MLM-MU-89-66-0002

A Study of Microclad Thickness Variation (1987)

Ram S. Ramachandran and Kenneth P. Armstrong

June 22, 1989

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P.O. Box 3000, Miamisburg, Ohio 45343-0987

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U. S. DEPARTMENT OF ENERGY
Contract No. DE-AC04-88DP43495

DISCLAIMER

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Contents

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Abstract

A study was conducted to investigate the thickness variation of microclad material used in fabricating 1E38 bridges. For the role sampled (nine reels), standard deviations within reels ranged from 6.11 to 12.07 µin. Thickness variations within reels ranged from 16.2 to 40.9 µin., with the average thickness between 142.90 and 161.28 µin.

Introduction

The MC3926 and 1E38 detonators were developed based on studies conducted by Quality, Production, and Development personnel. In the early stages of the programs, the tape process studies were documented in memos. To formally record these studies and make them easily available to interested persons, these memos are being compiled as Mound technical reports. This report documents research performed by R. S. Ramachandran in 1987.

To investigate the thickness variation of microclad (a copper-coated polyimide) used in 1E-38 bridges, a 12-in. role of 175-µin. microclad was slit into nine 35-mm reels. Reels 2 through 9 were each 250 ft long, and copper thickness was measured approximately every 5 ft. For reel one, which was 30 in. long, 75 readings were taken.

Thickness variations within the reels ranged from 16.2 to 40.9 µin. The most significant variations were noted in the outermost reels of the roll (1, 2, 8, and 9). The middle five reels showed acceptable variation. Standard deviations ranged from 6.11 to 12.07 µin., and the average reel thickness was between 142.90 and 161.28 µin.

Content

This report comprises three memos summarizing work performed in the tape process area. The memos are reproduced unedited.

MOUND

Inter-Office Correspondence

From : R. S. Ramachandran

cc : Distribution
File

Date : January 12, 1987

Subject : Thickness variation of microclad bridge material (2 mil)

Reference :

TO : L. J. Karnowski

A 12" roll of 175 microinch microclad material for the 1E38 bridge (Roll number 1 from QC #36396) was slit into nine 35 mm reels. Reels #2 thru #9 were tested for thickness variation by the Eddy Current method (calibrated with PVD materials). Thickness measurements (approx. every 5 feet) were taken along the length of 250 feet of each reel and the summary data are provided in the attached table. Reel #1 which was measured earlier (75 readings within 30 inch length) gave an average thickness of 142.9 microinch (lowest) and a standard deviation of 12.07 micro-inches (highest).

Chart 2 (Standard deviation of thickness measurements on reels by position on the 12-inch roll width of microclad material) exhibits a significant thickness variation within the length of the reel, especially, for the extreme four reels (#1, #2, #8 and #9). The center five reels (#3 thru 7) show acceptable deviation along with acceptable average thickness (Chart 1) measurement. It should be noted that Eddy Current method has a bias of an absolute value by about -32 microinches.

I recommend that reels 3, 4, 5, 6, and 7 which show good consistency in thickness reading be used for the 1E38 Qual 1 lot production. The other four reels should be placed on HOLD for developmental studies.

The current plan is to use the Reel #2 for correlation studies of thickness measurement capability of Eddy Current vs. Laseruler and vs. Betaback scatter. For this study reel #2 needs to be etched (1E38 bridge configuration). Please let me know when the reel will be available for the correlation study after completing the wet process on reel #2.

Also, when available, please provide me with the individual reel data on the remainder of rolls from this QC Stock (#36396). Further analysis of data will be performed to verify the trend of thickness variation within the length of the reel across the width of a microclad roll.

R.S Ramachandran

R. S. Ramachandran

TABLE 1

SUMMARY DATA OF 2 MIL MICROCLAD THICKNESS MEASURED

BY EDDY CURRENT METHOD

Reel #*	Number of tests **	Average thickness	Std. Dev. within the reel length	High Value	Low Value	Thickness Range within the reel
1	75***	142.90	12.07	150.2	134.0	16.2
2	50	147.94	12.06	167.5	126.6	40.9
3	50	154.40	7.36	166.4	137.0	29.4
4	51	160.41	6.11	169.3	144.1	25.2
5	35	155.96	7.05	167.6	141.4	26.2
6	36	155.72	8.16	167.7	139.4	28.3
7	50	157.81	7.10	172.2	139.9	32.3
8	50	161.28	9.77	179.5	141.3	38.2
9	38	158.66	11.55	174.3	137.0	37.3

* Roll #1 from QC Stock #36396.
** Thickness measured every five (5) feet (approximately).
*** 75 readings within 30 inch length tape of the reel #1.

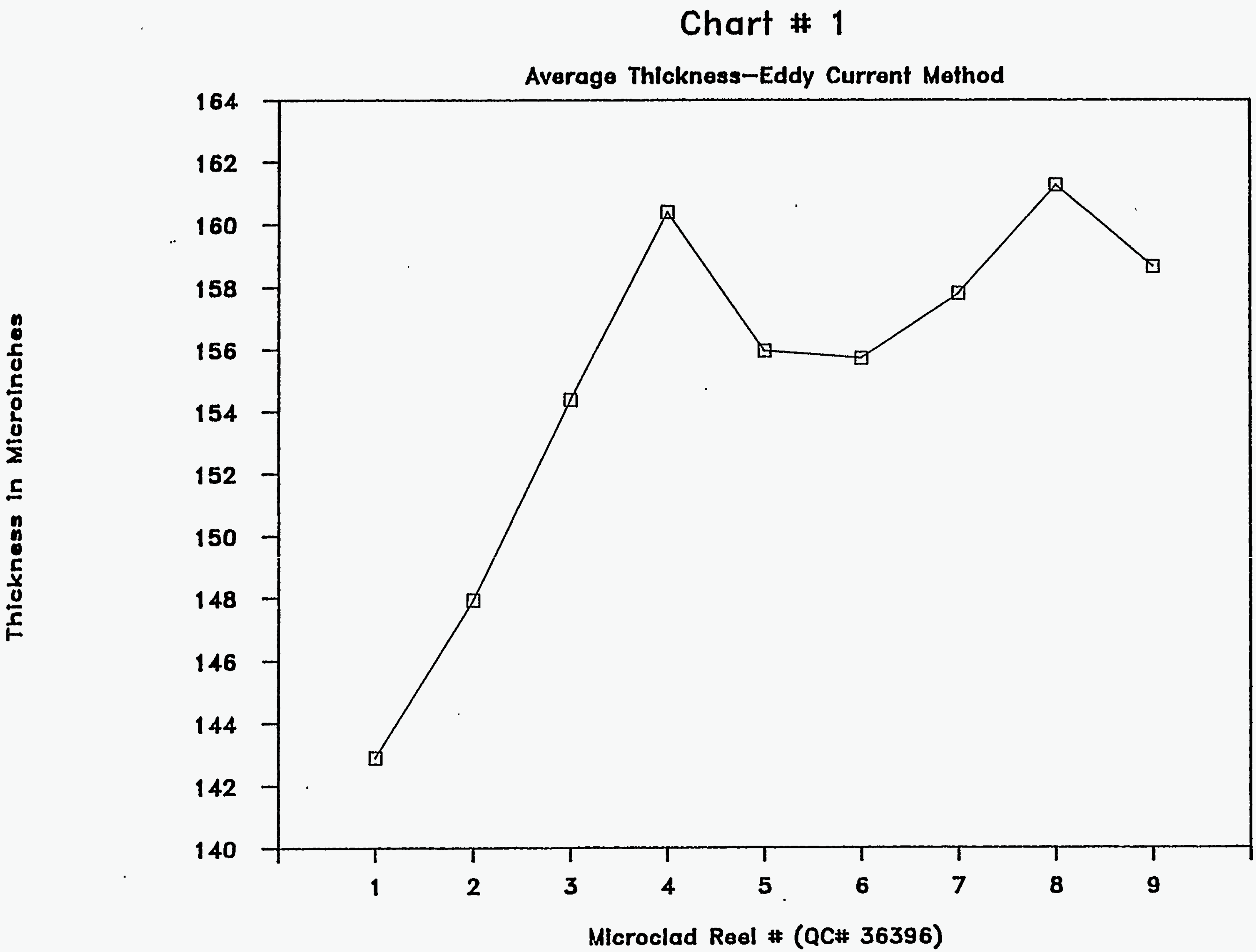
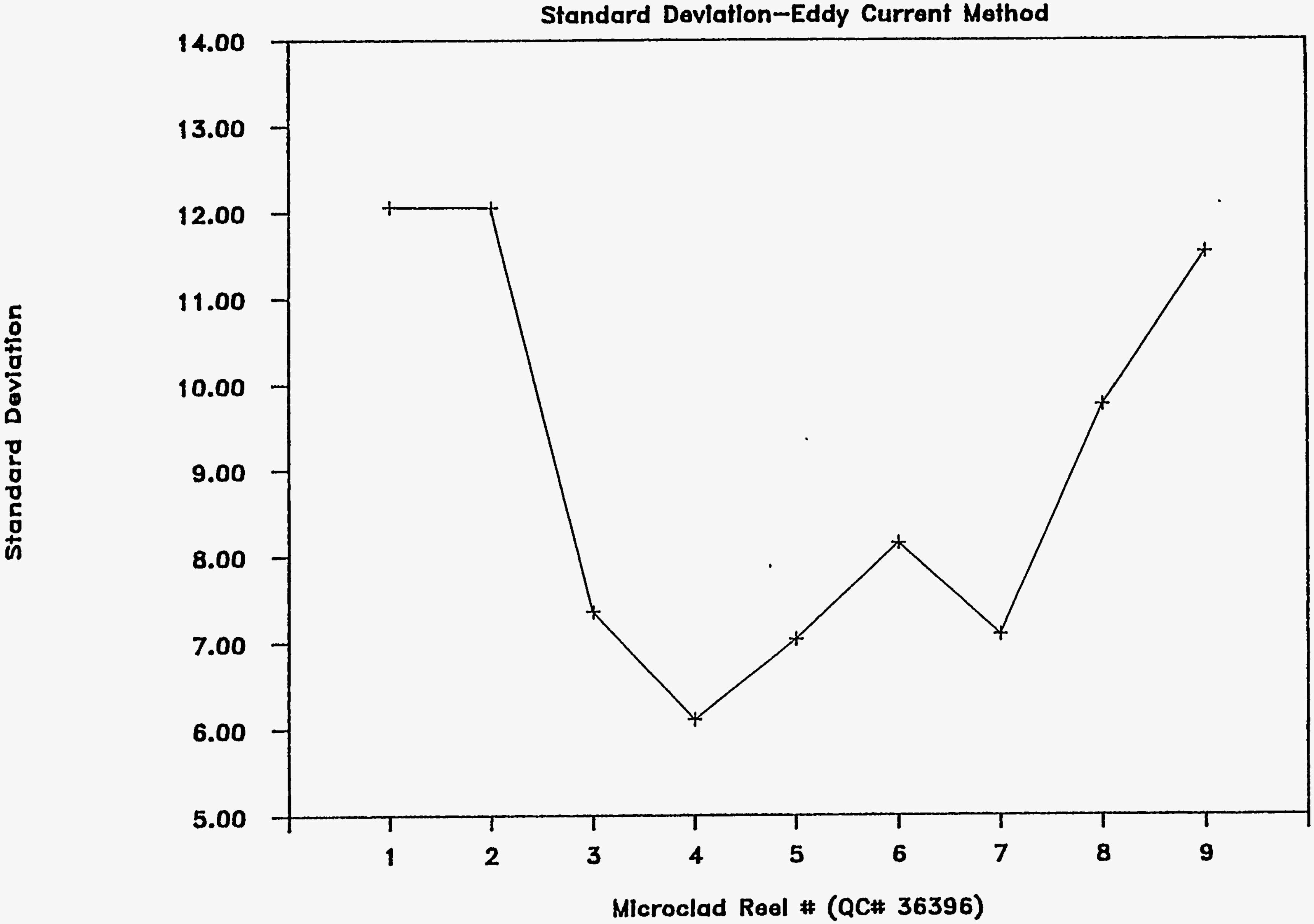


