NORSK INSTITUTT FOR VANNFORSKNING

BLINDERN

0-85/68 - REPORT NO. 2

VACUUM FILTRATION OF RAW AND SEPTIC TANK SLUDGE FROM THE BÆRUM COMMUNITY

Project leader: Sanit.Eng. P. Aarne Vesilind

The report submitted January 24, 1969.

NORSK INSTITUTT FOR VANNFORSKNING
NORGES TEKNISK-NATURVITENSKAPELIGE FORSKNINGSRÅD

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Bærum kommune

SANDVIKA

Deres ref.: Deres brev av: Vår ref.: PAV/dwi 0-85/68 OSLO 3, January 24, 1969

Sir:

In accordance with our agreement, we have performed additional filterability tests on the samples of sludge delivered to the Institute. The report on these studies is intended to be an addendum to the first report, submitted to you on 10 December 1968.

The primary objective of the studies herein reported is to determine if freezing the sludge prior to filtration has any effect on the dewatering characteristics and if freezing has any economic value. Accordingly, tests were performed on both the septic tank sludge and the raw sludge before and after freezing. In addition, the samples were mixed, on a ratio of 1:1 by volume, and filterability was again determined before and after freezing. Two chemical conditioners which seemed to hold the most promise based on the earlier studies, inorganic ferric chloride and organic cationic Purifloc C-31, were used in these studies. The results can be summarized as follows:

1. Freezing does not hold any promise as a method of pre-treatment.

2. The effect of freezing differs for each sludge and for the chemical conditioners used. In general, it tends to improve filterability, but not enough to justify the added expense and cost.

3. Ferric chloride and Purifloc C-31 seem to be economically competitive. The cost of both chemicals will be about N.Kr. 4500 per ton of dry sludge solids treated.

4. Freezing improved the cake solids dryness, but again not enough to justify the extra cost.

5. With either chemical, it should be possible to dewater the sludge to between 20% and 25% dry solids by weight. This sludge cake is dry enough to be handled as a solid.

We hope that these results will be helpful in the selection of sludge dewatering methods for the Bærum kommune. We appreciate your confidence in the Institute and please contact us again if we can be on any further service.

Respectfully yours,
NORSK INSTITUTT FOR VANNFORSKNING

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INTRODUCTION

During the investigation of sludge filterability for the Bærum kommune which resulted in the report entitled "A PRELIMINARY FEASABILITY REPORT ON THE VACUUM FILTRATION OF COMBINED SEPTIC AND RAW SLUDGE FROM THE BÆRUM COMMUNITY", submitted on 10 December 1968, it was determined that freezing did not seem to affect sludge filterability. This result was unexpected, and it was recommended that a check be made to see if the sludge delivered to the Institute had previously been frozen. This was later determined to be the case, and it was suggested that an additional series of experiments be conducted to see just what effect freezing had on filterability and cake solids dryness. Accordingly, two samples of unfrozen sludge were delivered to the Institute on 10 January 1969, one was raw sludge and the other septic tank sludge. Filtration experiments were conducted on these samples. The samples were then frozen, and additional experiments were conducted to see if freezing improved filterability. The results of these experiments are reported in this communication.

PURPOSE AND SCOPE OF THIS INVESTIGATION

The purpose of this investigation was to see if freezing has any economic promise as a method of pre-treatment. Only two chemical conditioners were used, inorganic ferric chloride and an organic polyelectrolite, Dow Chemical "Purifloc C-31". These two chemicals seemed to be the most effective in conditioning the sludge tested in the previous investigation.

Tests were performed on the sludge as received at the Institute. No additional treatment such as elutriation of stabilization was investigated. The septic tank sludge and raw sludge were also combined on a volume ratio of 1:1 (denoted as "Combined Sludge" in the report) and filterability tests performed on this mixture.

EXPERIMENTAL METHODS

The experimental equipment and methods were indentical to those described in the previous report. The solids determinations, as before, were performed using aluminium dishes dried at 105° C. The chemicals were added to the sludge from prepared stock solutions. The ferric chloride stock solution was 1.0 % $FeCl_3$ by weight (technical grade), and the Purifloc C-31 stock solution was 0.1 % by weight.

EXPERIMENTAL RESULTS

Effect of Freezing on Filterability

Filterability is described by the specific resistance, which is sometimes known as the specific resistance to filtration. High values of the specific resistance indicate that the sludge does not filter easily, and low values indicate that dewatering is rapid and that the sludge can be easily filtered. A specific resistance of 1×10^8 is usually considered the limit of economical operation, in that if the sludge has a specific resistance below this value, vacuum filtration (or filter pressing) may be economically feasable.

Freezing can have a beneficial effect on sludge filterability. When sludge freezes, the water crystallizes and is drawn out of the sludge particles. This process has been found to be very effective in the dewatering of alum sludge in water treatment. It has not, however, been used in the treatment of waste biological sludge, since the increase in filterability has not been generally found to be sufficient to warrant the additional trouble and expense. It is thought that although freezing drives the bound water out of the biological sludge particles, the water is readsorbed by the particles when the sludge is thawed. The extent of this readsorption is different for various sludges. The filterability of biological sludge does change after it has been frozen, however, and the chemical requirements for conditioning will likewise change. It is necessary, therefore, to conduct laboratory tests on sludge samples which have not been frozen if the proper chemical requirements are to be estimated.

Effect of Freezing on Septic Tank Sludge Filterability

Figures 1 and 2 show the effect of freezing on septic tank sludge dewaterability, for both ferric chloride and Purifloc C-31 conditioned sludge. Surprisingly enough, freezing seemed to have a detrimental effect on the filterability with ferric chloride, as shown by the higher specific resistance values for the frozen sample at any given percent ferric chloride addition (Figure 1). Freezing had a rather dramatic effect on filterability with Purifloc C-31, however, as shown on Figure 2.

Purifloc C-31 was not able to decrease the specific resistance very much at all for the unfrozen sample, and therefore does not seem to be an appropriate chemical conditioner if septic tank sludge alone is to be dewatered. Ferric chloride seems to be effective at about 8 % of dry solids treated (by weight) which is quite high. We may conclude from these experiments that septic tank

