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BRIDGE DECK REPAIR DEMONSTRATION

Dave Woodham
Colorado Department of Highways
4201 E. Arkansas Ave.
Denver, CO 80222

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U.S. Department of Transportation
Federal Highway Administration

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16. Abstract

Six bridges on I-25 north of Denver were rehabilitated in 1984. Long-term monitoring of the three deck toppings (Colorado DT, low slump with fly ash, and latex modified) was done to evaluate the relative corrosion resistance of the three materials.

Comparisons between the low slump (LS) with fly ash and latex-modified bridge toppings showed that the LS was easier to work with, was a more uniform product and limited chloride intrusion as well as the latex-modified concrete. Half-cell testing was performed yearly on the decks as well as visual checks on the condition of the deck surface. Cost data showed that the use of Colorado DT mix cost approximately half of the installed cost of latex-modified concrete. LS deck topping cost approximately 70% of the latex modified concrete.

Implementation

Currently latex-modified concrete is not used in deck toppings in Colorado. The use of fly ash in deck toppings is allowed but not generally used.

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I. Background

This study was begun in 1985 to demonstrate bridge deck rehabilitation techniques and to gather long-term data on the relative performance of several techniques. The rehabilitation of bridge decks is usually required due to scaling, cracking, and spalling as a result of deicing chemical use.

The bridges considered under this study were rehabilitated with state-of-the-art techniques (as of 1984). In order to determine at least the relative performance of each treatment, the performance of the various treatments was observed for a 5-year period.

II. Introduction

This report presents the results of a long-term evaluation of six bridges rehabilitated in 1984 and 1985. The bridges have been inspected and tested yearly for corrosion potential or membrane soundness since 1985.

In July of 1984, the seminar entitled **Bridge Deck Repair and Rehabilitation** was given to approximately 300 engineers from around Colorado. The seminar was held north of Denver and offered participants the opportunity to observe several demonstrations on bridge deck inspection techniques and rehabilitation methods conducted during the week of the seminar. A total of 26 bridges were repaired and rehabilitated in the Summer/Fall of 1984 and the Spring/Summer of 1985. Three types of concrete deck toppings were used including low slump, latex modified and Colorado's class DT concrete. Two decks of each type were selected for long-term evaluations.

III. Construction

The bridge rehabilitation work was done under project IR 25-3(77) north of the Denver metropolitan area. All structures were between 20 and 28 years old and most were found to have severe chloride contamination. Prior to the rehabilitation, the condition of each deck was determined by half cell readings, chloride sampling, chain drag, and visual assessment techniques. In conjunction with the bridge repair seminar, several different methods of deck removal were demonstrated. Included were the use of the Scabbler, a CMI milling machine, and air powered hand tools. In addition, the Turbo-Blast machine was demonstrated as a tool for cleaning concrete surfaces.lasting. The amount and type of removal (as constructed) is summarized below:

	Removal Type			Type of
Structure	Class 1	Class 2A	Class 2B	Concrete Used
D-17-AT	100%	43%	0%	DT
D-17-CX	100%	0%	0%	DT
C-17-AT	100%	0%	0%	LS
C-17-BQ	100%	27%	0%	LS
C-17-DY	100%	9%	0%	Latex Modified
C-17-CE	100%	0%	0%	Latex Modified

Class 1 : Nominal 3/4" below top of existing deck
Class 2A : 1/2" below top transverse rebar
Class 2B : Maximum of one-half of deck thickness

Three different concrete mixes were used on the bridge decks and all of the concrete used was mixed at the structure using mobile mixers.

The low slump (LS) concrete contained 140 lb. of fly ash along with 700 lb. of cement per cu. yd.. The fly ash used was Class F and had 0.85% loss on ignition with 22.2% retained on the 325 screen. Type I, low alkali cement was used as well as water reducing and air entraining agents. The maximum water/cement ratio was 0.35. The low slump concrete was bid at $400 / cubic yard (installed).

Colorado's DT mix is a fairly high-strength mix (28 day $f'_c \geq$ 4500 psi) which uses 700 lbs. of cement per cubic yard and has a maximum slump of 2.5 inches and a maximum water/cement ratio of 0.44. Colorado DT concrete was bid at $285 / cubic yard.

Latex modified concrete was also used on two bridge decks. The latex admixture was used at 26.1 gal./cu. yd. in a mix which contained 700 pounds of portland cement per cubic yard with a water/cement ratio of less than 0.24. Latex-modified concrete cost $575/ cubic yard on this project.

It was the general opinion of the project personnel that the lack of metering devices on some components of the mix resulted in considerable variability in the concrete. It was also felt that a better method of controlling the sand moisture was necessary. However, these were not major problems and all mix specifications were met or exceeded.

IV. Evaluations

Each of the six bridge decks under study were evaluated on an annual basis usually in early Spring. The purpose of these evaluations was to determine the relative performance of each of the bridge deck rehabilitation methods.

Resistance or voltage measurements were taken on each deck to provide an objective measure of the probable corrosion present in the deck. The general procedure was as follows. Once traffic control was in place and the lane had been closed off, a 10 foot square grid was laid out over the deck. For consistency, the origin of the grid was always the south-east corner of the deck. The 10 foot increments were marked on the guardrail and then across the lanes on the pavement. A electrical ground was secured by tying into the reinforcing steel under the bridge. In most cases, a tie wire provided the necessary ground (this was verified with an ohmmeter). In decks where a Moly/Moly-oxide half-cell was installed in the deck, the ground wire (black) from the cell provided an adequate ground.

A garden type spray can was used to wet the deck at each of the grid intersections with a mixture of soap and water. The water helps to provide the necessary conduction path to complete the circuit.

The membranes on two of the decks, at SH 119 and at the St. Vrain River, were tested using resistance measurements. Resistance measurements are taken between a 1 ft^2 copper plate in contact with the asphalt mat and the ground wire. In the case of resistance measurements, a reading of 200 kΩ and over indicates that there is only a weak electrical path between the pavement surface and the reinforcing steel. This implies that the membrane between the deck and pavement surface is intact.

The other four decks were tested with a copper/copper-sulfate half-cell using voltage as the criterium. The half-cell was placed on the deck at each of the prewetted grid points and a DC voltage was recorded. For these readings, a voltage greater in magnitude than 0.35 Volts indicates the presence of active corrosion. Similarly, a reading in magnitude greater than 0.30 volts indicates probable corrosion at that point.

Each set of measurements were gathered on the same day with a crew of three. Traffic control required another three people during the evaluation day.

V. Results

TABLE A. CORROSION TESTING RESULTS

	1985	1986	1987	1988	1989	1990
C-17-AT active/ probable	0/12%	0/2%	8/22%	0/0%	0/0%	86/94%
C-17-BQ active/ probable	8/15%	20/40%	7/13%	13/15%	0/2%	21/33%
D-17-DY active/ probable	2/22%	7/27%	9/25%	13/16%	0/0%	20/22%
C-17-CE active/ probable	7/24%	0/0%	13/16%	11/20%	0/11%	100/100%
D-17-AT percent <200 kΩ	0	0	19%	65%	NA*	NA*
D-17-CX percent <200 kΩ	0	0	2%	4%	25%	42%

Note: On decks with membranes, the percentages listed are the number of readings less than 200kΩ. On bare decks, the first number is the percentage of readings over 0.35 V (active corrosion) and the second number is the percentage of readings over 0.30 V (probable corrosion).

Latex modified deck topping.

Low slump concrete with fly ash

DT low slump concrete.

* This bridge was widened and redecked in the Spring of 1989.

Plots of the half-cell readings for each deck for each of the six evaluations are shown in Appendix B. The plots show the half-cell voltages plotted as a surface above the deck. Apparent from the readings, is the increase in voltage near the ends of the deck. Most readings are in the range of 0.0 to 1.0 volt. For the purpose of evaluation, a reading of 0.3 V indicates probable corrosion and a reading over 0.35 V indicates the presence of active corrosion.

On the decks where a membrane and an asphalt overlay covered the deck, resistance measurements were taken to indicate the effectiveness of the waterproof membrane. Readings over 200 kΩ were considered evidence that the membrane was functioning as desired.

In all cases, the rehabilitation methods have reduced the amount of corrosion for only a relatively short time. It is unknown whether chlorides remaining in the deck or those applied after rehabilitation are responsible for the observed increases in corrosion over the five-year period.

In July, 1990 chloride samples were obtained from the uncovered decks. All samples were taken at a depth of 2½ inches below the deck surface (the depth of cover) with a minimum of 10 samples taken from the shoulder of the decks. Chloride contents prior to the replacement of the deck overlays The samples were from the same grid intersections used for the half-cell testing. The results are tabulated below:

Structure	Type Concrete	Mean Chloride Content*	Standard Deviation	Previous Test*
C-17-AT	LS w/ fly ash	0.8	±0.2	1.1
C-17-BQ	LS w/ fly ash	0.7	±0.2	2.0
C-17-CE	Latex modified	0.8	±0.3	3.1
C-17-DY	Latex modified	0.8	±0.5	1.2

* in units of lb./yd.^{3}
Previous chloride samples were obtained prior to bridge rehabilitation. The values nearest the shoulder of each deck are reported here.

The chloride contents from all four decks were very similar with slightly lower chloride contents in the LS concrete with fly ash.

No test for debonding of the deck overlays was done.

VI. Conclusions

The evaluations indicate that both the latex modified concrete and the low slump concrete were similar in their resistance to chloride intrusion. One conclusion regarding the half-cell testing is that the numbers are variable depending on the time of the year that the deck is tested, the amount of moisture in the deck, and the operator errors due to the choice of a suitable ground. In one case (1989), the readings were all lower than normal due to the later testing (June instead of April). The chloride samples indicate that the LS with fly ash and the latex modified concretes were comparable in resistance to chloride intrusion.

The results are also somewhat discouraging in that chlorides were detected in the concrete in the reported quantities (0.8 lb./cu. yd.) in only 5 years. The generally recognized threshold for corrosion is somewhere between 1 and 2 pounds of chloride per cubic yard. The reported values indicate that the rehabilitation techniques (both new concrete overlays and overlays with membranes) are only partially effective. The presence of corrosion in all overlays at this time shows that other methods are needed to stop corrosion in bridge decks.

Because the low slump concrete with fly ash is roughly 70% of the cost of the latex modified concrete and provides better or equal resistance, the low slump concrete with fly ash appears to be a better deck topping. It is unfortunate that all decks using DT low slump concrete were treated with a waterproof membrane and an overlay. A direct comparison between the results from the DT decks and the other two deck toppings would have been useful.

VII. Implementation

The problems experienced with latex modified concrete (primarily workability) have led to the choice of low slump concrete as the preferred deck topping. As a result, latex modified concrete is no longer being used in Colorado. The low-slump concrete containing fly ash is allowed at the contractor's option, however, most contractors have chosen not to use large amounts of fly ash in concrete for workability and quality control reasons. Colorado's DT mix has proven to be a deck topping which combines good workability, known setting properties, moderate protection against chloride intrusion as well as a moderate cost.

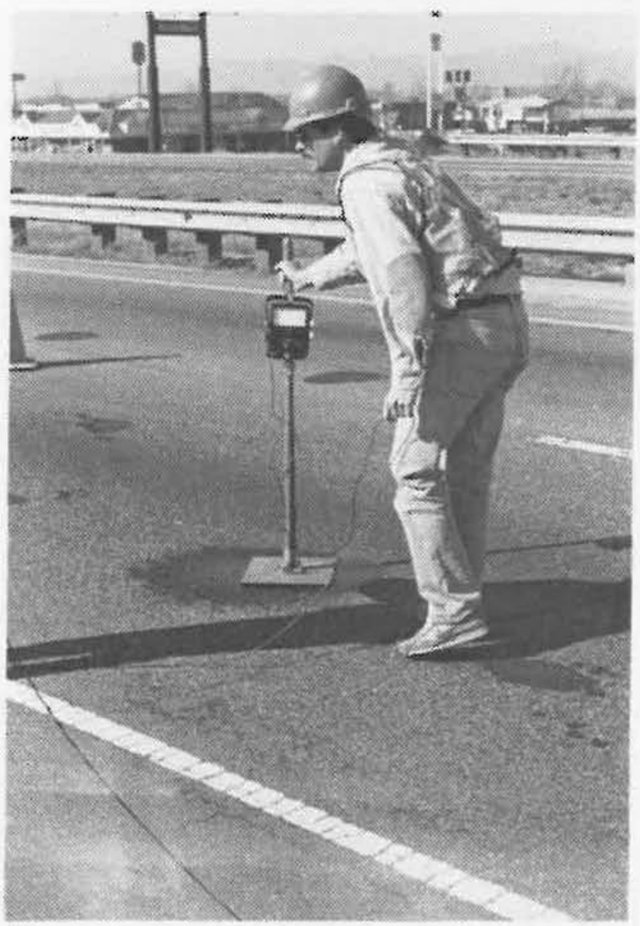
Appendix A

Photographs of Bridge Testing

Photograph 1.
Prior to testing, the deck is pre-wetted with a mixture of water and soap.
The tests are taken on a ten-foot grid.