Chart # 1
Average Thickness–Eddy Current Method
Thickness in Microinches
164
162
160
158
156
154
152
150
148
146
144
142
140
1
2
3
4
5
6
7
8
9
Microclad Reel # (QC# 36396)

Chart # 2



Standard Deviation–Eddy Current Method
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
Standard Deviation
1
2
3
4
5
6
7
8
9
Microclad Reel # (QC# 36396)

MOUND

Inter-Office Correspondence

From :	Quality Engineering, Administration R. S. Ramachandran	cc :	J. Thomes D. Lentz T. Bruggeman W. Stitzel A. Hodapp A. Smith W. Hugo G. Morris A. Cox D. Hastings B. Hubbard J. Griffith B. Warner
Date :	June 23, 1987		
Subject :	Microclad raw material thickness study and Disposition of QC#37826		
Reference :			
TO :	M. Robinson		

Test Data: Receiving Inspection provided Eddy Current test data of QC#37826, microclad copper on kapton, 1E38 raw material. Measurements were made on the eight reels (22-29 from roll #2) which were slit into 35 mm from a roll of 12" width. Each of these reels contained approximately 250 length of material and measurements for copper thickness were made approximately every five feet.

Conclusion: The microclad copper thickness measurment by Eddy Current showed higher variation between the eight 35 mm reels (width of the roll) as compared to within the 250 feet length of reel. The same conclusion was obtained with the roll #1.

Results: Table 1 shows the average copper thickness for eight reels, adjusted for the bias (-32 microinches) due to the calibration technique using the PVD master standards and the standard deviation within each reel. The copper thickness variation along the 250 feet length is about 2.51 microinches (pooled standard deviation within the reels) with an overall average thickness of 172.3 microinches, excluding the outliers (n=326). The standard deviation between reels across the width of the roll was calculated to be 12.97 microinches.

Observations: Chart 1 provides a perspective view of response surface of the 359 data points across the width and length of the roll #2. Chart 2 shows the frequency distribution with all the data points (n=359) indicating some skewness and the Chart 3 shows the frequency plot deleting the data points after the 43rd (n=326) measurement along the length of each roll.

Plot 1 shows graphically the average copper thickness measurements by reel and the standard deviation within the reel for the eight reels, considering all the data points. Plot 2 shows average copper thickness across the width for each successive reading along the length of the reel for 43 data points and plot 3 is the standrd deviation between reels at each successive points across the width.

Disposition: Based on plot 1, 6, 7, 8, and 11, reels 4, 5, 6, and 9 show a good consistency in thickness measurements with an acceptable average. These reels are acceptable for 1E38 Qual 2 production. It is recommended that all the reels be visually inspected at 25X for pits, scratches, pin holes, etc. on the copper side first and then flyer side prior to dispositions.

The other reels 2, 3, 7, and 8 can also be accepted based on plots 4, 5, 9, and 10 after discarding the 40 feet of the lead end of the roll which shows some unusual high copper thickness. The rest of the 210 feet of the reels indicate the thickness to be within +/- 10 microinches.

Further Action: Please address the average copper thickness level of 173 microinches, which is a slight shift in the target from 170 microinches requirement, with the Design Agency, LANL for future Quality acceptance of raw material.

Also, it is suggested that we discuss with the vendor, Fortin Industries, Inc., the variation across the width of the roll for possible improvement in future shipment.

Ram/gc

R. S. Ramachandran

RSR/gc
Attachments

TABLE 1

STATISTICAL DATA ON COPPER ON KAPTON
THICKNESS MEASUREMENT BY EDDY CURRENT

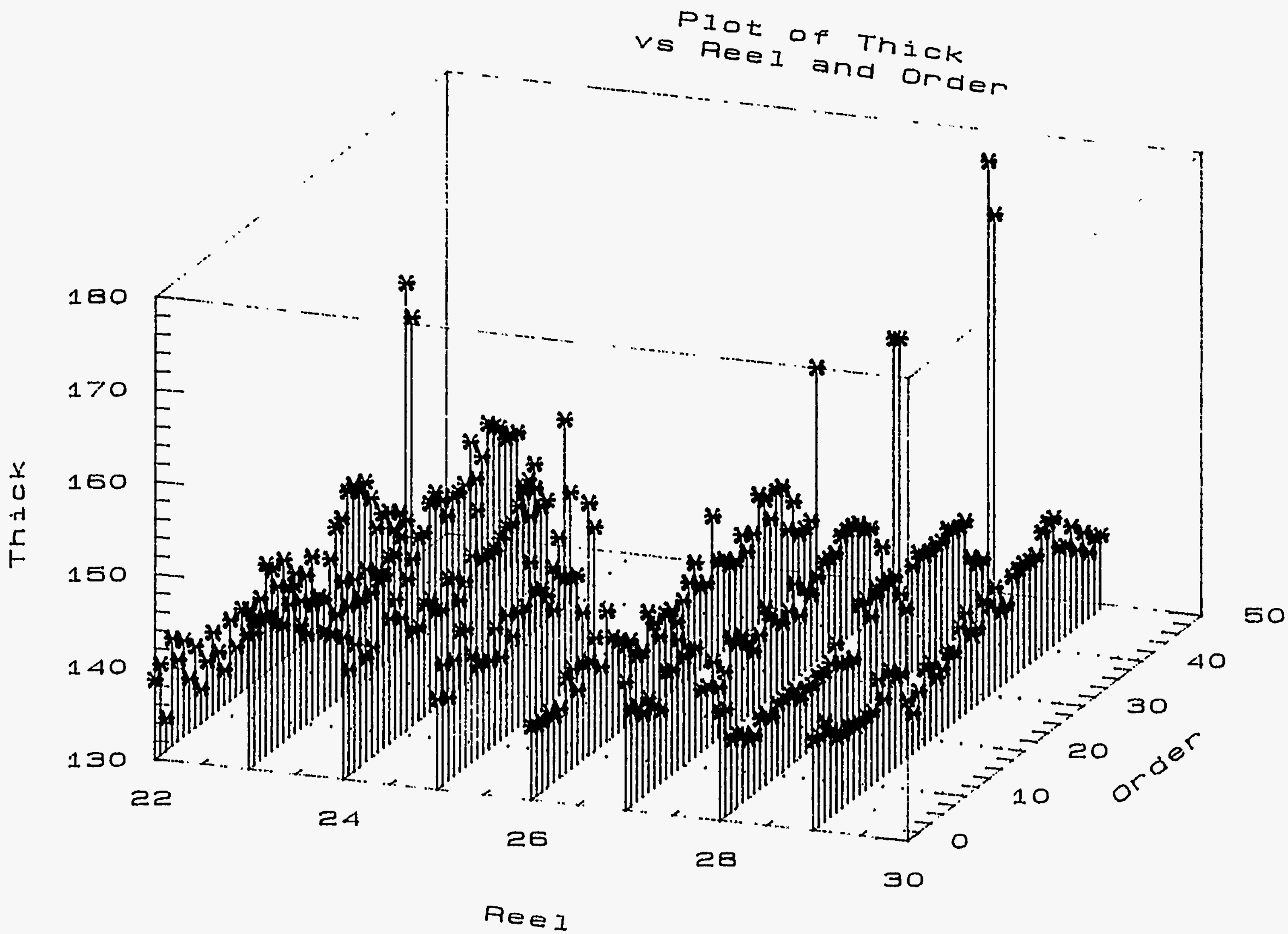
ROLL-REEL#	SAMPLE SIZE	$\bar{X}$	SIGMA	MIN	MAX
2-2	43	169.4	2.69	165.1	175.1
2-3	43	175.0	3.29	169.7	182.7
2-4	40	175.2	2.97	167.4	182.4
2-5	28	174.1	2.51	169.0	180.3
2-6	43	171.7	2.07	168.8	177.6
2-7	43	171.5	2.02	167.5	176.1
2-8	43	171.3	2.28	168.3	174.5
2-9	43	171.3	2.02	166.4	175.8
	326	172.3	2.51	165.1	182.7

-The data is adjusted for the Eddy Current bias of -32 microinches

-33 data points after 210 feet of the roll #2 considered as outliers, not included