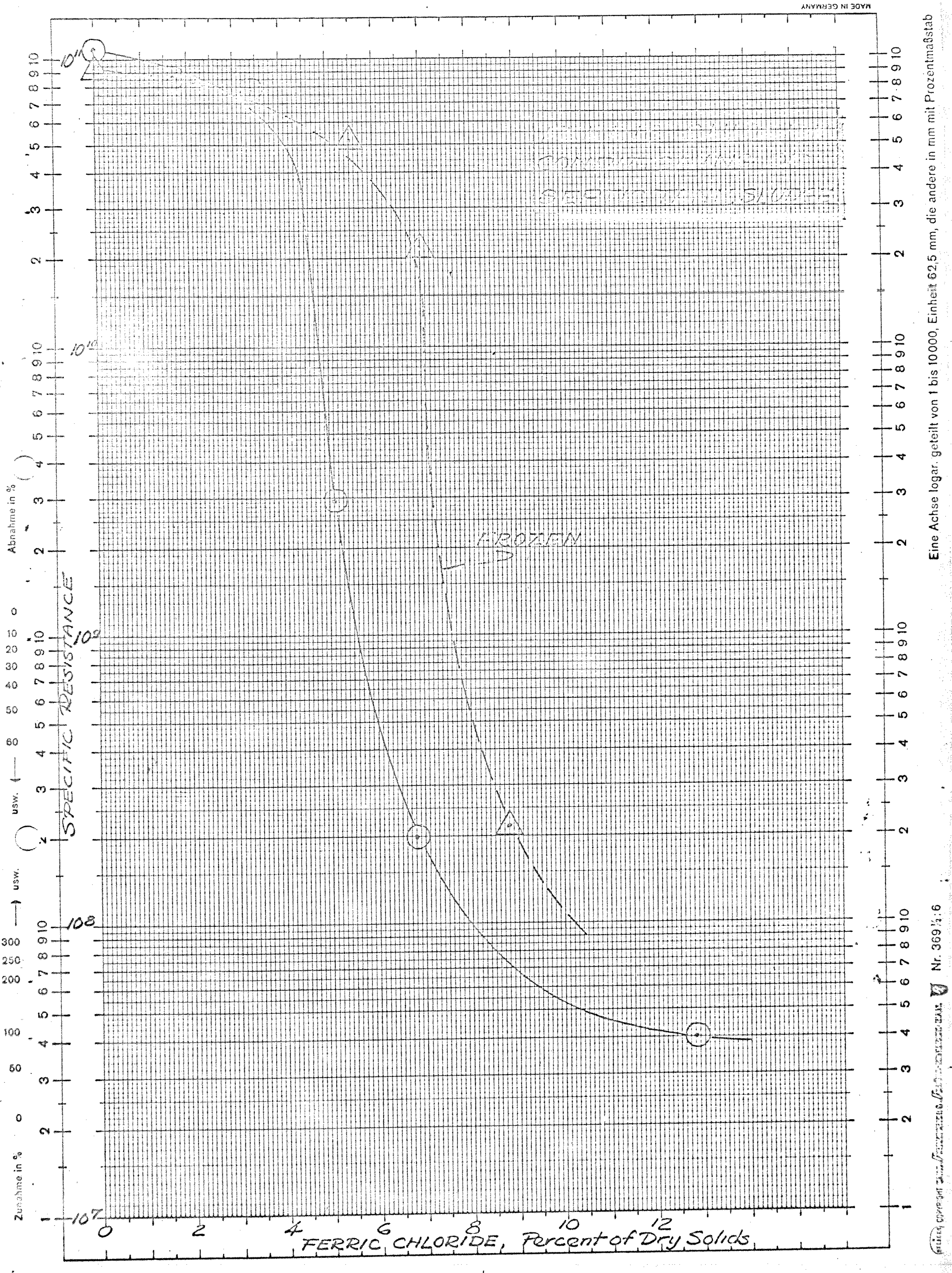
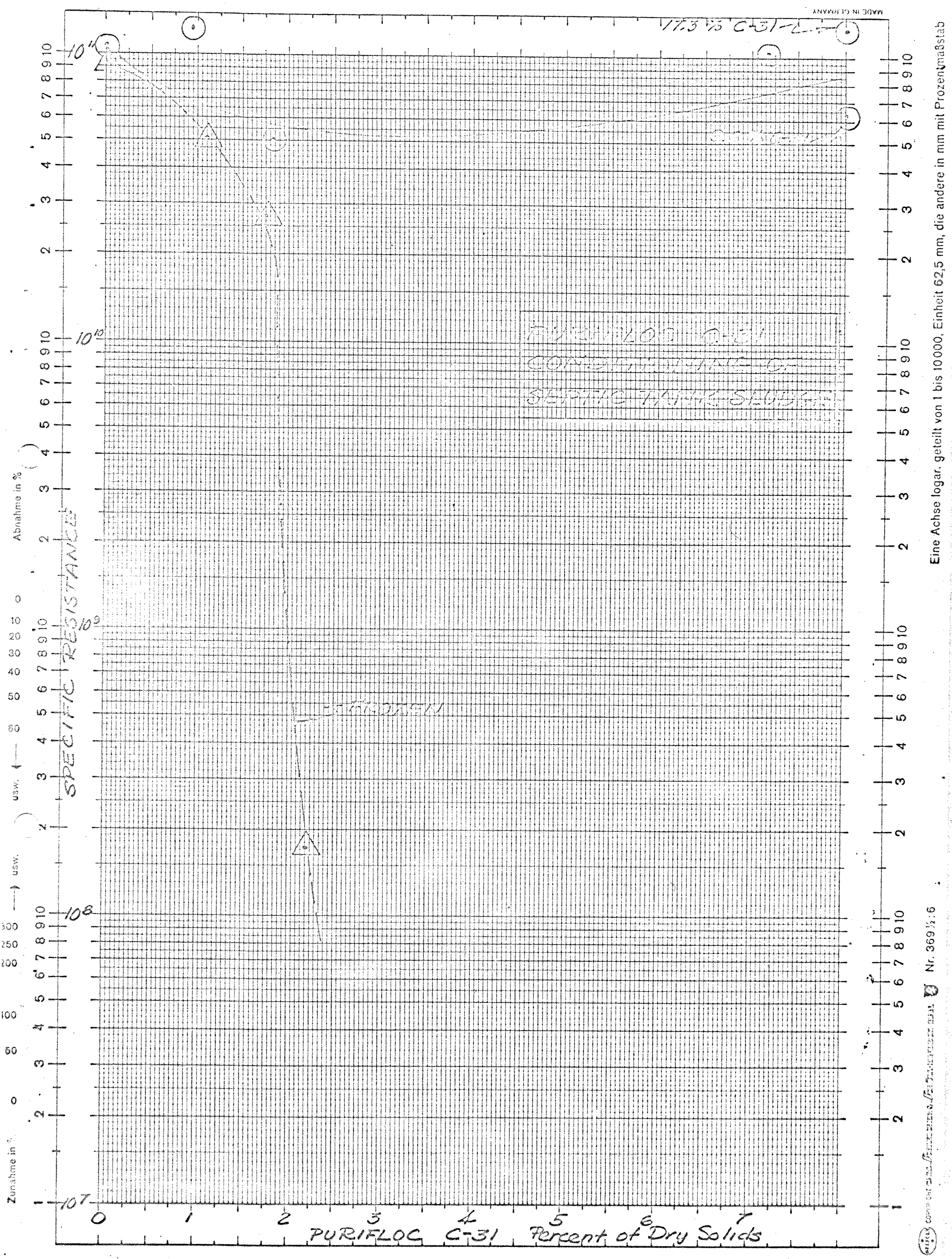

SPECIFIC RESISTANCE
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
FROZEN
0
2
4
6
8
10
12
FERRIC CHLORIDE, Percent of Dry Solids
MADE IN GERMANY
Eine Achse logar. geteilt von 1 bis 10000, Einheit 62,5 mm, die andere in mm mit Prozentmaßstab
Nr. 369 1/2 6
Abnahme in %
Zunahme in %
usw.

FIGURE 1


17.3 % C-31
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
SPECIFIC RESISTANCE
0 1 2 3 4 5 6 7
PURIFLOC C-31 Percent of Dry Solids
MADE IN GERMANY
Eine Achse logar. geteilt von 1 bis 10000, Einheit 62,5 mm, die andere in mm mit Prozentmaßstab
Nr. 369 ½ :6
Abnahme in %
Zunahme in %

sludge is a very difficult sludge to dewater, although with enough of the right kind of chemical, it can be done. Freezing has a beneficial effect with the organic polyelectrolite, but a minor effect (at least not a major positive effect) with ferric chloride.

Effect of Freezing on Raw Sludge Filterability

From Figure 3, it is clear that freezing did not seem to influence the dewatering characteristics of raw sludge treated with ferric chloride. There was a slight improvement if no chemicals were used, but not enough to make it economically feasable. Freezing seemed to be detrimental with Purifloc C-31, as shown in Figure 4. This was unexpected, and more data is needed to state this conclusively. Nevertheless, freezing does not seem to be an effective pre-treatment.

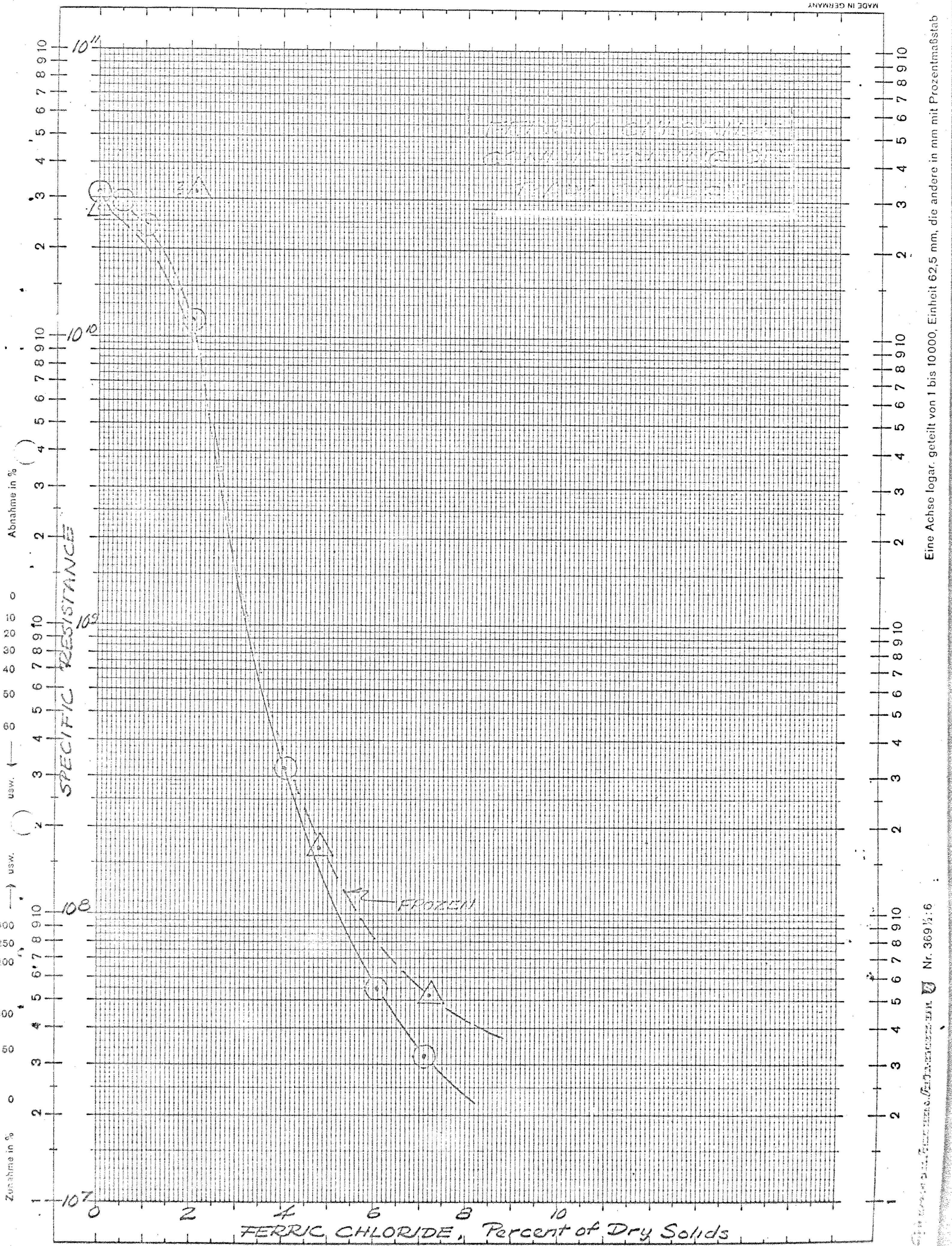
Effect of Freezing on Combined Sludge Filterability