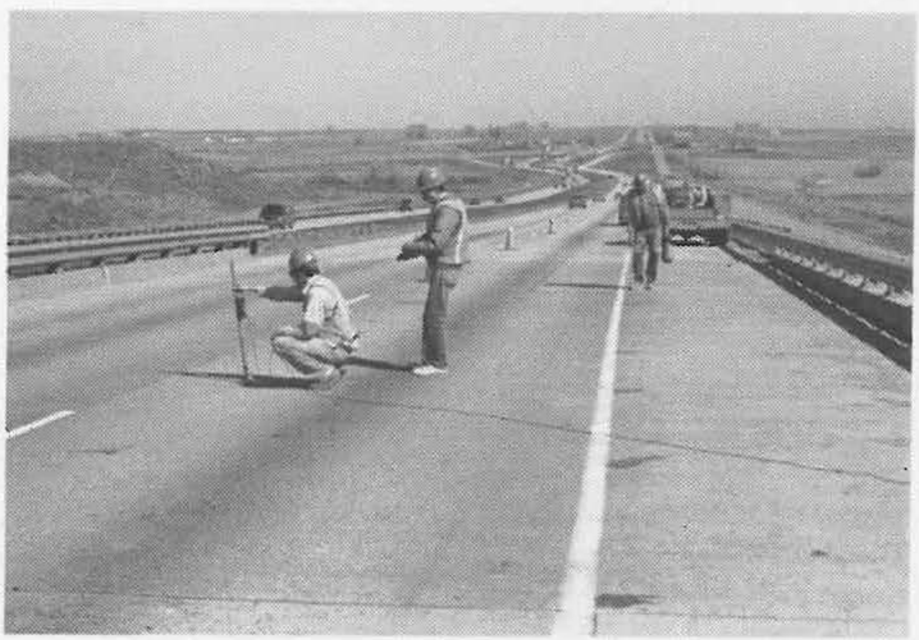
Photograph 2.
A ground was secured to complete the circuit.

Photograph 3. Testing on a deck with an asphalt mat. Resistance measurements are recorded.



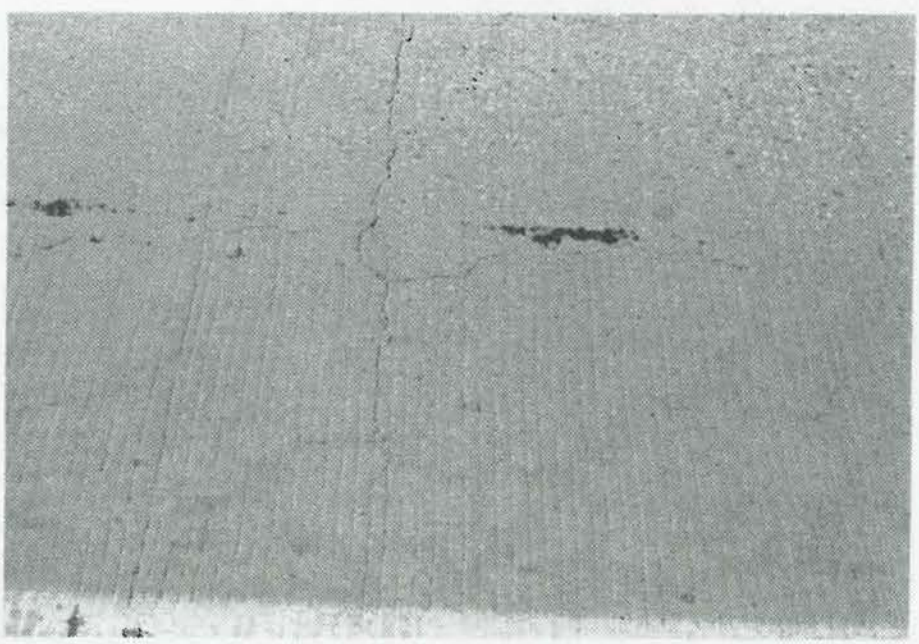
Photograph 4. Overall view of testing operation.

Photograph 5. Copper-copper sulfate half-cell is used on bare decks. Voltages are recorded.

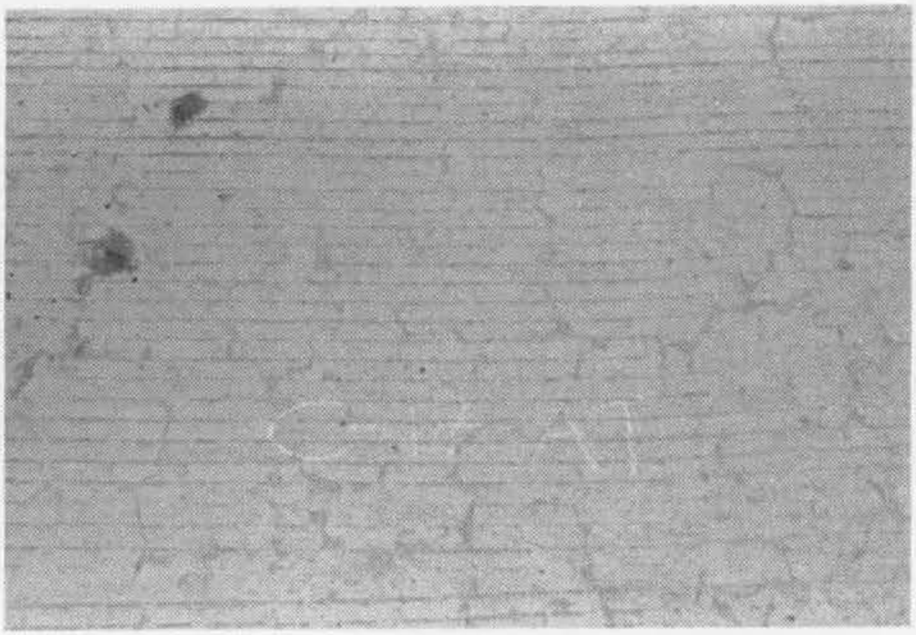


Photograph 6. View of testing.

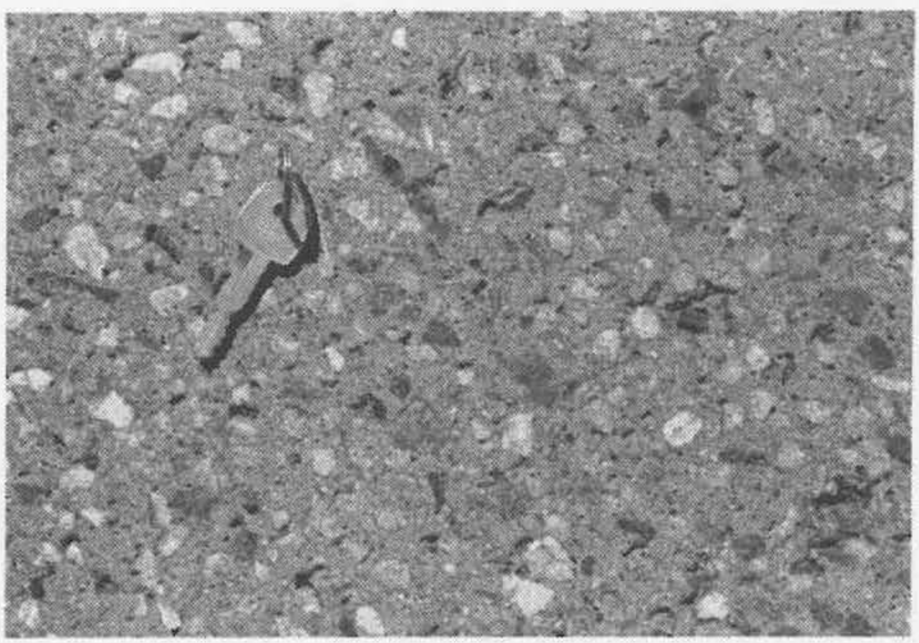
Photograph 7.
Surface detail of deck C-17-AT. April, 1990. Low slump concrete with fly ash.



Photograph 8.
Closeup of deck. Structure C-17-BQ. April, 1990. Low slump concrete with fly ash.



Photograph 9.
Hairline cracks in deck. Structure C-17-AT.
April, 1990.
Low slump with fly ash.



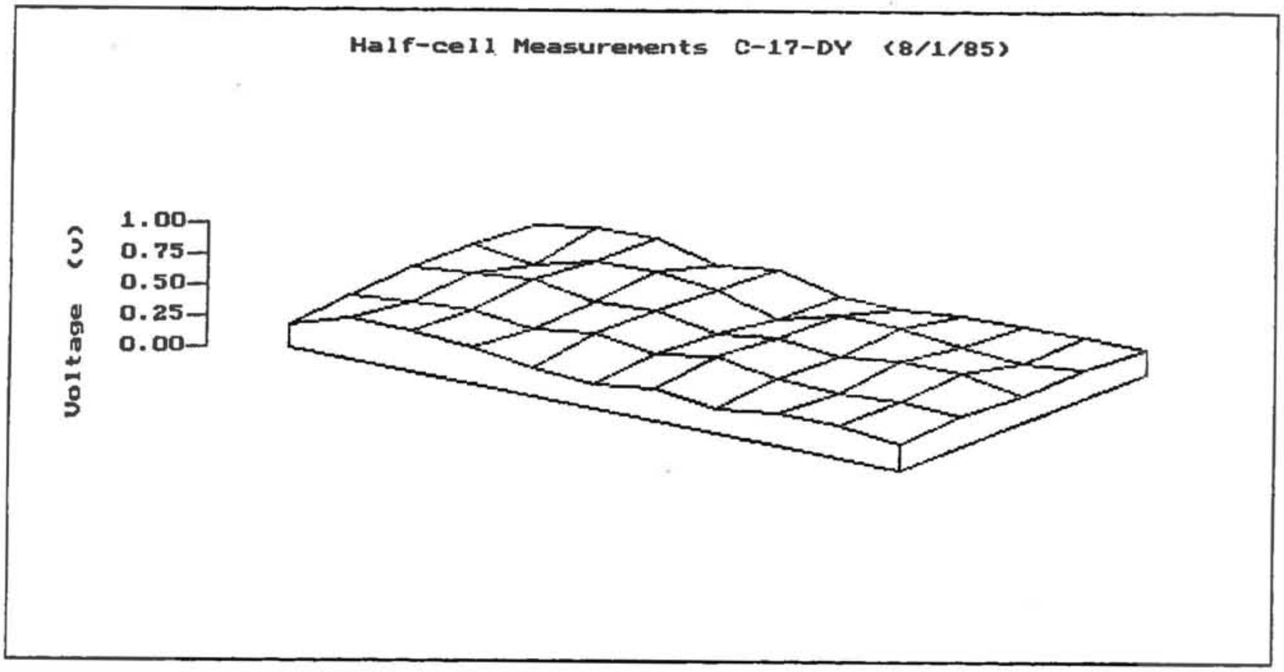
Photograph 10.
Surface texture.
Structure C-17-AT.
April, 1990.
Low slump with fly ash.

Photograph 11.
Cracks in deck.
Structure
C-17-DY.
April, 1990.
Latex modified.

Photograph 12.
Surface texture.
Structure C-17-DY.
April, 1990.
Latex modified.

