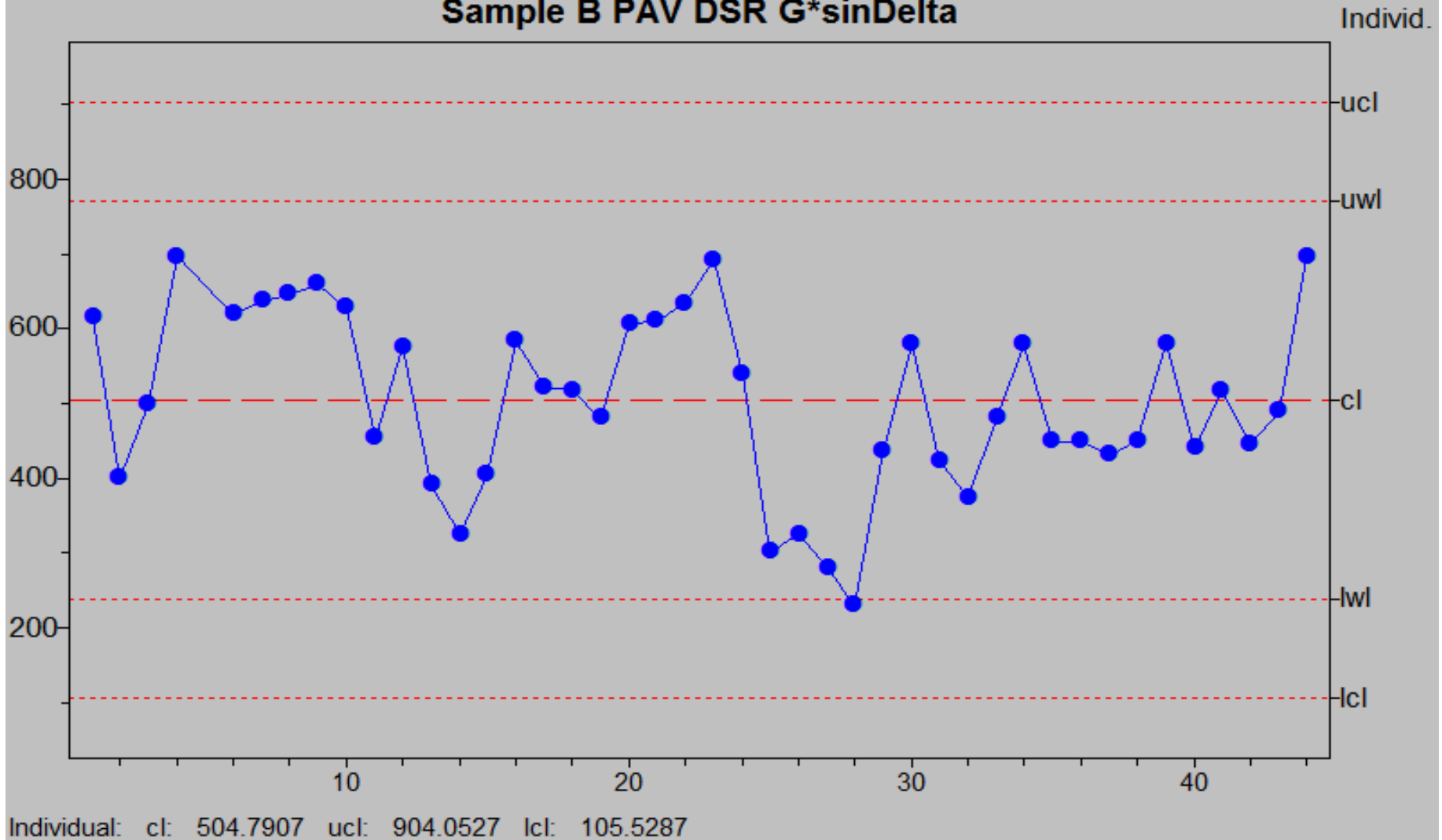
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Elastic Recovery



Samples:: 34  
Mean: 81.05294  
Std Dev:: 4.449531  
Skewness:: 0.67587  
Kurtosis: 3.6985

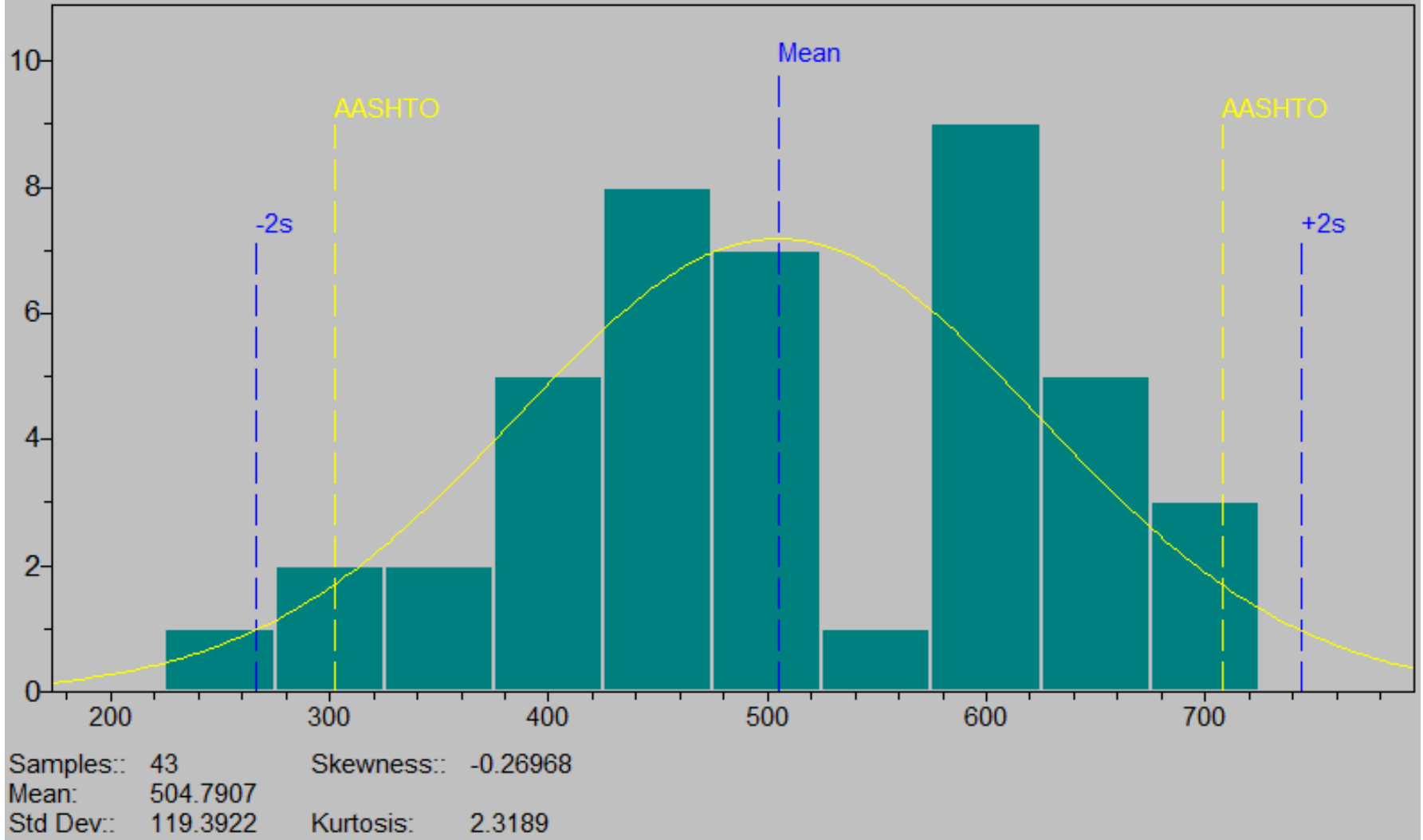
# Sample B PAV DSR G\* $\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR G\* $\sin\Delta$



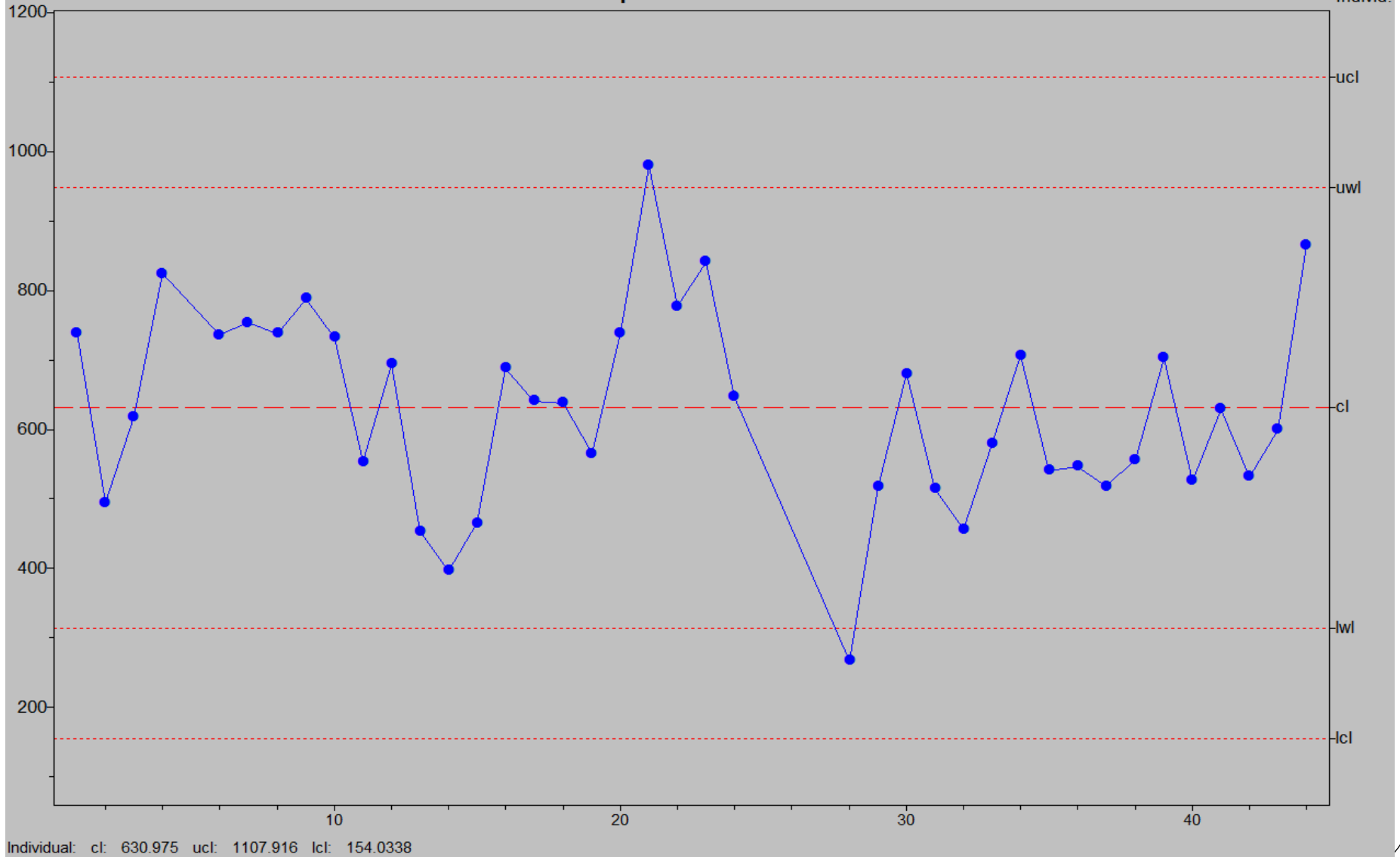
# Sample B PAV DSR $G^*\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR  $G^*\sin\Delta$



# Sample B PAV DSR G\*

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR G\*

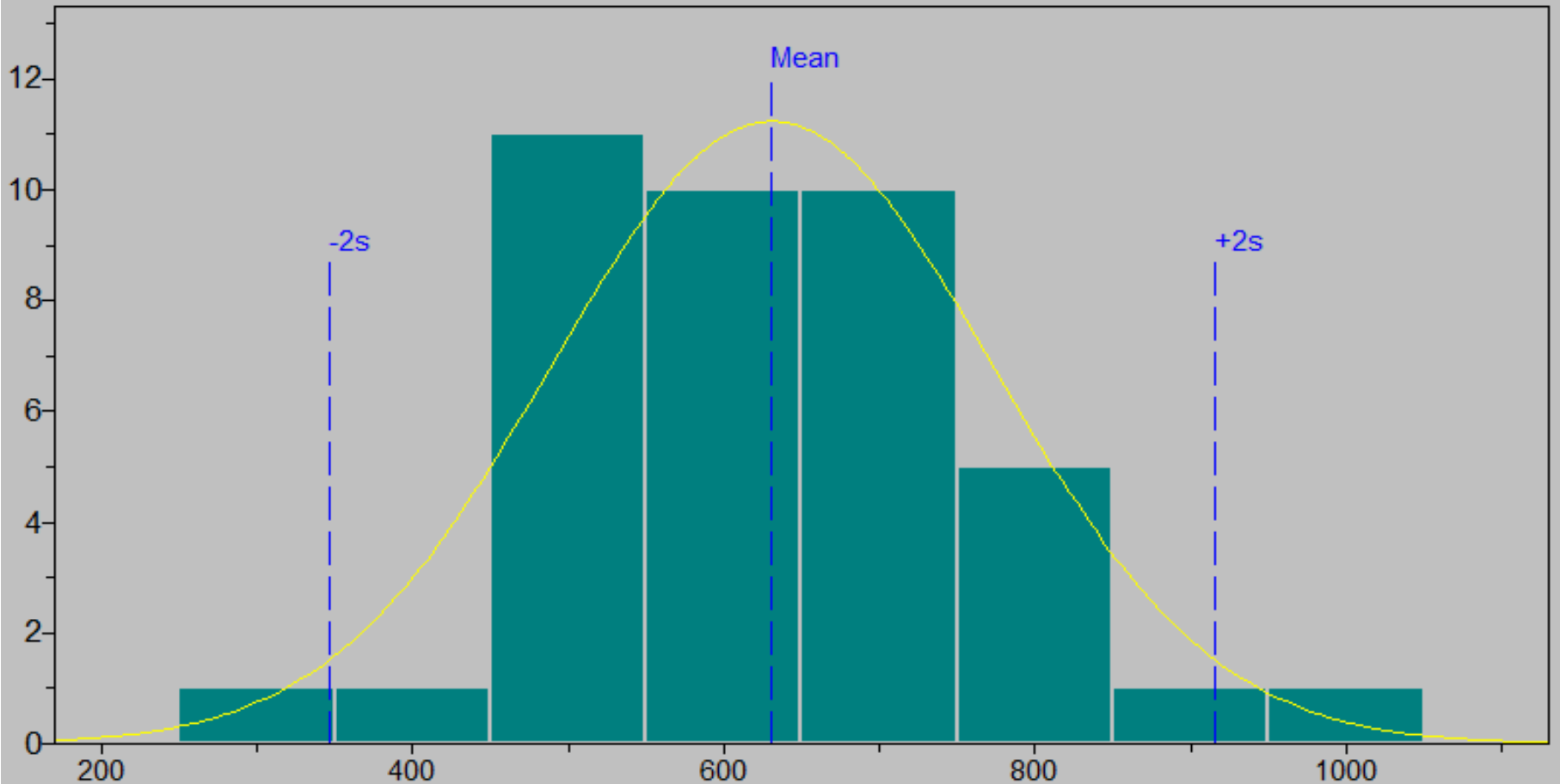


Individual: cl: 630.975 ucl: 1107.916 lcl: 154.0338



# Sample B PAV DSR G\*

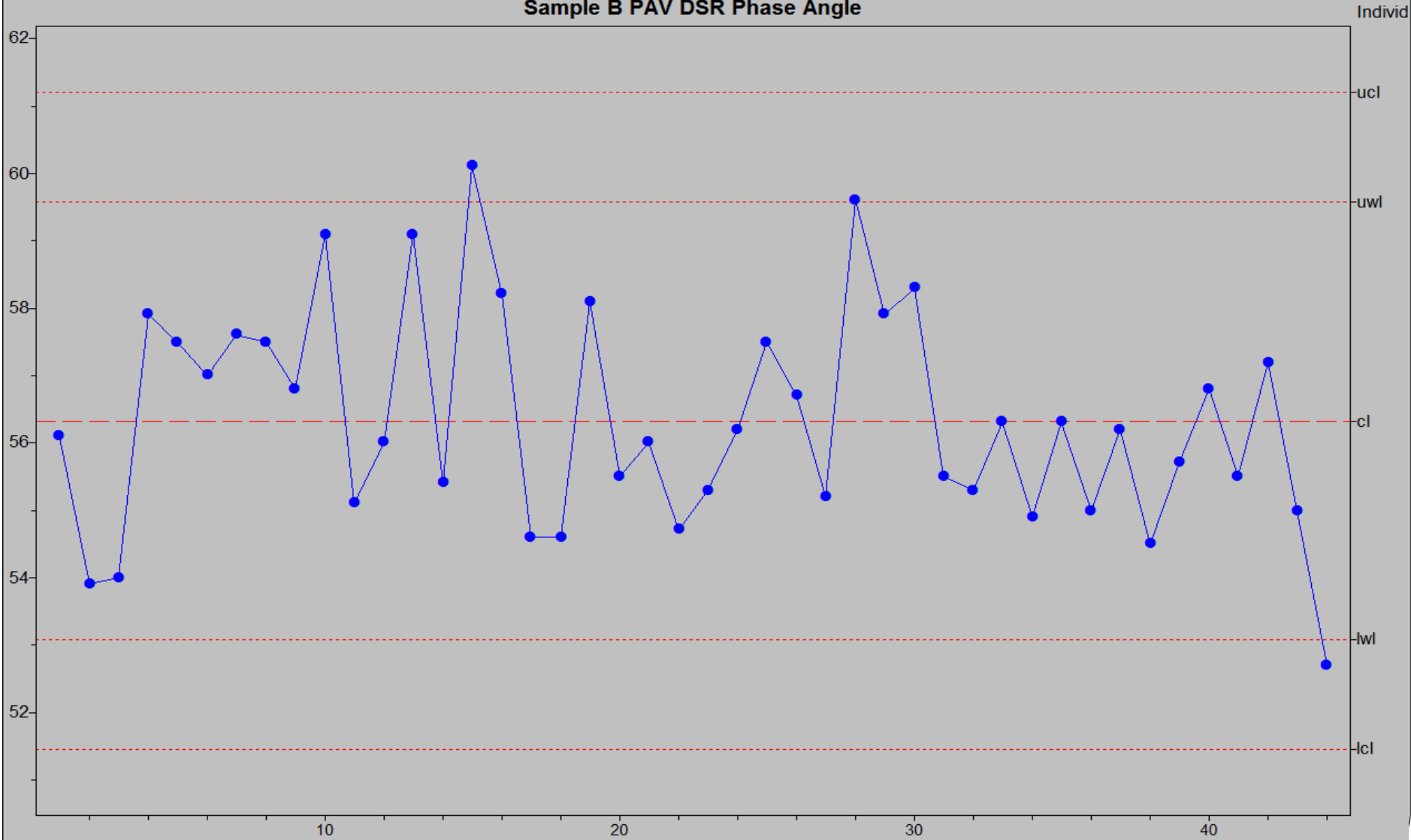
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR G\*