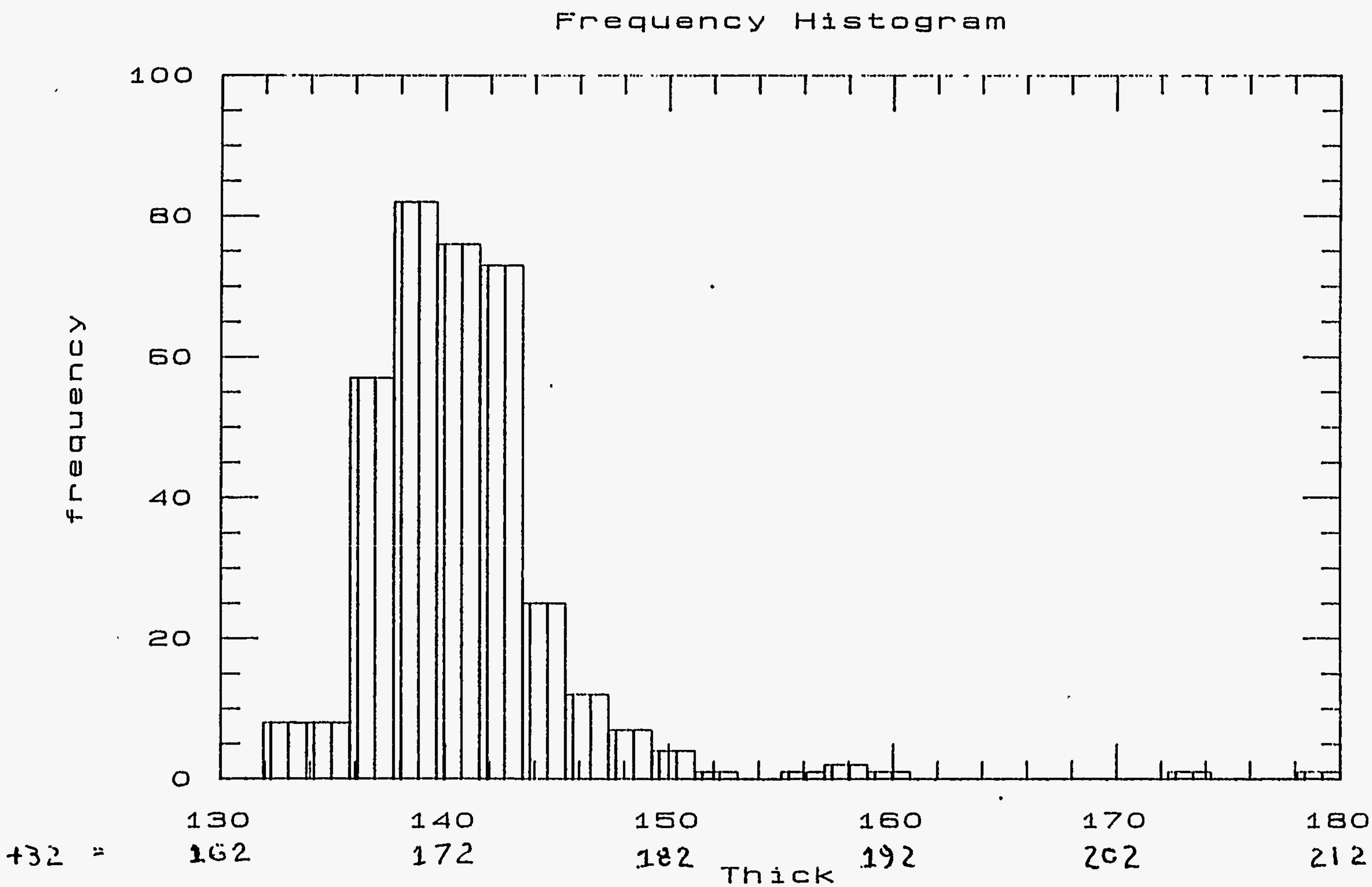
-The overall average thickness of the roll #2, including the outliers (n=359), is 172.8 microinches with a pooled standard deviation of 4.45 μin.

CHART 1



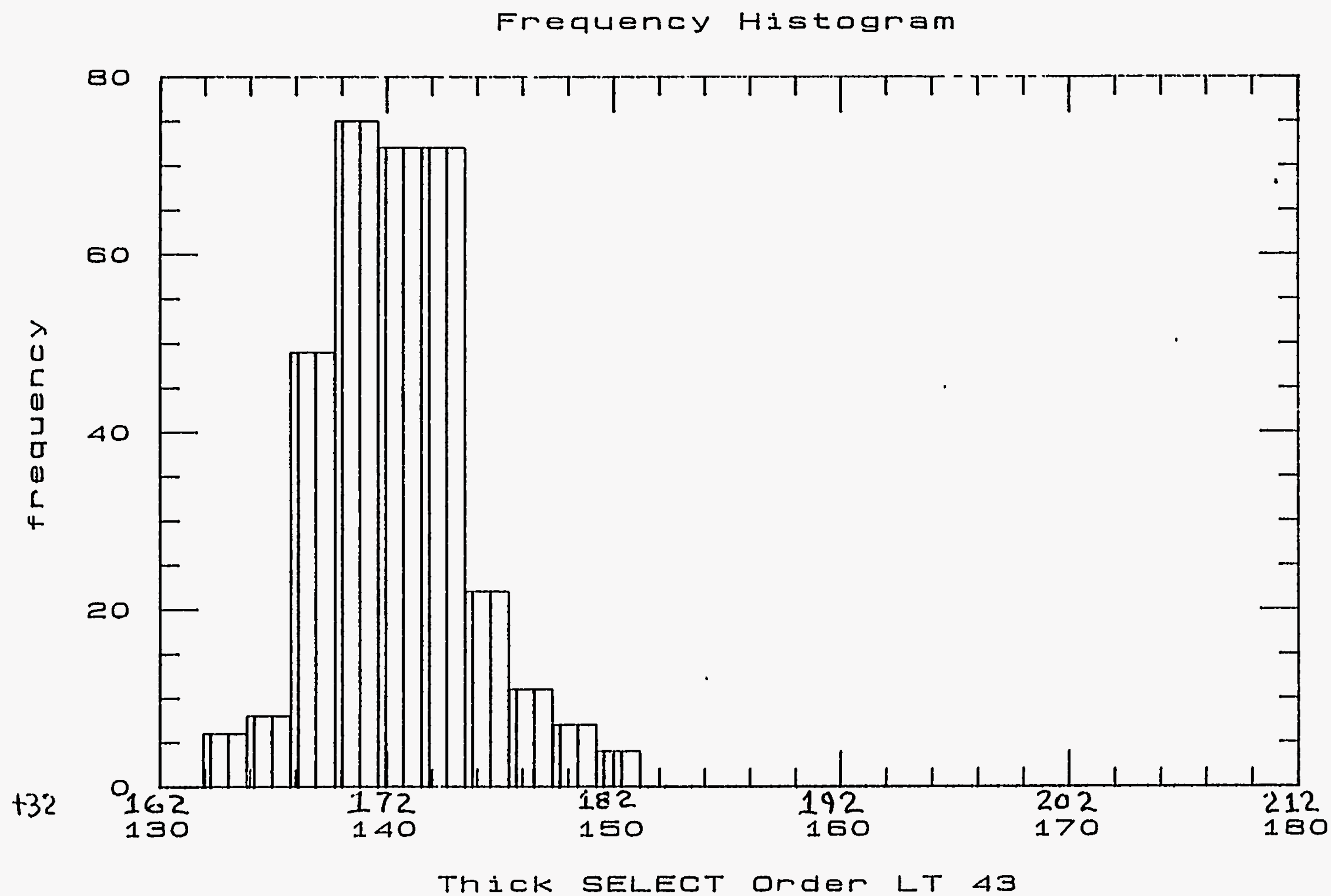
Plot of Thick
vs Reel and Order
Thick
180
170
160
150
140
130
22
24
26
28
30
Reel
0
10
20
30
40
50
Order

CHART 2

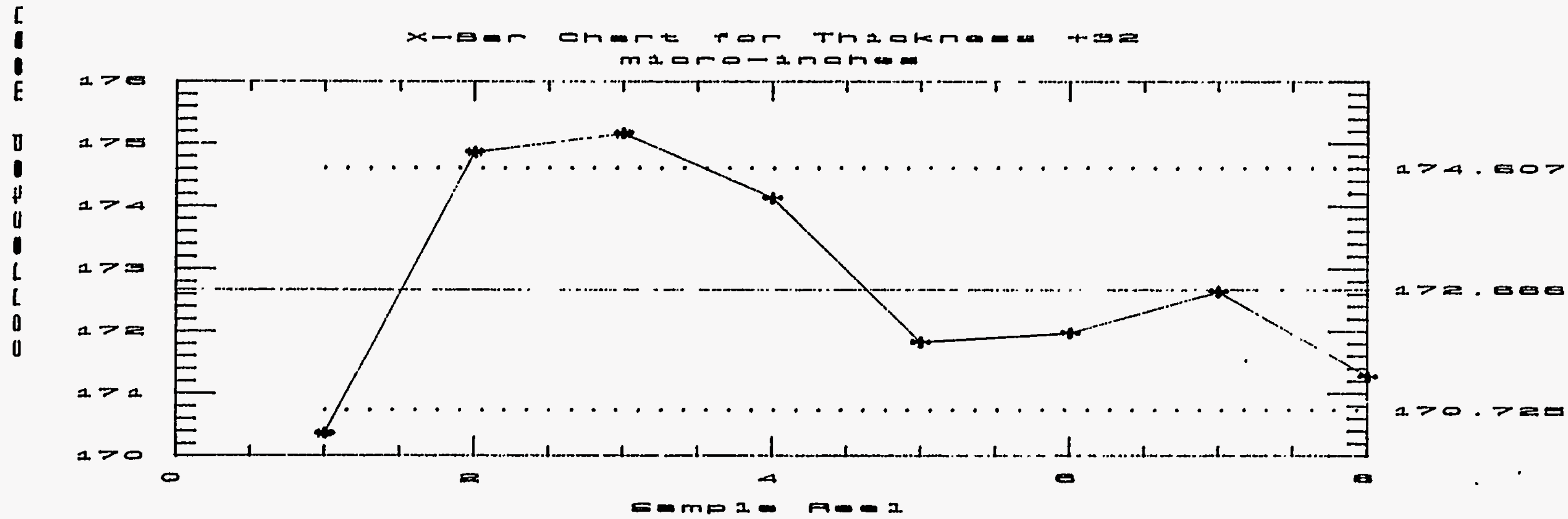


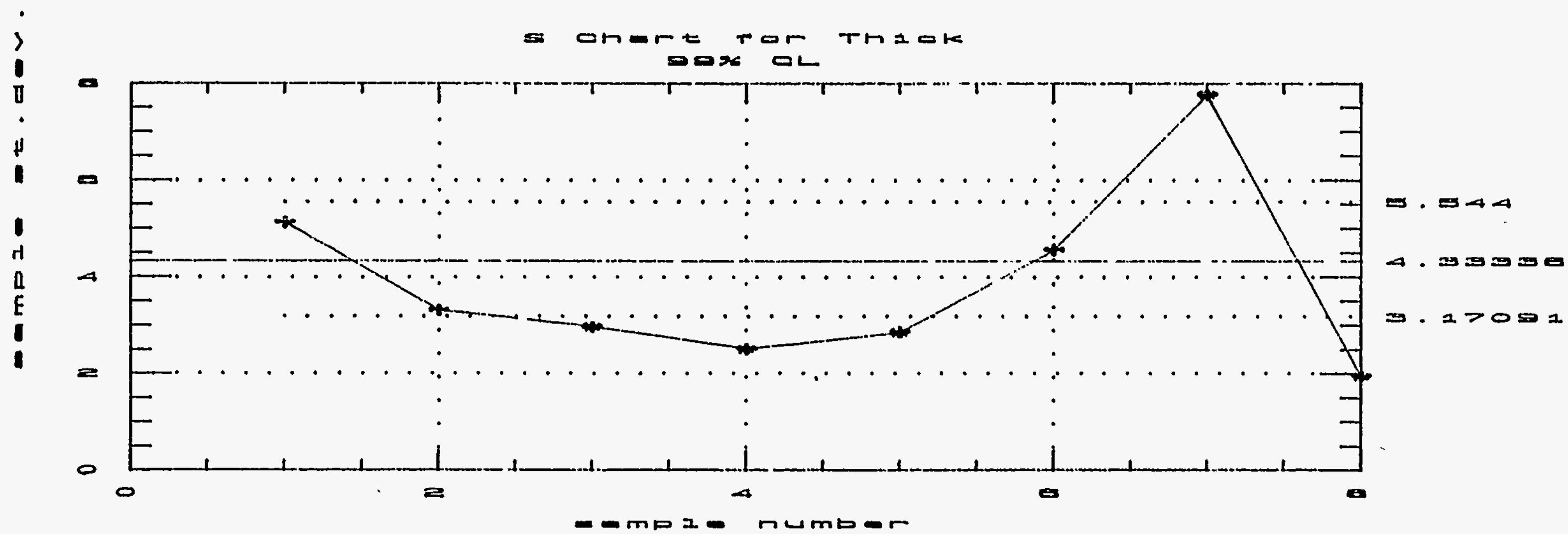
Frequency Histogram
frequency
100
80
60
40
20
0
130
140
150
160
170
180
+32 =
162
172
182
192
202
212
Thick