Appendix B

Graphs of Bridge Testing Data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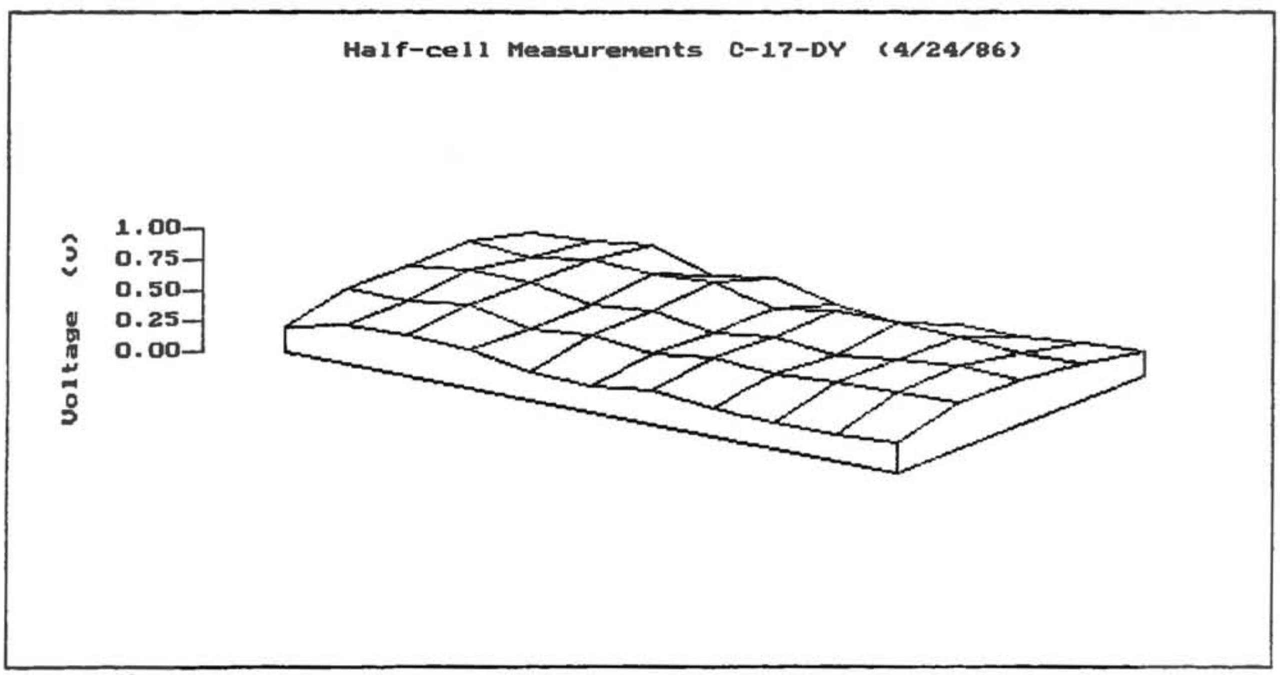
0.50
0.25
0.00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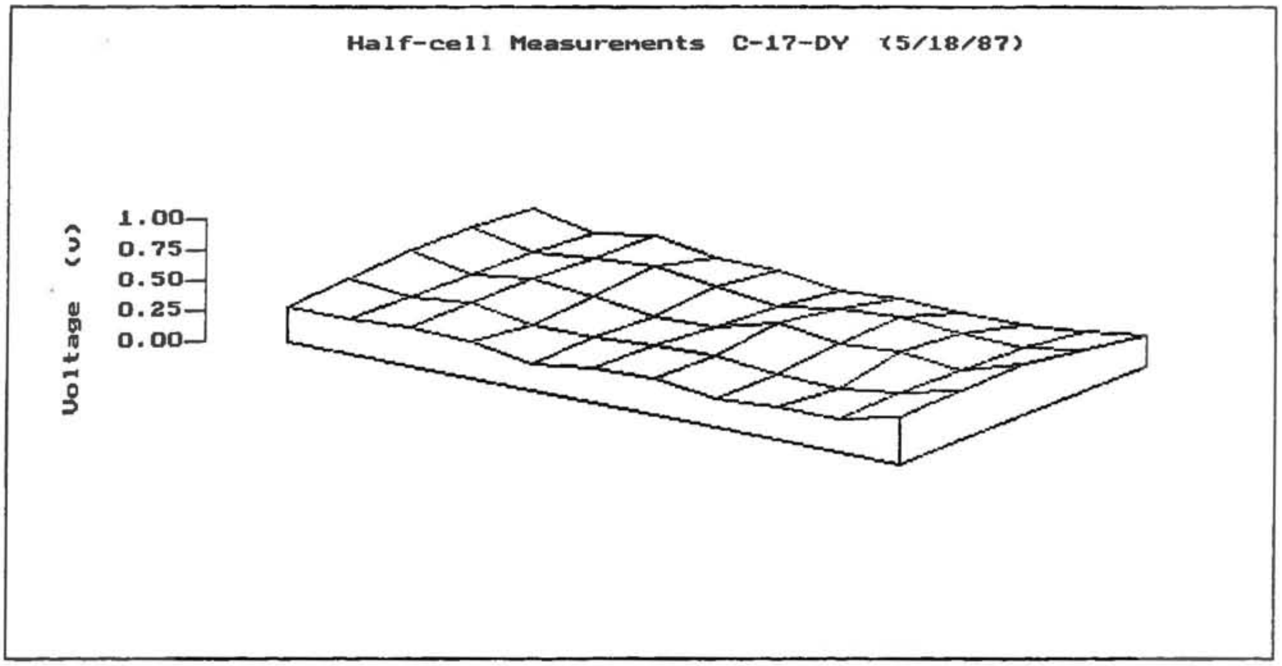
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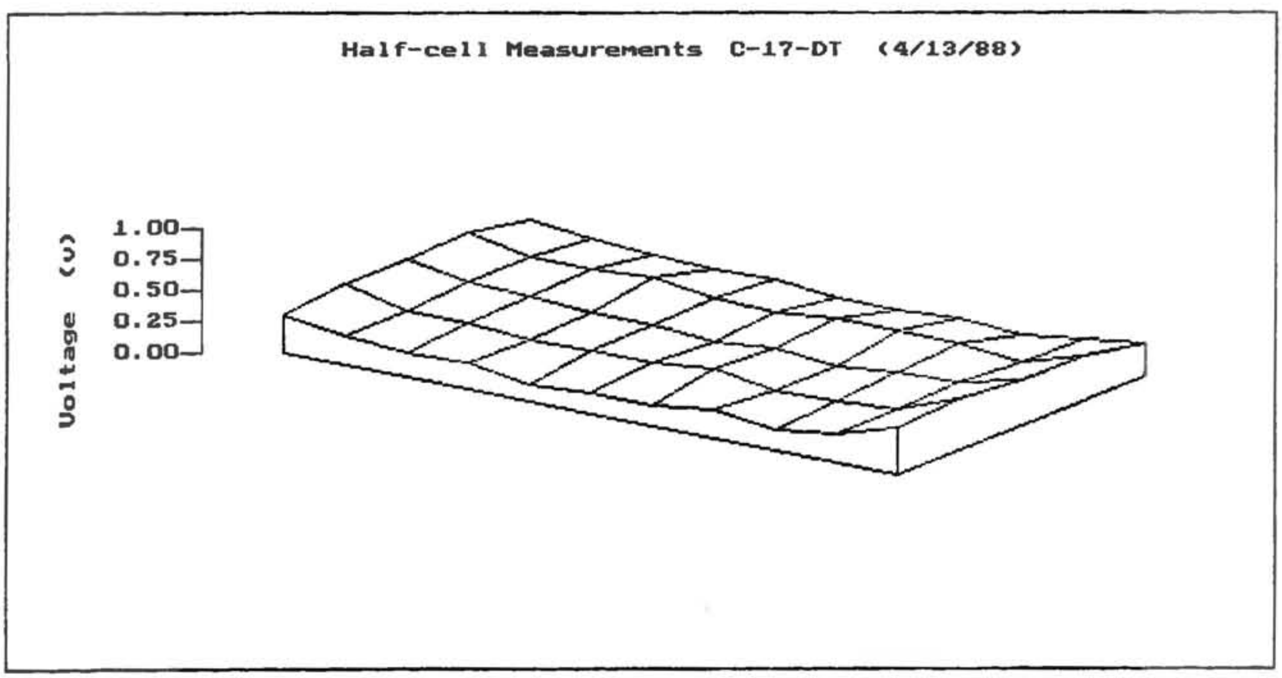
0.50
0.25
0.00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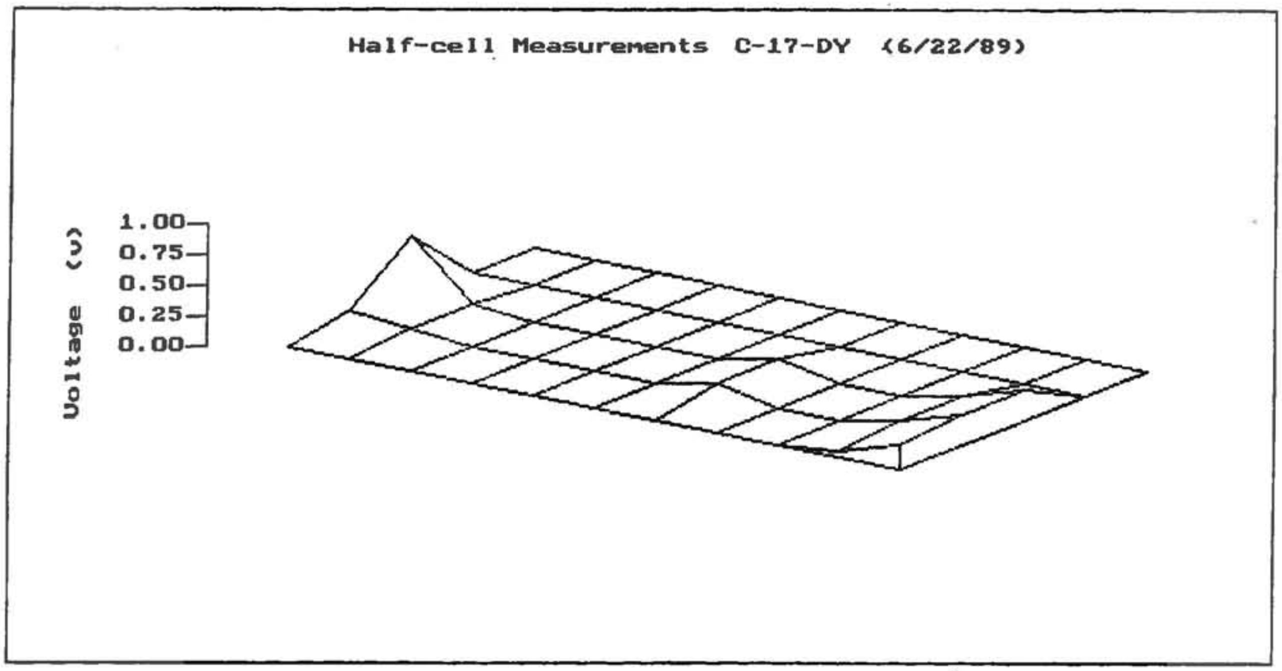
0.00



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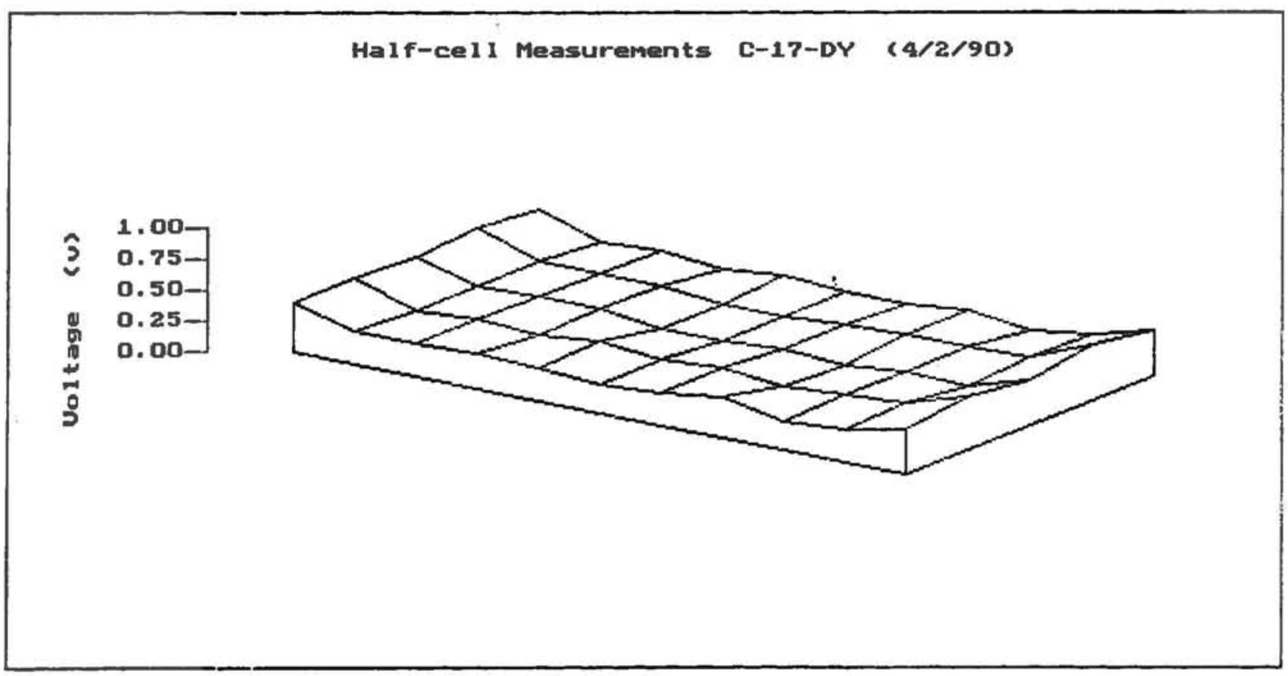
0.50
0.25
0.00