Samples:: 40      Skewness:: -0.0050421  
Mean:      630.975  
Std Dev:: 142.0385      Kurtosis: 3.0771

# Sample B PAV DSR Phase Angle

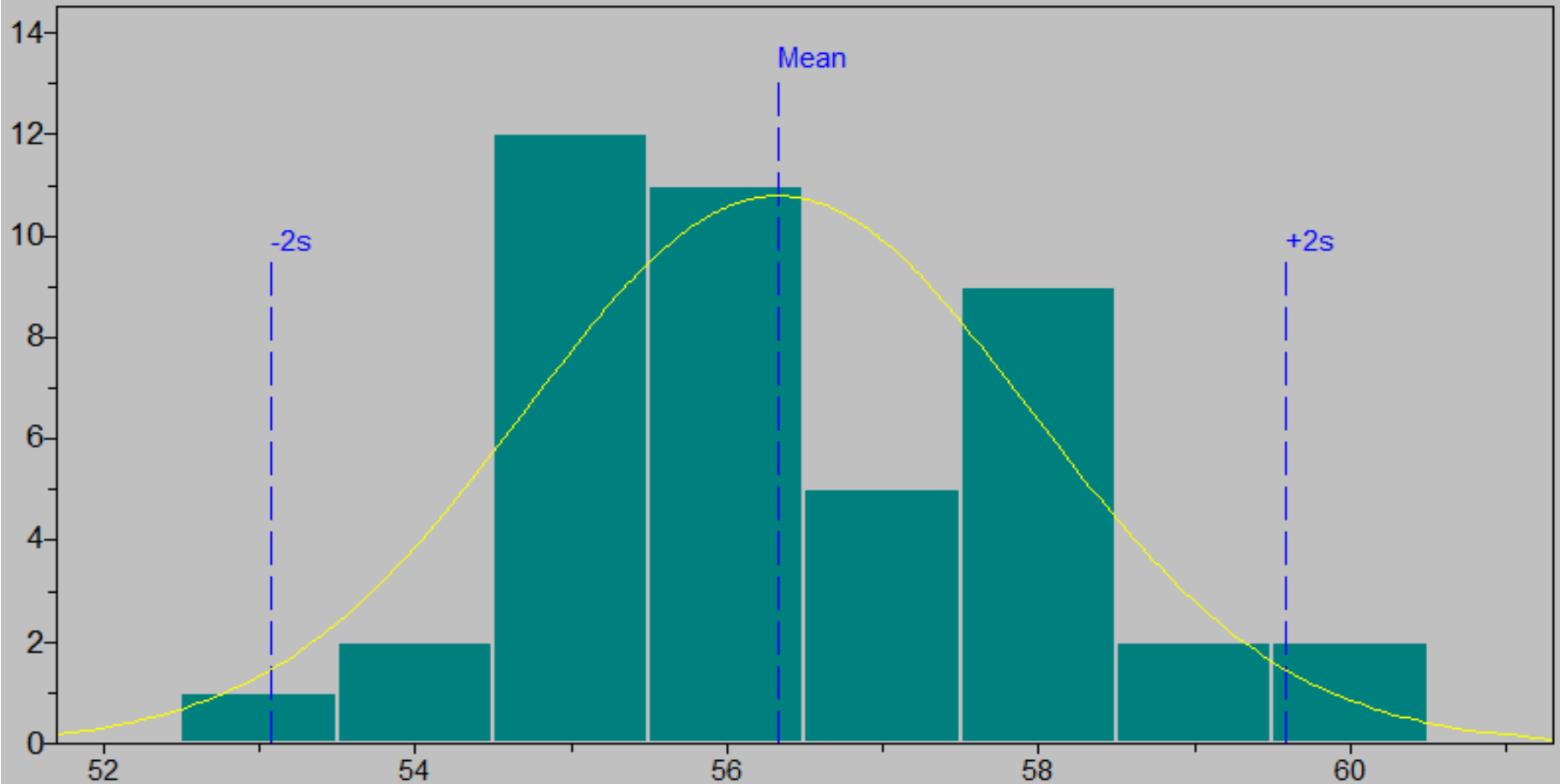
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR Phase Angle



Individual: cl: 56.32727 ucl: 61.20829 lcl: 51.44626

# Sample B PAV DSR Phase Angle

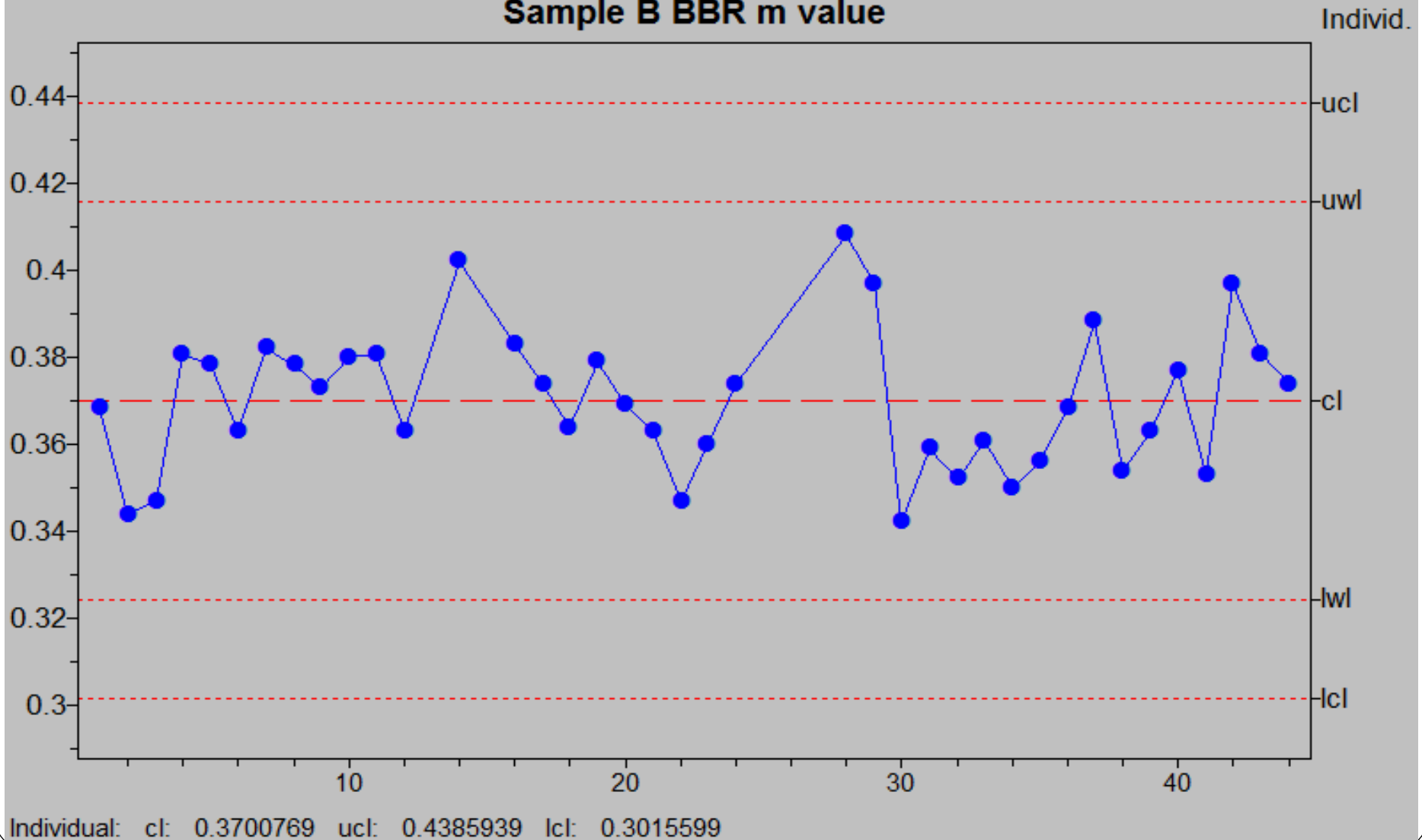
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B PAV DSR Phase Angle



Samples:: 44      Skewness:: 0.30536  
Mean: 56.32727  
Std Dev:: 1.627005      Kurtosis: 2.6699

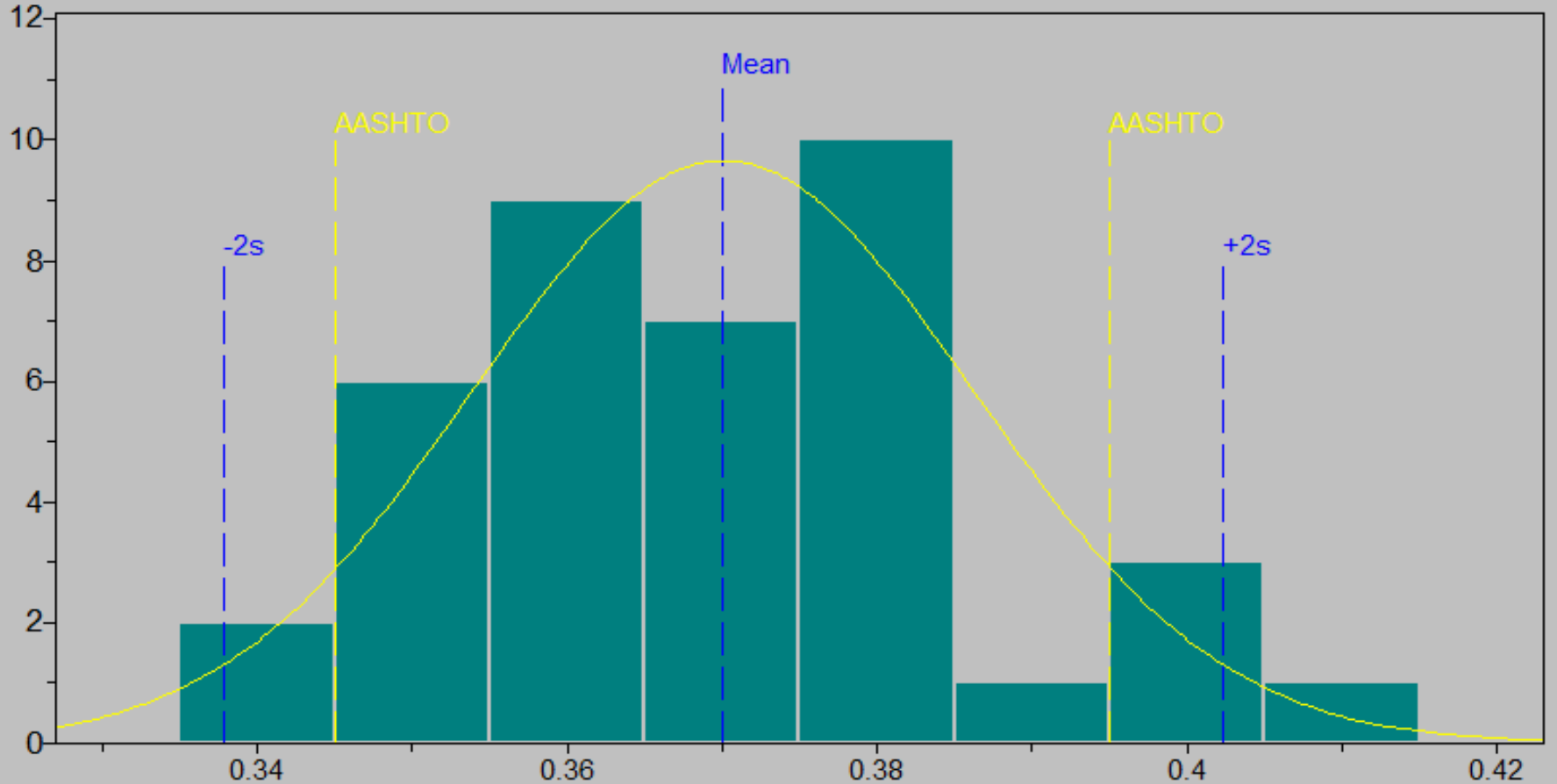
# Sample B BBR m value

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B BBR m value



# Sample B BBR m value

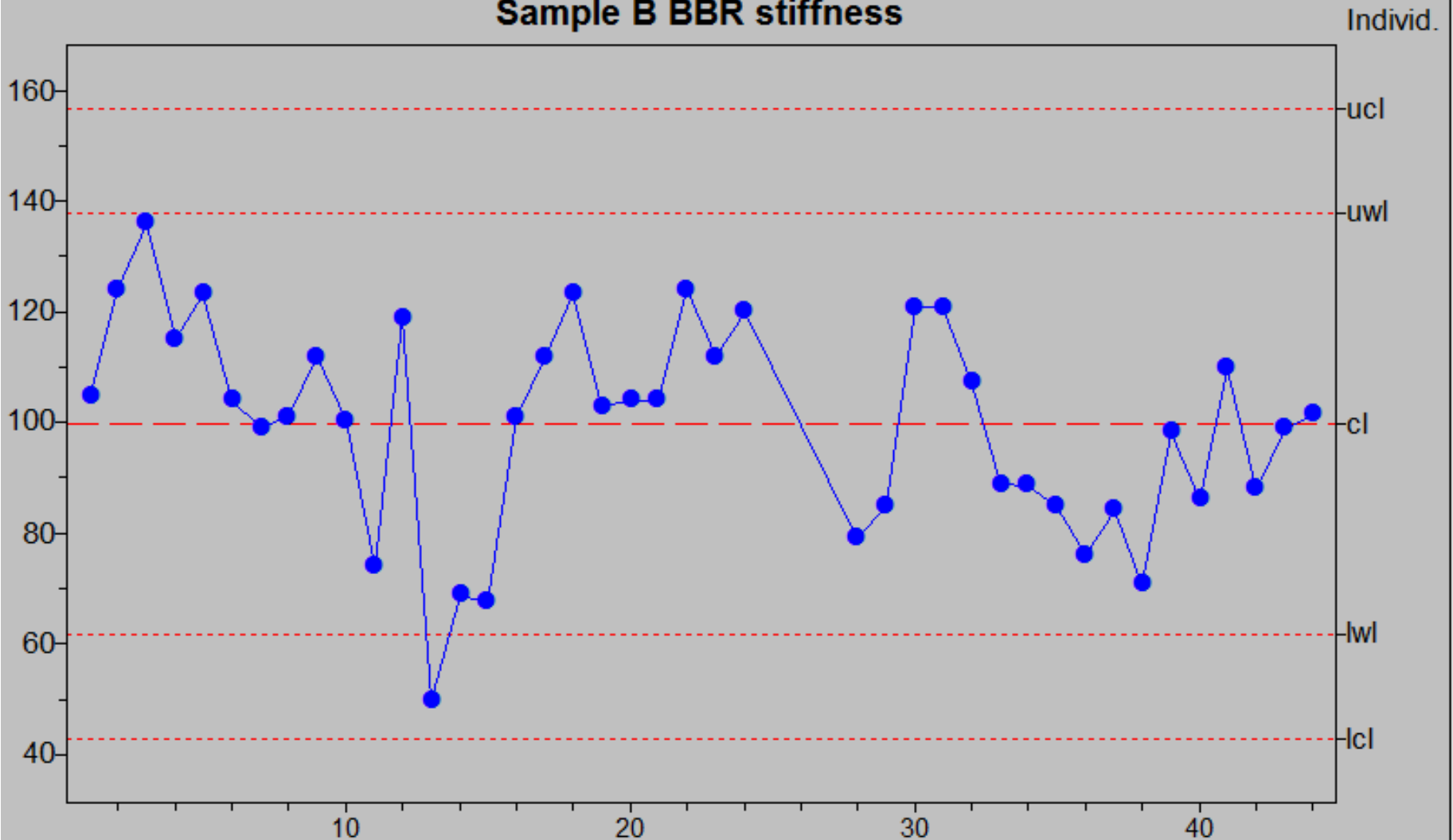
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B BBR m value



