PMMA & CAB

Weight and Base Curve Changes

Due to Hydration

Submitted by: John F. Labaza

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Submitted to: Dr. T. Wolf

Abstract

A study was performed to determine the water content by weight and base curve changes of polymethyl-methacrylate(PMMA), and cellulose acetate butyrate(CAB) with a hydration period of 0 to 168 hours.

Methods

Twelve minus lenses, 6 of PMMA and 6 of CAB were used in the measurements. The weight of the lenses was measured with the lenses in a dry state with at least 96 hours of dehydration. A fine weight balance scale with accuracy of $5.0 * 10^{-5}$ gm. was used for the measurements. Base curve measurements were taken with the aid of an American Optical monocular radiusgauge with the accuracy of $5 * 10^{-3}$ mm. The lenses were then submerged and hydrated in their cases with Burton-Parsons' Normol solution. Three measurements each were taken for the base curve and weight, with the resultant data being the average of these measurements. During the base curve measurements, if the lens was found to be warped, the two curves were added up and the average taken as the measurement. Before being measured dry, the lenses were wiped clean with a damp, lint-free, lens tissue. Following each hydration period, the lenses were blotted and wiped with a dry lint-free lens tissue, so no visible drops of Normol solution were noted. Handling of the lenses was done with a set of rubber tipped tweezers. Weight and base curve measurements were taken: dry, after 15 min., 30 min., 45 min., 1 hr., 2 hr., 4 hr., 8 hr., 16 hr. and 168 hr.(1 week). During the measurements, each lens was out of the Normol solution not more than 2.5 min.

Results

Hydration of the PMMA lenses peaked out to an initial high value,all lenses, after 45 minutes. They then decreased in % hydration untill they hit another peak around 4 hours, as is shown in Figure 1a & Ib. In general, the total hydration of the PMMA lenses increased significantly more than 1.4% which has been reported by other authors. Findings here, show an average hydration of 7.71% in the PMMA lenses over a period of 168 hours. The range was from 3.68% to 10.7% with significant hydration reached in all lenses within 30 minutes of soaking.

Hydration of the CAB lenses averaged 3.4% increase in weight with a range of 2.2% to 5.6%, as the final hydration weight after 168 hours. Significant hydration was much faster here, in 5 out of the 6 lenses, at 15 minutes versus 30 minutes for PMMA. There is a mild decrease in hydration after 1 hour, but at 2 hours, another peak is reached. At 4 hours there is another decrease which equals the amount of the initial hydration after 15 minutes.

At the end of 1 hour, in 5 out of the 6 PMMA lenses, the base curve had reached its steepest point, and began to flatten. Two lenses ended up with base curves steeper than originally measured dry. The range after 168 hours went from .02mm steeper to .08mm flatter(see table 2). For the CAB lenses, there was an initial flattening of the base curve, with the first trough around 30 minutes. Then there is a decrease in flattening until after 2 hours, and at 4 hours, all lenses averaged their base curve closest to the base curve measurement of the dehydrated state. Past 4 hours, the lens continues to flatten in base curve. The range after 168 hours, was from .03 mm to .18 mm flatter, with the average of .10 mm flatter base curve(see table 2).

Conclusion

It appears the PMMA lenses in this study have taken on much more water from the Normol solution than other authors have previously found(Flower & Hill, 1.4%; Lowther & Bier, 1.4%). For this, I have no plausible explanation except to repeat the experiment and compare results. The hydration of the CAB appears consistent with the physical properties of a gas permeable lens. The manufacturer's instructions state to soak the CAB in Flexol(Normol) for at least 4 hours prior to patient dispensing. This soaking is to hydrate and stabilize the lens. The findings of a low hydration point at 4 hours,(see Figure 2a & 2b) suggests a correlation of their previous study finding and this study.

The base curve flattening of PMMA according to this study, was .025 mm average after 168 hours of hydration. Morrison, Kaufman, and Cerulli found an average flattening of 100 lenses of .03 mm. The base curve fluxuation of the PMMA lenses during hydration, were relatively stable as noted on Figure 3a & 3b. The base curve fluxuation of CAB lenses was very significant. It was noted during the measurements, the actual lens reading showed varied amounts of warpage in reference to time of hydration. The average flattening of the CAB lens was .10mm or roughly 0.50 D. It is recommended in the Meso(CAB) fitting manual to fit 0.25 D steeper than K. Based on the results of this study, the clinician should fit at least 0.25 D steeper, or perhaps 0.50 D steeper to counter the amount of flattening due to hydration. However, that is compensated for by the larger diameter of the CAB. The CAB lens appears to be the lens of choice in the future. Enough expertise is present in the science of PMMA fitting today, to easily convert fitting tecniques to the new gas permeable type lens, providing the manufacturer provides good quality control and makes available full physical properties of their product.