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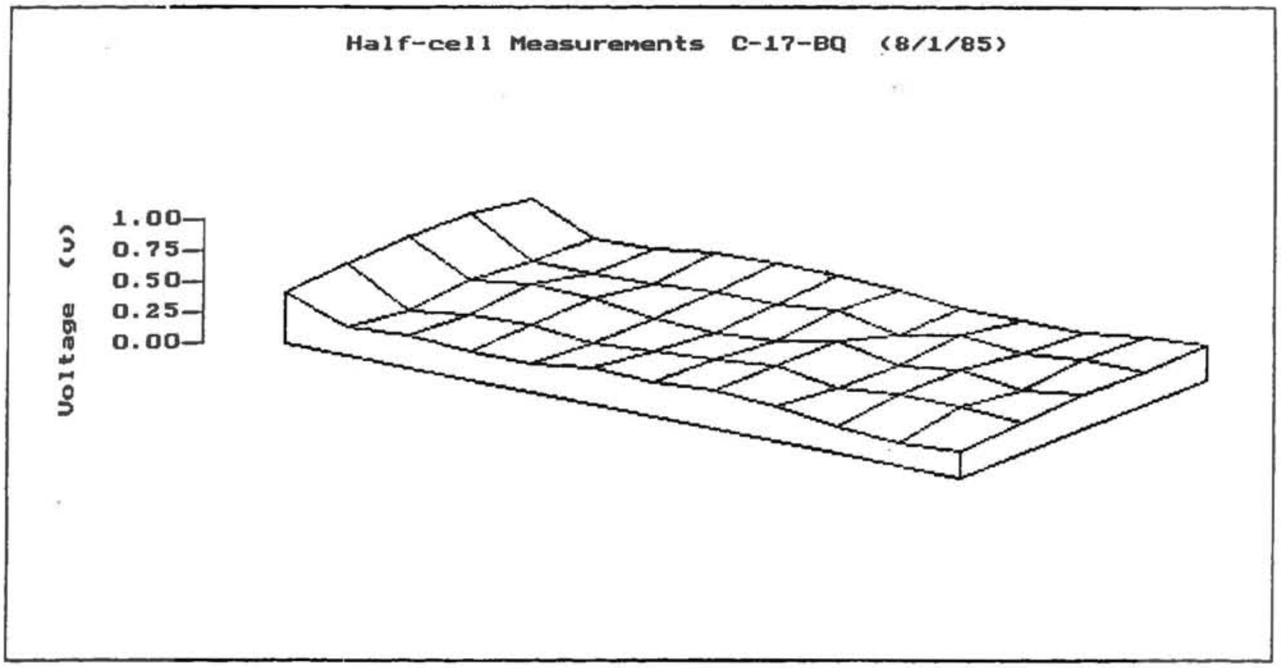
0.50
0.25
0.00



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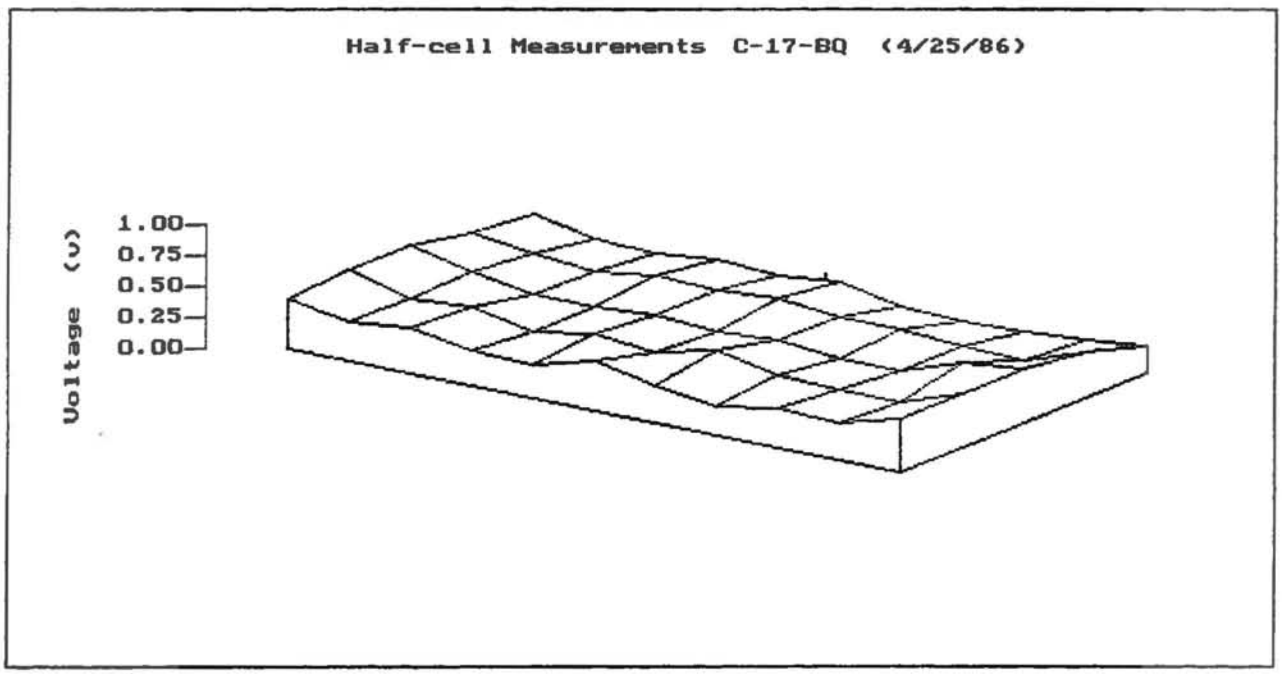
0.00



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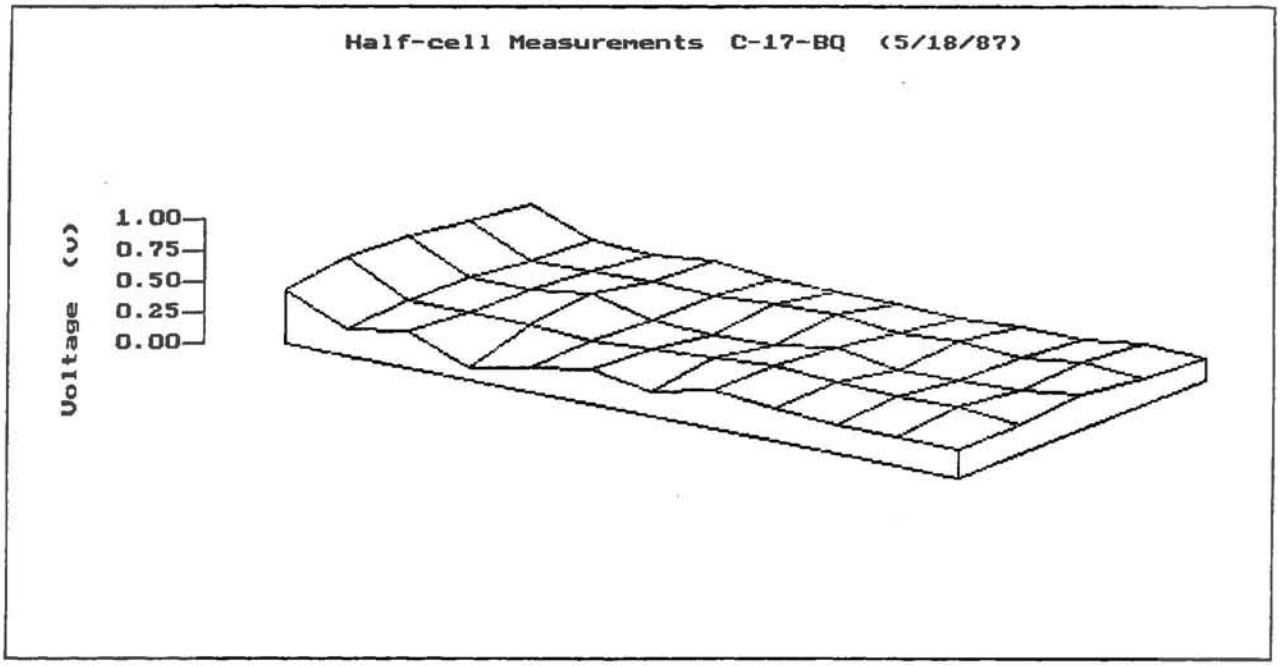
0.25
0.00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0.50
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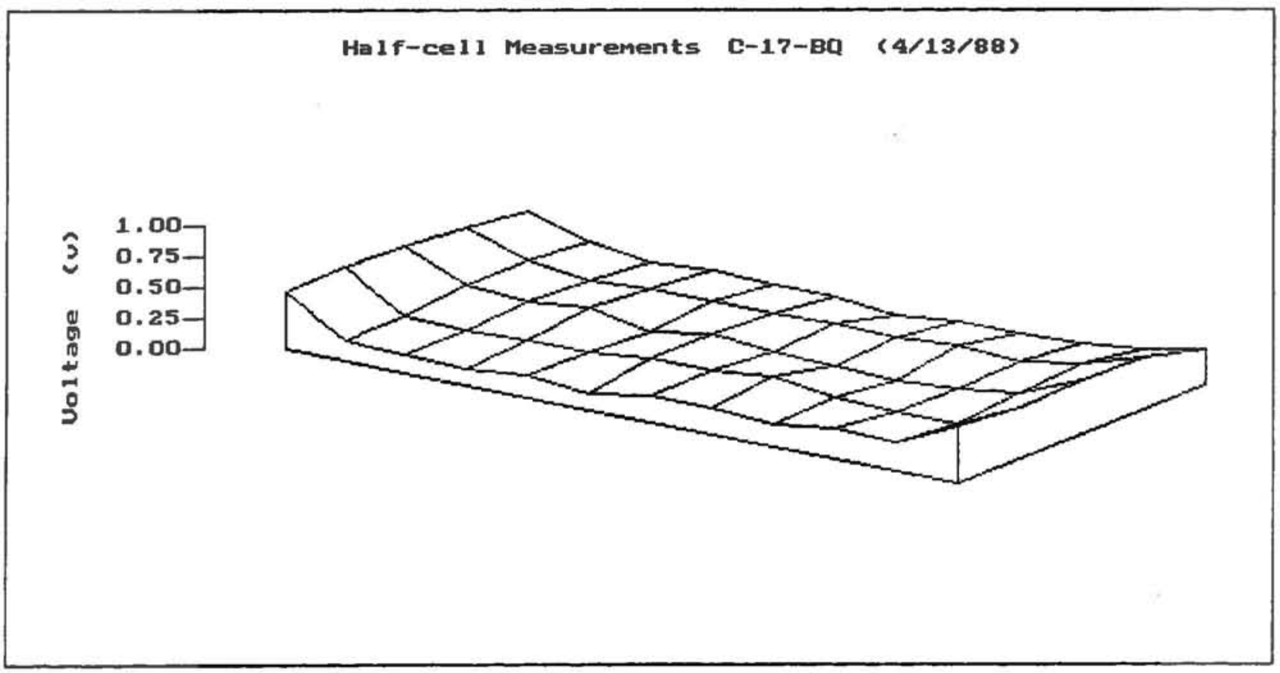
0.00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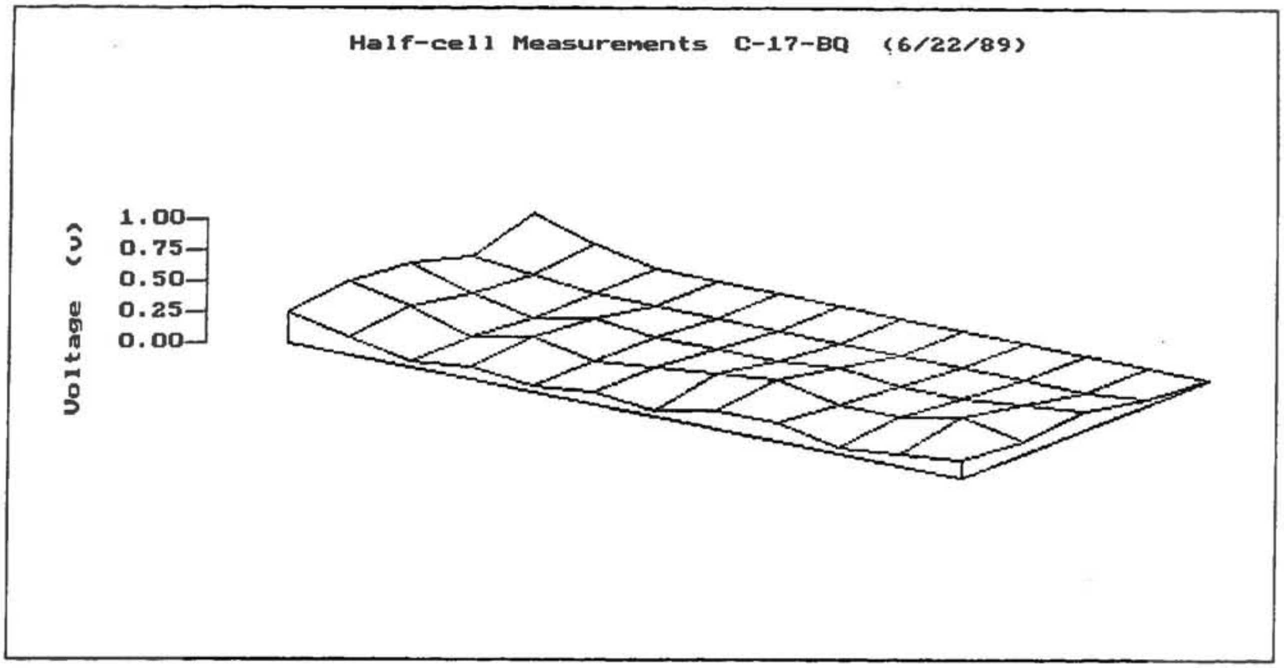
0.50
0.25
0.00