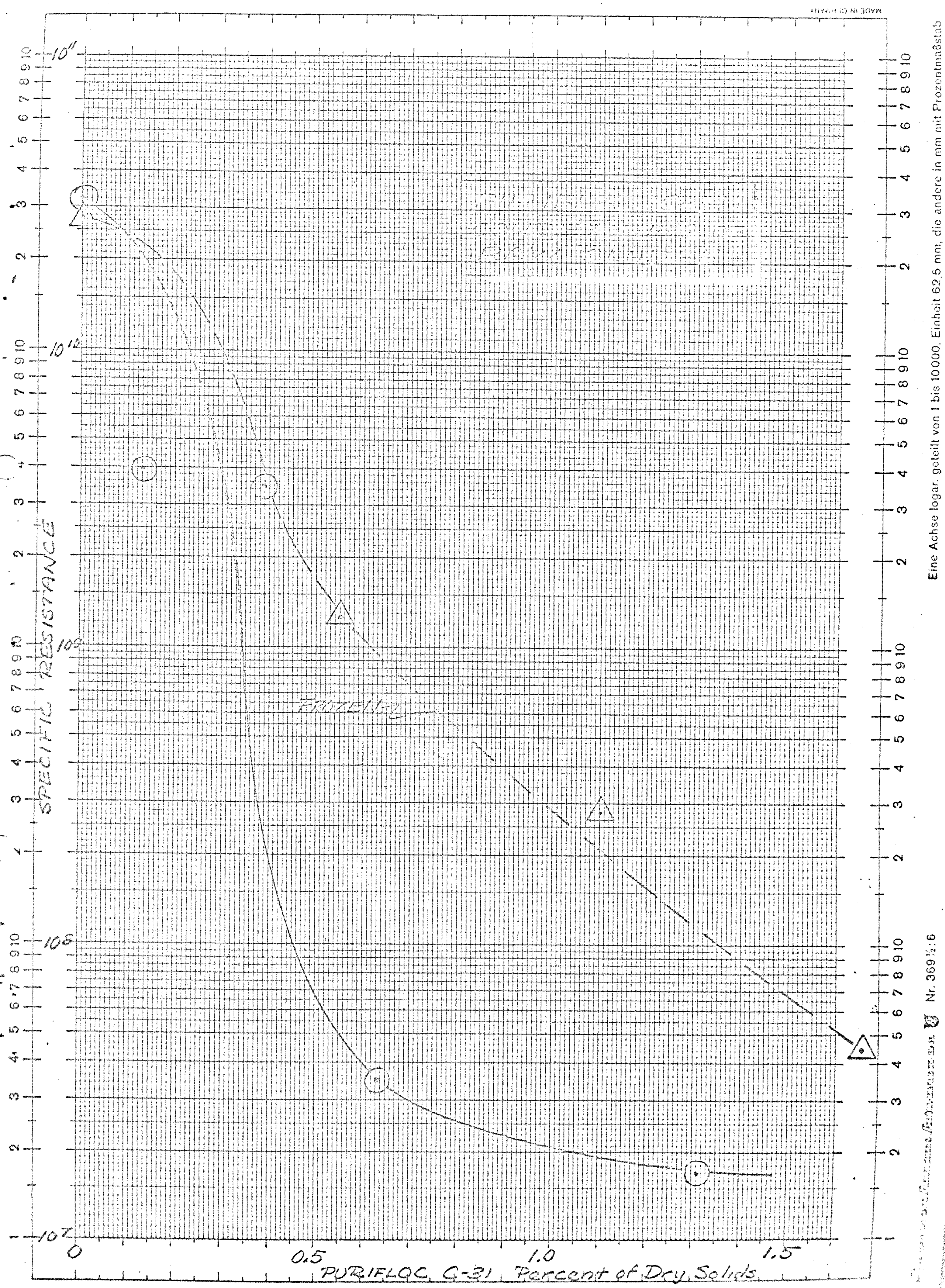
Of more interest is the effect of freezing on the mixture of septic tank and raw sludge. This mixture, made by combining the two sludges on a 1:1 basis by volume, is called "combined sludge". This is the sludge to be dewatered by the Kommune, and therefore derserves more analysis and consideretion.

Figure 5 shows the effect of freeezing on the combined sludge if ferric chloride is used as a conditioner. It is obvious that freezing has a negligibl effect on dewaterability in the range of interest, around 1×10^8 specific resistance. Without chemical addition, freezing lowered the specific resistance by about 1/2, but this is not enough to make it a useful method of pre-treatment. The effect of Purifloc C-31 is shown on Figure 6, and a greater effect due to freezing is noted. Freezing would seem to lower the chemical requirement for Purifloc C-31 (at the specific resistance of 1×10^8) from 7 % to 6 %. Even this, however, would not seem to make freezing advisable. We must conclude, therefore, that freezing as a method of pre-treatment is not feasable, and should not be used if it involves additional cost or trouble. If it can be done without extra cost, a small decrease in chemical costs might be realized.

Economic Comparison of Chemical Conditioners

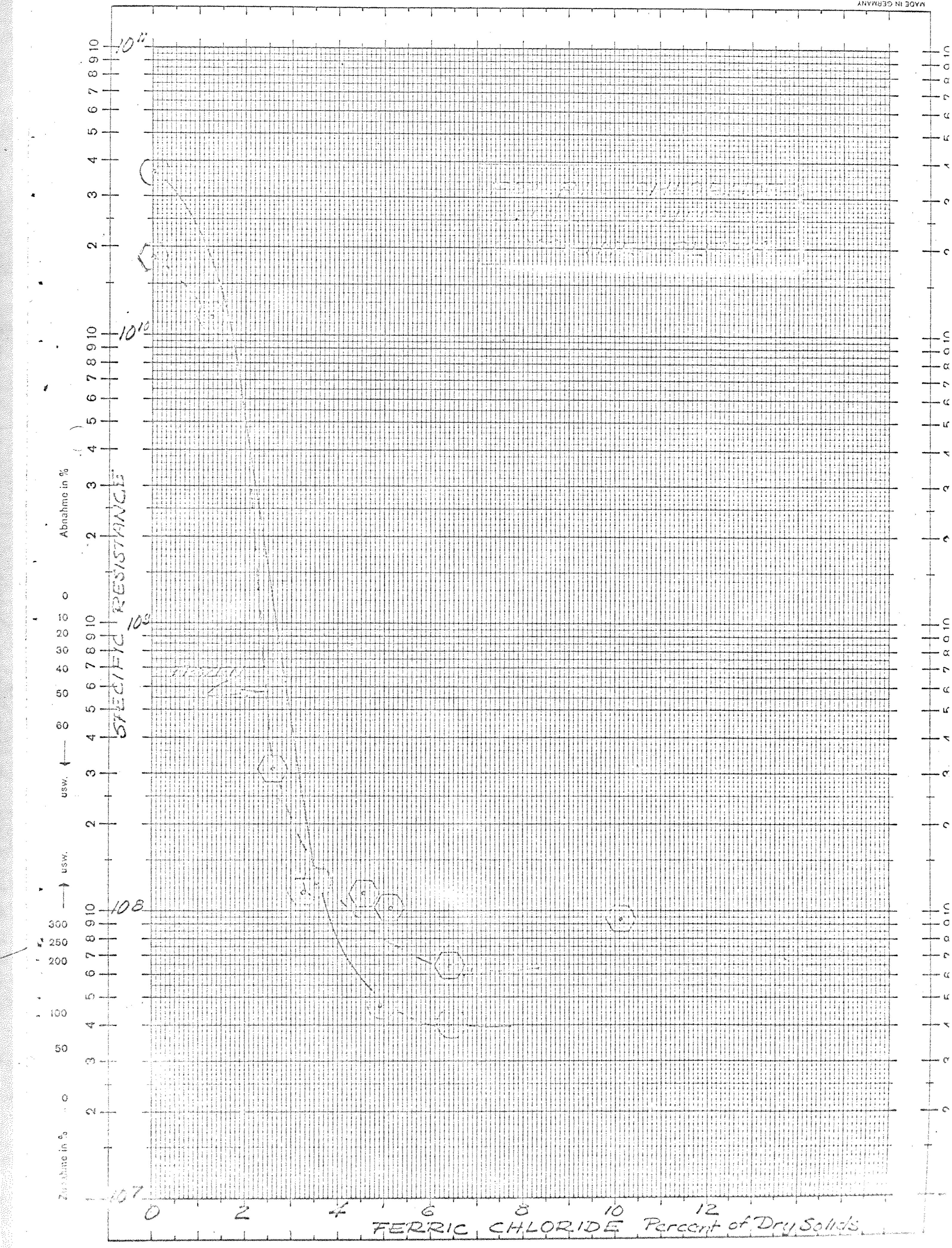
Ferric chloride is available in Norway at a bulk price of about N.Kr. 1200 per ton. Purifloc C-31 is available, again in bulk volume, at about N.Kr. 6750 per ton. It is possible to calculate the cost of treating the