CHART 3


Frequency Histogram
frequency
80
60
40
20
0
+32
162
172
182
192
202
212
130
140
150
160
170
180
Thick SELECT Order LT 43

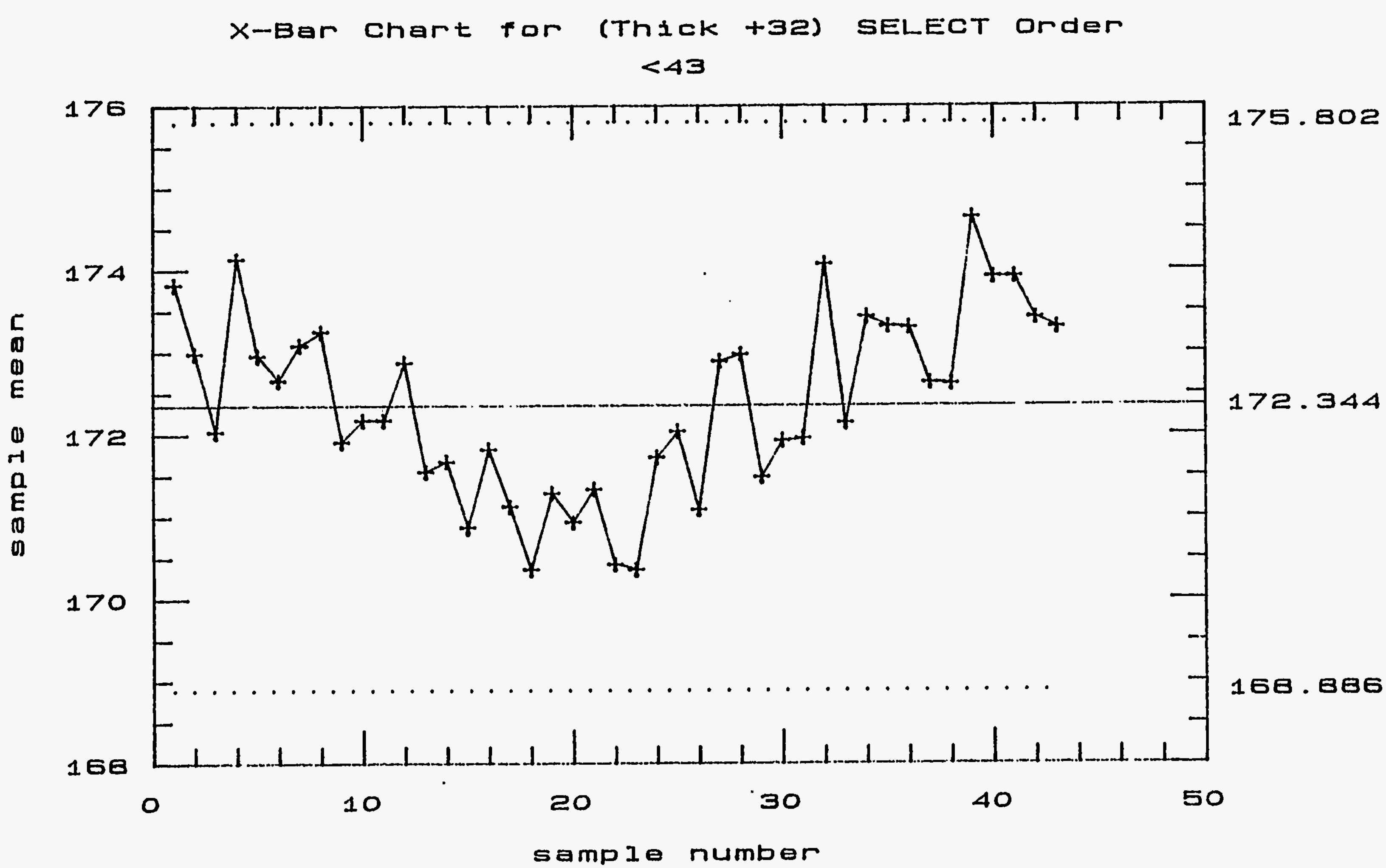
PLOT 1


X-Bar Chart for Thickness +32
micro-inches
170
171
172
173
174
175
176
174.607
172.666
170.725
0
2
4
6
8
Sample Reel