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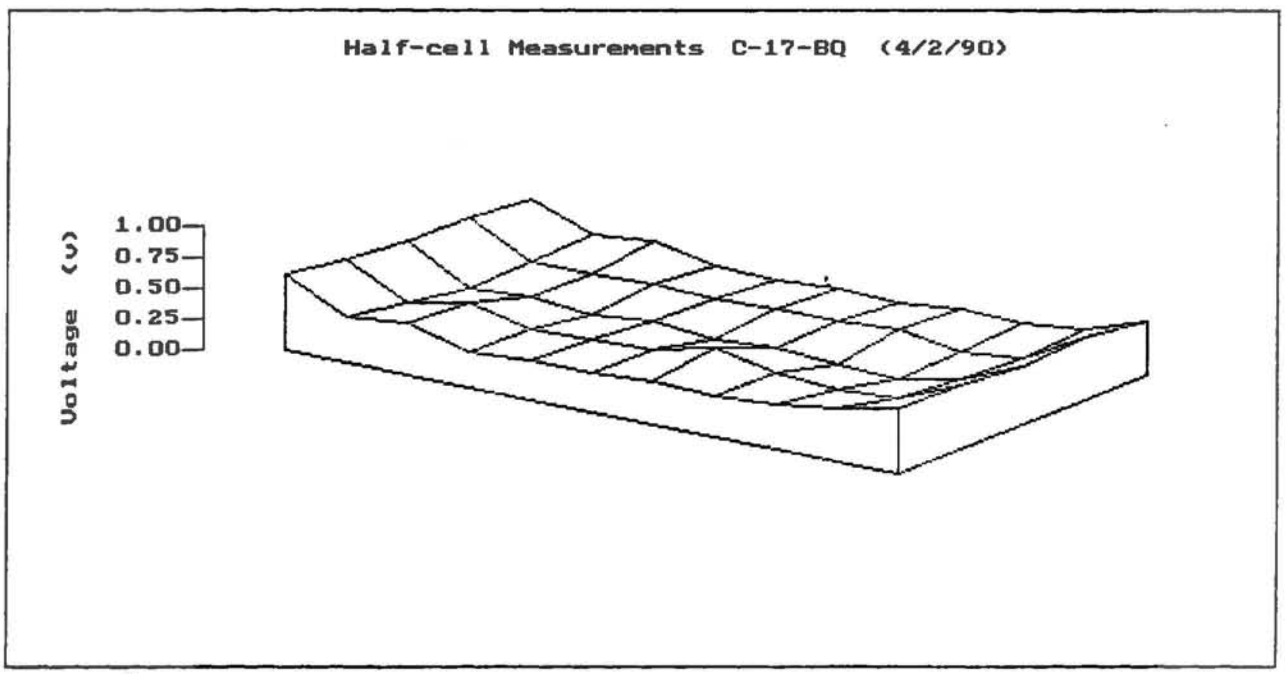
0.00
Voltage (v)