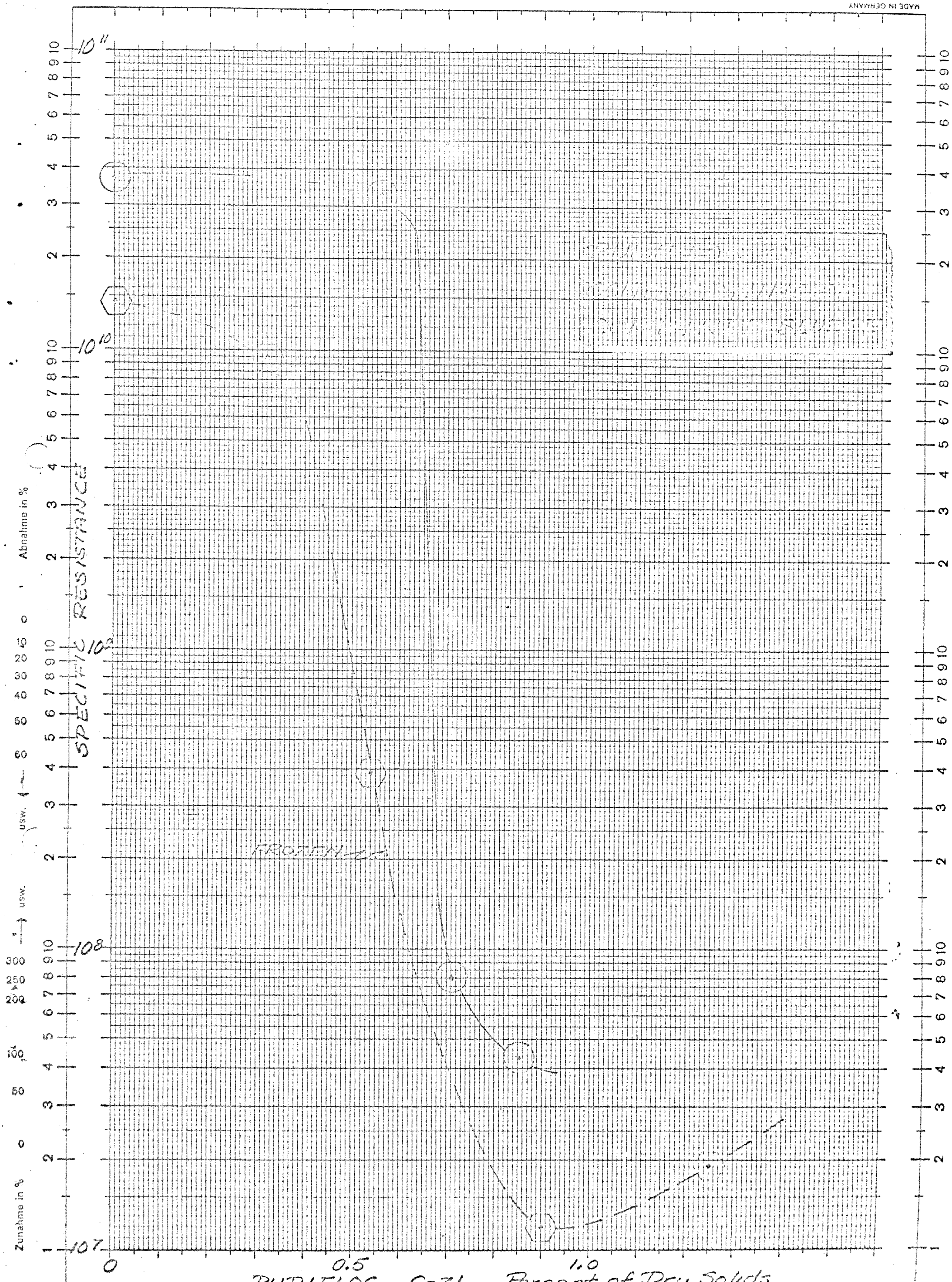

SPECIFIC RESISTANCE
FROZEN
FERRIC CHLORIDE, Percent of Dry Solids
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
0
2
4
6
8
10
MADE IN GERMANY
Eine Achse logar. geteilt von 1 bis 10000, Einheit 62,5 mm, die andere in mm mit Prozentmaßstab
Nr. 369½:6
Abnahme in %
Zunahme in %



SPECIFIC RESISTANCE
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
FROZEN
0
0.5
1.0
1.5
PURIFLOC C-31 Percent of Dry Solids
Eine Achse logar. geteilt von 1 bis 10000, Einheit 62,5 mm, die andere in mm mit Prozentmaßstab
Nr. 369½:6
MADE IN GERMANY

FIGURE 1


MADE IN GERMANY
SPECIFIC RESISTANCE
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
0
2
4
6
8
10
12
FERRIC CHLORIDE Percent of Dry Solids
Abnahme in %
Zunahme in %
usw.


MADE IN GERMANY
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
SPECIFIC RESISTANCE
Abnahme in %
Zunahme in %
usw.
FROZEN
0
0.5
1.0
PURIFLOC C-31 Percent of Dry Solids

sludge by these two chemicals in terms of tons of dry solids dewatered. This is done in Figure 7, which shows the cost of using either chemical to bring the specific resistance down to the limit of economical operation. It seems, from these data, that the two chemicals are quite competitive, and that either one will condition the sludge sufficiently at a cost of about N.Kr. 4500 per ton of dry solids dewatered.

Effect of Freezing on Cake Solids Concentration

The dryness of the cake is also an important consideration in vacuum filtration. If the cake is too wet, it is not possible to handle it as a solid. This would necessitate further treatment or expensive removal and transport methods. Accordingly, the cake solids dryness was measured for the different chemical conditioners and for both frozen and unfrozen sludge. The results are shown on Figure 8. Exept for the raw sludge treated with ferric chloride, freezing seemed to improve cake dryness. With ferric chloride conditioning, the frozen combined sludge attained a 31 % dryness (31 % solids by weight). Unfrozen sludge cake was about 20 % solids, but this is still dry enough for the sludge to be handled as a solid. Purifloc C-31 gave a slightly dryer cake, having 25 % solids for the unfrozen sample. In general, it seems that it is possible to attain a 20% to 25% solids concentration in the cake with either chemical.

CONCLUSIONS

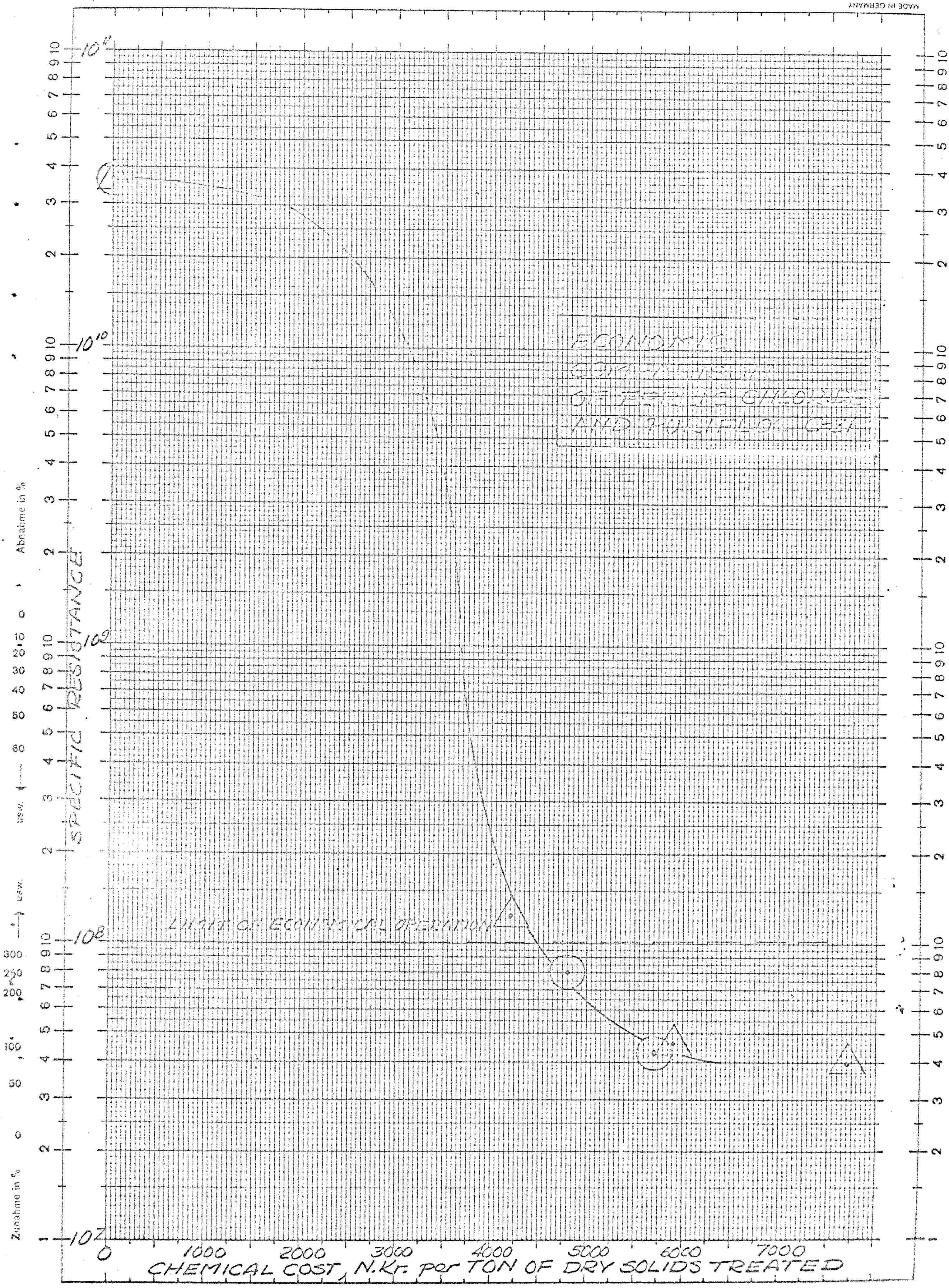
Freezing does not seem to be an economical method of pre-treatment. Freezing has different effects on the three sludges tested, and seems to affect the action of the chemicals conditioners differently as well. We can conclude from these experiments that:

1. Freezing seems to be detrimental for ferric chloride conditioned septic tank sludge.

2. Freezing has a dramatic beneficial effect on Purifloc C-31 treated septic tank sludge. Without freezing, Purifloc C-31 does not seem to be the proper chemical for conditioning septic tank sludge.

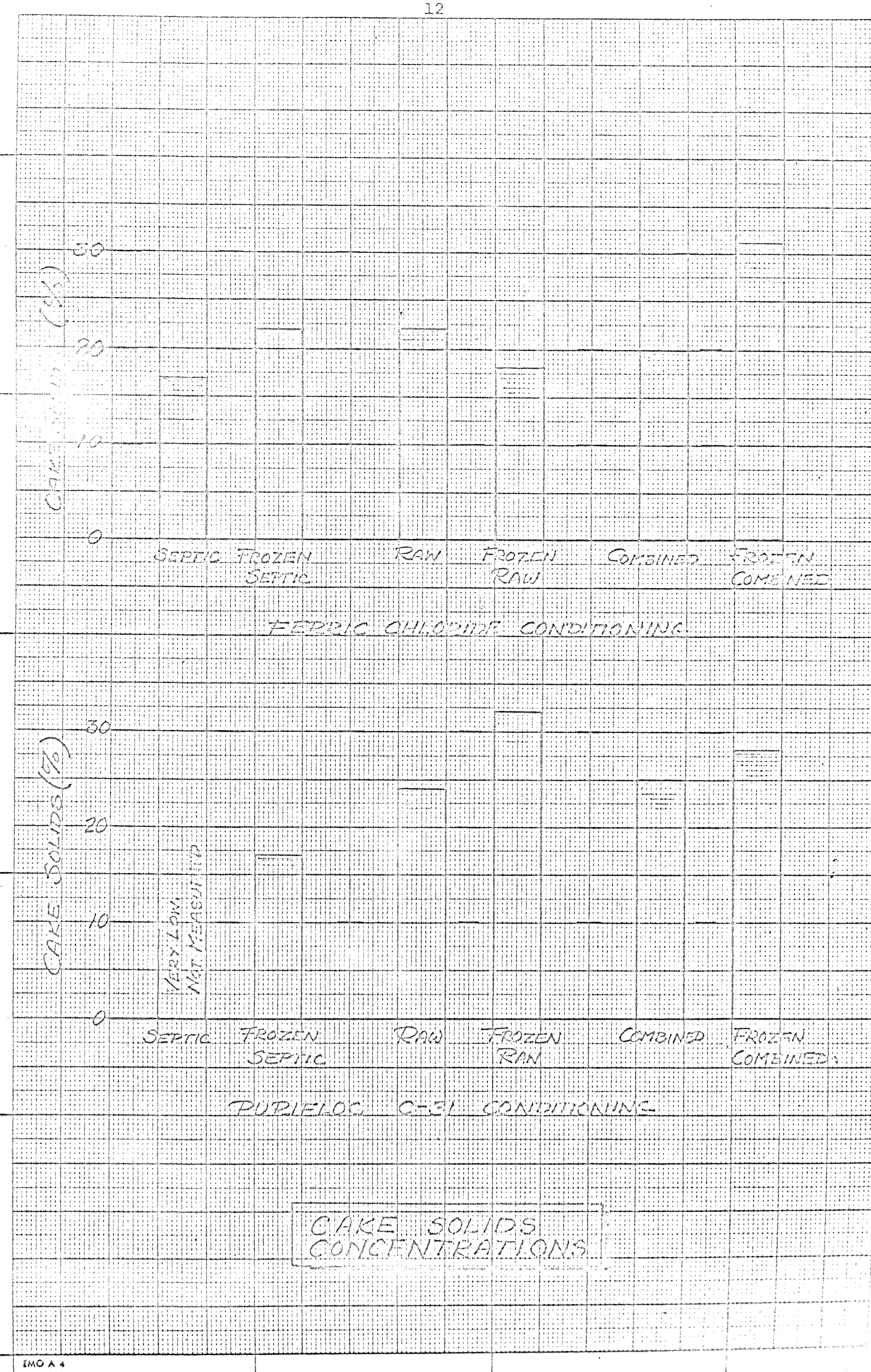
3. Freezing had a negligible influence on ferric chloride conditioned raw sludge.

4. Freezing seemed to be detrimental for Purifloc C-31 conditioned raw sludge.



SPECIFIC RESISTANCE
ECONOMIC
COMPARISON
OF FERRIC CHLORIDE
AND PURIFLOC C-31
LIMIT OF ECONOMICAL OPERATION
CHEMICAL COST, N.Kr. per TON OF DRY SOLIDS TREATED

FIGURE 7


CAKE SOLIDS (%)
30
20
10
0
SEPTIC
FROZEN SEPTIC
RAW
FROZEN RAW
COMBINED
FROZEN COMBINED
FERRIC CHLORIDE CONDITIONING
CAKE SOLIDS (%)
30
20
10
0
VERY LOW, NOT MEASURED
SEPTIC
FROZEN SEPTIC
RAW
FROZEN RAW
COMBINED
FROZEN COMBINED
PURIFLOC C-31 CONDITIONING
CAKE SOLIDS CONCENTRATIONS
EMO A 4

5. For the combined sludge, freezing did not affect the dewaterability of ferric chloride treated combined sludge.

6. Freezing had some beneficial effect on the dewatering of Purifloc C-31 treated combined sludge. This effect is due mainly to the increased dewaterability of the septic tank sludge with Purifloc C-31 (See conclusion number 2 above).

7. Both chemicals seem to be economically competitive, and these experiments do not indicate that one is superior to the other on the basis of sludge dewaterability.

8. A cake solids concentration of about 20 % to 25 % can be expected with either chemical if the filterability is increased sufficiently.