Table 1

PMMA

	base curve	power	OAD	C.T.	tint	% hydration after 168 hr.	average % hydration
#1	7.1	-3.00	8.8	.12	cl.	3.68	
#2	7.2	-3.00	8.8	.12	cl.	6.8	
#3	7.3	-3.00	8.8	.12	cl.	6.9	
#4	7.4	-3.00	8.8	.12	cl.	10.4	7.71
#5	7.9	-3.00	8.8	.12	cl.	7.7	
#6	8.0	-3.00	8.8	.12	cl.	10.7	

CAB

	base curve	power	OAD	C.T.	tint	% hydration after 168 hr.	average % hydration
#1	7.50	-3.00	8.9	.18	cl.	2.2	
#2	7.34	-3.00	8.8	.18	cl.	4.4	
#3	7.42	-3.00	8.9	.18	cl.	2.4	
#4	7.76	-3.00	9.0	.18	cl.	4.5	3.4
#5	7.67	-3.00	9.0	.18	cl.	2.7	
#6	7.58	-3.00	8.9	.18	cl.	5.4	

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Table 2

PMMA

	net base curve in mm	average base curve in mm
#1	.02 steeper	
#2	.01 steeper	
#3	.015 flatter	
#4	.02 flatter	.025
#5	.08 flatter	
#6	.065 flatter	

CAB

	net base curve in mm	average base curve in mm
#1	.03 flatter	
#2	.07 flatter	
#3	.10 flatter	
#4	.18 flatter	.10
#5	.06 flatter	
#6	.12 flatter	

Table 3

	% hydration after 168 hrs.	base curve in mm after 168 hrs.
PMMA		
#1	3.68	.02 steeper
#2	6.8	.01 steeper
#3	6.9	.015 flatter
#4	10.4	.02 flatter
#5	7.7	.08 flatter
#6	10.7	.065 flatter
CAB		
#1	2.2	.03 flatter
#2	4.4	.07 flatter
#3	2.4	.10 flatter
#4	4.5	.18 flatter
#5	2.7	.06 flatter
#6	5.4	.12 flatter

Bibliography

Bier, Norman, Lowther, Gerald E., Contact lens Correction Butterworth & Co, London, Boston; 1977.

Flower, Frances C., Hill, Richard M., Polymethylmethacrylate, Measures of Hydration. American Journal of Optometry, pps. 935-937, 1972.

Kline, Lawrence, DeLuca, Thomas, A Clinical Study of CAB lens wear. Journal of American Optometric Association. pps.229-302, March, 1972.

Morrison, Robert J., Kaufman, Karl J., Cerulli, Eduardo. Base Curve Changes of Polymethylmethacrylate contact Lenses. American Journal of Optometry. pps. 17-20, January, 1965.