Samples:: 39      Skewness:: 0.30383  
Mean: 0.3700769  
Std Dev:: 0.01611372      Kurtosis: 2.6174

# Sample B BBR Stiffness

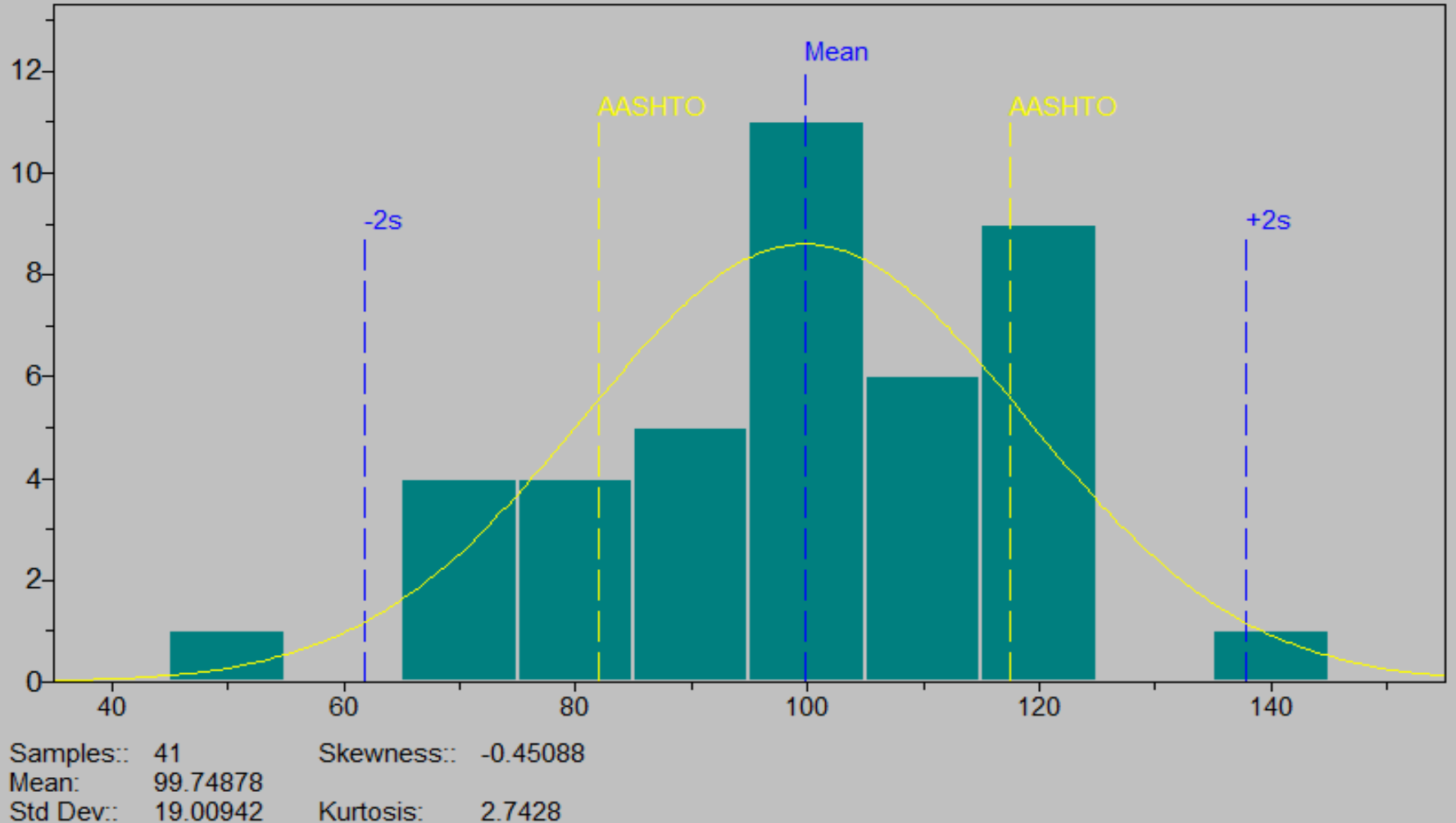
File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B BBR stiffness



Individual: cl: 99.74878 ucl: 156.777 lcl: 42.72052

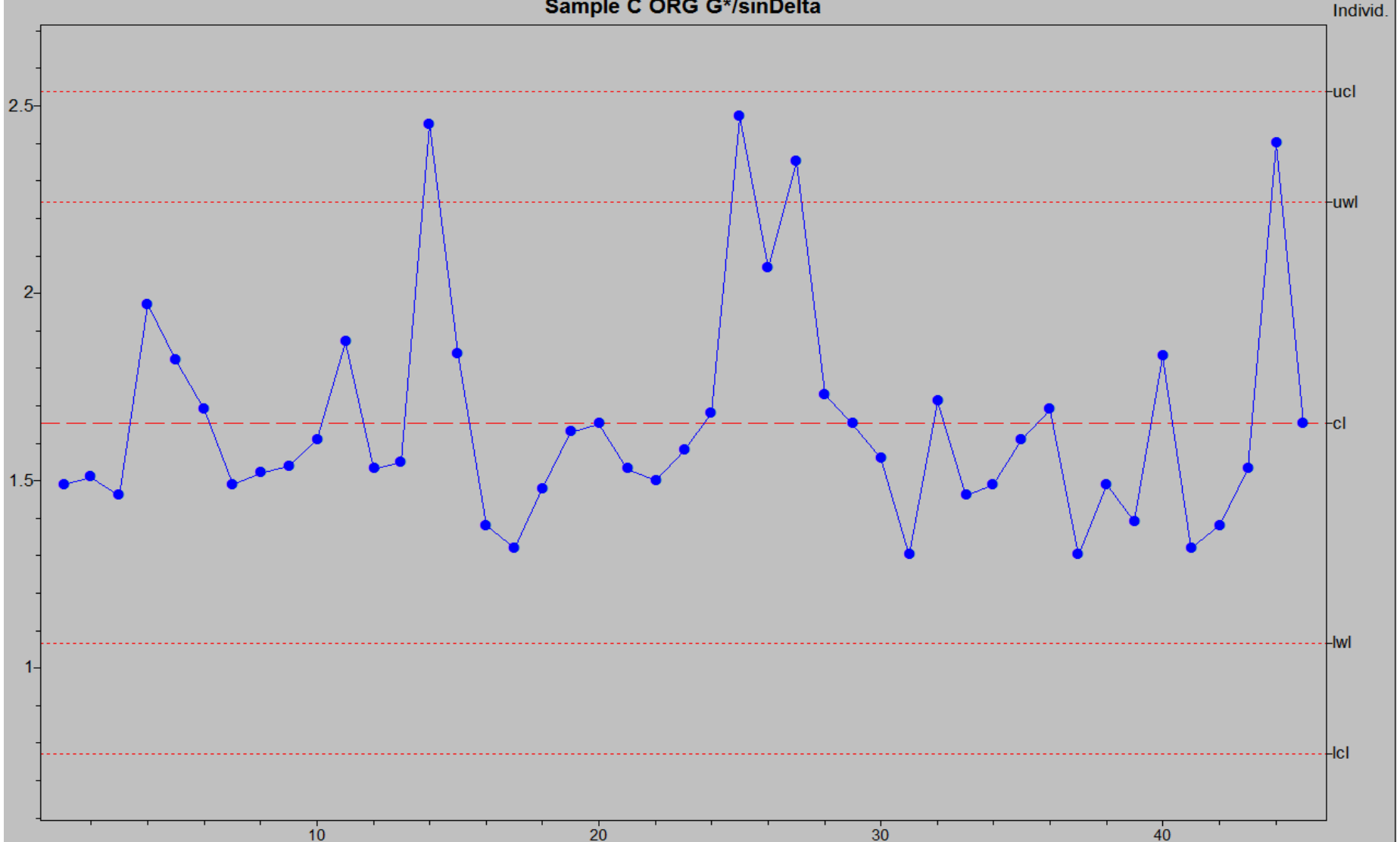
# Sample B BBR Stiffness

File: PCCAS Asphalt Rubber Binder Sample B.DAT  
Sample B BBR stiffness



# Sample C ORG. $G^*/\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C ORG  $G^*/\sin\Delta$

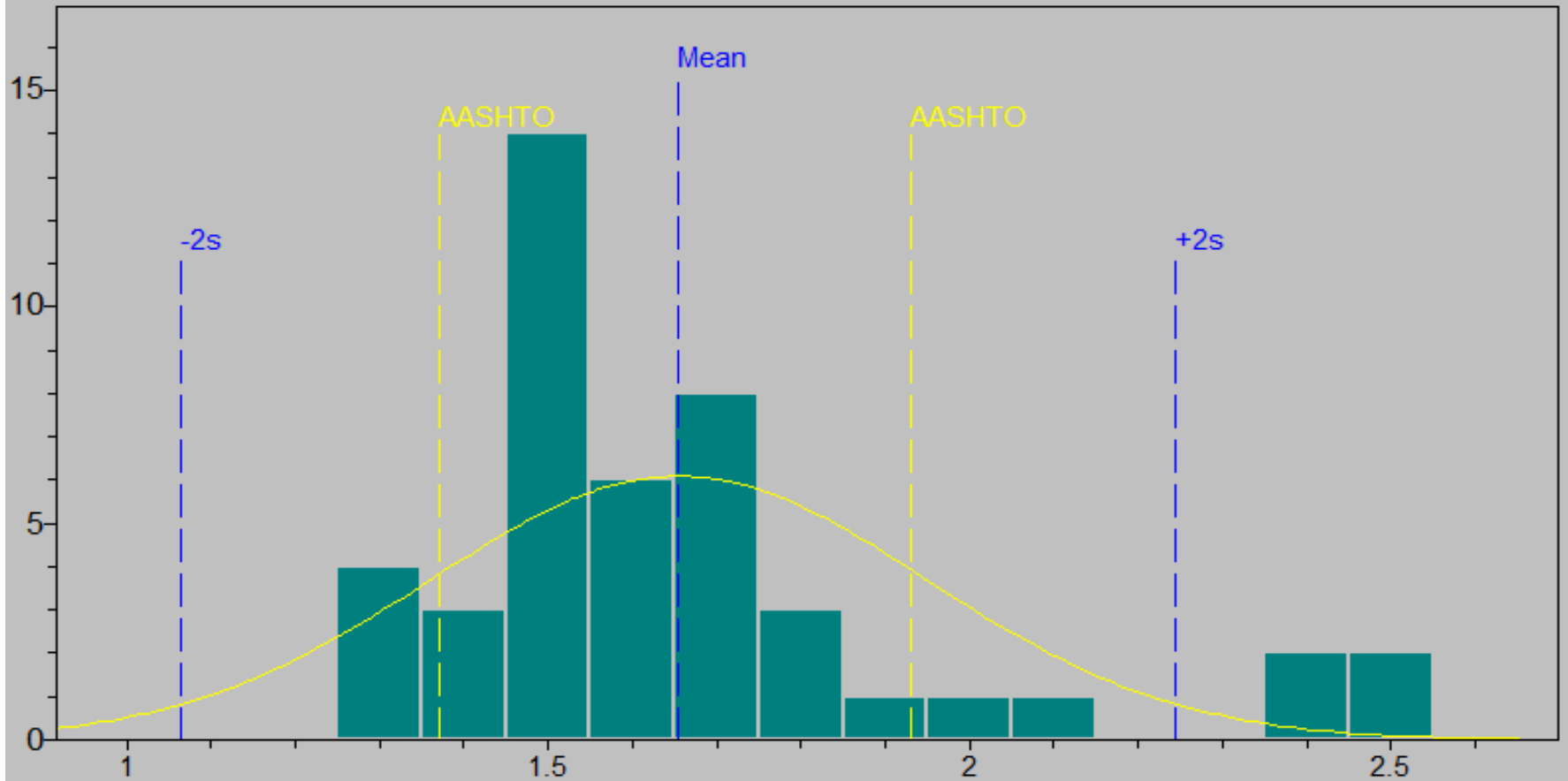


Individual: cl: 1.654889 ucl: 2.539198 lcl: 0.7705797



# Sample C ORG. $G^*/\sin\Delta$

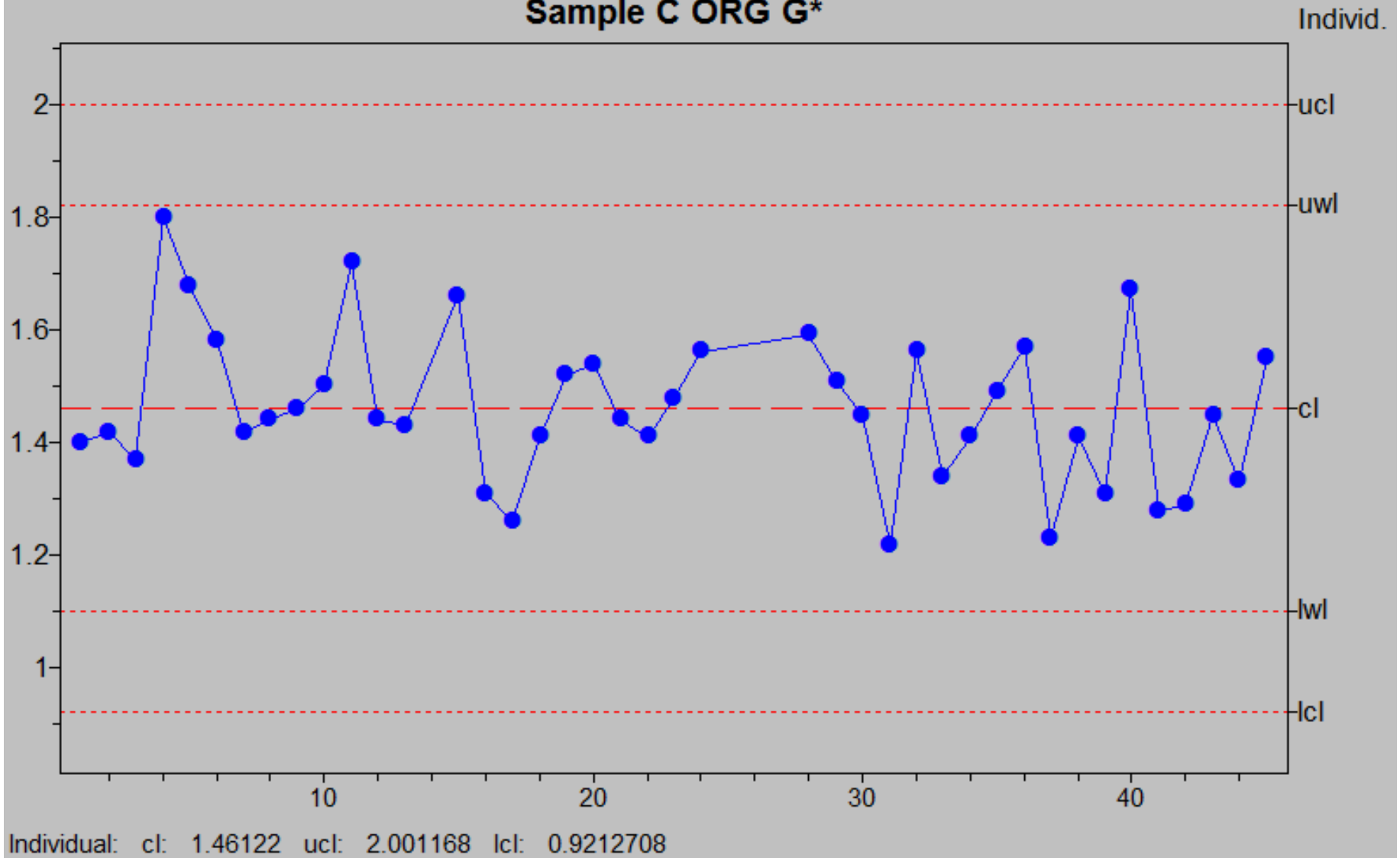
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C ORG  $G^*/\sin\Delta$



Samples:: 45      Skewness:: 1.4731  
Mean: 1.654889  
Std Dev:: 0.2947697      Kurtosis: 4.6486