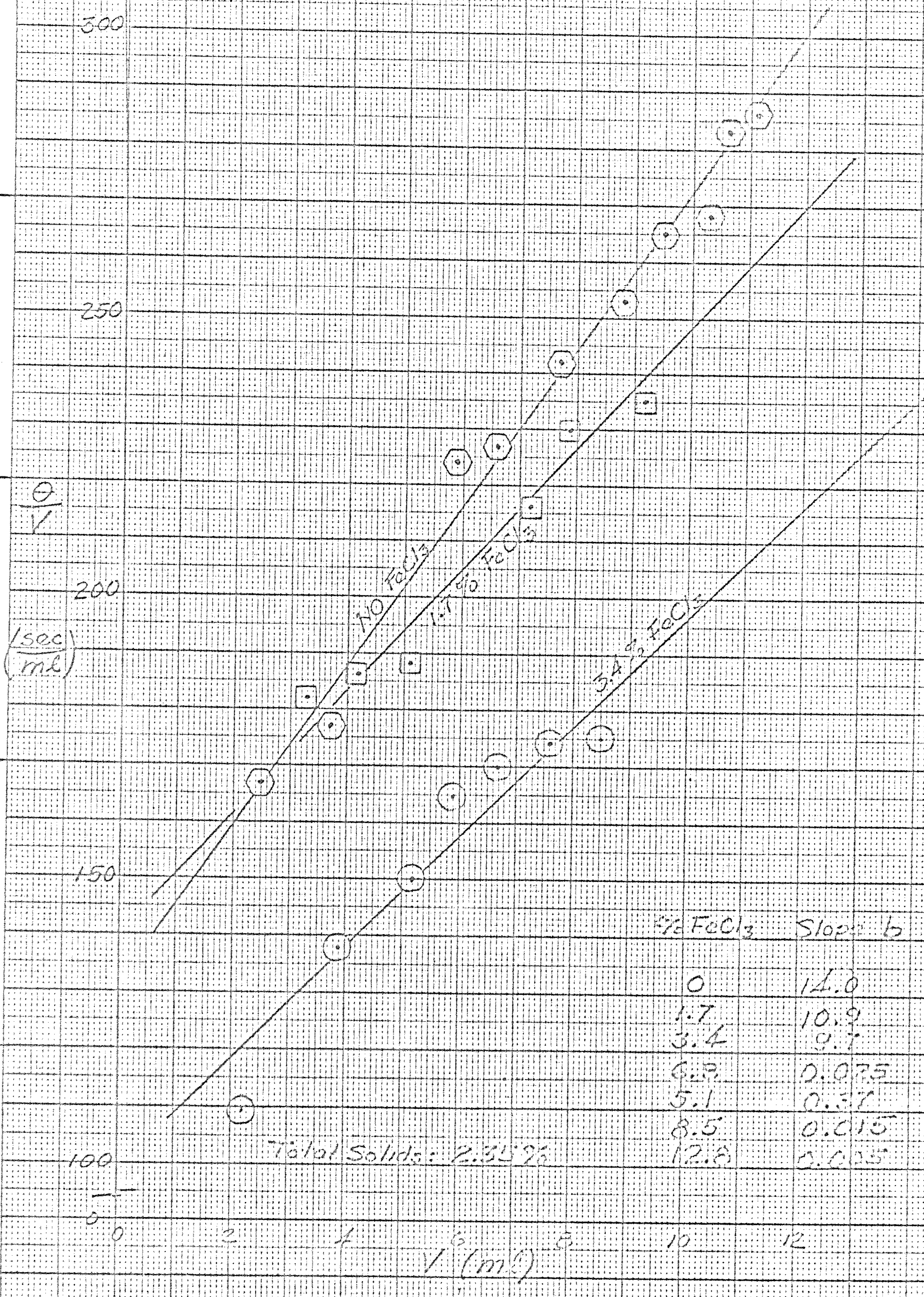
PAV/dwi
24.1.1969

APPENDIX

Run No. 11
15-7-59

SEPTIC TANK SLUDGE

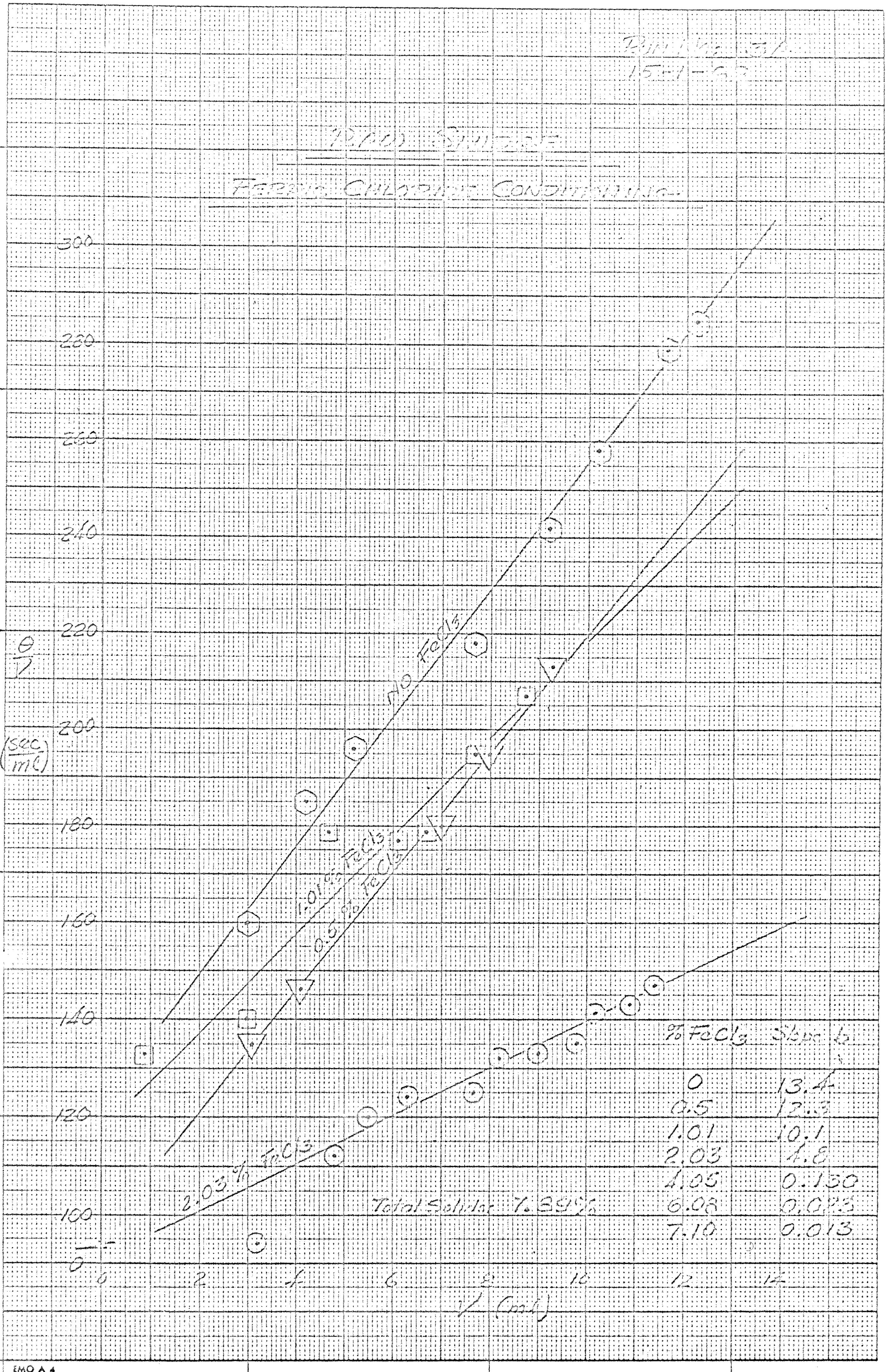
FERRIC CHLORIDE CONDITIONING

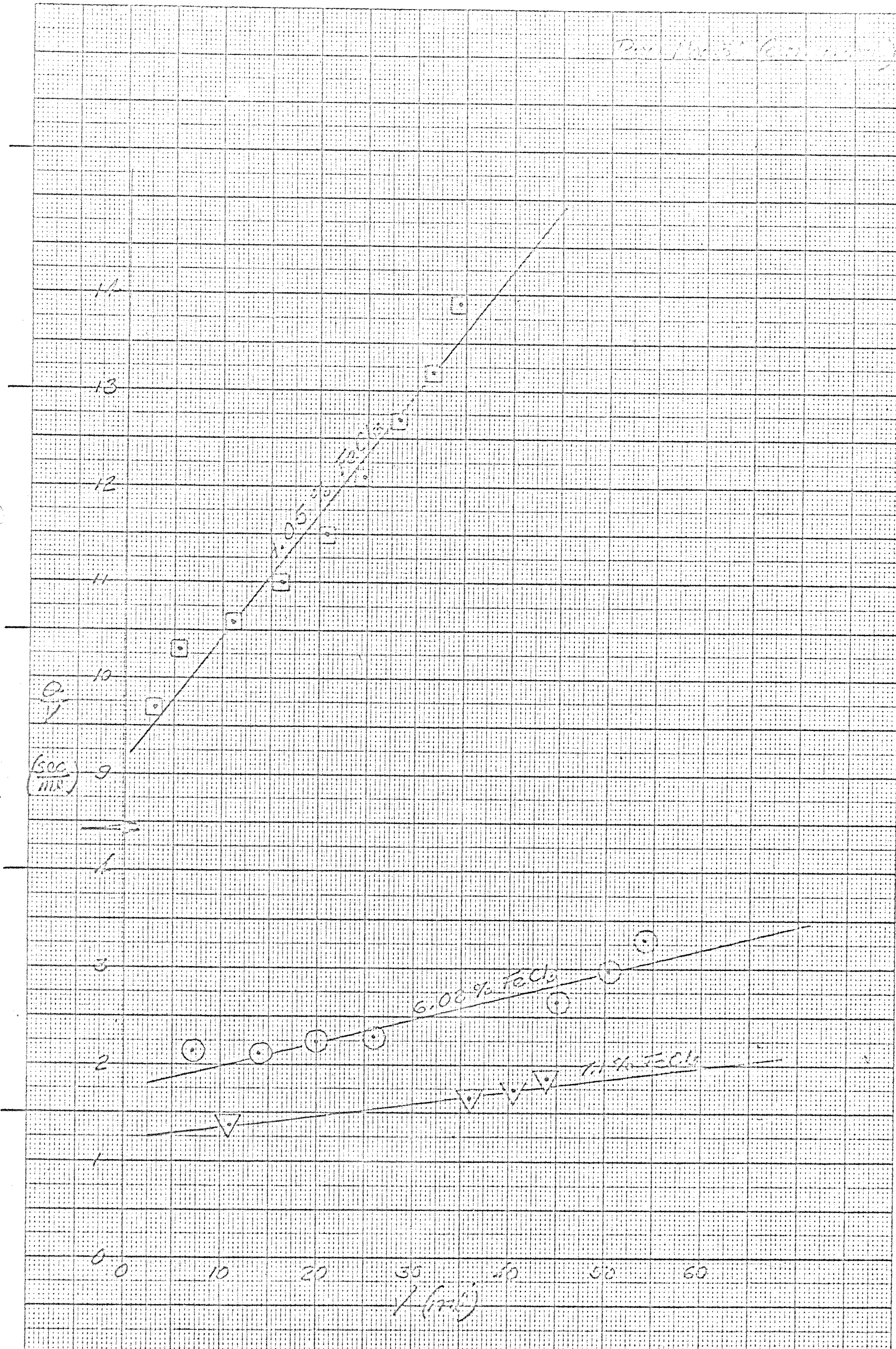


Run No. 1A (Continued)
θ/V
(sec/ml)
V (ml)
5.1% FeCl3
6.8% FeCl3
8.5% FeCl3
12.8% FeCl3

EMO A 4

SEPTIC TANK SLUDGE


Ferric Chloride Conditioning
No FeCl3
1.01% FeCl3