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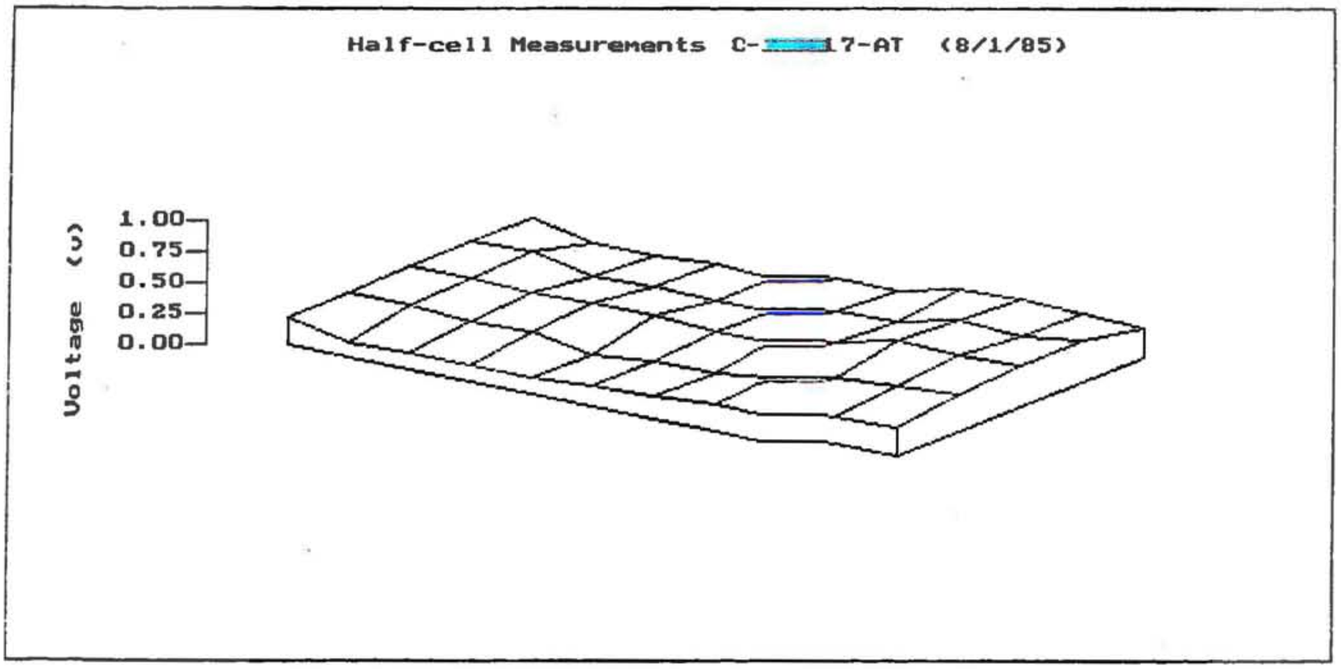
Voltage (v)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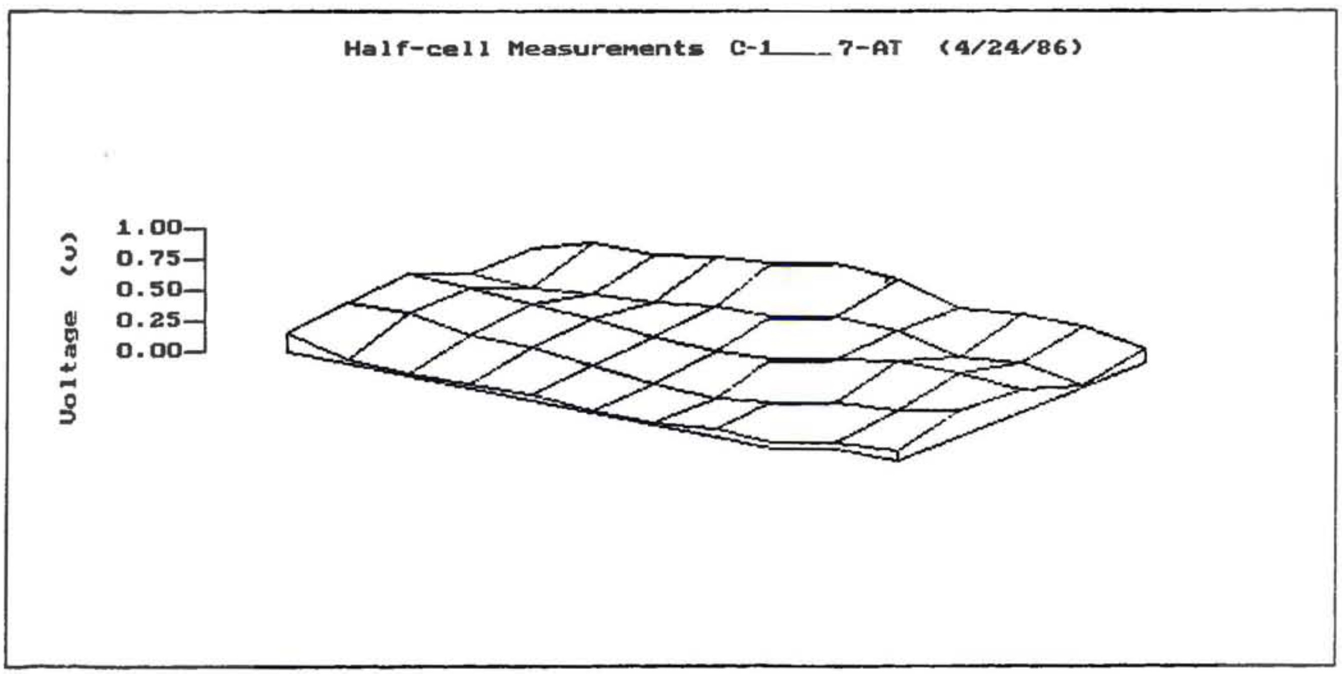
0.00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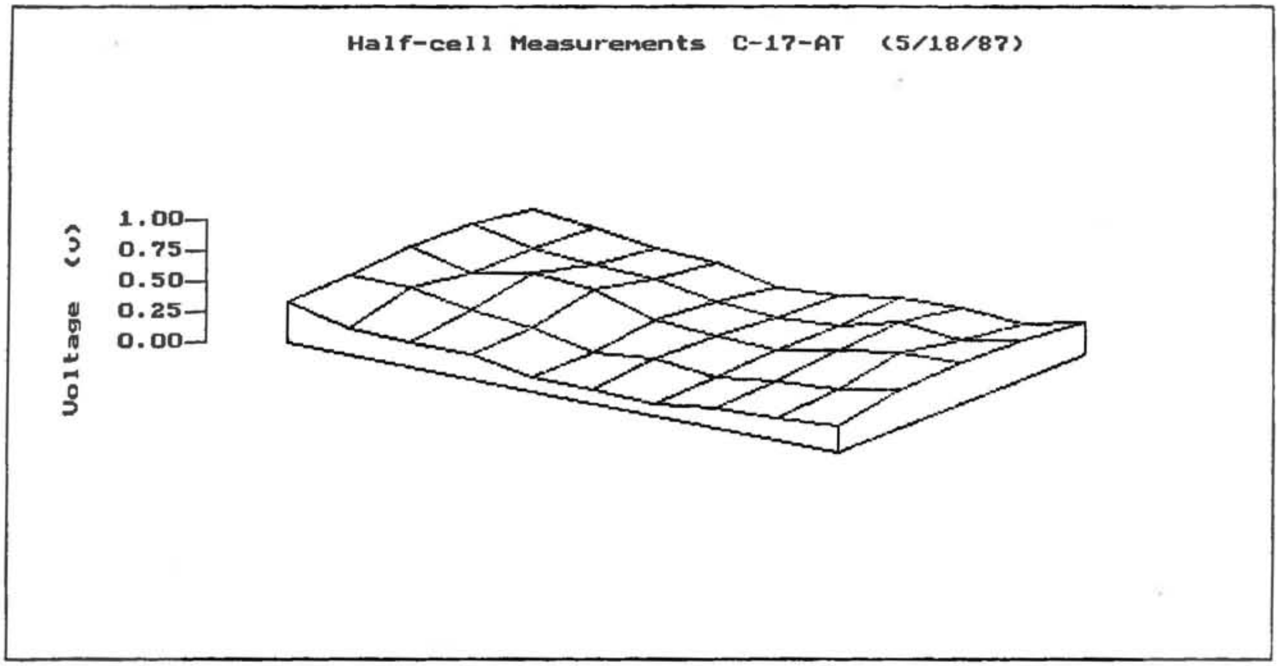
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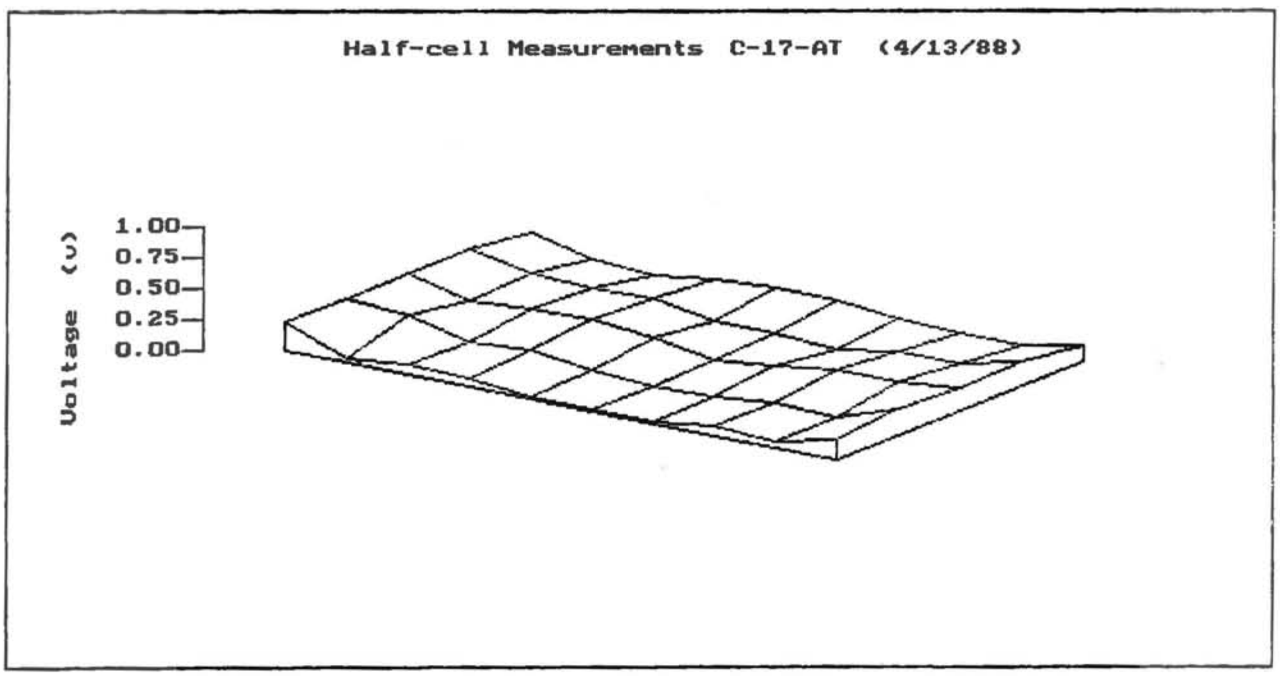
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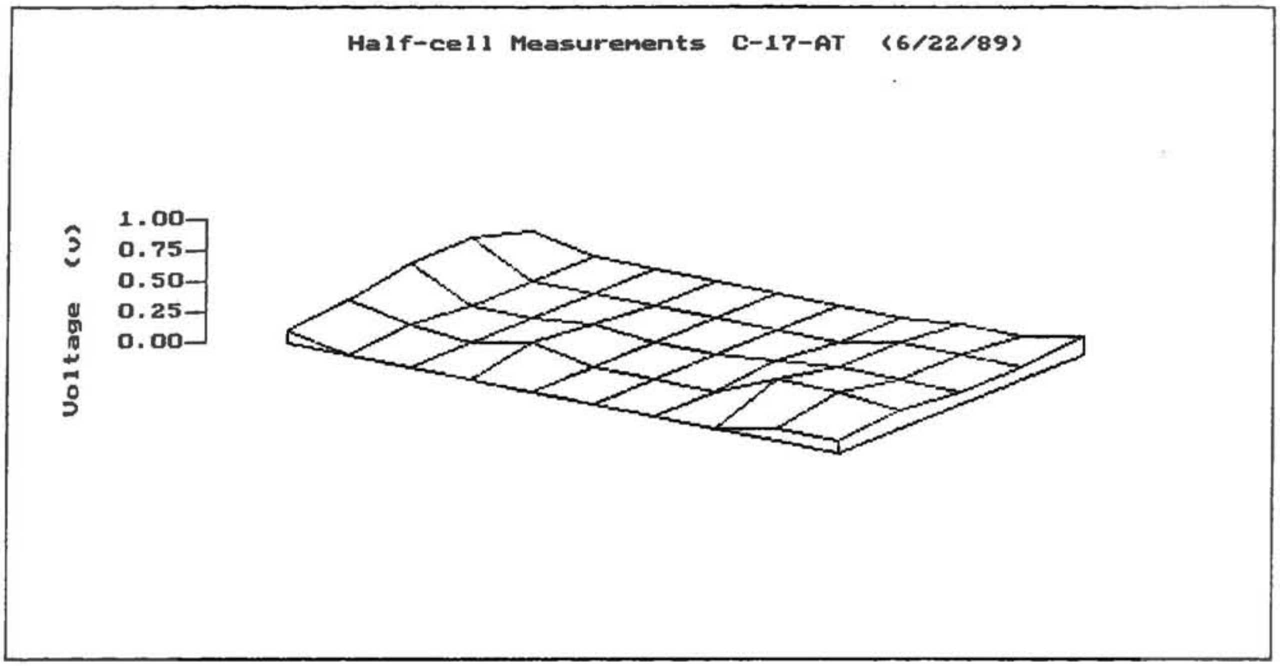
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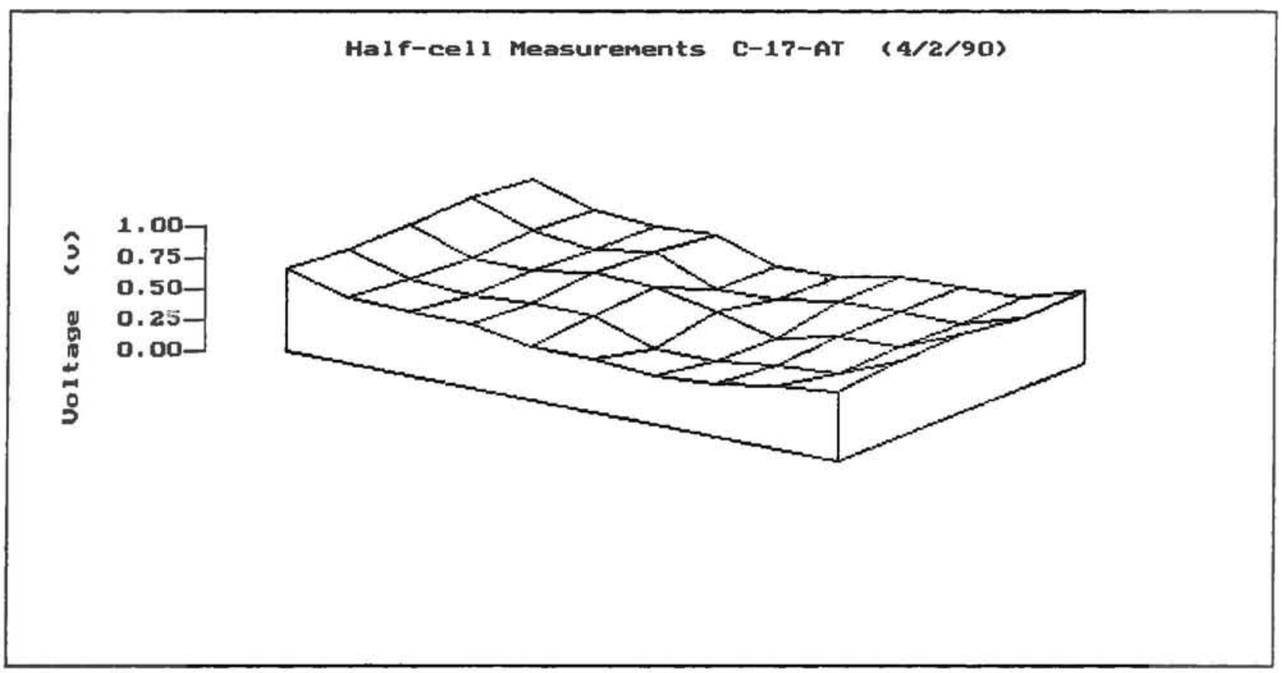
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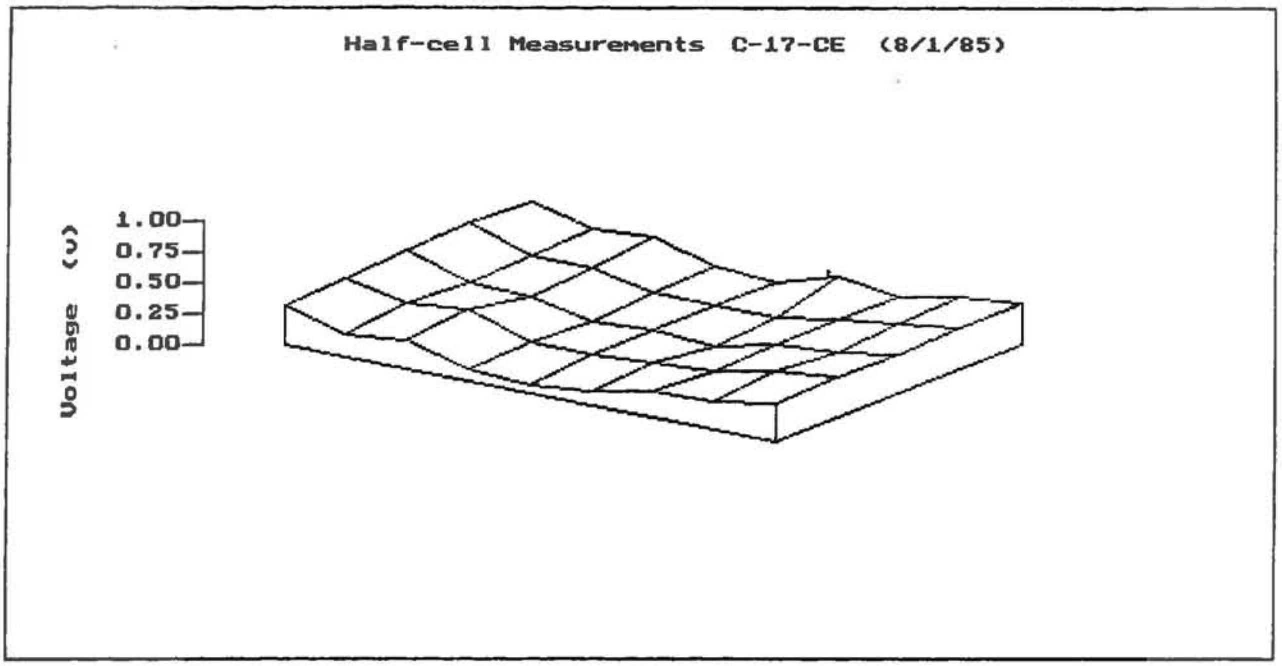