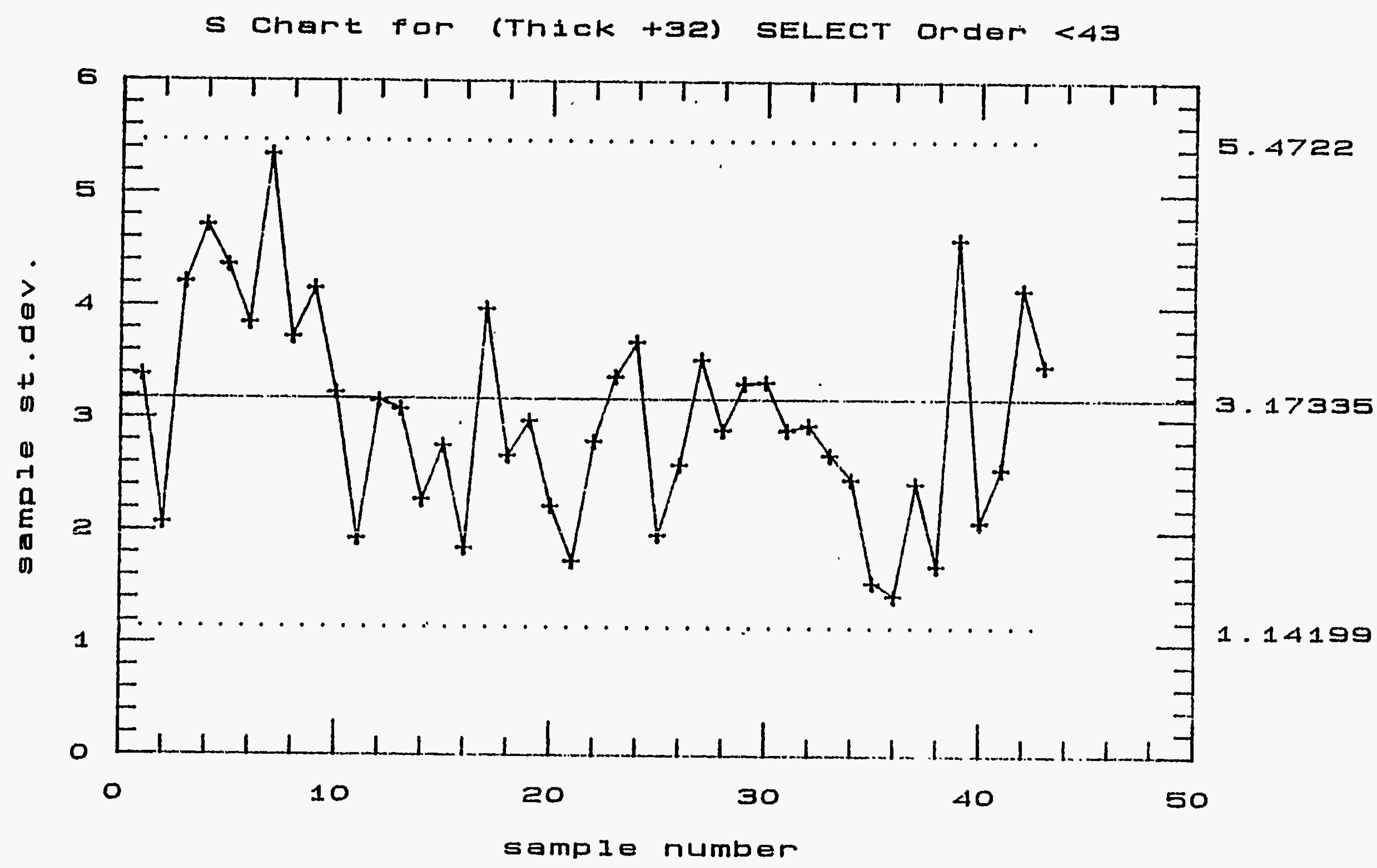

S Chart for Thick
99% CL
0
2
4
6
8
5.544
4.33338
3.17091
sample number

14

PLOT 2

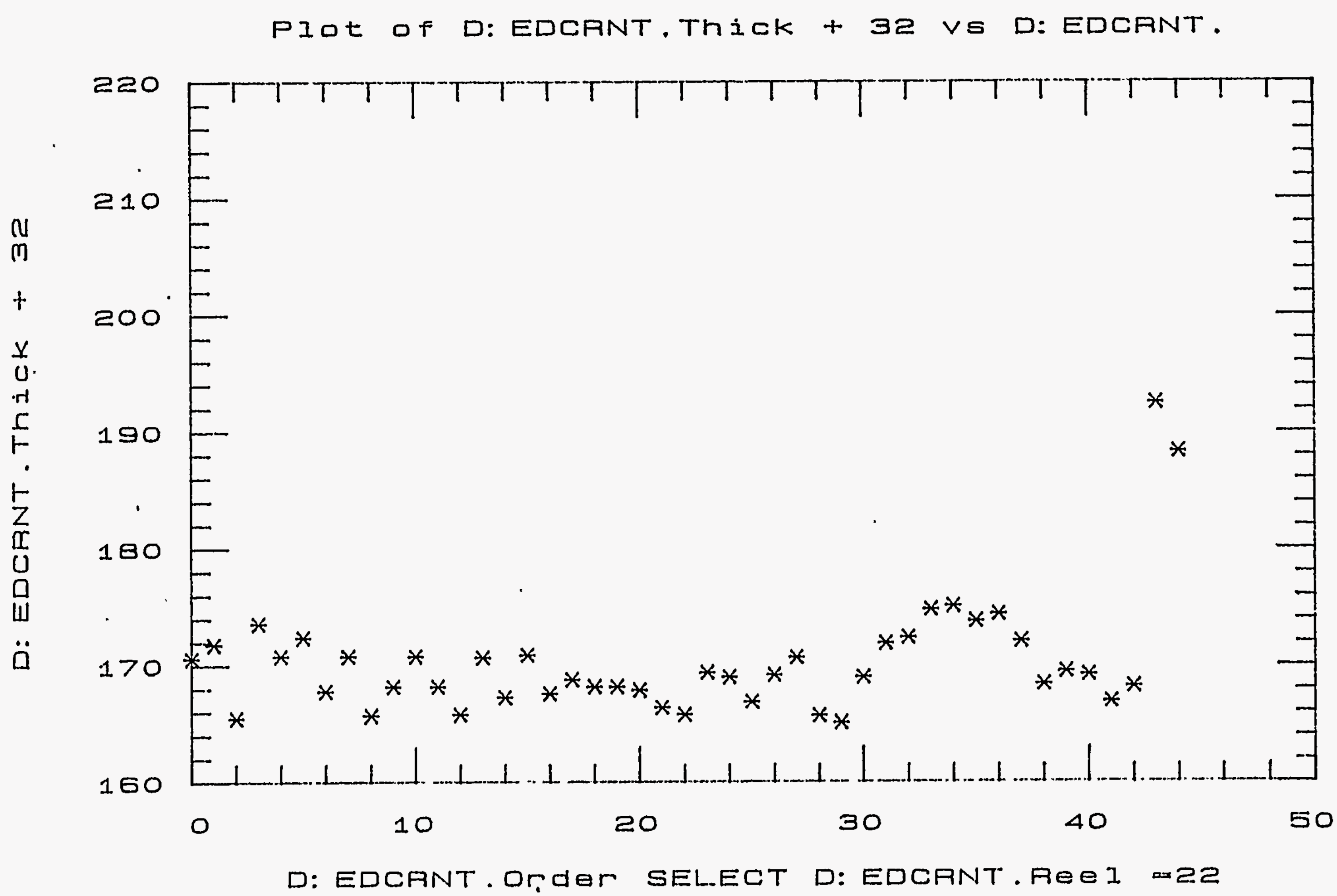

X-Bar Chart for (Thick +32) SELECT Order
<43
176
174
172
170
168
175.802
172.344
168.886
0
10
20
30
40
50
sample mean
sample number

PLOT 3

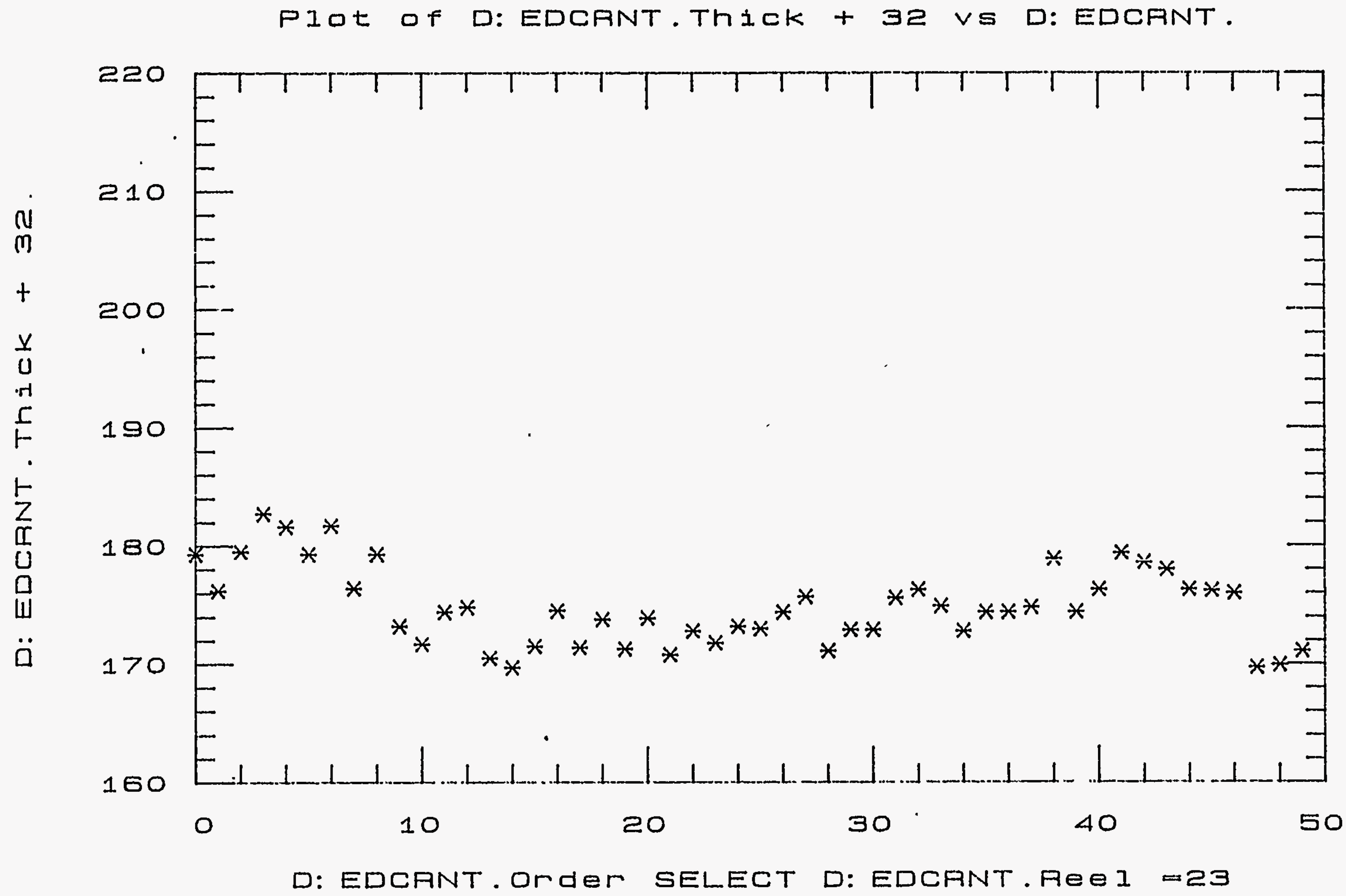


S Chart for (Thick +32) SELECT Order <43
sample st.dev.
sample number
0
1
2
3
4
5
6
10
20
30
40
50
5.4722
3.17335
1.14199

PLOT 4

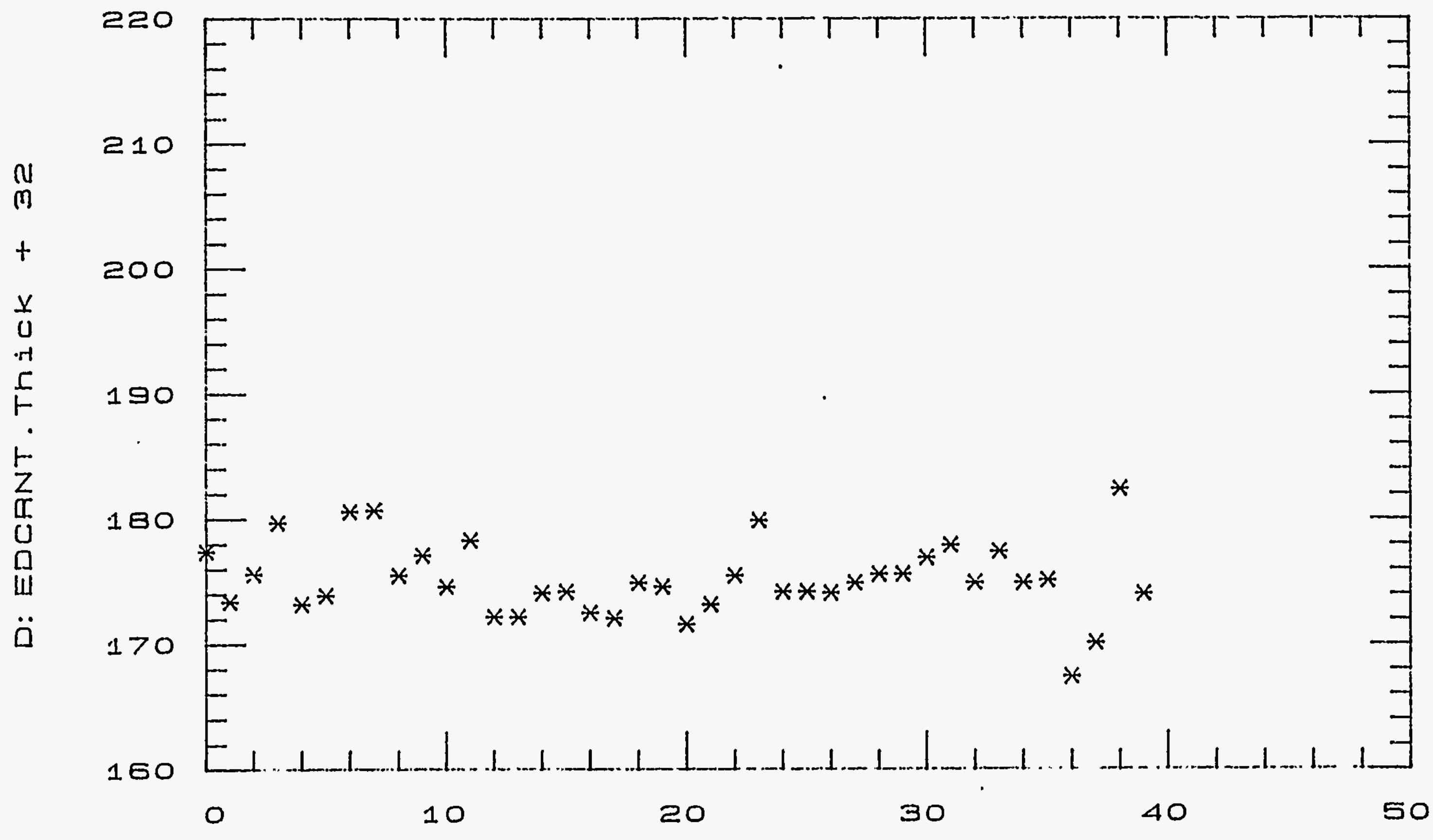

Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.
D: EDCRNT.Thick + 32
160
170
180
190
200
210
220
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =22