0.5% FeCl3
2.03% FeCl3
θ/V (sec/ml)
300
280
260
240
220
200
180
160
140
120
100
0
0
2
4
6
8
10
12
14
V (ml)
% FeCl3
0
0.5
1.01
2.03
4.05
6.08
7.10
13.4
10.1
4.8
0.150
0.023
0.013
Total Solids 7.39%
EMO A 4

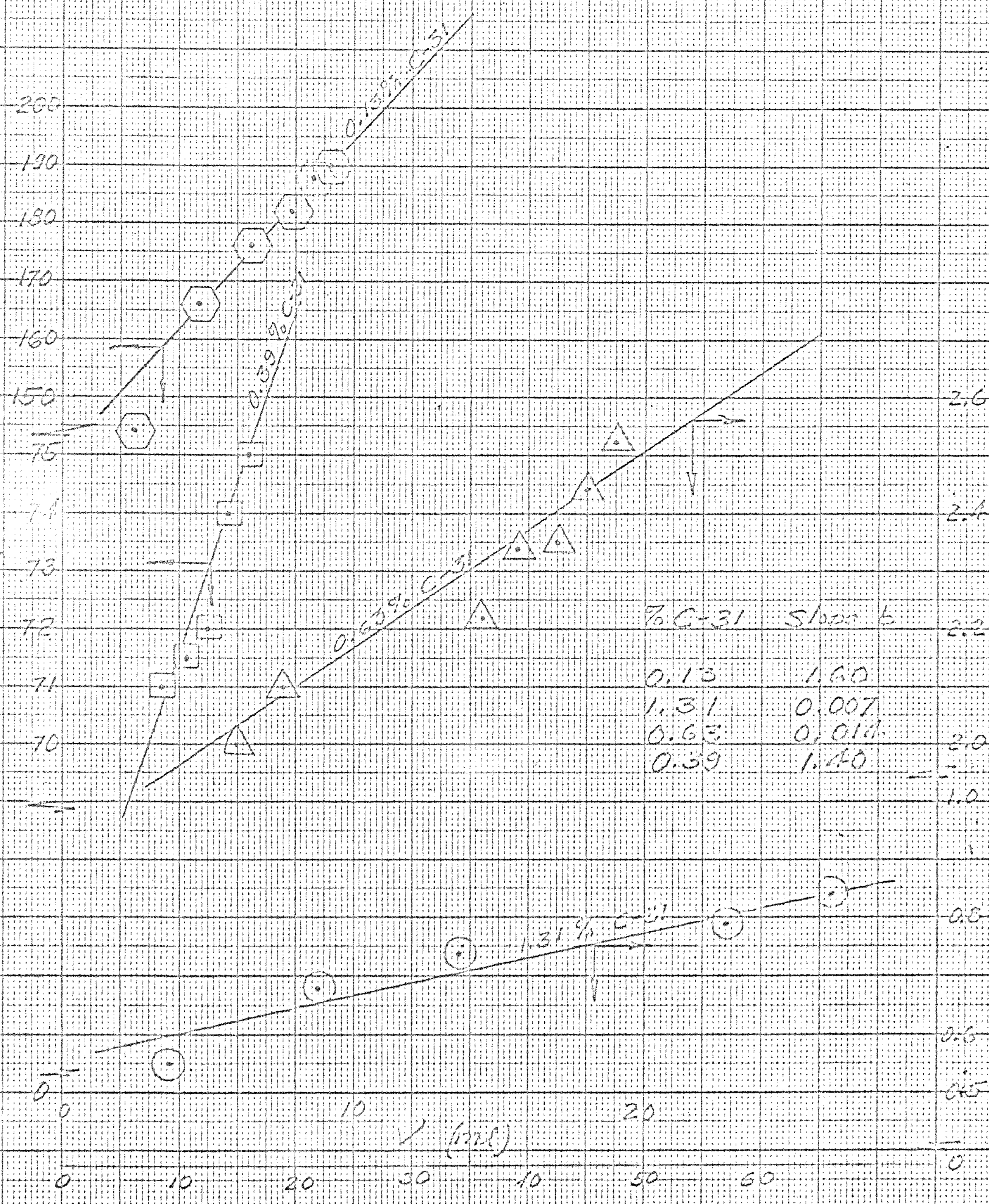

1.05 % $FeCl_3$
6.08 % $FeCl_3$
11 % $FeCl_3$
$\frac{\theta}{V}$
$\left(\frac{sec}{ml}\right)$
V (ml)
0
10
20
30
40
50
60
1
2
3
9
10
11
12
13
14