# Sample C ORG. G\*

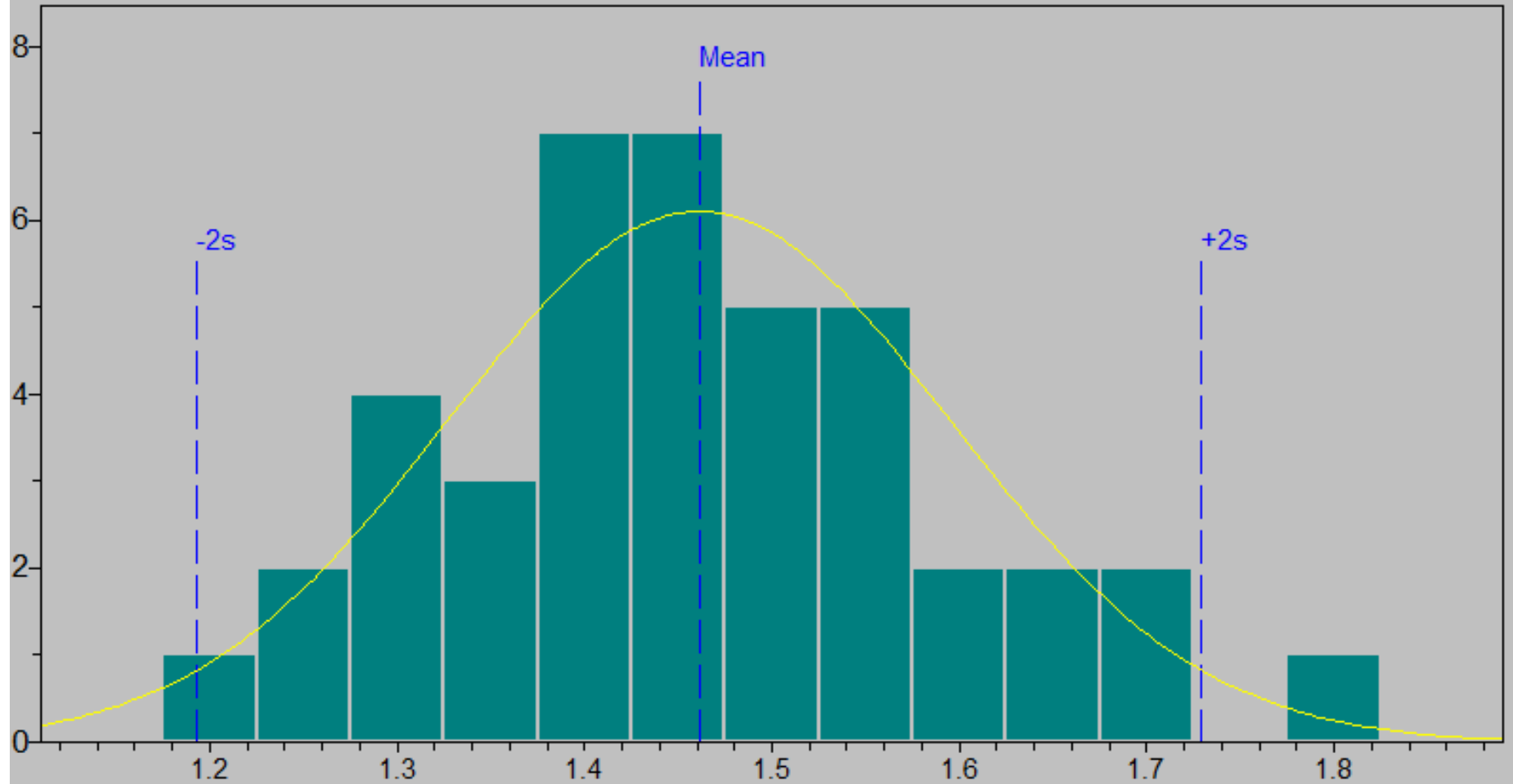
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C ORG G\*



# Sample C ORG. G\*

File: PCCAS Asphalt Rubber Binder Sample C.DAT

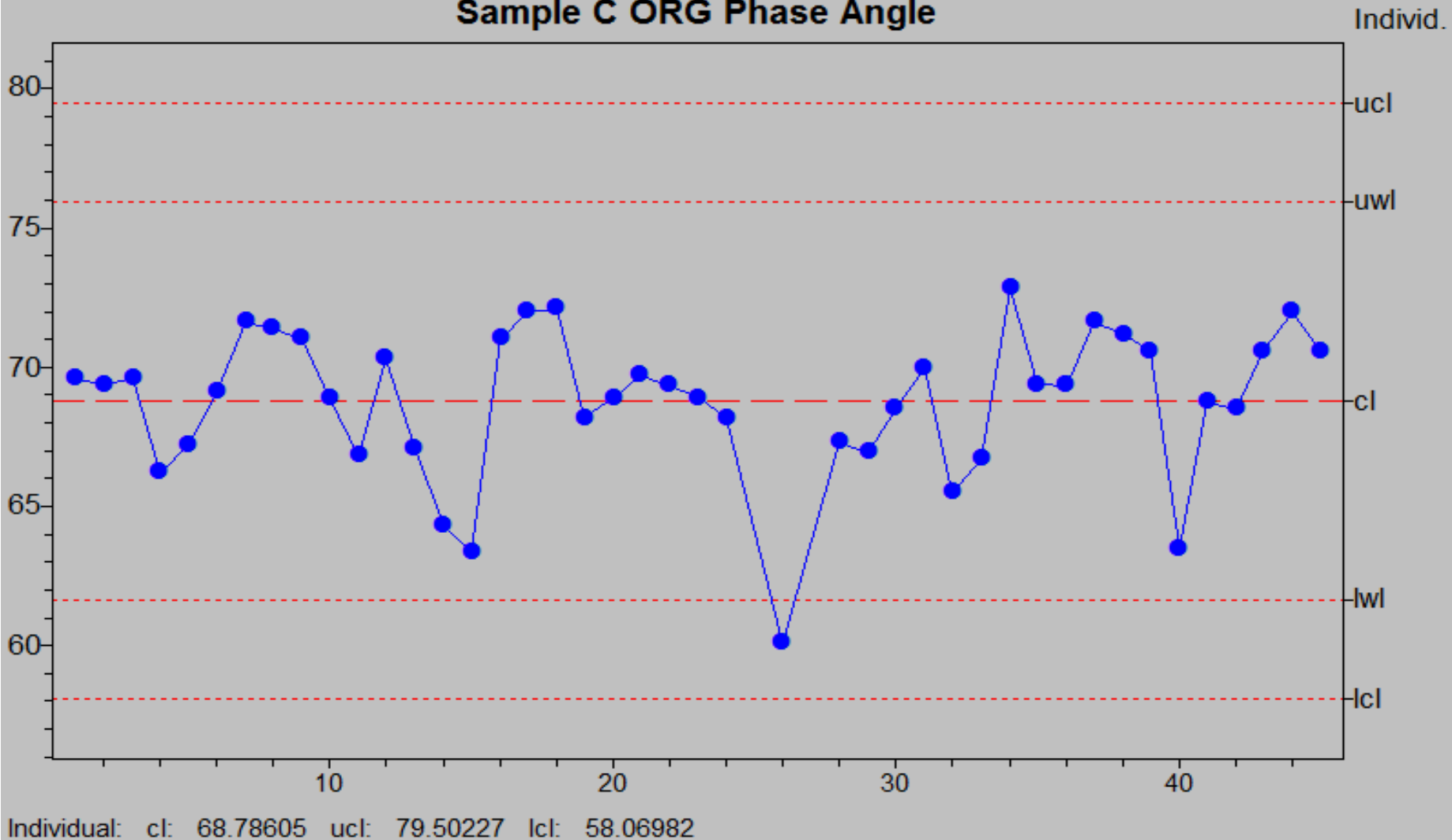
Sample C ORG G\*



Samples:: 41      Skewness:: 0.35862  
Mean: 1.46122  
Std Dev:: 0.1339626      Kurtosis: 2.8511

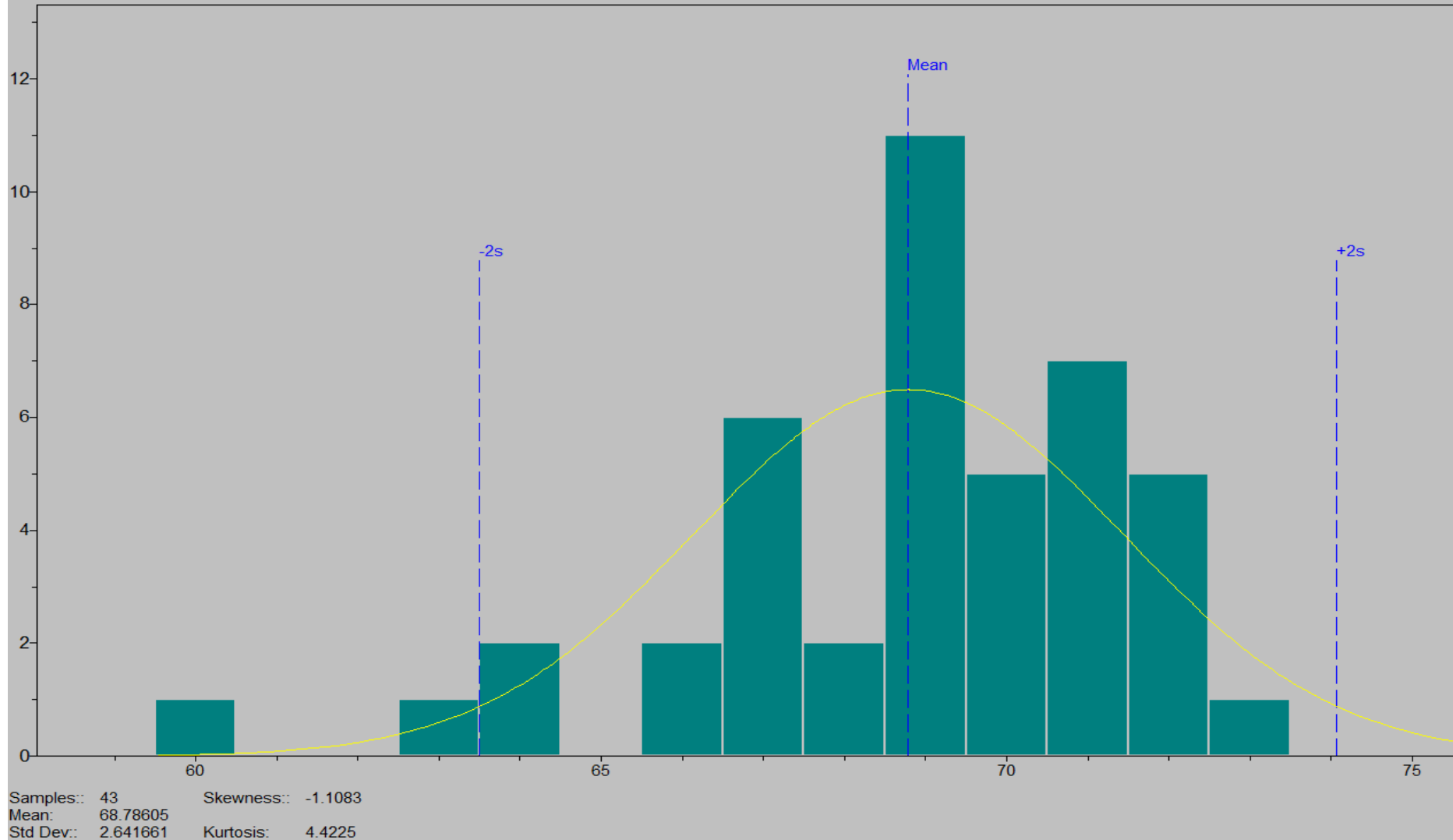
# Sample C ORG. Phase Angle

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C ORG Phase Angle



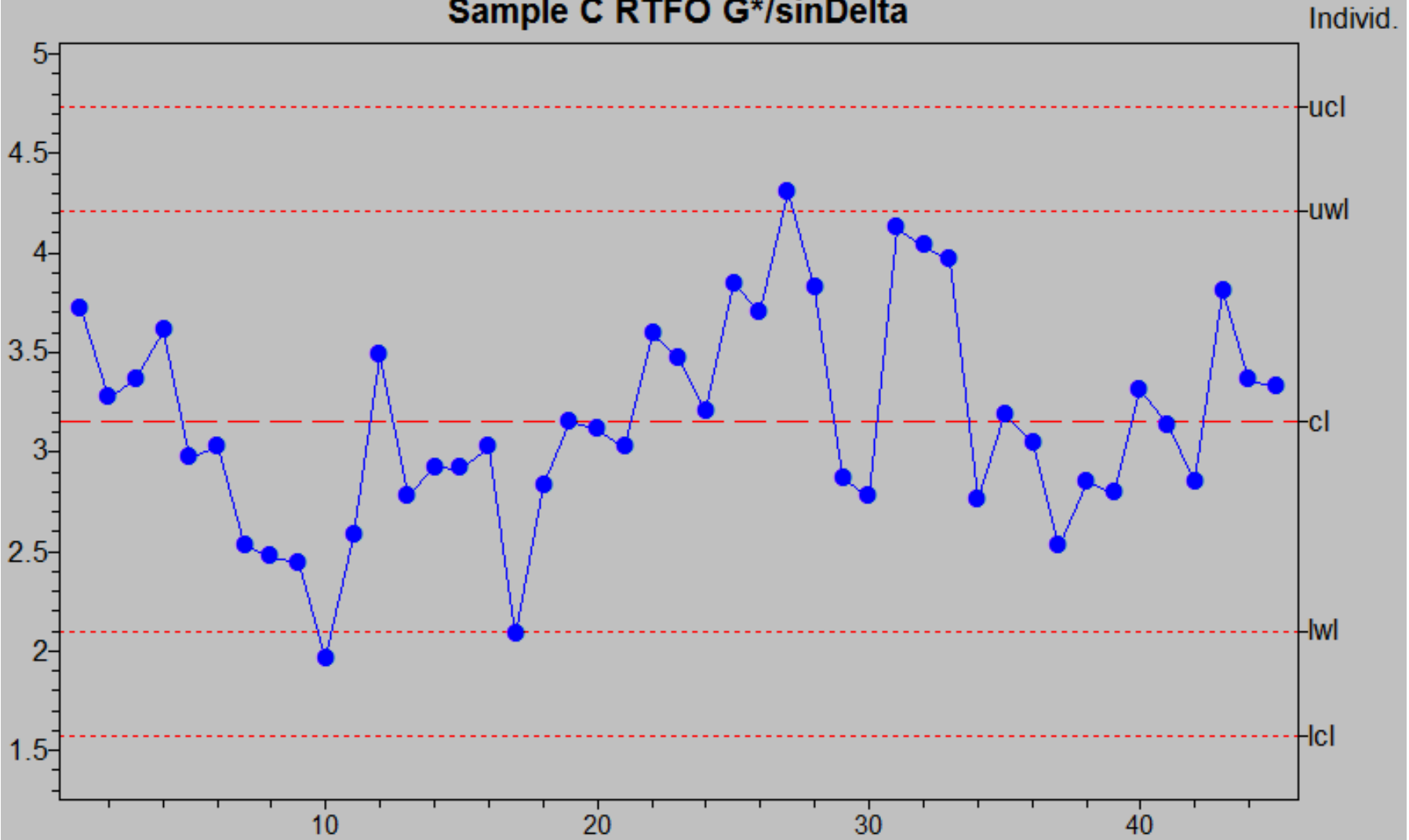
# Sample C ORG. Phase Angle

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C ORG Phase Angle



# Sample C RTFO $G^*/\sin\Delta$

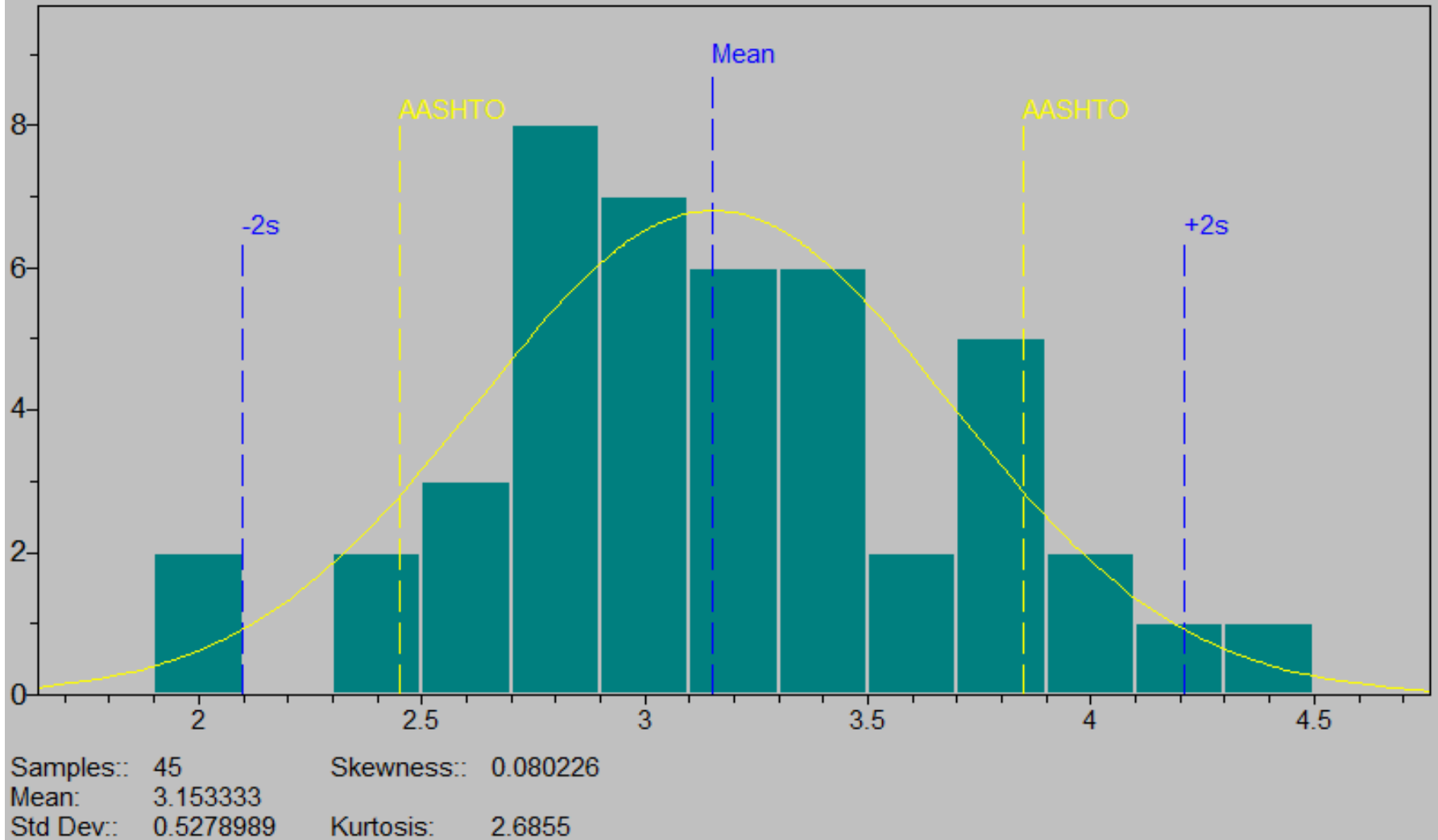
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C RTFO  $G^*/\sin\Delta$