0.00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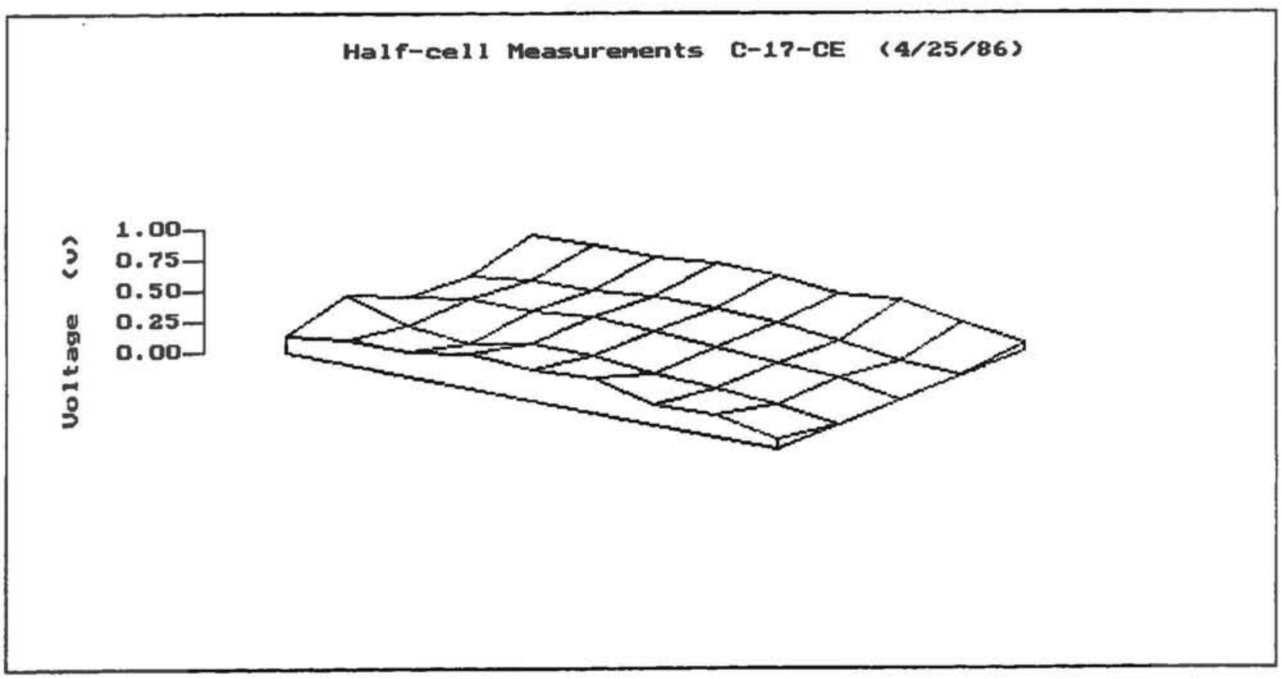
0.50
0.25
0.00
Voltage (v)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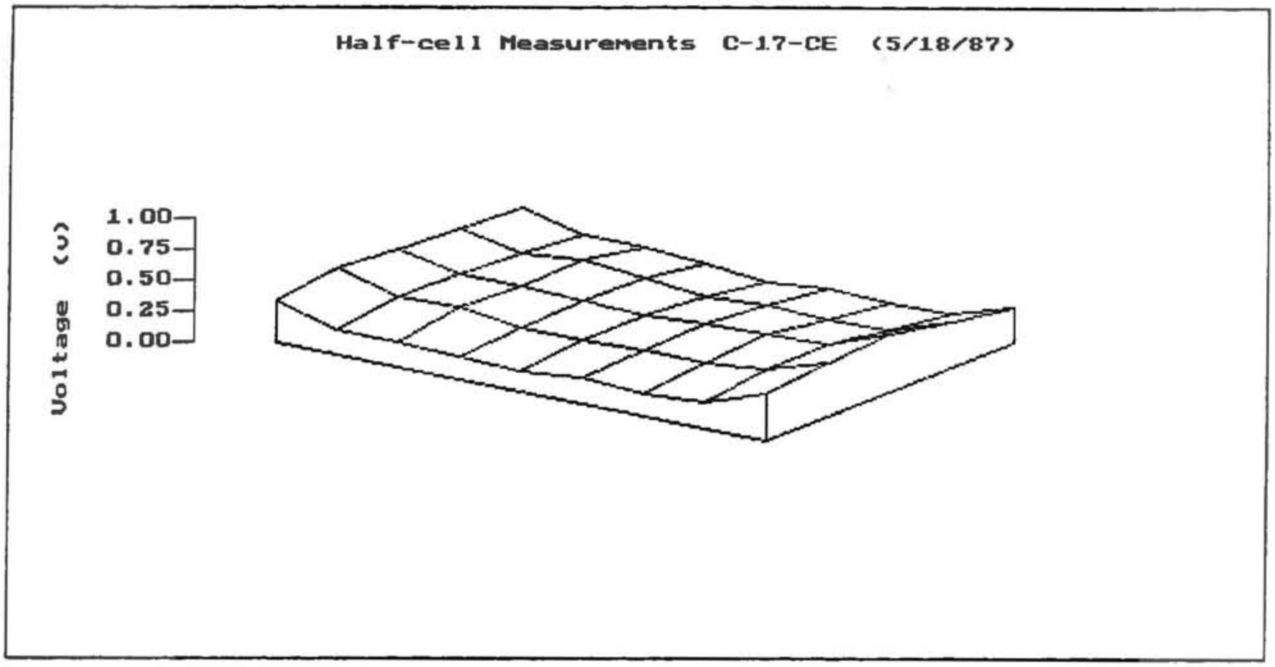
0.25
0.00
Voltage (v)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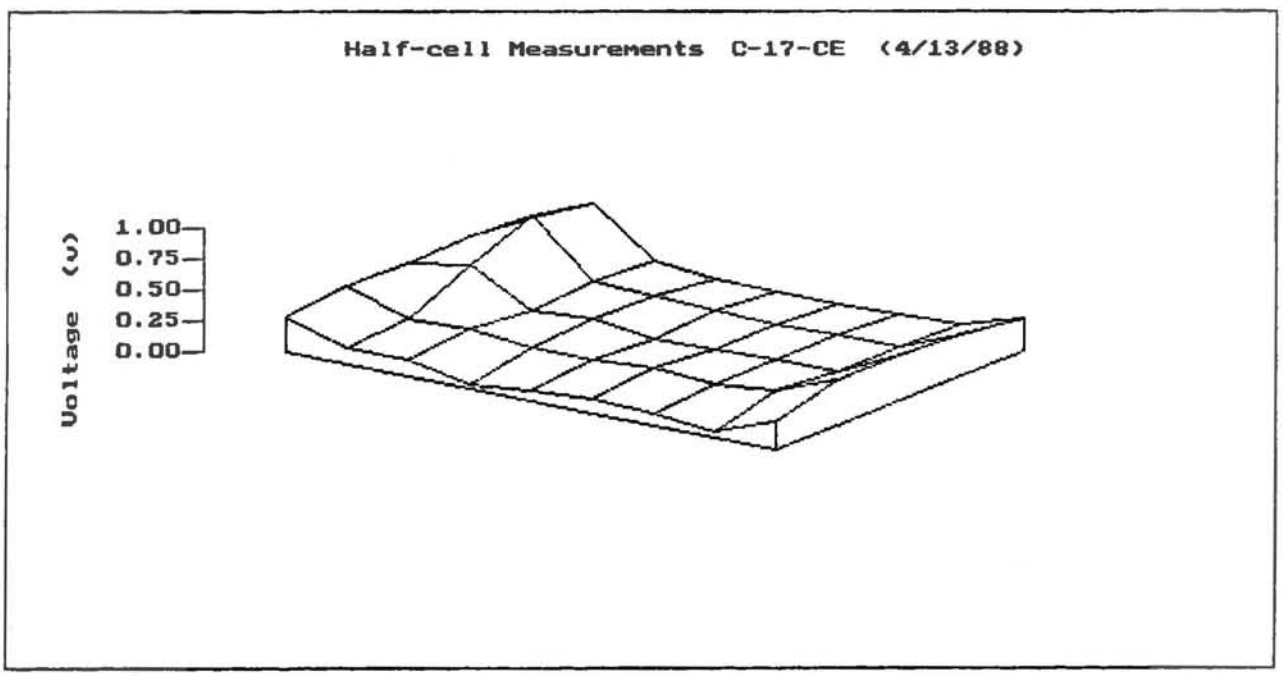
Voltage (v)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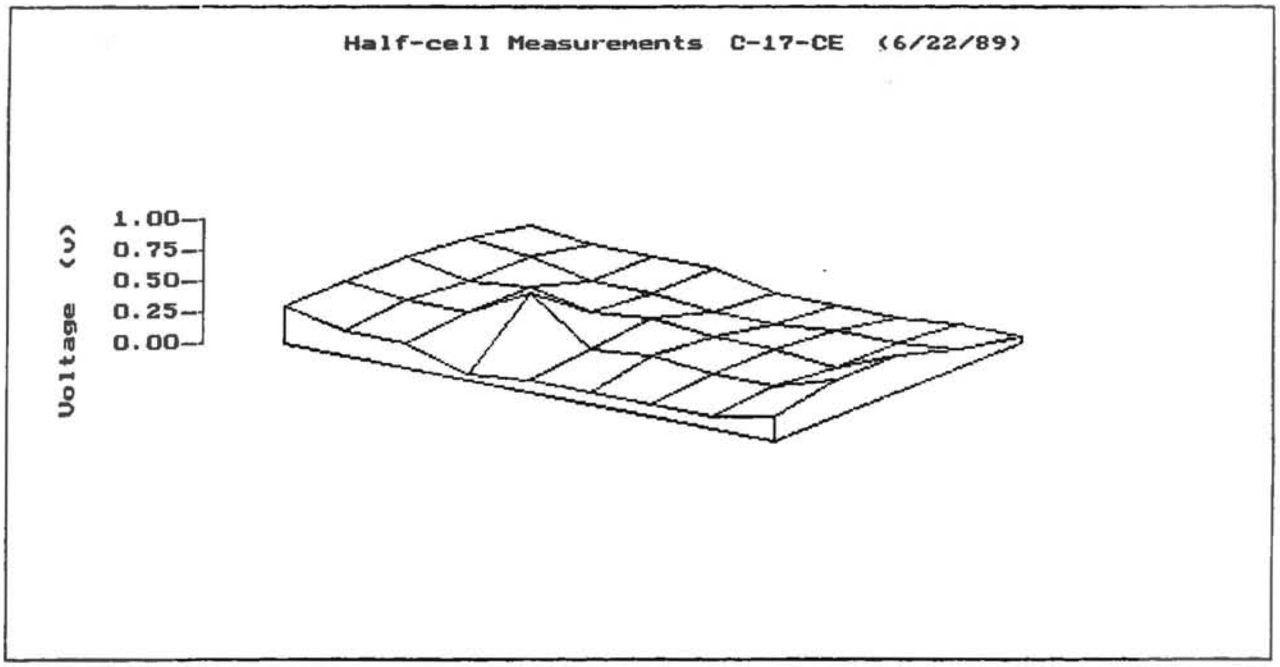
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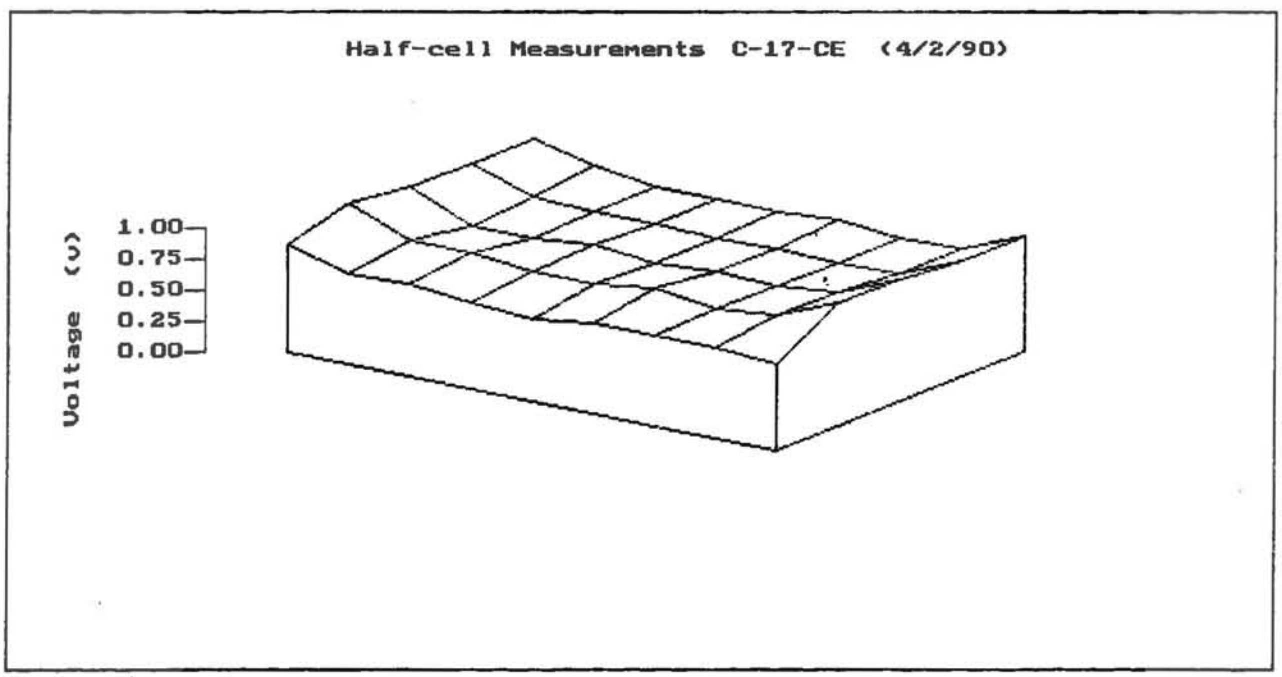
Half-cell Measurements C-17-CE (4/2/90)
Voltage (v)
1.00
0.75
0.50
0.25
0.00