PLOT 5

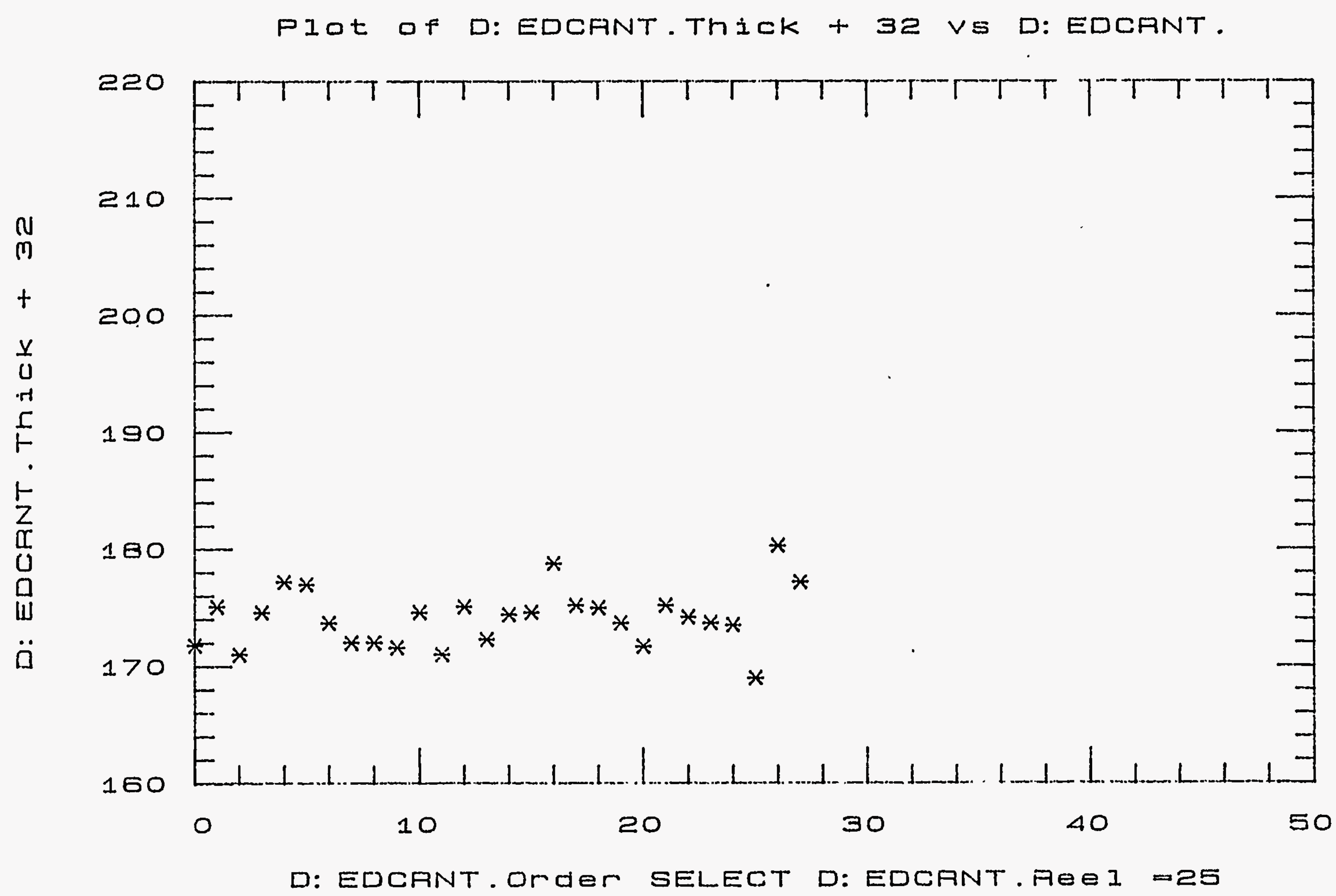

Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.
220
210
200
190
180
170
160
D: EDCRNT.Thick + 32.
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =23

PLOT 6

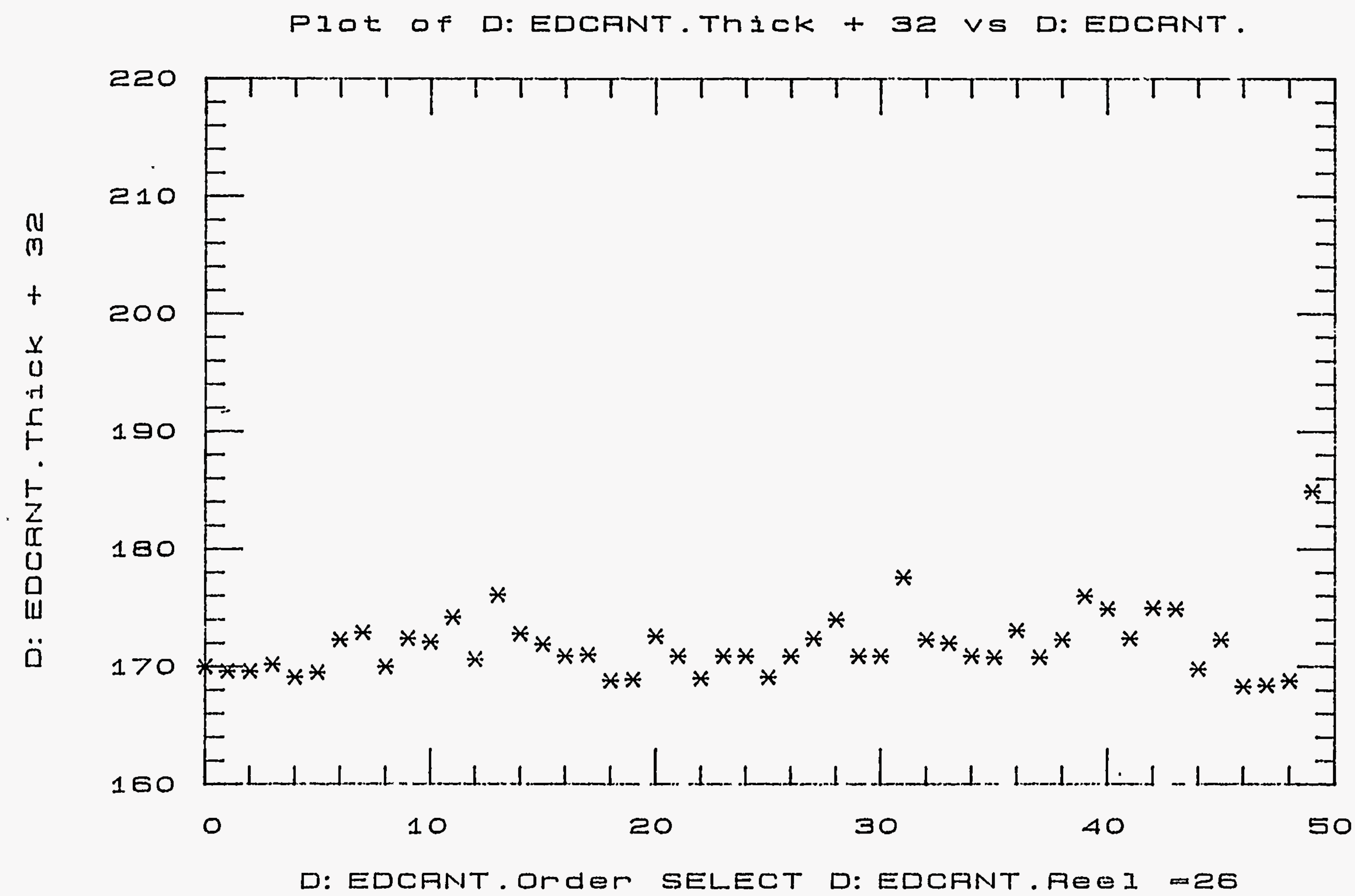
Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.



PLOT 7

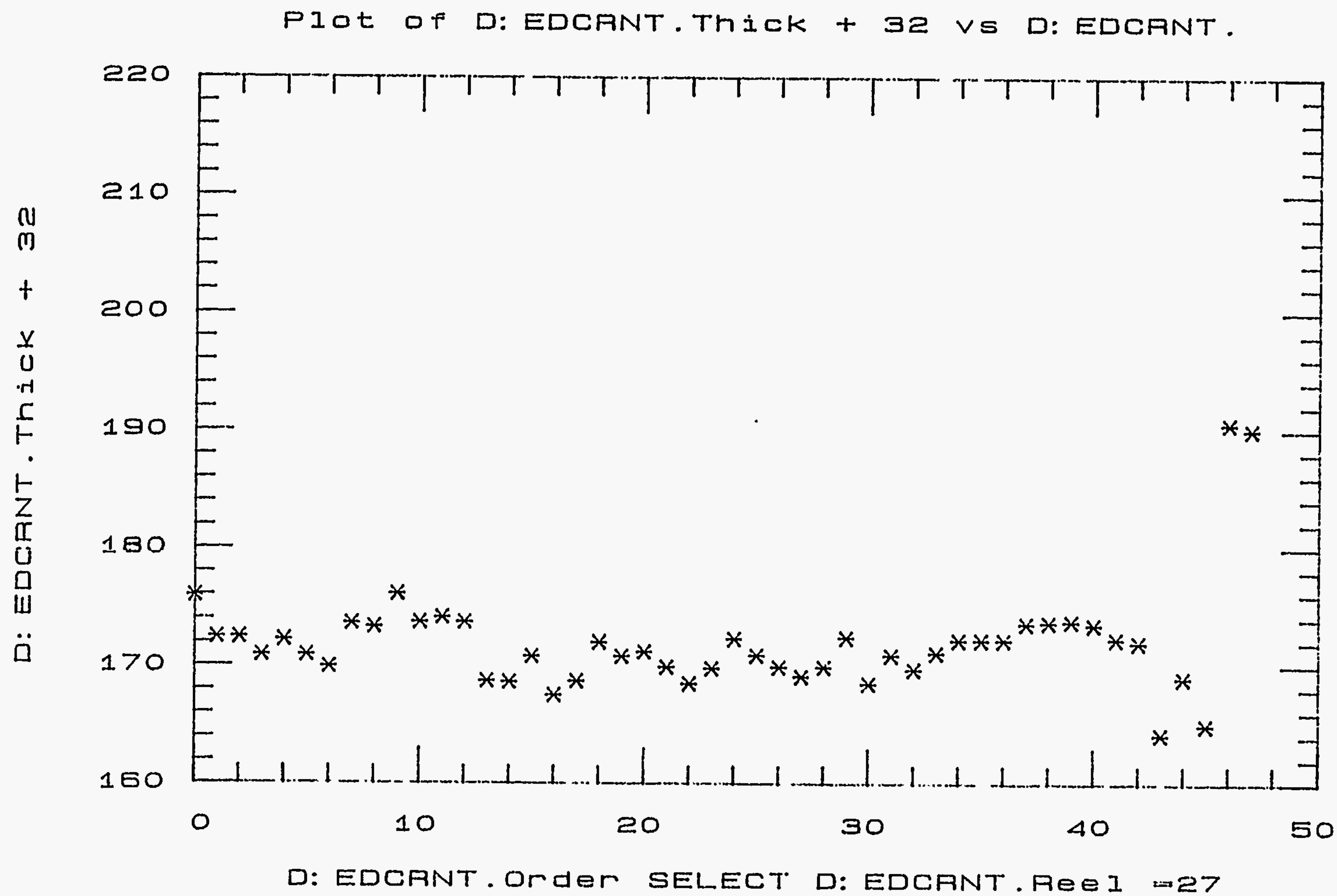

Plot of D: EDCANT.Thick + 32 vs D: EDCANT.
220
210
200
190
180
170
160
D: EDCANT.Thick + 32
0
10
20
30
40
50
D: EDCANT.Order SELECT D: EDCANT.Reel =25