Individual: cl: 3.153333 ucl: 4.73703 lcl: 1.569637

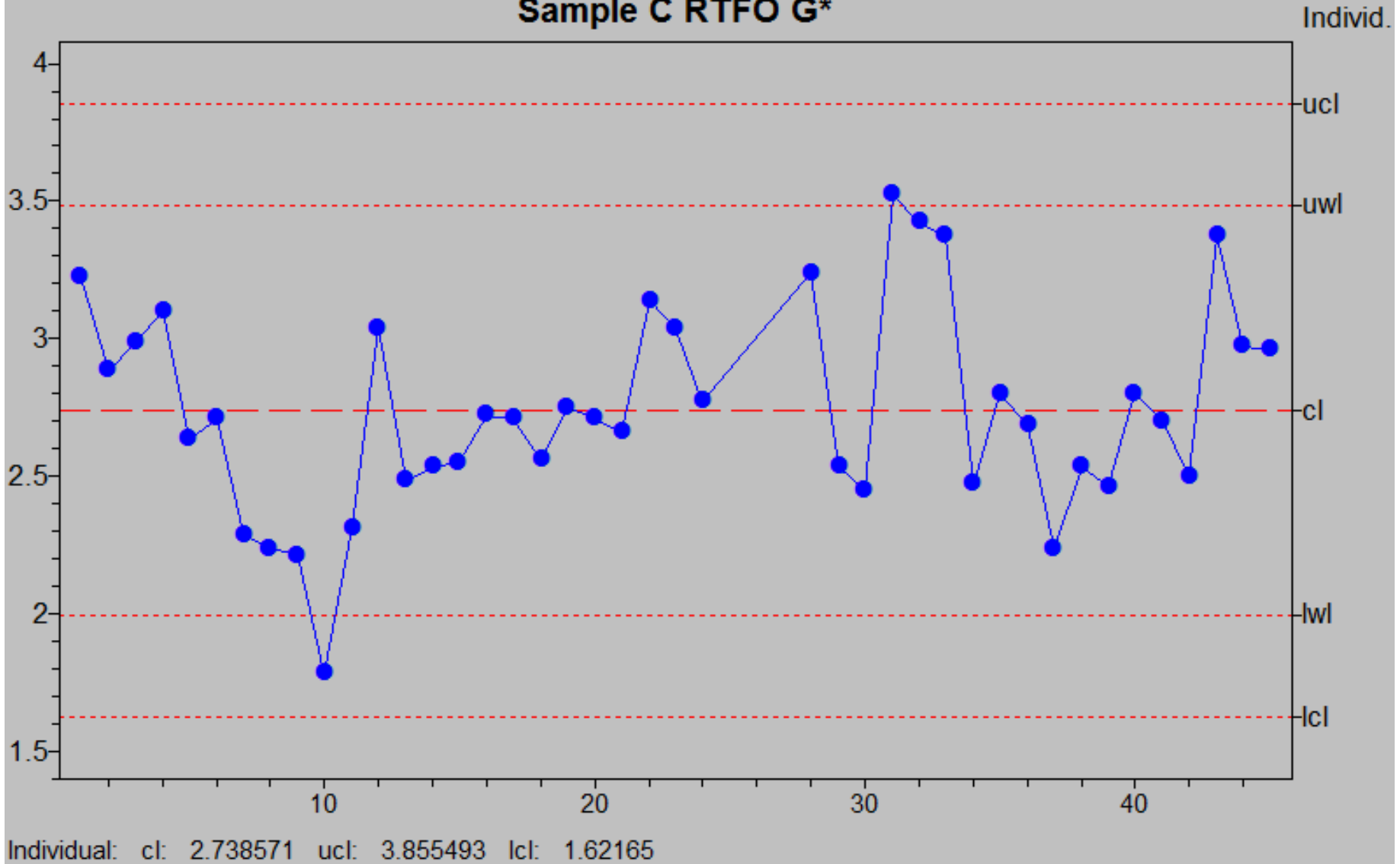
# Sample C RTFO $G^*/\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C RTFO  $G^*/\sin\Delta$



# Sample C RTFO G\*

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C RTFO G\*

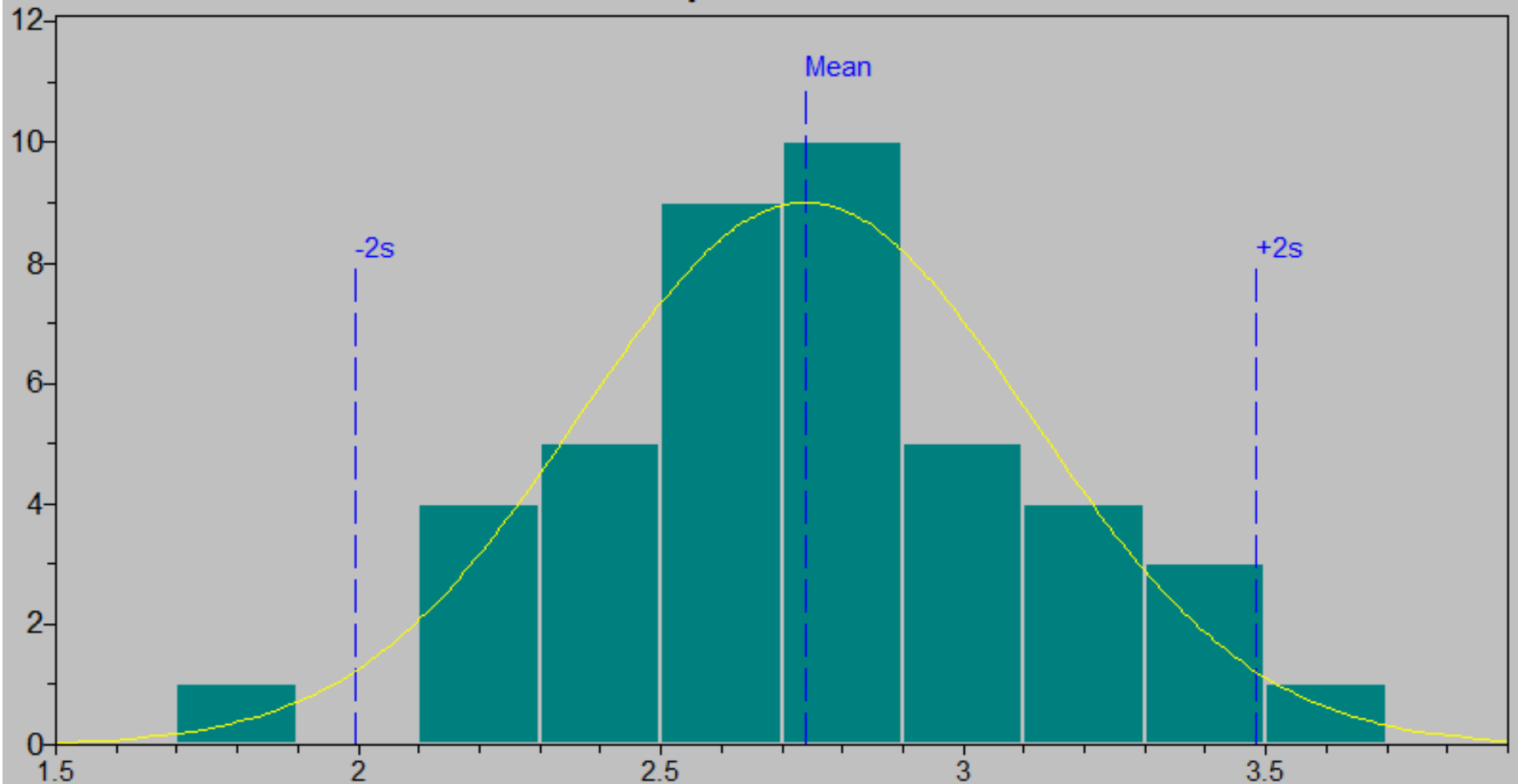




# Sample C RTFO G\*

File: PCCAS Asphalt Rubber Binder Sample C.DAT

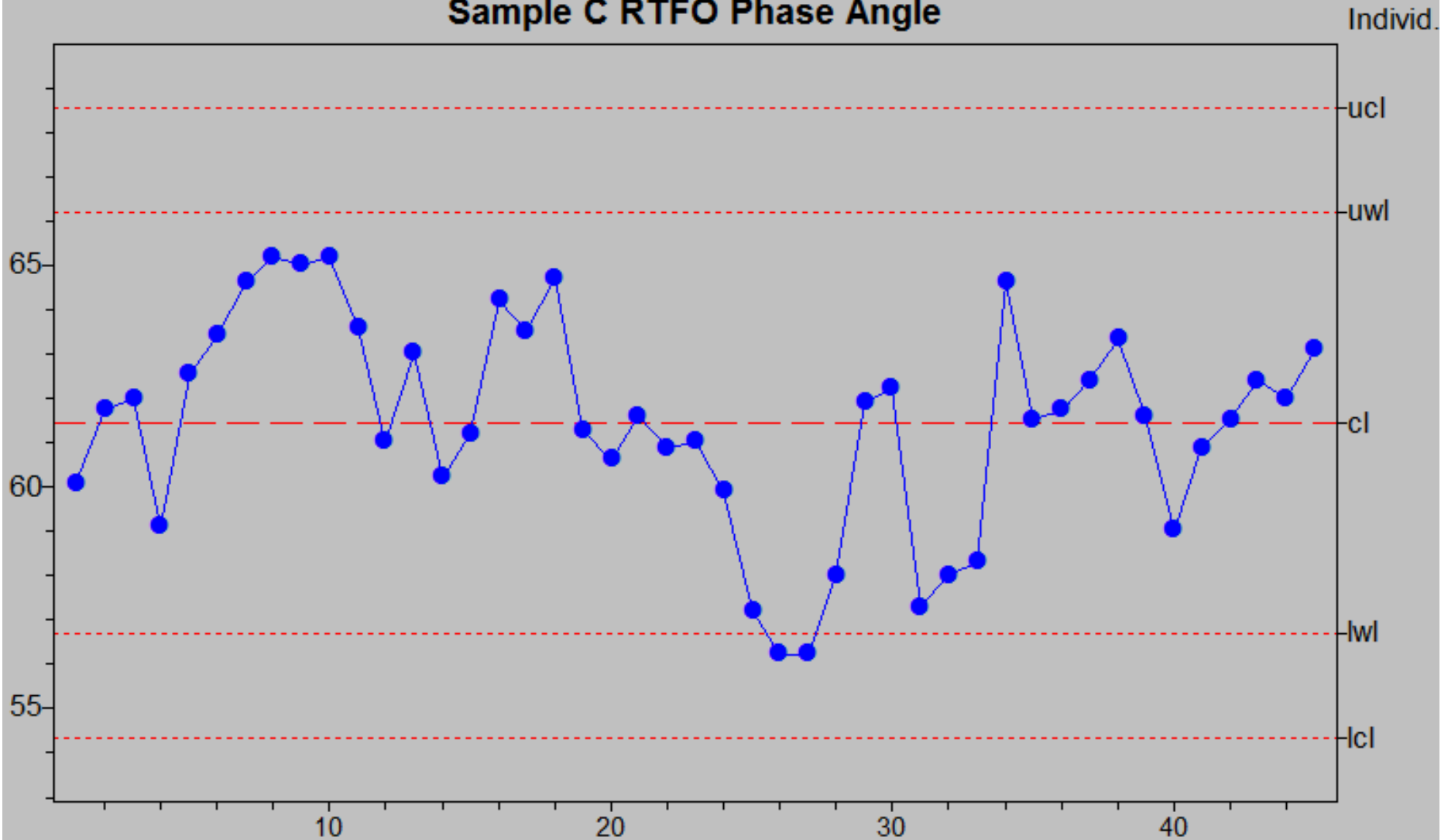
Sample C RTFO G\*



Samples:: 42  
Mean: 2.738571  
Std Dev:: 0.3723071  
Skewness:: 0.078266  
Kurtosis: 2.9256

# Sample C RTFO Phase Angle

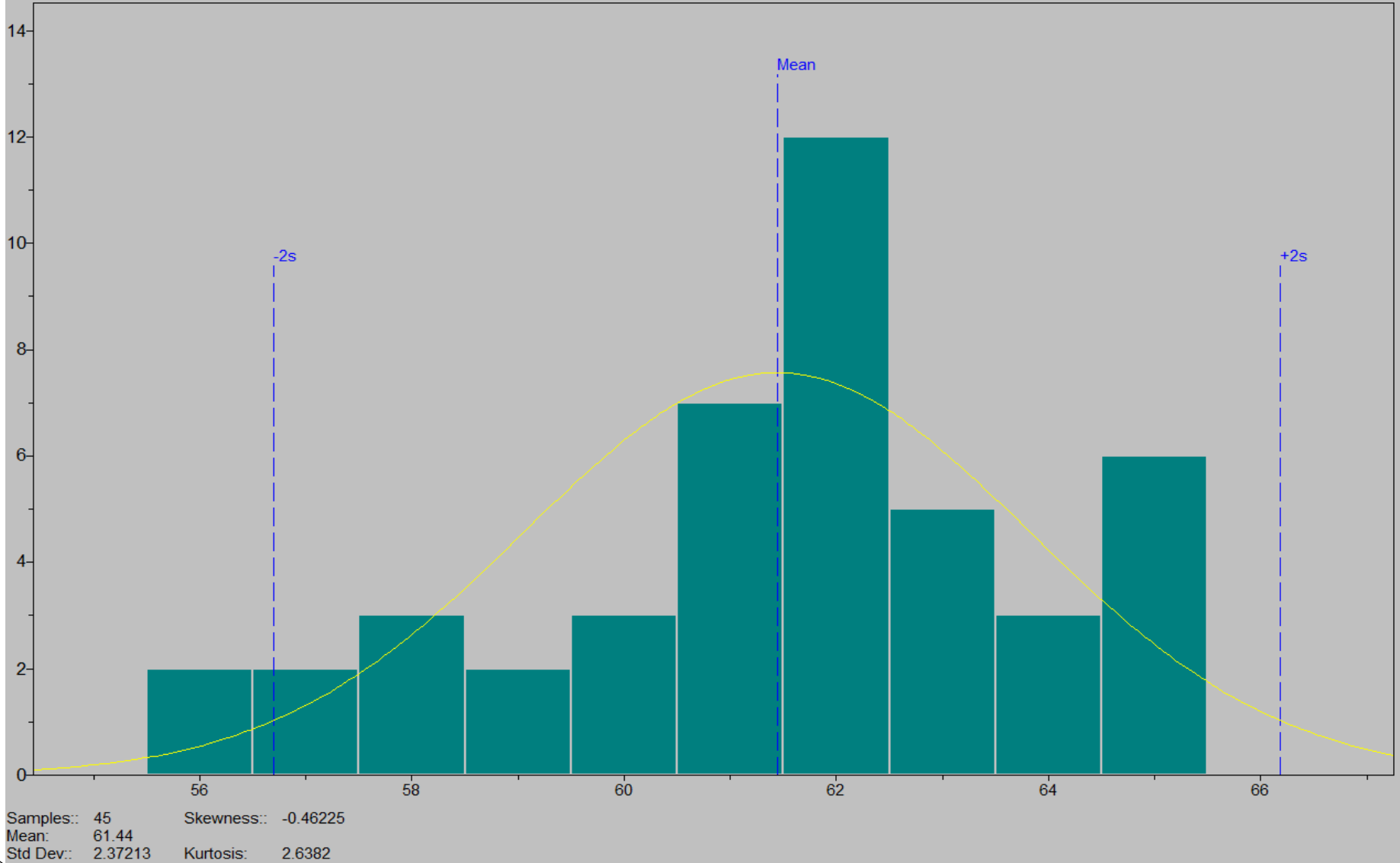
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C RTFO Phase Angle