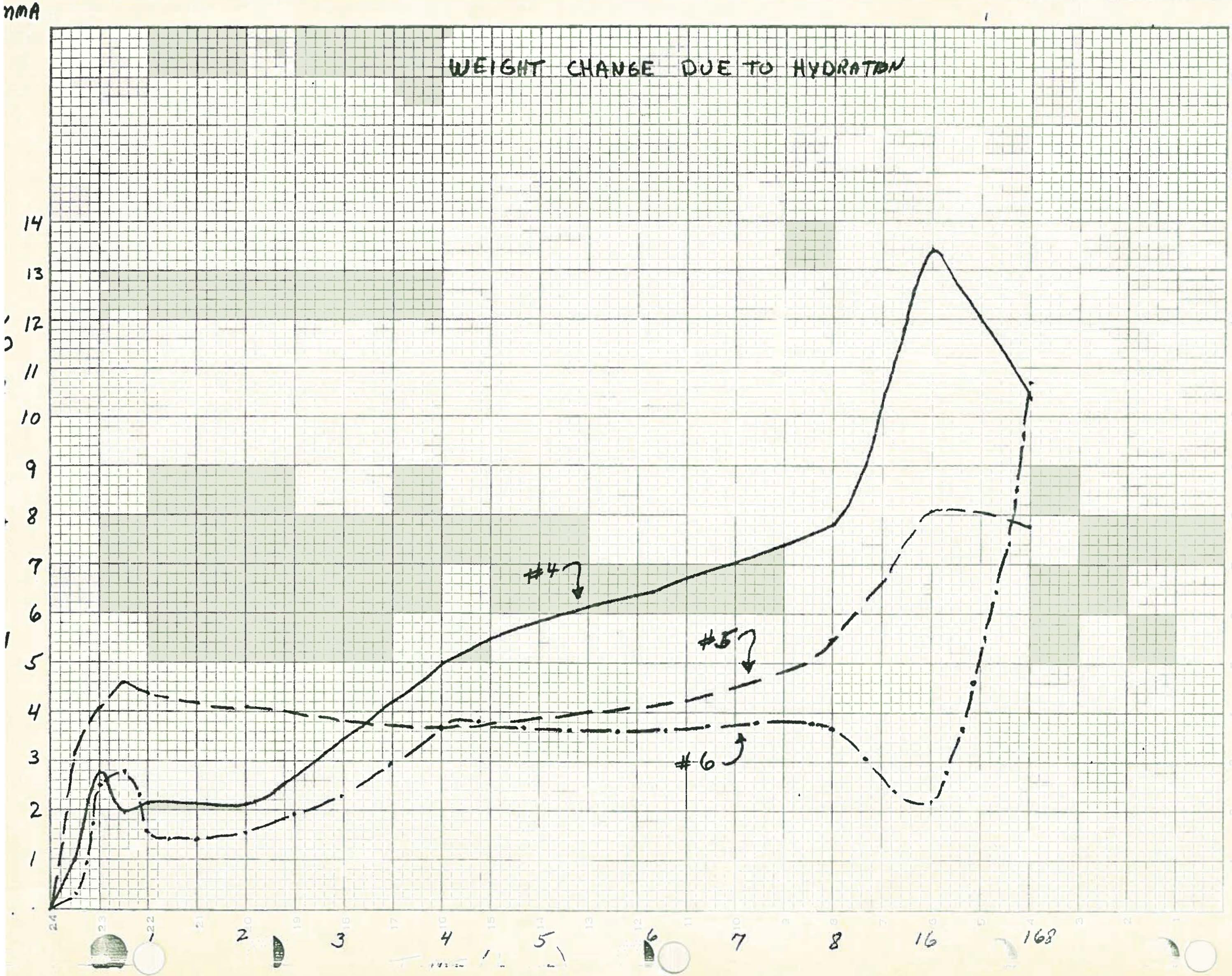

WEIGHT CHANGE DUE TO HYDRATION
#4
#5
#6
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1
2
3
4
5
6
7
8
16
168