PLOT 8

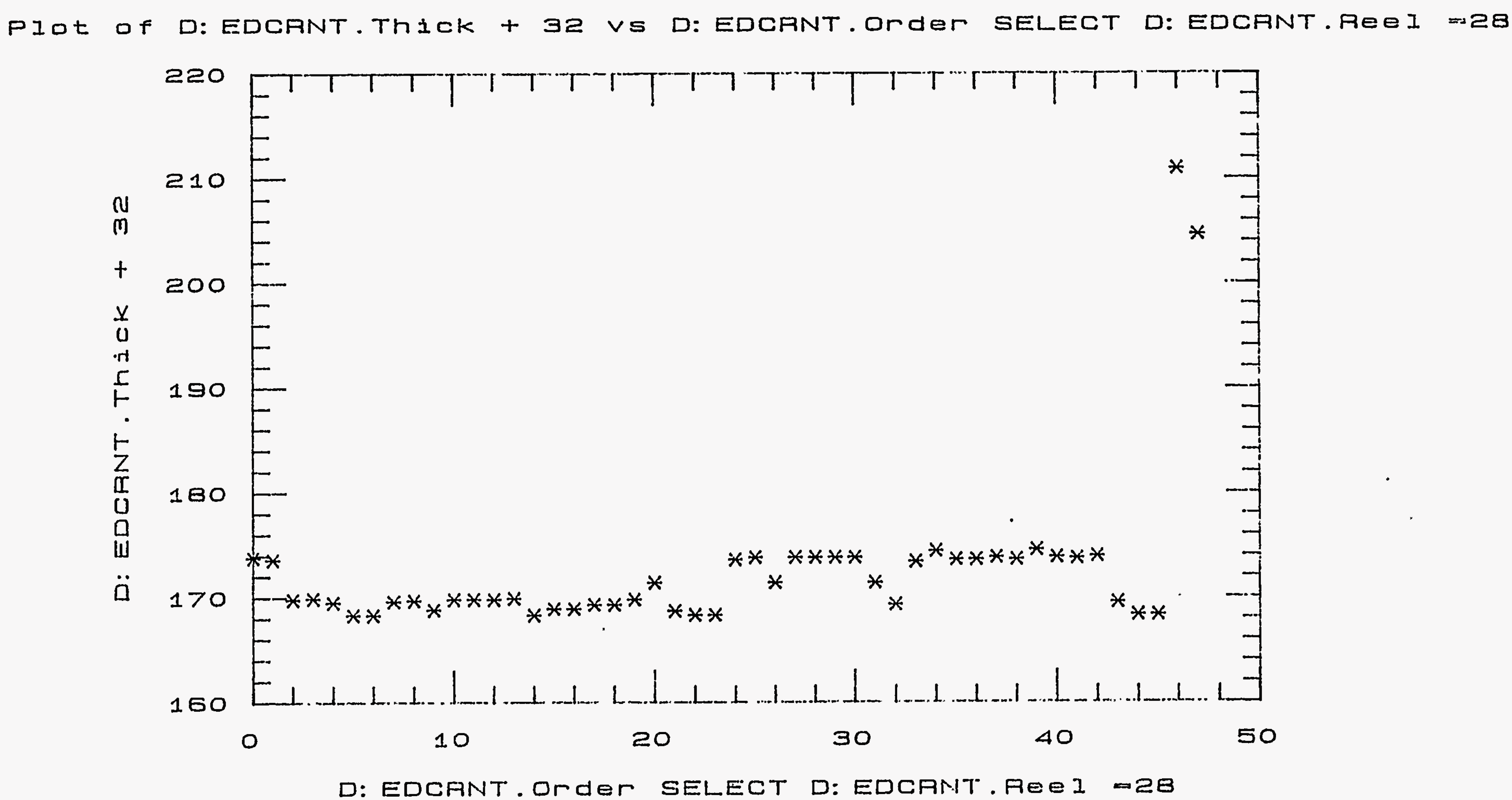


Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.
D: EDCRNT.Thick + 32
220
210
200
190
180
170
160
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =26

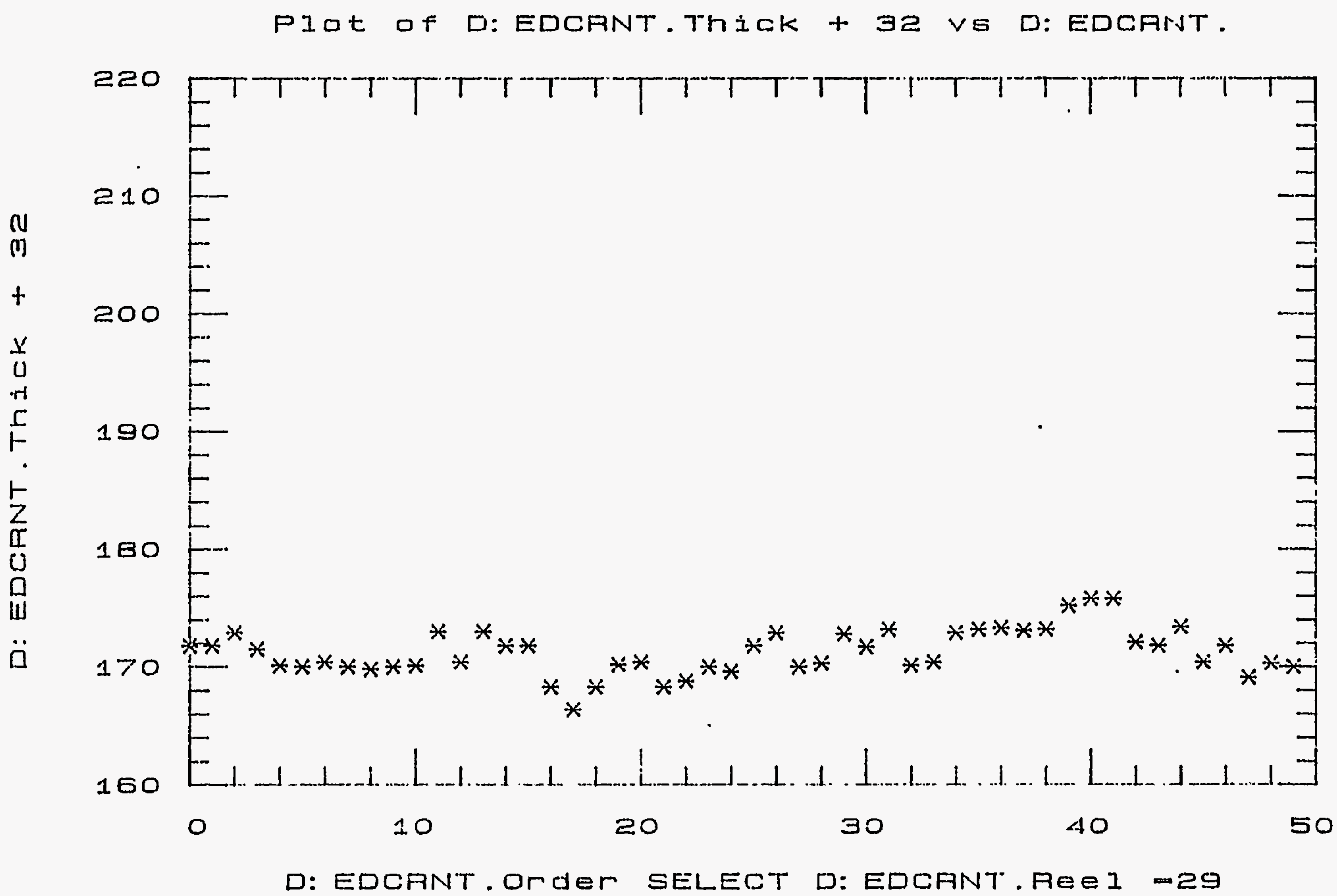
PLOT 9


Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.
D: EDCRNT.Thick + 32
160
170
180
190
200
210
220
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =27

PLOT 10


Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.Order SELECT D: EDCRNT.Reel =28
220
210
200
190
180
170
160
D: EDCRNT.Thick + 32
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =28

PLOT 11


Plot of D: EDCRNT.Thick + 32 vs D: EDCRNT.
D: EDCRNT.Thick + 32
220
210
200
190
180
170
160
0
10
20
30
40
50
D: EDCRNT.Order SELECT D: EDCRNT.Reel =29

MOUND

Inter-Office Correspondence

From : Quality Engineering, Administration
R. S. Ramachandran

Date : September 9, 1987

Subject : Copper Thickness Measurement of Microclad Raw Material by Eddy Current

Reference :

TO : J. Griffith/B. Hubbard

cc : W. Stitzel
B. Warner
M. Robinson
K. Armstrong
J. Thomes
G. Morris
L. Karnowski
D. Lentz
D. Hastings
G. Houston
T. Bruggeman

Microclad copper on kapton standards were selected to be used for Eddy Current calibration in measuring the thickness of raw material for making tape processed bridges. The copper thickness of reel #1, MC3926, QC# 37831 was measured by Eddy Current using two calibration standards: PVD standards and the new Microclad standards. Material Acceptance group performed these measurements.

In the past the PVD standards gave a bias of 32 microinches that had to be corrected. The new microclad standards should not have a bias and the data should not have to be corrected. The purpose of these measurements is to compare the data from the PVD standards to that of the new microclad standards.

The data in Table 1 showed only a difference of 12 microinches higher on the average with the microclad standards calibration vs. the expected bias of 32 microinches with the PVD standards. Chart #1 shows that the reel thickness average is below the target of 175 +/- 12 microinches tolerance. Chart #2 shows that the bias between the individual readings generated by PVD and Microclad standard calibration varies between +9 and -29.5 microinches.