Individual: cl: 61.44 ucl: 68.55639 lcl: 54.32361

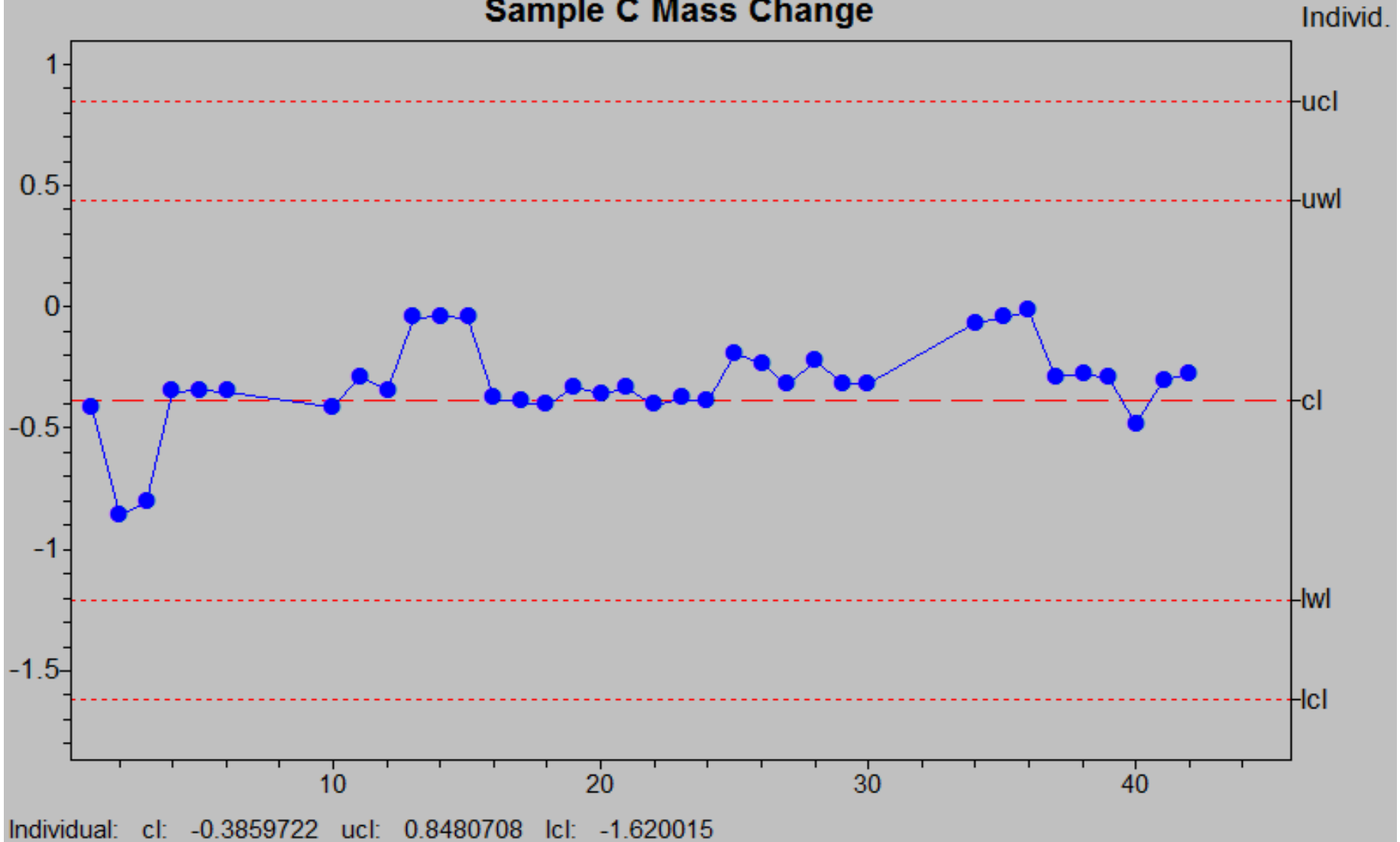
# Sample C RTFO Phase Angle

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C RTFO Phase Angle



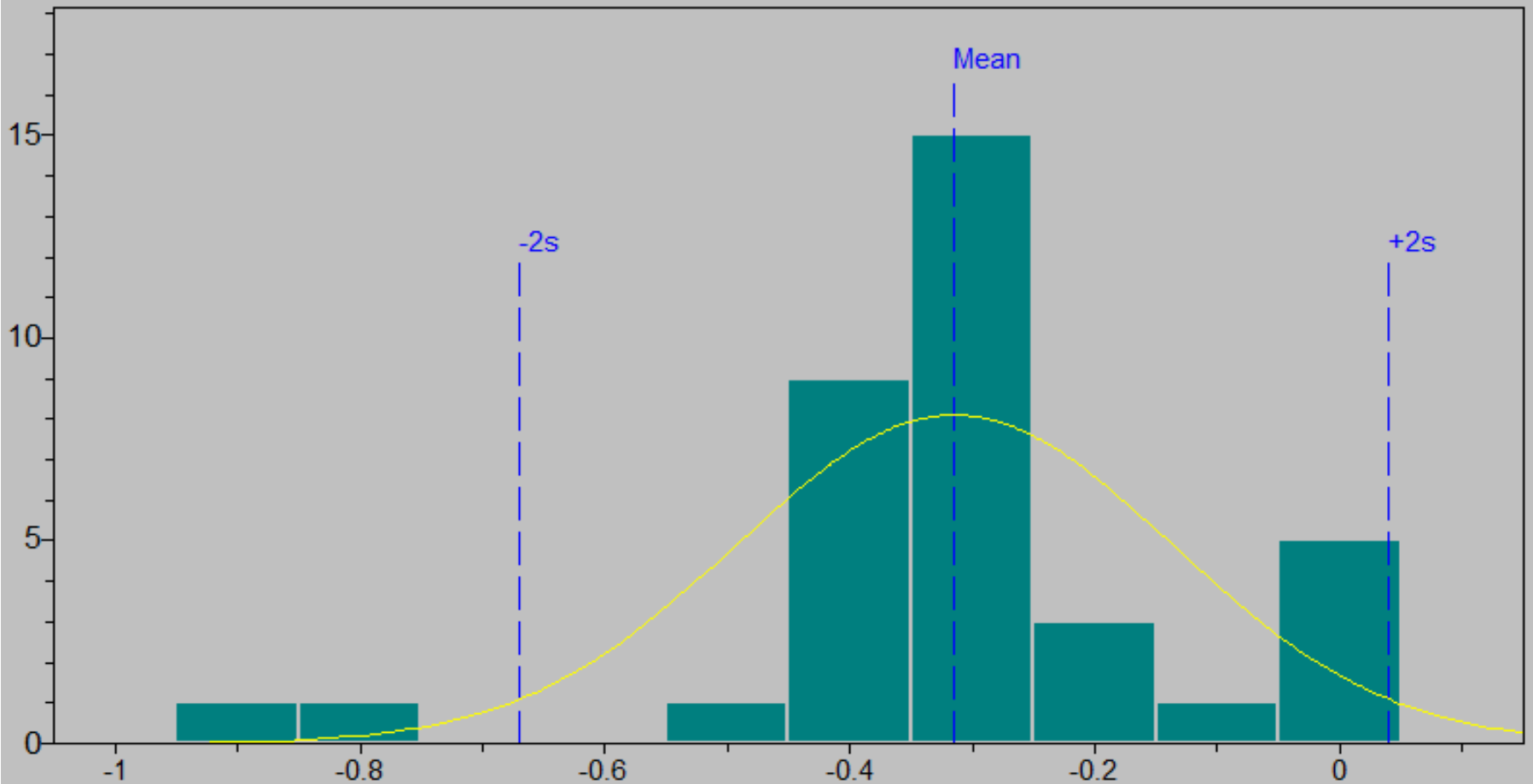
# Sample C Mass Change

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C Mass Change



# Sample C Mass Change

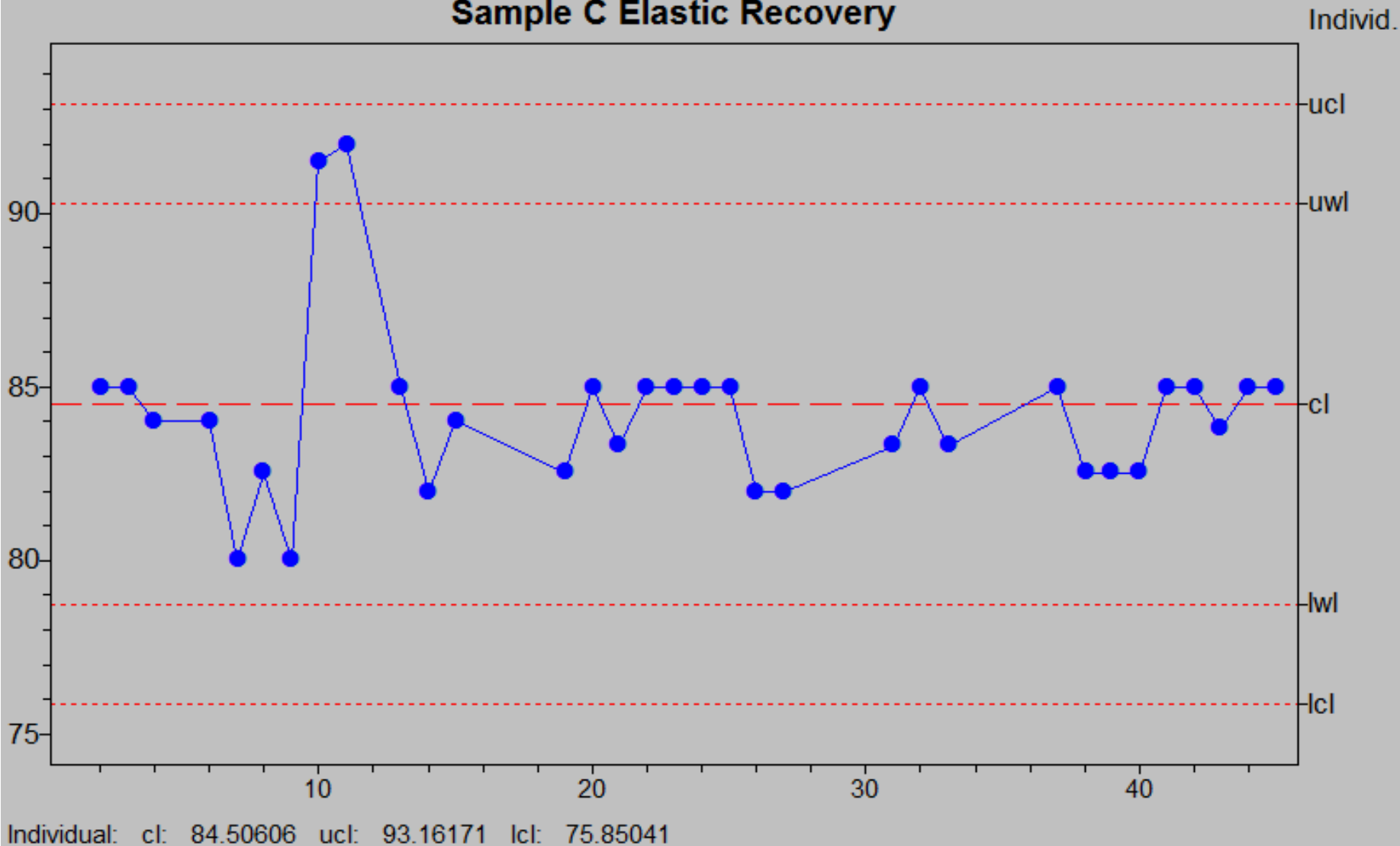
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C Mass Change



Samples:: 36      Skewness:: -0.87525  
Mean: -0.3148611  
Std Dev:: 0.1772219      Kurtosis: 5.3382