Figure 1b

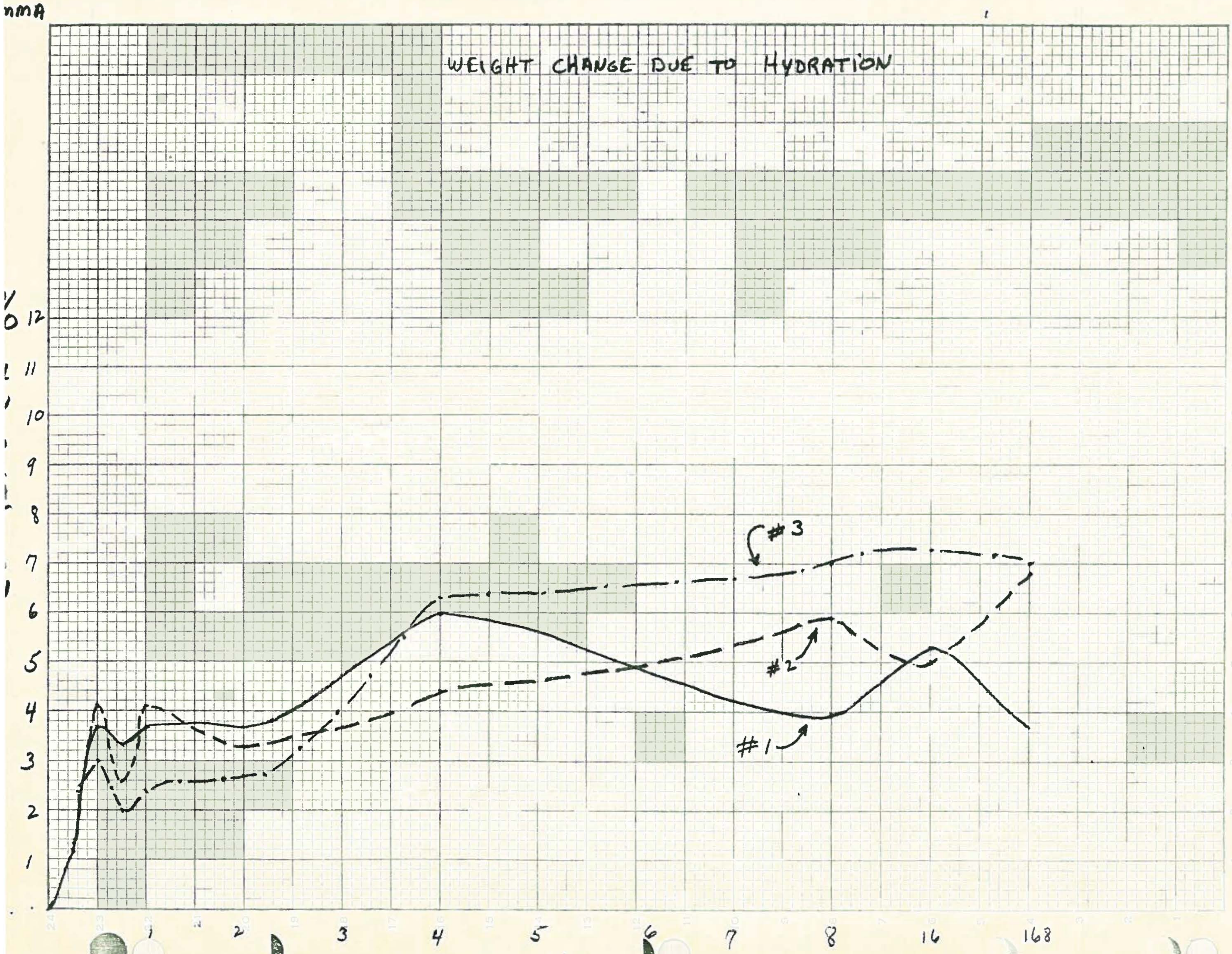

WEIGHT CHANGE DUE TO HYDRATION
#1
#2
#3
1
2
3
4
5
6
7
8
16
168
1
2
3
4
5
6
7
8
9
10
11
12
%

Figure 1a