The following pages repeat the data given in the surface plots. The data is organized in the following manner: all numbers given are in volts and are reported for a ten-foot grid that begins at the south-east corner of each deck. As an example, the first number given (row 1, column 1) is the grid point on the south-east corner of the deck. The last number in the first row is the south-west corner of the deck. The structure number and test date are given at the beginning of each data block.

C-17-AT (8/1/85)

			<--- width --->		
	0.21	0.22	0.23	0.24	0.21
l	0.12	0.22	0.23	0.25	0.11
e	0.13	0.18	0.22	0.15	0.12
n	0.14	0.20	0.24	0.16	0.15
g	0.13	0.11	0.23	0.15	0.14
t	0.16	0.16	0.20	0.16	0.14
h	0.18	0.16	0.22	0.18	0.25
	0.22	0.24	0.33	0.3	0.27
	0.22	0.26	0.32	0.27	0.25
	0.23	0.3	0.33	0.33	0.24

C-17-AT (4/24/86)

			<--- width --->		
	0.15	0.2	0.23	0.03	0.04
	0.04	0.22	0.21	0.01	0.19
l	0.02	0.13	0.19	0.07	0.19
e	0.03	0.13	0.16	0.1	0.27
n	0.05	0.09	0.12	0.17	0.32
g	0.01	0.03	0.1	0.19	0.29
t	0.01	0.01	0.14	0.17	0.15
h	0.07	0.08	0.21	0.05	0.2
	0.05	0.11	0.22	0.1	0.2
	0.08	0.21	0.18	0.02	0.12

C-17-AT (5/18/87)

			<--- width --->		
	0.33	0.35	0.38	0.37	0.29
	0.21	0.35	0.27	0.27	0.24
l	0.2	0.26	0.37	0.24	0.16
e	0.2	0.22	0.33	0.22	0.15
n	0.11	0.12	0.18	0.13	0.05
g	0.12	0.16	0.15	0.1	0.08
t	0.1	0.11	0.14	0.14	0.17
h	0.17	0.18	0.23	0.26	0.18
	0.19	0.21	0.32	0.21	0.15
	0.22	0.31	0.34	0.32	0.27

C-17-AT (4/13/88)

			<--- width --->		
	0.24	0.22	0.22	0.21	0.15
	0.04	0.18	0.1	0.12	0.03
l	0.09	0.06	0.14	0.1	0.0
e	0.06	0.1	0.15	0.11	0.06
n	0.02	0.03	0.1	0.03	0.1
g	0.01	0.0	0.01	0.04	0.1
t	0.02	0.01	0.06	0.0	0.05
h	0.09	0.06	0.14	0.09	0.03
	0.05	0.05	0.14	0.08	0.04
	0.16	0.22	0.19	0.2	0.14

C-17-AT (6/22/89)

			<--- width --->		
	0.1	0.15	0.25	0.25	0.1
	0.0	0.05	0.0	0.0	0.0
l	0.0	0.0	0.0	0.0	0.0
e	0.0	0.1	0.05	0.0	0.0
n	0.0	0.0	0.0	0.0	0.0
g	0.0	0.0	0.0	0.0	0.0
t	0.0	0.0	0.05	0.0	0.0
h	0.0	0.2	0.1	0.1	0.05
	0.1	0.2	0.1	0.1	0.05
	0.1	0.15	0.1	0.1	0.15

C-17-AT (4/2/90)

			<--- width --->		
	0.667	0.623	0.618	0.634	0.578
	0.534	0.487	0.442	0.465	0.441
l	0.521	0.451	0.442	0.42	0.4
e	0.518	0.489	0.531	0.501	0.431
n	0.438	0.48	0.518	0.296	0.29
g	0.432	0.316	0.416	0.323	0.297
t	0.405	0.323	0.304	0.402	0.398
h	0.431	0.38	0.41	0.421	0.418
	0.525	0.42	0.439	0.425	0.44
	0.575	0.623	0.634	0.569	0.579

C-17-BQ (8/1/85)

<-- width -->

	0.42	0.45	0.46	0.45	0.37
	0.23	0.16	0.21	0.17	0.15
	0.27	0.24	0.28	0.17	0.16
l	0.23	0.25	0.26	0.19	0.24
e	0.24	0.20	0.2	0.21	0.25
n	0.3	0.24	0.18	0.21	0.25
g	0.28	0.26	0.21	0.27	0.23
t	0.32	0.32	0.32	0.16	0.18
h	0.28	0.24	0.22	0.27	0.19
	0.22	0.29	0.28	0.22	0.18
	0.18	0.29	0.22	0.27	0.25
	0.22	0.25	0.28	0.27	0.29

C-17-BQ (4/25/86)

<-- width -->

	0.4	0.43	0.43	0.33	0.29
	0.31	0.3	0.31	0.26	0.18
	0.36	0.33	0.24	0.22	0.17
l	0.28	0.24	0.23	0.28	0.21
e	0.27	0.32	0.27	0.27	0.19
n	0.4	0.27	0.24	0.3	0.23
g	0.30	0.39	0.27	0.25	0.14
t	0.23	0.29	0.22	0.25	0.12
h	0.31	0.27	0.21	0.22	0.13
	0.3	0.27	0.38	0.2	0.16
	0.44	0.43	0.43	0.37	0.22

C-17-BQ (5/18/87)

<-- width -->

	0.43	0.5	0.46	0.38	0.32
	0.21	0.25	0.23	0.16	0.13
	0.3	0.25	0.23	0.19	0.11
l	0.1	0.25	0.3	0.2	0.17
e	0.2	0.21	0.19	0.19	0.12
n	0.29	0.25	0.16	0.21	0.11
g	0.2	0.28	0.19	0.24	0.11
t	0.31	0.31	0.27	0.18	0.1
h	0.26	0.28	0.19	0.22	0.13
	0.24	0.26	0.2	0.19	0.13
	0.24	0.28	0.21	0.25	0.2
	0.24	0.24	0.29	0.22	0.18

C-17-BQ (4/13/88)

	<-- width -->				
	0.47	0.46	0.44	0.38	0.32
	0.17	0.16	0.21	0.21	0.16
	0.15	0.15	0.18	0.15	0.1
l	0.13	0.17	0.23	0.18	0.14
e	0.19	0.16	0.14	0.18	0.12
n	0.14	0.21	0.21	0.18	0.12
g	0.22	0.21	0.16	0.2	0.07
t	0.22	0.26	0.15	0.19	0.11
h	0.18	0.2	0.14	0.21	0.11
	0.25	0.19	0.16	0.18	0.14
	0.24	0.18	0.23	0.27	0.19
	0.46	0.41	0.43	0.42	0.28

C-17-BQ (6/22/89)

	<-- width -->				
	0.25	0.3	0.25	0.1	0.25
	0.15	0.2	0.1	0.05	0.1
	0.05	0.05	0.0	0.0	0.0
l	0.1	0.15	0.1	0.0	0.0
e	0.05	0.05	0.05	0.0	0.0
n	0.1	0.1	0.05	0.0	0.0
g	0.05	0.15	0.05	0.0	0.0
t	0.15	0.2	0.1	0.0	0.0
h	0.15	0.1	0.05	0.0	0.0
	0.05	0.1	0.05	0.0	0.0
	0.1	0.2	0.1	0.0	0.0
	0.15	0.1	0.15	0.05	0.0

C-17-BQ (4/2/90)

	<-- width -->				
	0.61	0.54	0.49	0.47	0.42
	0.37	0.28	0.2	0.21	0.23
	0.42	0.38	0.23	0.22	0.28
l	0.28	0.27	0.18	0.23	0.18
e	0.31	0.29	0.23	0.21	0.16
n	0.31	0.30	0.18	0.23	0.20
g	0.35	0.41	0.22	0.23	0.19
t	0.34	0.31	0.18	0.27	0.24
h	0.37	0.29	0.17	0.19	0.21
	0.43	0.32	0.26	0.24	0.27
	0.54	0.52	0.46	0.50	0.44

C-17-CE (8/1/85)

			<-- width -->		
	0.31	0.34	0.37	0.38	0.35
	0.19	0.23	0.20	0.22	0.23
l	0.23	0.29	0.19	0.22	0.26
e	0.1	0.11	0.09	0.11	0.14
n	0.07	0.11	0.11	0.12	0.1
g	0.11	0.15	0.09	0.11	0.25
t	0.21	0.19	0.2	0.2	0.19
h	0.24	0.28	0.24	0.26	0.28
	0.31	0.34	0.31	0.33	0.33

C-17-CE (4/25/86)

			<-- width -->		
	0.13	0.26	0.05	0.01	0.15
	0.20	0.11	0.13	0.09	0.16
l	0.2	0.06	0.14	0.1	0.16
e	0.28	0.17	0.18	0.15	0.22
n	0.25	0.16	0.16	0.15	0.22
g	0.29	0.11	0.14	0.14	0.17
t	0.17	0.1	0.1	0.09	0.21
h	0.18	0.06	0.09	0.02	0.14
	0.09	0.0	0.0	0.0	0.06

C-17-CE (5/18/87)

			<-- width -->		
	0.33	0.4	0.35	0.32	0.29
	0.2	0.26	0.25	0.22	0.16
l	0.2	0.29	0.25	0.26	0.17
e	0.19	0.22	0.23	0.21	0.13
n	0.16	0.22	0.21	0.17	0.09
g	0.22	0.23	0.25	0.2	0.14
t	0.18	0.23	0.27	0.19	0.12
h	0.21	0.28	0.29	0.20	0.14
	0.38	0.43	0.47	0.37	0.28

C-17-CE (4/13/88)

<-- width -->

	0.28	0.34	0.31	0.33	0.29
	0.13	0.17	0.4	0.6	0.5
l	0.13	0.19	0.13	0.17	0.13
e	0.03	0.13	0.16	0.15	0.09
n	0.09	0.14	0.1	0.13	0.09
g	0.11	0.16	0.12	0.12	0.09
t	0.1	0.14	0.14	0.13	0.1
h	0.05	0.18	0.13	0.14	0.12
	0.24	0.36	0.37	0.34	0.26

C-17-CE (6/22/89)

<-- width -->

	0.3	0.3	0.3	0.25	0.15
	0.2	0.25	0.2	0.2	0.1
l	0.2	0.25	0.25	0.1	0.1
e	0.05	0.5	0.15	0.1	0.1
n	0.1	0.15	0.2	0.05	0.0
g	0.1	0.2	0.15	0.05	0.0
t	0.1	0.15	0.15	0.1	0.0
h	0.1	0.15	0.1	0.1	0.05
	0.2	0.3	0.3	0.15	0.05

C-17-CE (4/2/90)

<-- width -->

	0.87	1.0	0.93	0.92	0.92
	0.74	0.8	0.72	0.75	0.8
l	0.75	0.8	0.71	0.74	0.73
e	0.7	0.75	0.77	0.74	0.74
n	0.66	0.75	0.72	0.71	0.73
g	0.74	0.82	0.75	0.74	0.77
t	0.74	0.75	0.73	0.71	0.72
h	0.73	0.8	0.78	0.73	0.74
	0.7	1.0	0.99	0.93	0.93

C-17-DY (8/1/85)

			<-- width -->		
	0.19	0.21	0.25	0.23	0.19
	0.33	0.27	0.3	0.17	0.27
	0.33	0.3	0.35	0.3	0.29
l	0.30	0.25	0.26	0.32	0.16
e	0.23	0.31	0.3	0.26	0.24
n	0.2	0.25	0.22	0.14	0.11
g	0.27	0.33	0.29	0.26	0.12
t	0.20	0.25	0.23	0.27	0.17
h	0.26	0.23	0.3	0.22	0.19
	0.26	0.27	0.3	0.19	0.2
	0.21	0.25	0.22	0.23	0.2

C-17-DY (4/24/86)

			<-- width -->		
	0.2	0.32	0.3	0.3	0.17
	0.31	0.32	0.37	0.27	0.2
	0.33	0.38	0.37	0.35	0.26
l	0.31	0.28	0.29	0.34	0.12
e	0.23	0.34	0.33	0.36	0.20
n	0.21	0.28	0.25	0.25	0.09
g	0.28	0.35	0.31	0.34	0.04
t	0.23	0.32	0.26	0.33	0.12
h	0.22	0.35	0.34	0.31	0.12
	0.22	0.37	0.39	0.29	0.16
	0.25	0.39	0.36	0.3	0.2

C-17-DY (5/18/87)

			<-- width -->		
	0.28	0.31	0.35	0.34	0.29
	0.29	0.26	0.25	0.24	0.19
	0.32	0.31	0.32	0.29	0.26
l	0.3	0.24	0.27	0.31	0.19
e	0.21	0.24	0.2	0.25	0.18
n	0.28	0.26	0.22	0.19	0.12
g	0.3	0.28	0.35	0.27	0.15
t	0.24	0.23	0.29	0.30	0.14
h	0.26	0.22	0.31	0.26	0.14
	0.27	0.29	0.26	0.25	0.18
	0.38	0.4	0.41	0.34	0.25

C-17-DT (4/13/88)

<-- width -->

	0.3	0.35	0.35	0.37	0.27
	0.23	0.24	0.26	0.26	0.21
	0.2	0.24	0.25	0.27	0.19
l	0.22	0.2	0.22	0.3	0.17
e	0.14	0.21	0.22	0.23	0.18
n	0.16	0.21	0.19	0.21	0.13
g	0.17	0.26	0.23	0.26	0.14
t	0.24	0.18	0.19	0.27	0.17
h	0.16	0.2	0.24	0.26	0.14
	0.23	0.24	0.25	0.21	0.2
	0.38	0.42	0.36	0.37	0.26

C-17-DY (6/22/89)

<-- width -->

	0.0	0.10	0.5	0.0	0.0
	0.0	0.05	0.05	0.0	0.0
	0.0	0.0	0.0	0.0	0.0
l	0.0	0.0	0.0	0.0	0.0
e	0.0	0.0	0.0	0.0	0.0
n	0.0	0.0	0.0	0.0	0.0
g	0.0	0.1	0.1	0.0	0.0
t	0.0	0.0	0.0	0.0	0.0
h	0.0	0.0	0.0	0.0	0.0
	0.05	0.10	0.10	0.0	0.0
	0.20	0.25	0.25	0.0	0.0

C-17-DY (4/2/90)

<-- width -->

	0.4	0.4	0.37	0.4	0.35
	0.26	0.24	0.23	0.24	0.18
	0.26	0.26	0.25	0.23	0.21
l	0.28	0.23	0.25	0.24	0.17
e	0.26	0.29	0.18	0.18	0.21
n	0.23	0.23	0.19	0.19	0.19
g	0.26	0.26	0.21	0.22	0.19
t	0.34	0.21	0.19	0.23	0.23
h	0.24	0.25	0.23	0.23	0.17
	0.27	0.28	0.22	0.25	0.23
	0.37	0.43	0.37	0.45	0.37