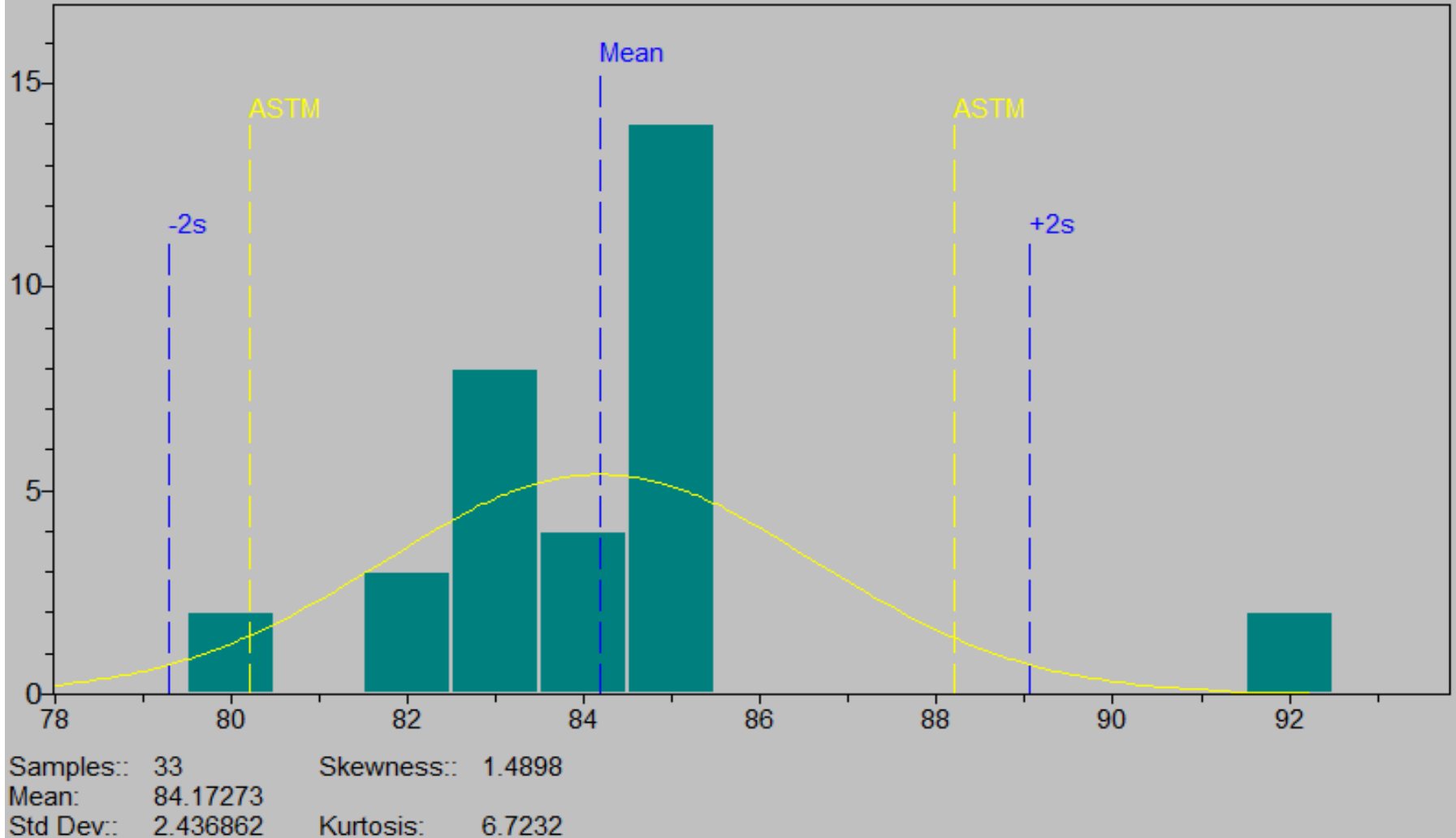
# Sample A Elastic Recovery

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C Elastic Recovery



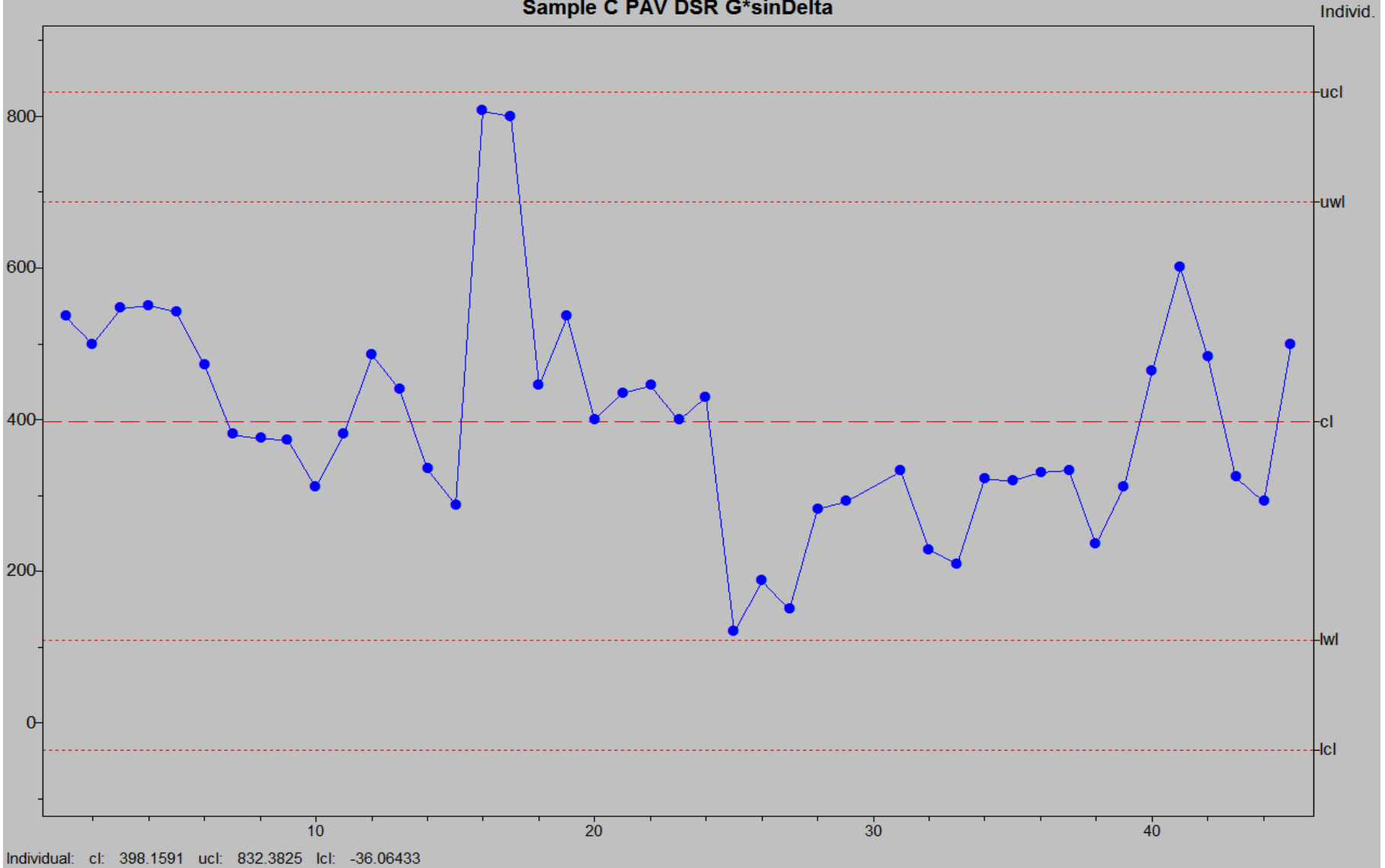
# Sample C Elastic Recovery

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C Elastic Recovery



# Sample C PAV DSR G\* $\sin\Delta$

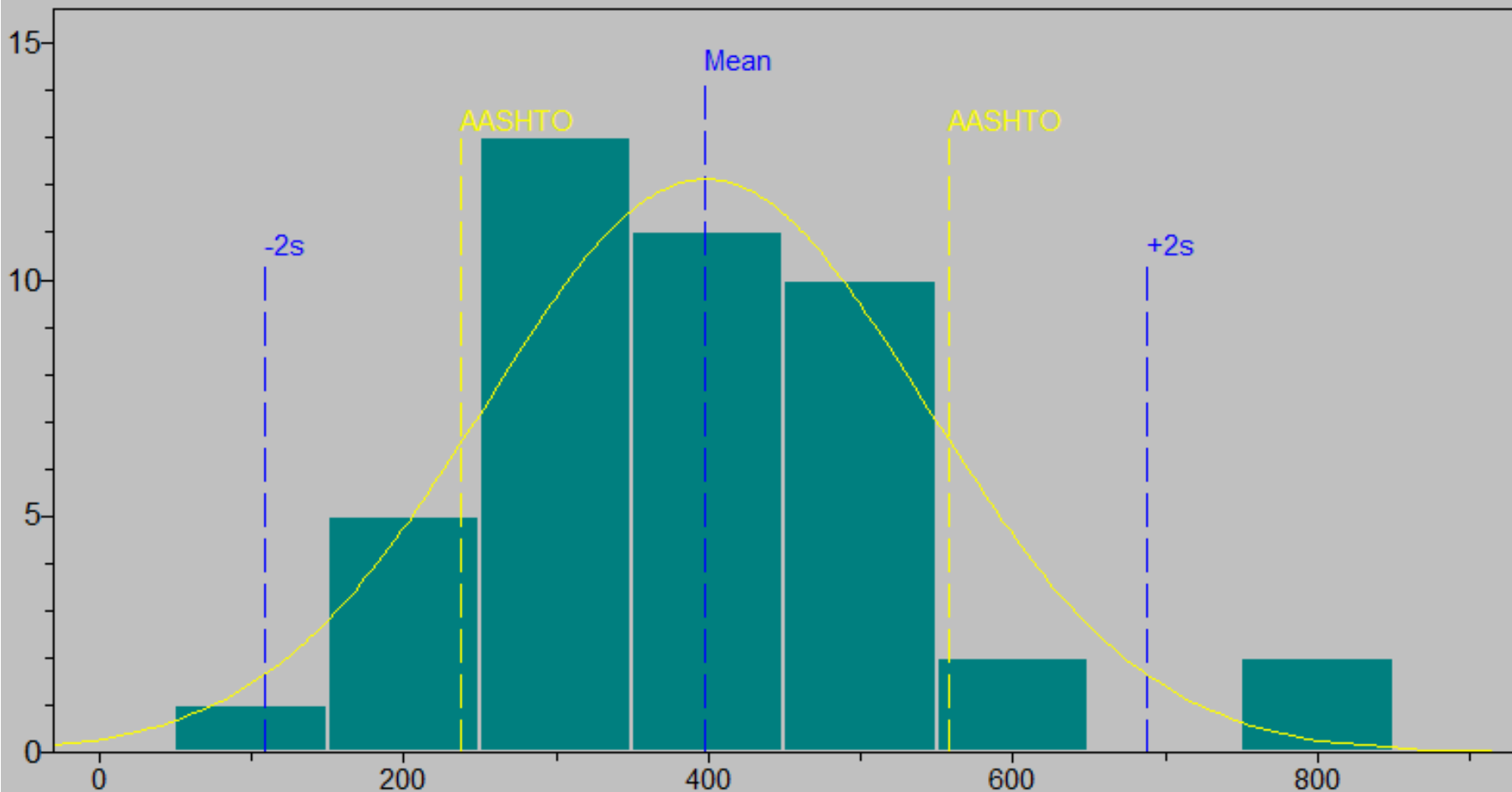
File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C PAV DSR G\* $\sin\Delta$





# Sample C PAV DSR G\* $\sin\Delta$

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C PAV DSR G\* $\sin\Delta$

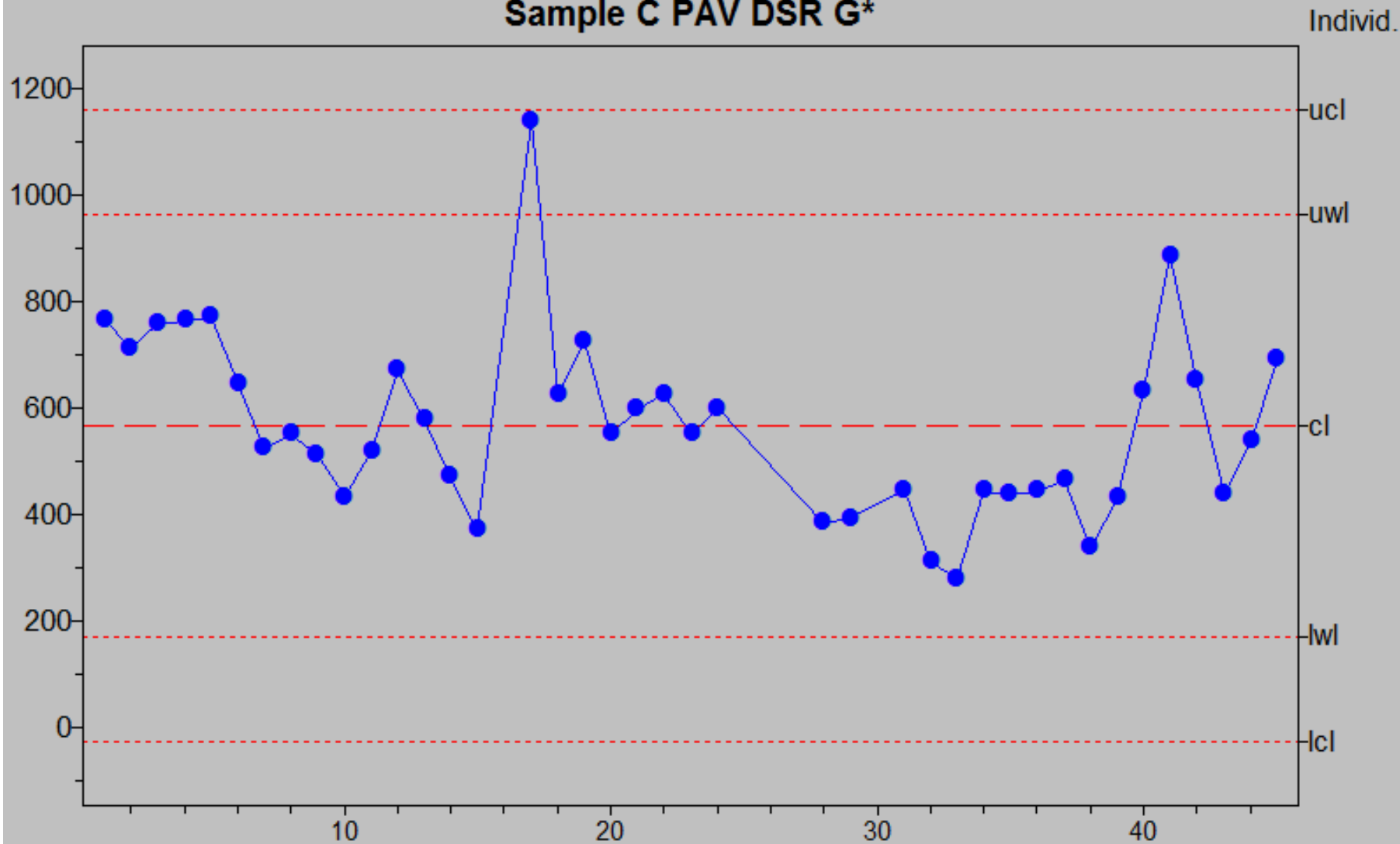


Samples:: 44      Skewness:: 0.69313  
Mean: 398.1591  
Std Dev:: 144.7411      Kurtosis: 3.9941

# Sample C PAV DSR G\*

File: PCCAS Asphalt Rubber Binder Sample C.DAT

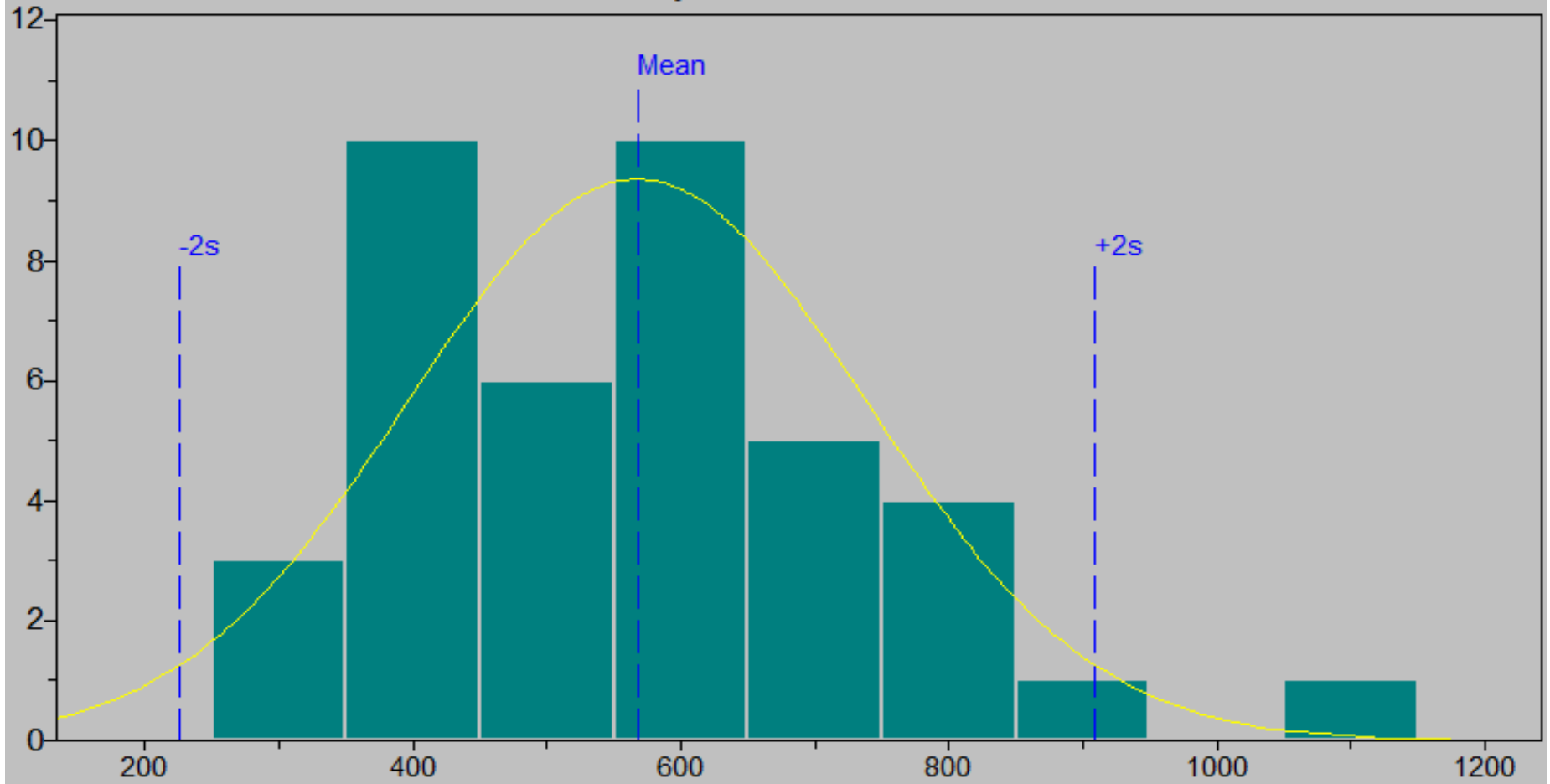
Sample C PAV DSR G\*



Individual: cl: 567.45 ucl: 1162.409 lcl: -27.5088

# Sample C PAV DSR G\*

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C PAV DSR G\*

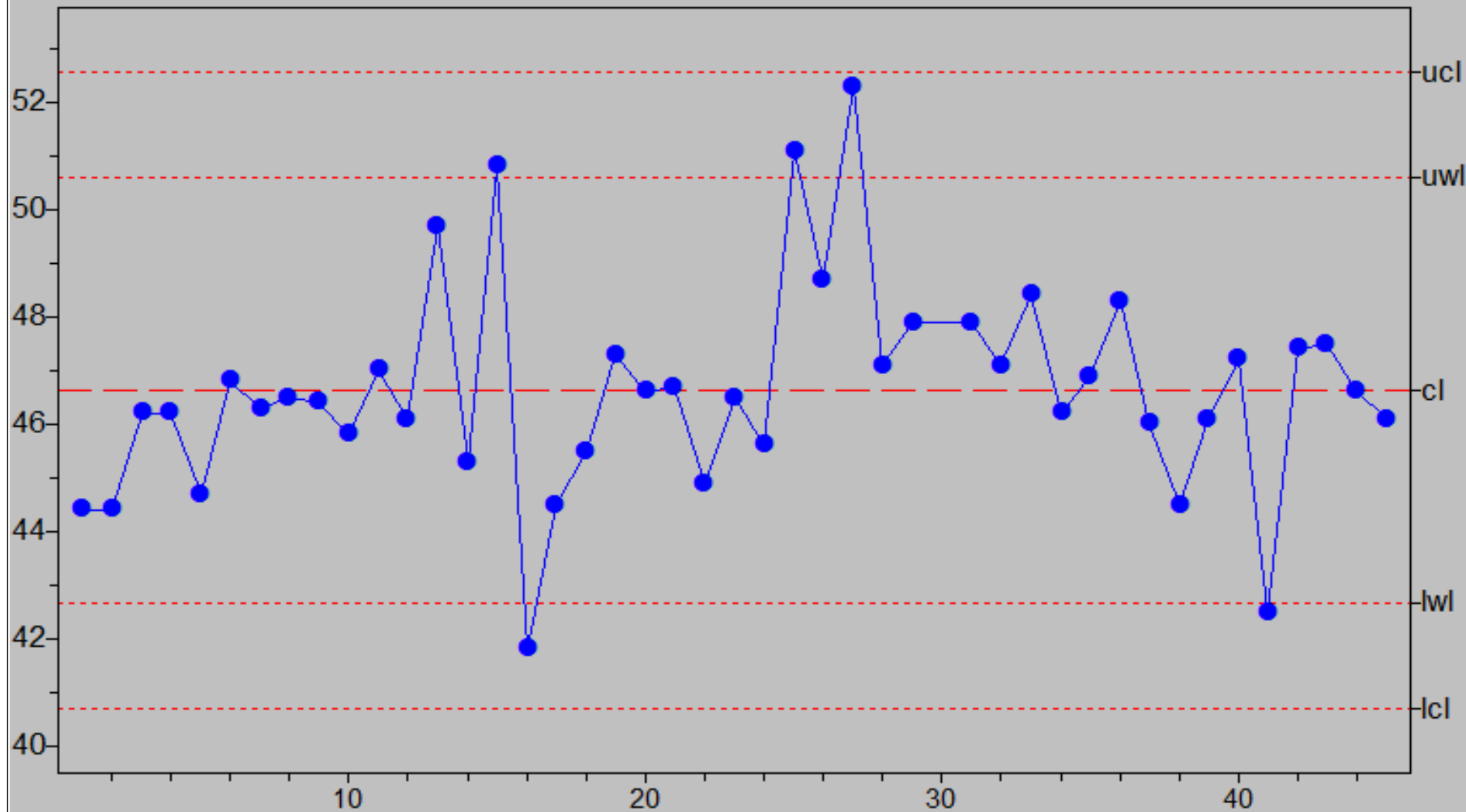


Samples:: 40      Skewness:: 0.91786  
Mean: 567.45  
Std Dev:: 170.5157      Kurtosis: 4.5209