A second reel is currently being measured by Eddy Current using both calibration techniques to obtain additional data. This reel will also be verified by X-ray Fluorescence to determine the true product value prior to incorporating the Microclad standard to eliminate the bias. The results of the second reel are not completed and will be summarized later.

R. S. Ramachandran

R. S. Ramachandran

CHART 1

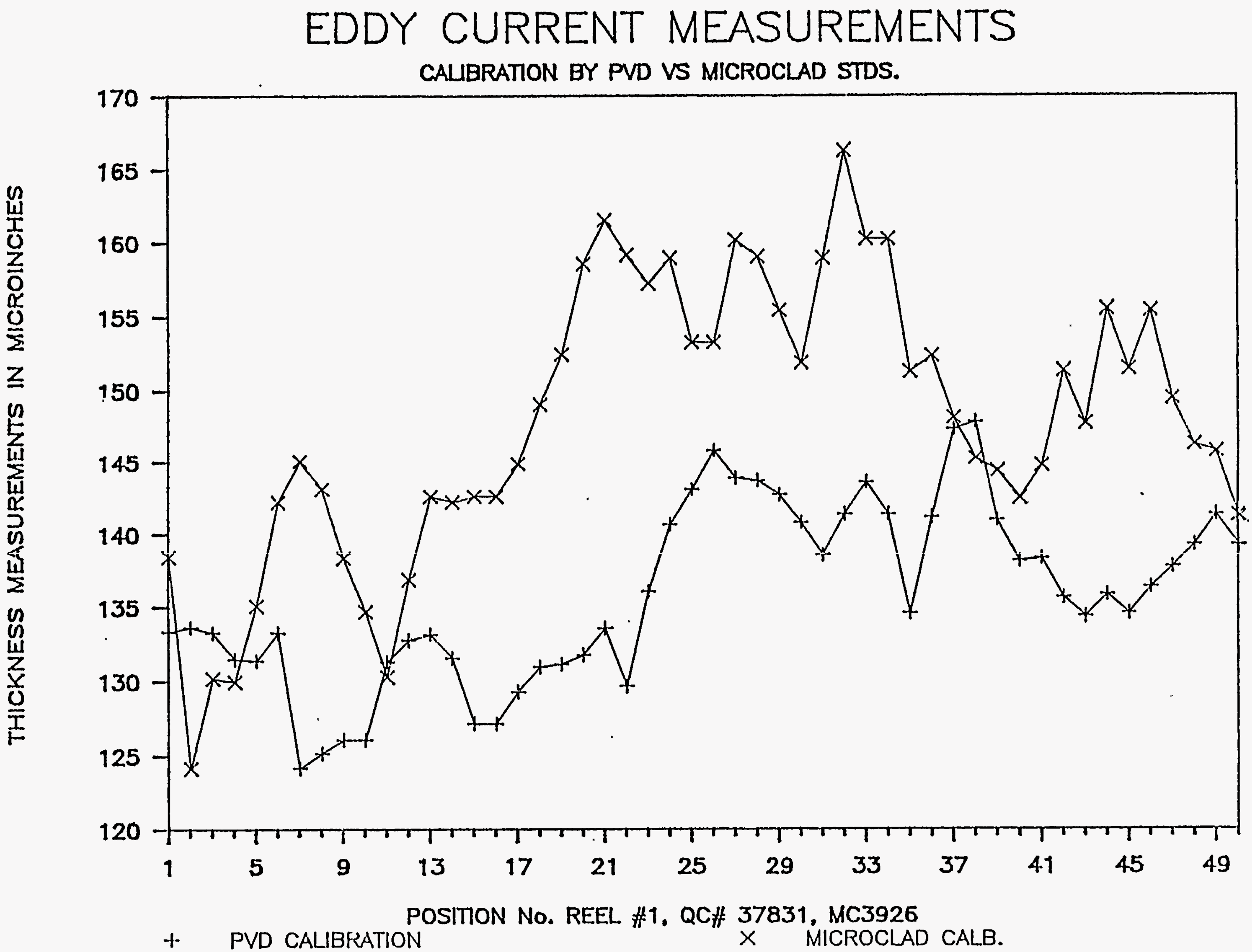
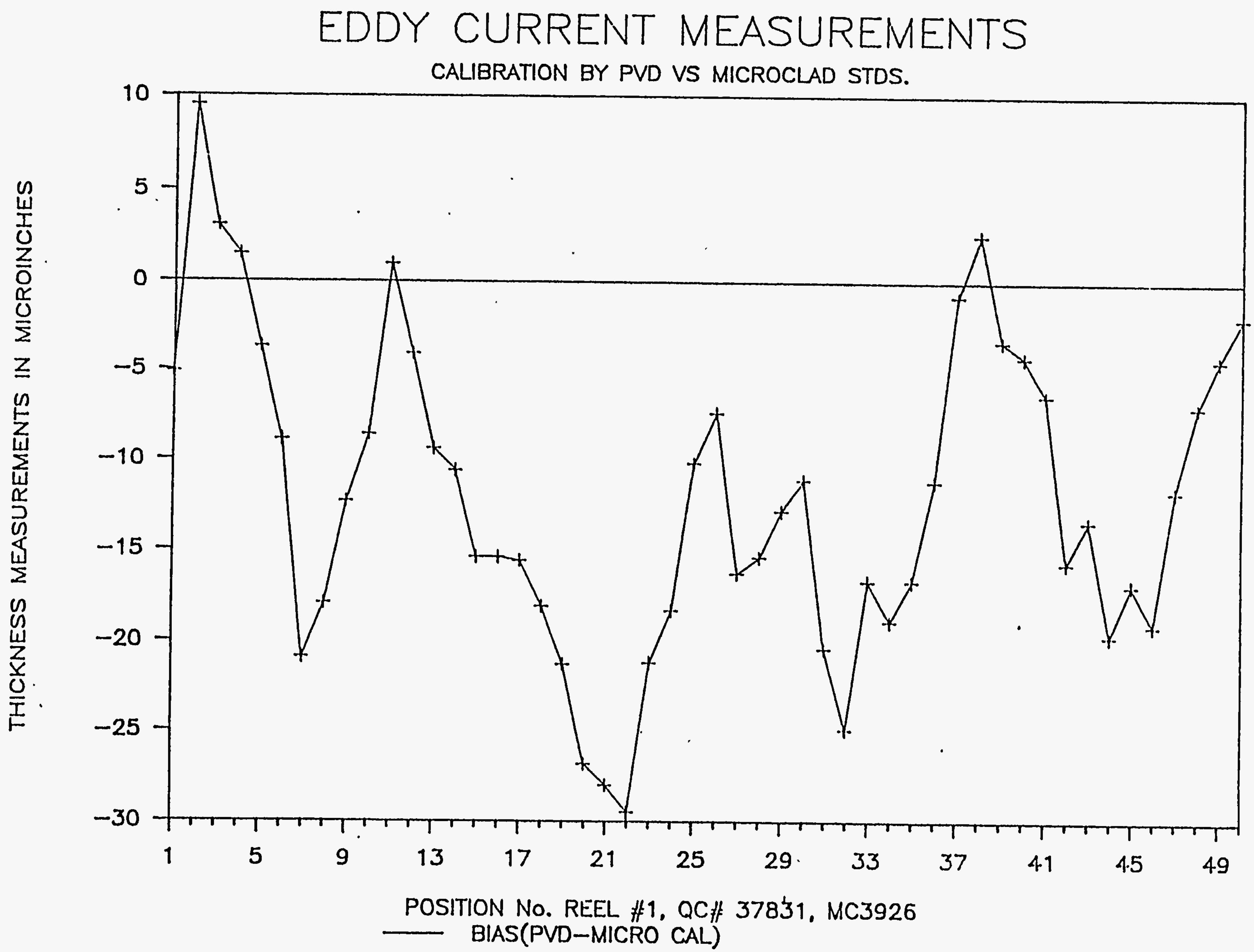

EDDY CURRENT MEASUREMENTS
CALIBRATION BY PVD VS MICROCLAD STDS.
THICKNESS MEASUREMENTS IN MICROINCHES
170
165
160
155
150
145
140
135
130
125
120
1
5
9
13
17
21
25
29
33
37
41
45
49
POSITION No. REEL #1, QC# 37831, MC3926
+ PVD CALIBRATION
× MICROCLAD CALB.

CHART 2



EDDY CURRENT MEASUREMENTS
CALIBRATION BY PVD VS MICROCLAD STDS.
THICKNESS MEASUREMENTS IN MICROINCHES
10
5
0
-5
-10
-15
-20
-25
-30
1
5
9
13
17
21
25
29
33
37
41
45
49
POSITION No. REEL #1, QC# 37831, MC3926
BIAS(PVD-MICRO CAL)

Acknowledgments

The authors would like to thank B. E. Hubbard and J. D. Hastings for their contribution to tape process development. The authors also extend special recognition to those Production, Quality, and Development personnel who contributed to the data collection and reduction. K. P. Armstrong claims no recognition for the research, only for the effort required to document it.

Glossary

Artwork	See phototool.
Bridge	Functioning copper foil portion of a slapper that drives the flyer.
Bridge Length	Dimension of a bridge parallel to the electric current.
Bridge Width	Dimension of a bridge perpendicular to the electric current.
Eddy Current	Nondestructive technique for measuring substrate thickness; used to determine copper thickness on bridge (microclad) material.
Flyer	Portion of a slapper detonator driven by rapid ionization of the bridge element (usually 0.001-in. to 0.002-in. Kapton).
Kapton	Trade name for a polyimide product produced by duPont.
LANL	Los Alamos National Laboratory.
Laseruler	Tool used to nondestructively measure substrate thickness; used to determine copper thickness on finished bridge circuits.
LLNL	Lawrence Livermore National Laboratory.
Microclad	Trade name of a copper-coated polyimide produced by Fortin Industries and used in fabricating bridges and flyers.
Phototool	Tool used to create a circuit image. A phototool contains the image of the desired circuit and exposes the image onto a chemically conditioned surface.
Radius Bridge	Bridge for which the length is defined by a radius such that the center of the bridge is in the thinnest region.
Reel	Sample of material slit to a width of 35 mm and wound around a core.
Receiving Inspection	Area at Mound where incoming material is inspected for conformance to specifications.
Roll	Sample of material as purchased from a vendor. A roll is the original width, usually 12 in. A roll is later slit to thinner widths to become reels.

SNLA	Sandia National Laboratories, Albuquerque.
Square Bridge	Bridge for which the width is uniform from end to end.
Tape Process	Method of producing flexible circuits in a reel-to-reel fashion. This process is unique to Mound.
Vidicom	Vision system produced by Vidicom to inspect bridge length and width.
Wet Processing	Process of laminating, exposing, developing, etching, and stripping a flexible circuit image.

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