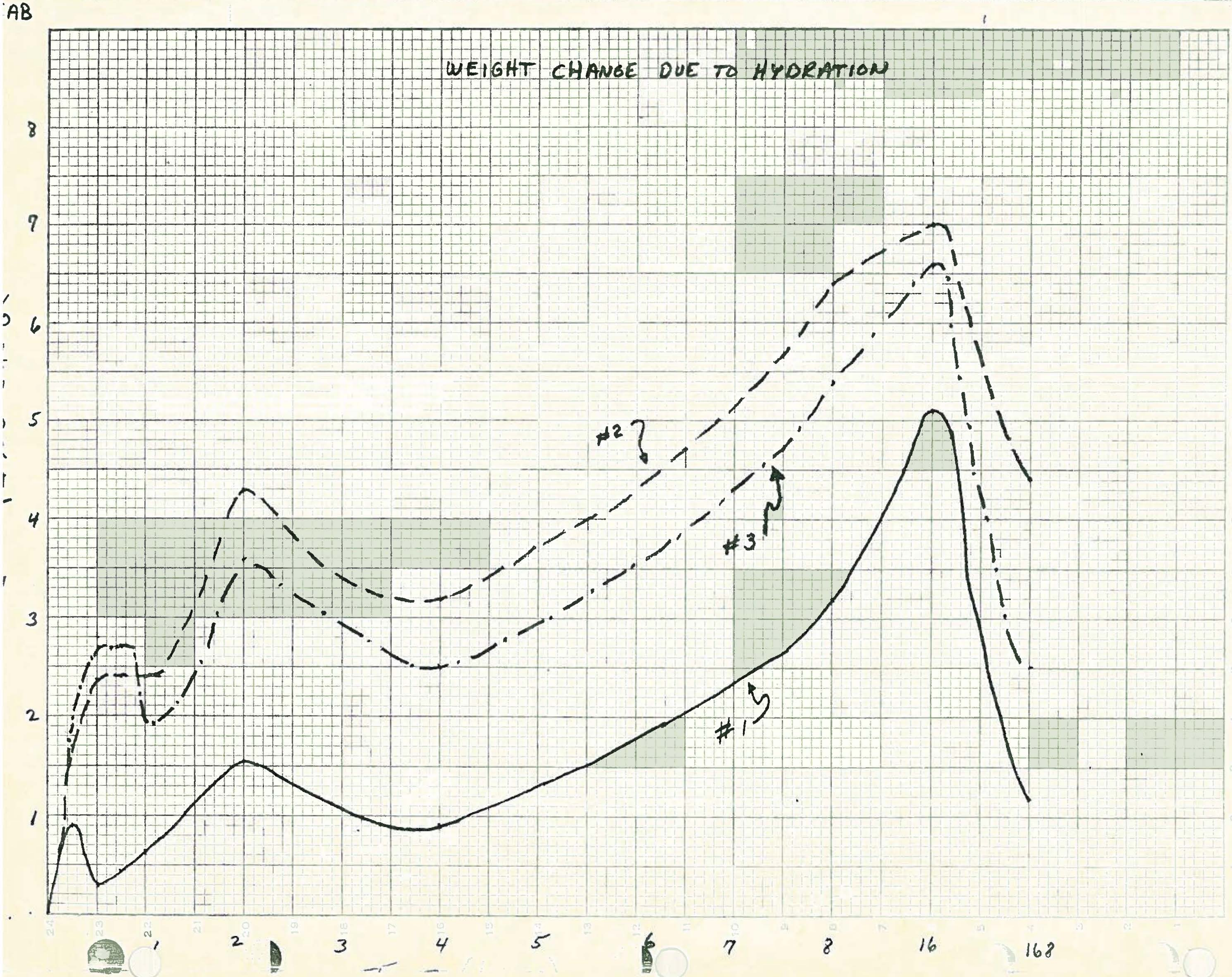

WEIGHT CHANGE DUE TO HYDRATION
#1
#2
#3
1
2
3
4
5
6
7
8
1
2
3
4
5
6
7
8
16
168

Figure 2a

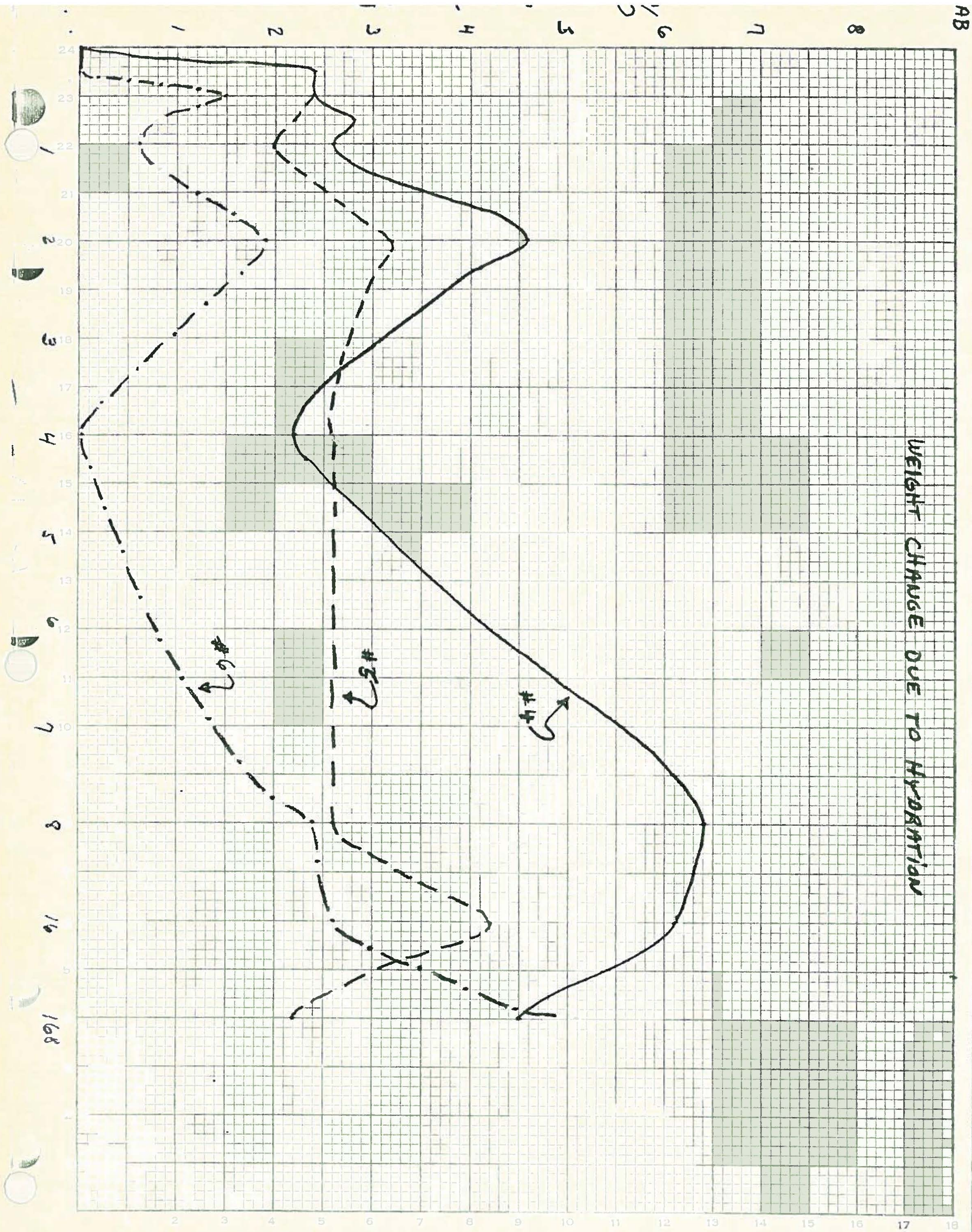


Figure 2b