# Sample C PAV DSR Phase Angle

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C PAV DSR Phase Angle

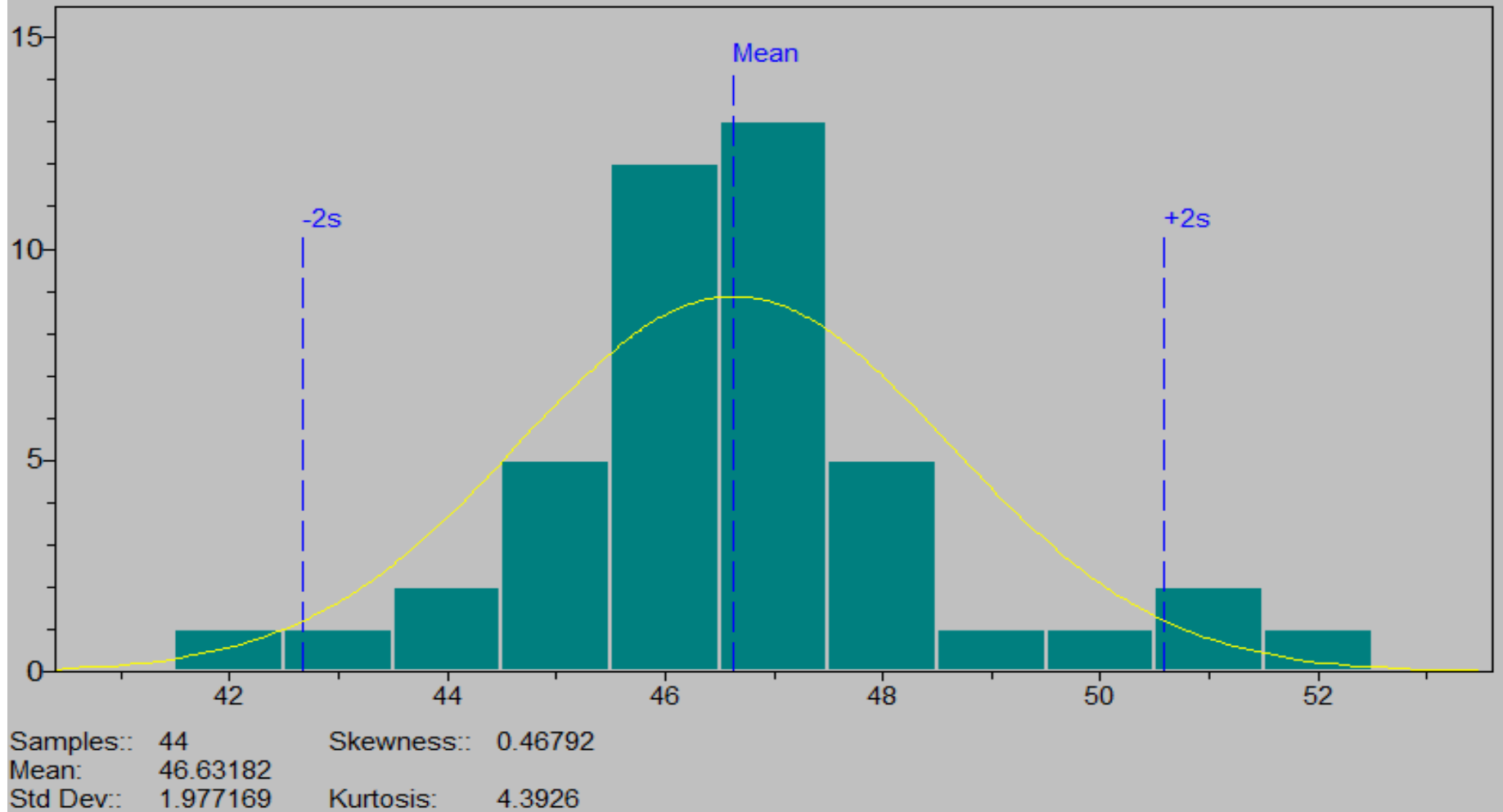
Individ.



Individual: cl: 46.63182 ucl: 52.56332 lcl: 40.70031

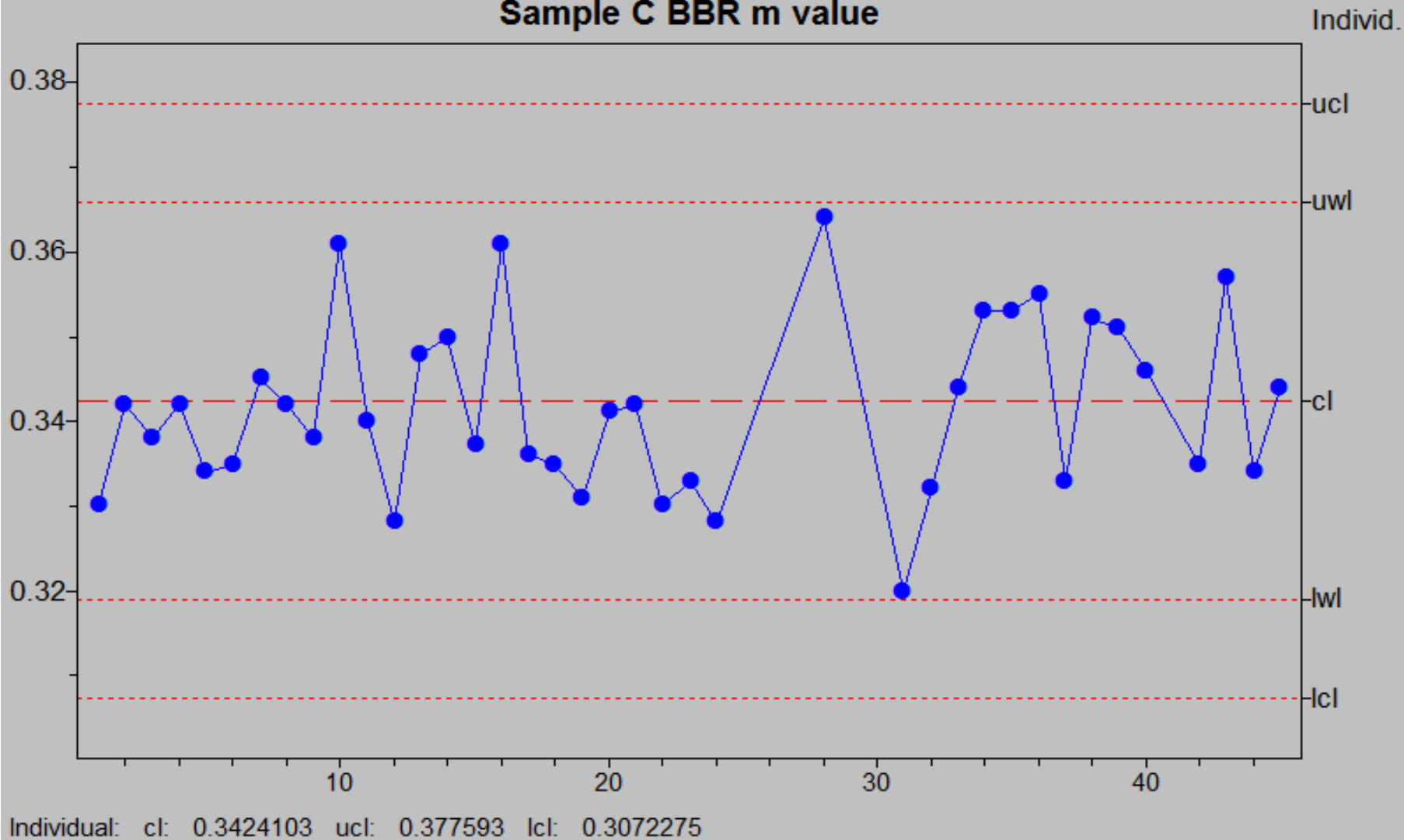
# Sample C PAV DSR Phase Angle

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C PAV DSR Phase Angle



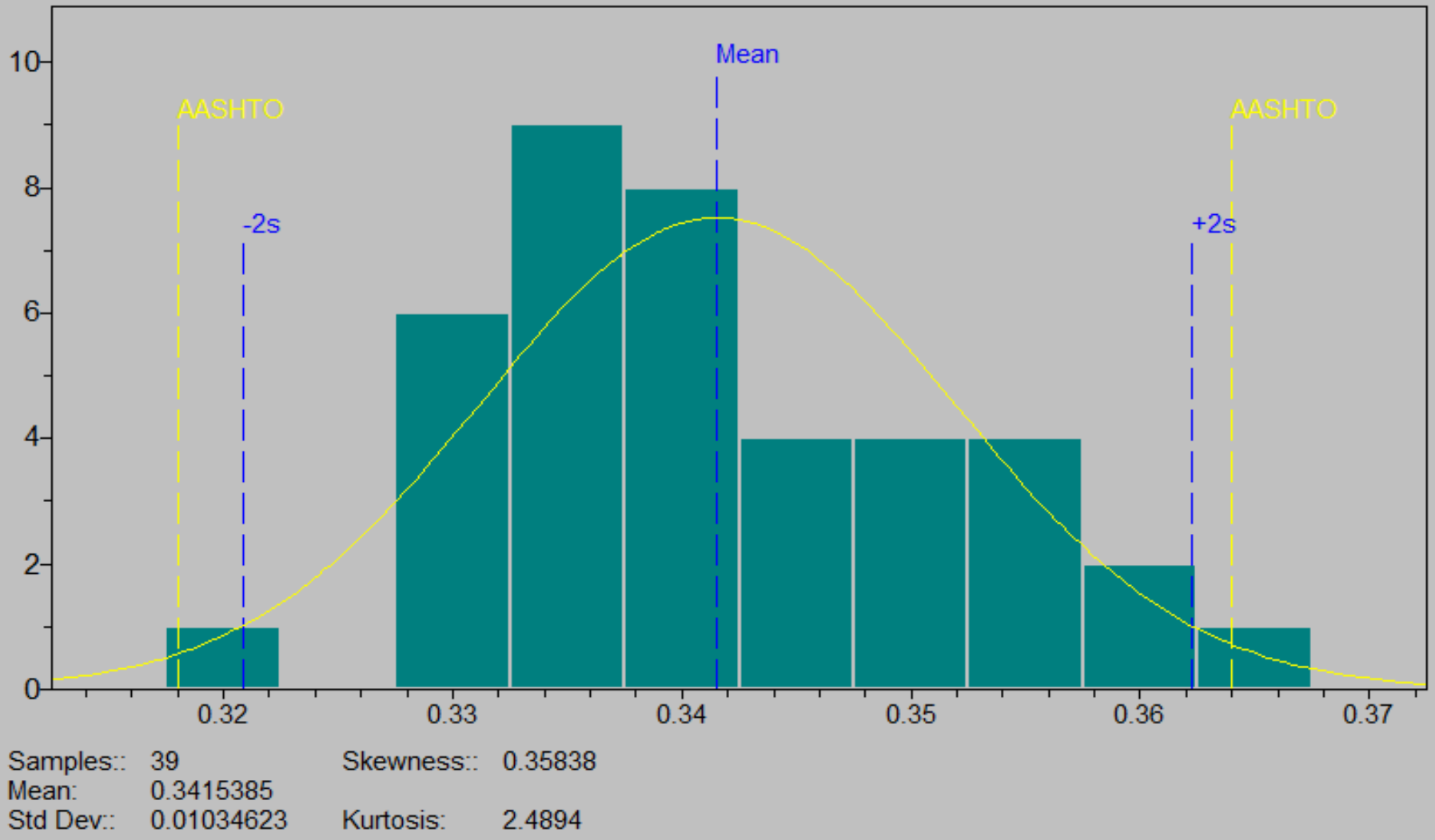
# Sample C BBR m value

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C BBR m value



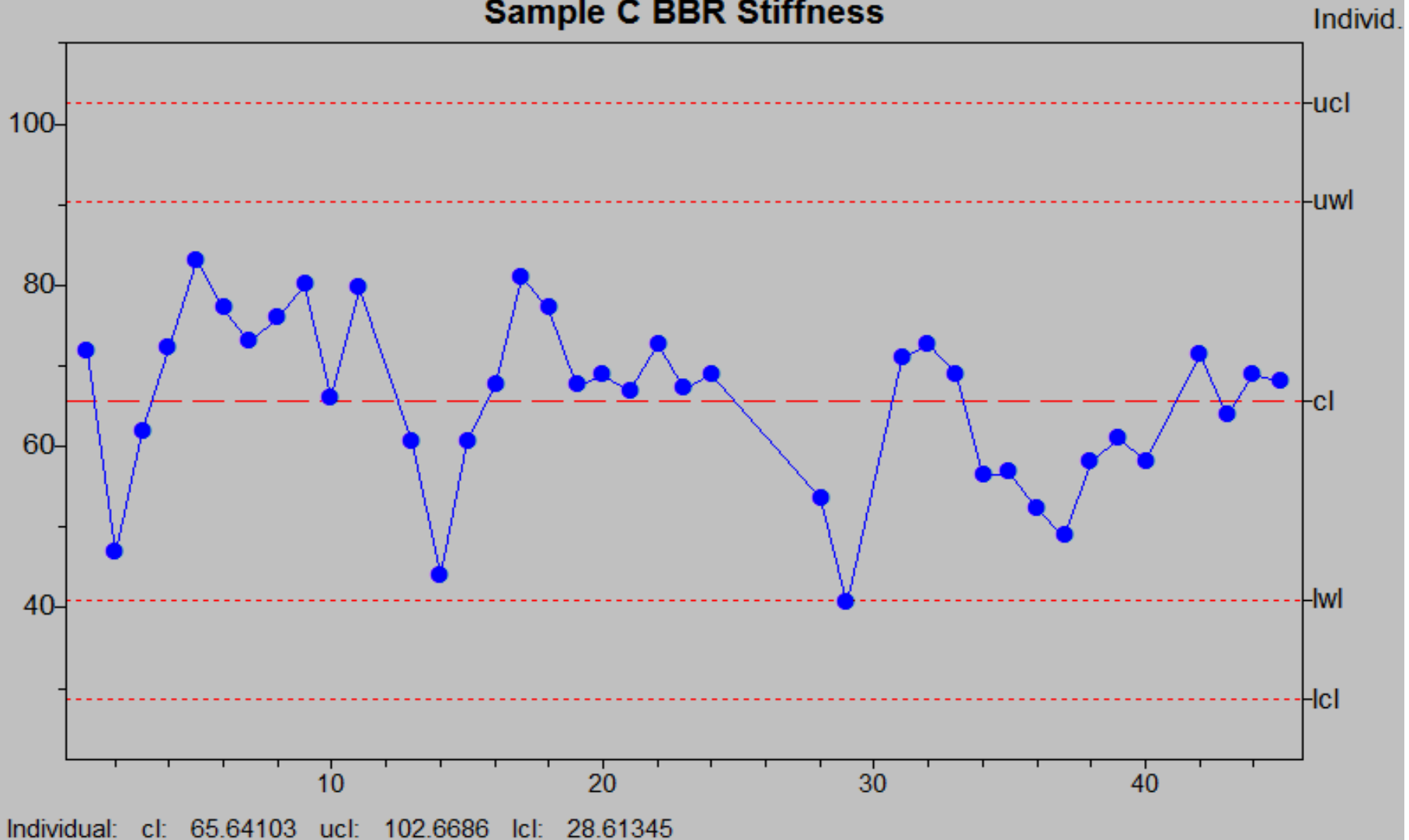
# Sample C BBR m value

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C BBR m value



# Sample C BBR Stiffness

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C BBR Stiffness





# Sample C BBR Stiffness

File: PCCAS Asphalt Rubber Binder Sample C.DAT  
Sample C BBR Stiffness