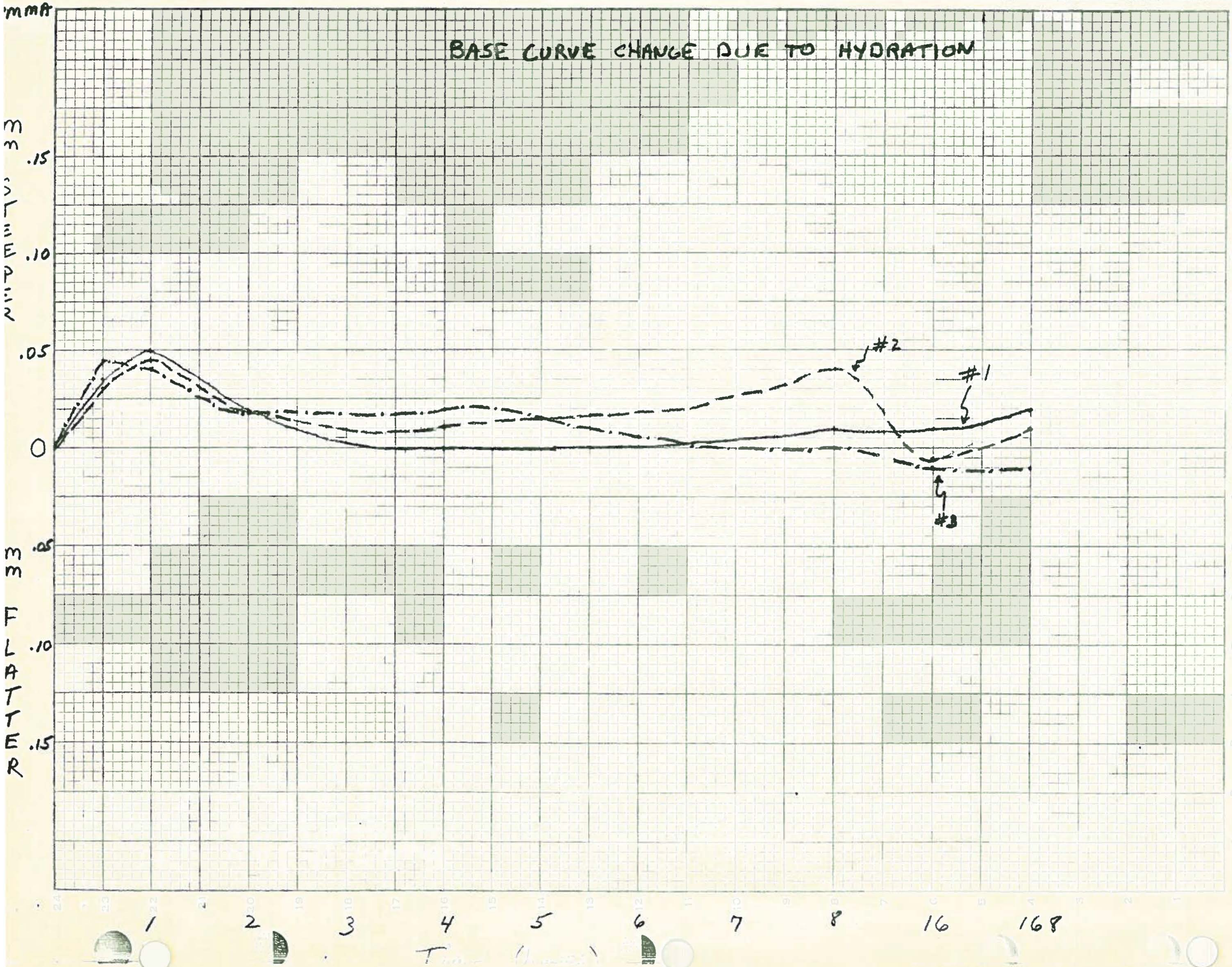

BASE CURVE CHANGE DUE TO HYDRATION
mm STEEPER
mm FLATTER
.15
.10
.05
0
.05
.10
.15
#1
#2
#3
1
2
3
4
5
6
7
8
16
168

Figure 3a

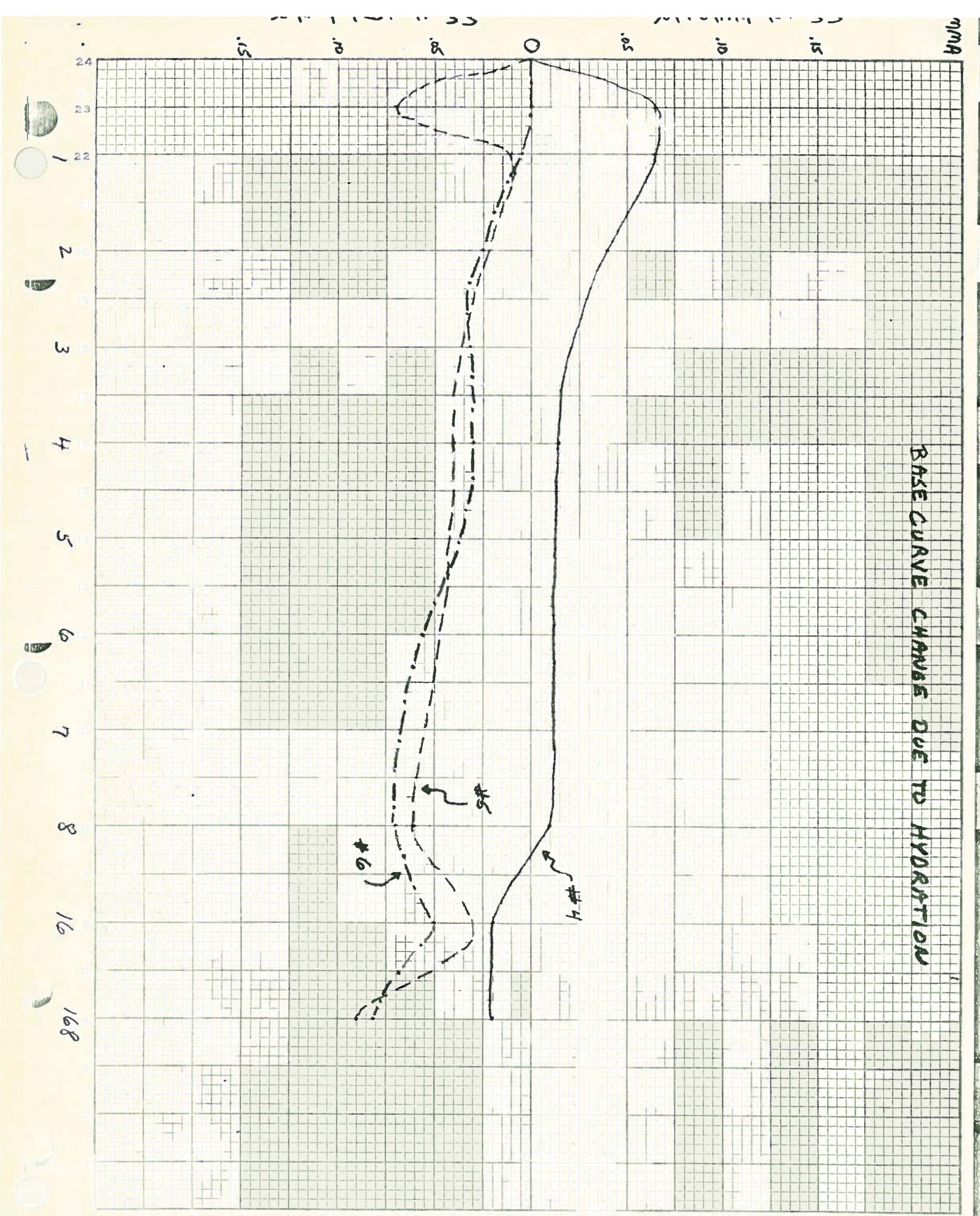
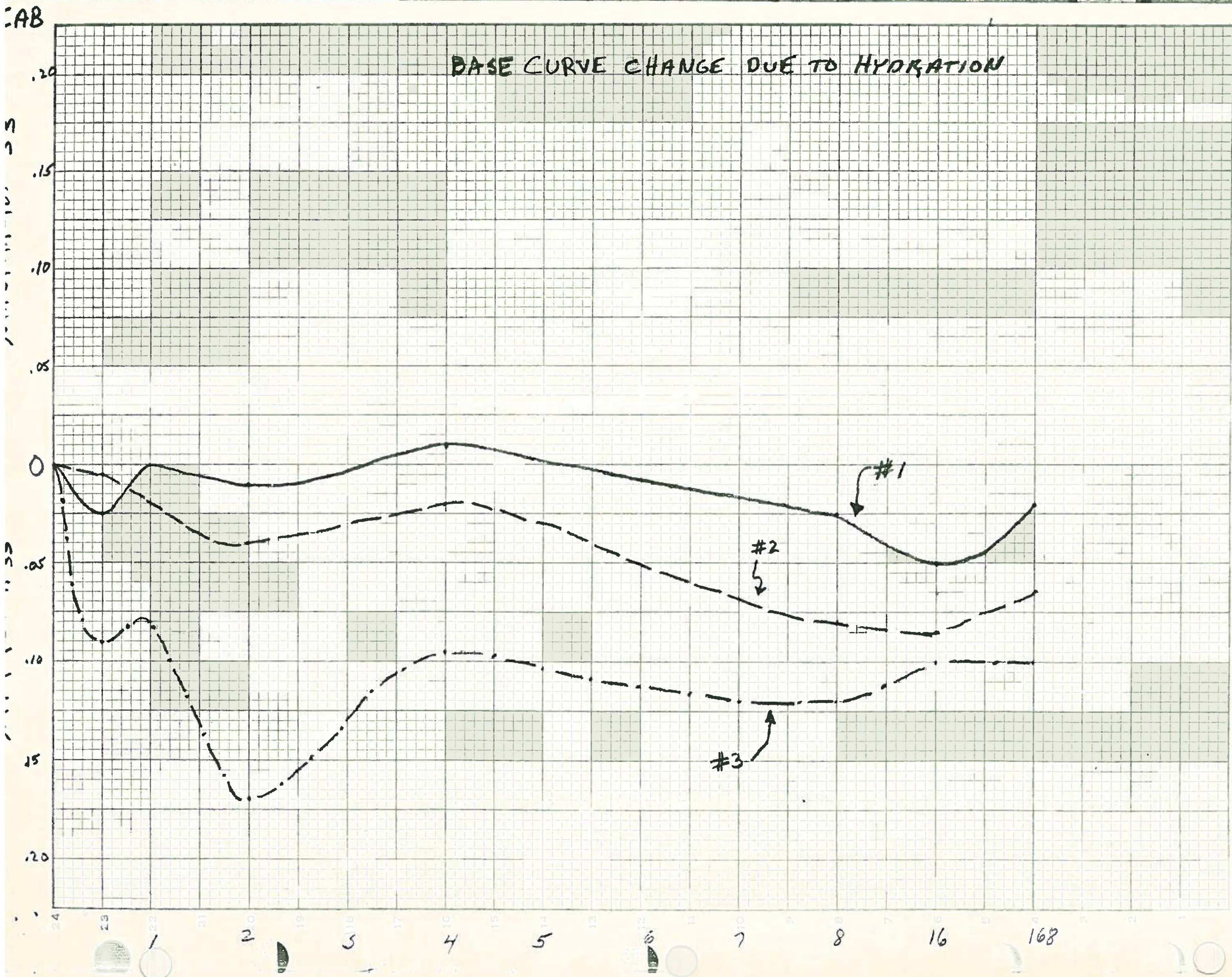
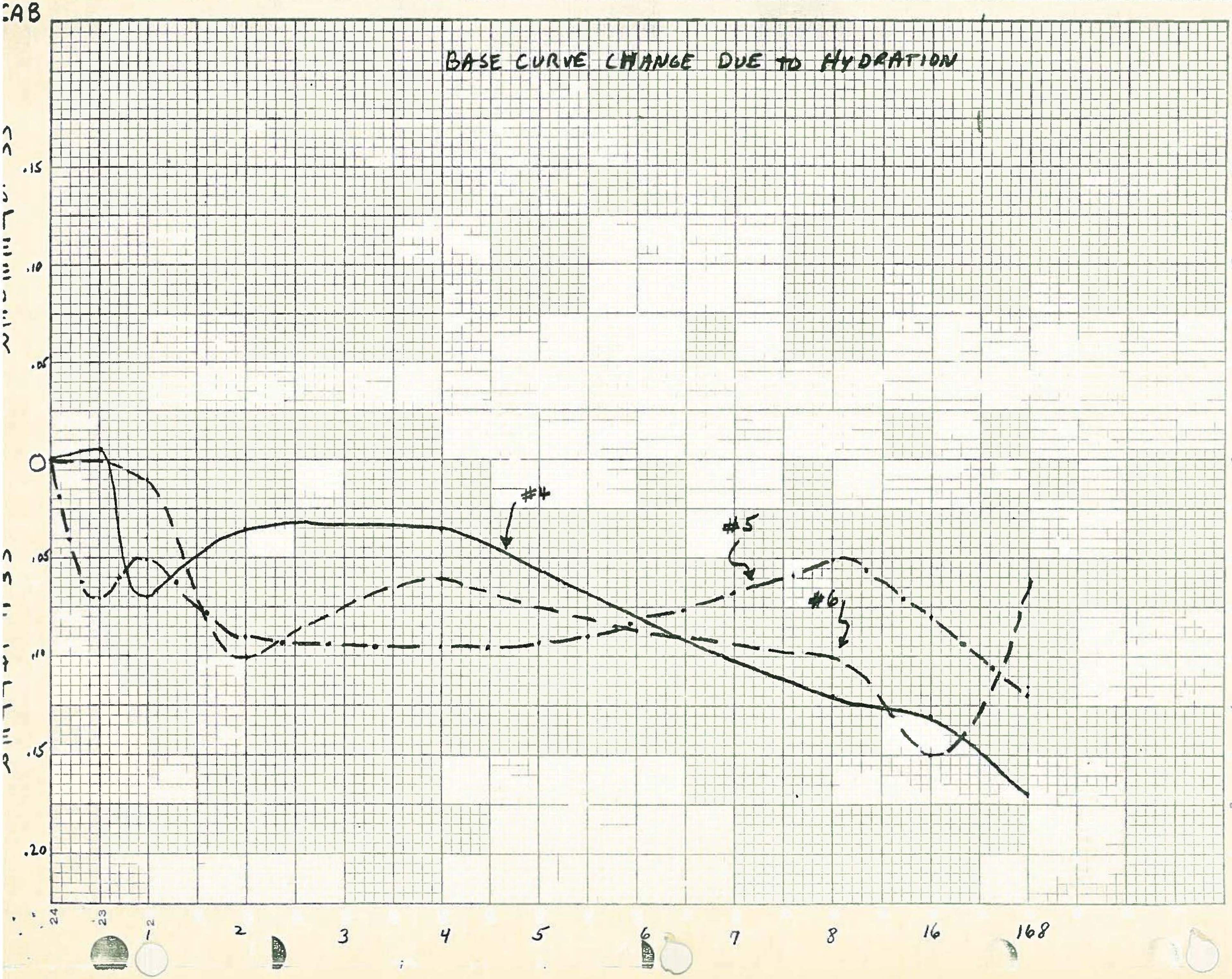


Figure 3b



BASE CURVE CHANGE DUE TO HYDRATION
CAB
.20
.15
.10
.05
0
.05
.10
.15
.20
#1
#2
#3
1
2
3
4
5
6
7
8
16
168

Figure 4a



BASE CURVE CHANGE DUE TO HYDRATION
#4
#5
#6
0
.05
.10
.15
.20
24
23
1
2
3
4
5
6
7
8
16
168

Figure 46