EMO A 4

16-1-62

RAW SLUDGE

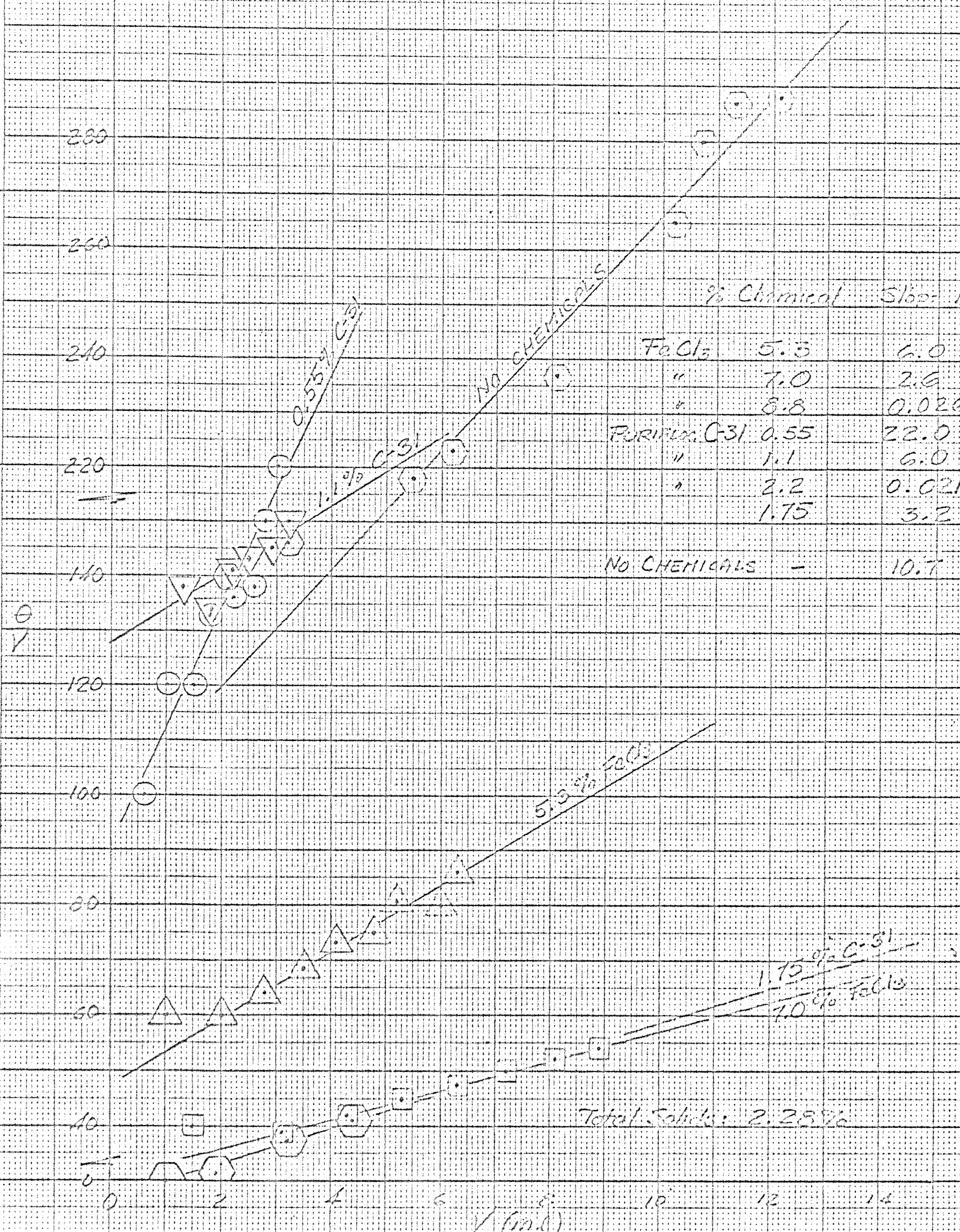
PURIFLOC C-31 CONDITIONING



EMO A 4

Run No. 5A
17-1-63

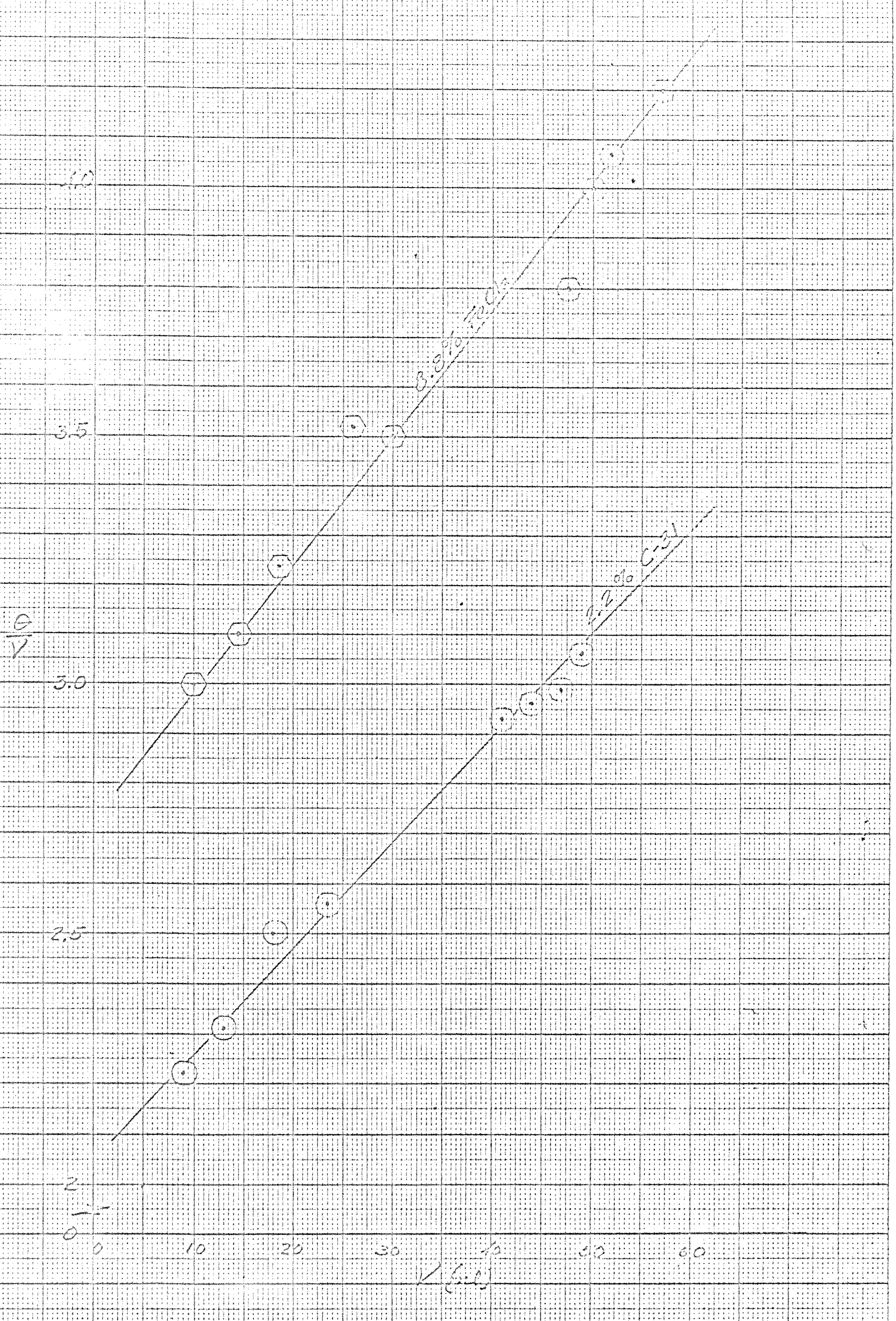
FROZEN SEPTIC TANK SLUDGE



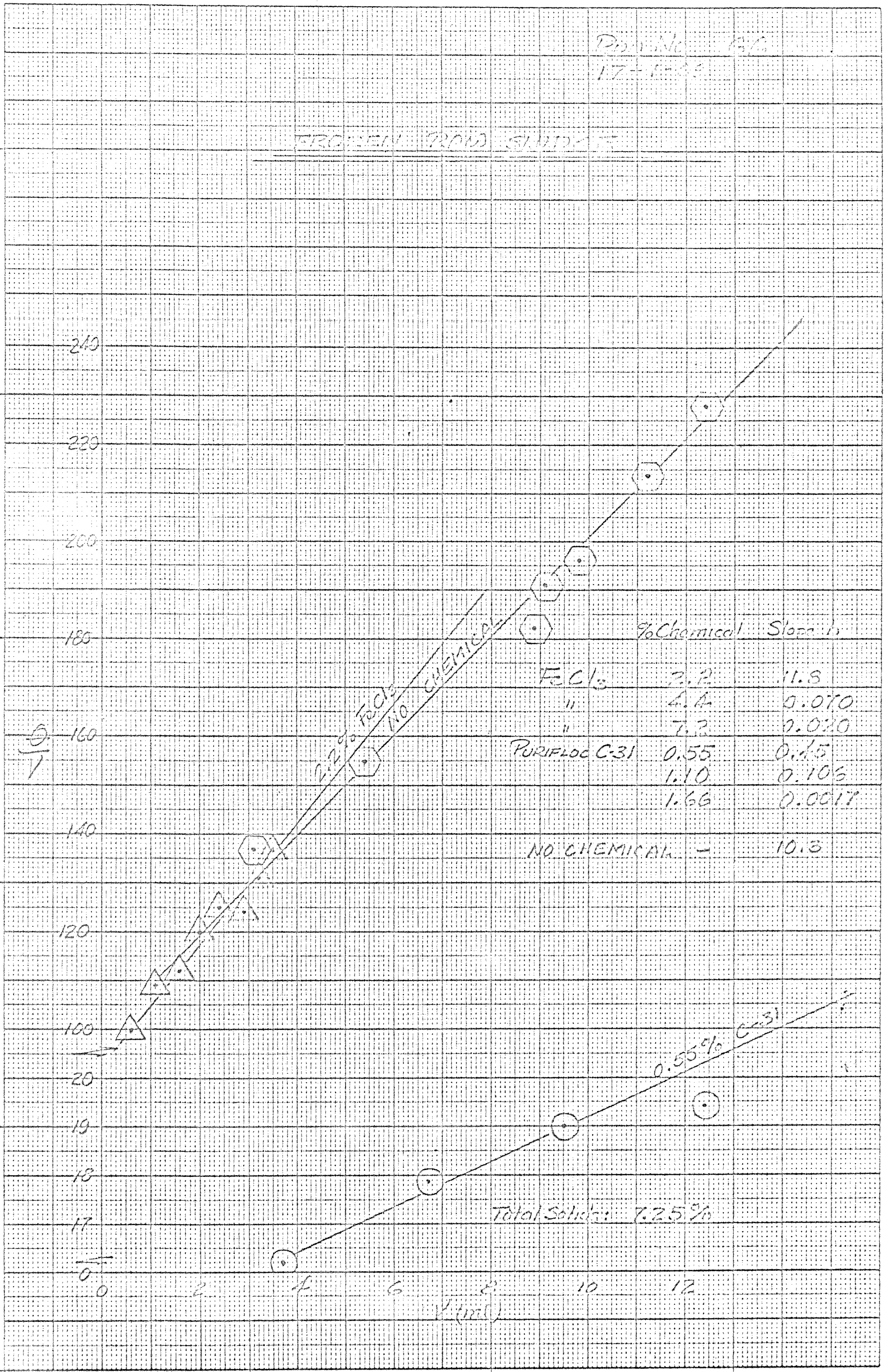
	% Chemical	Slope b
$FeCl_3$	5.3	6.0
"	7.0	2.6
"	8.8	0.026
PURIFLOC C-31	0.55	22.0
"	1.1	6.0
"	2.2	0.021
	1.75	3.2
NO CHEMICALS	–	10.7

EMO A 4

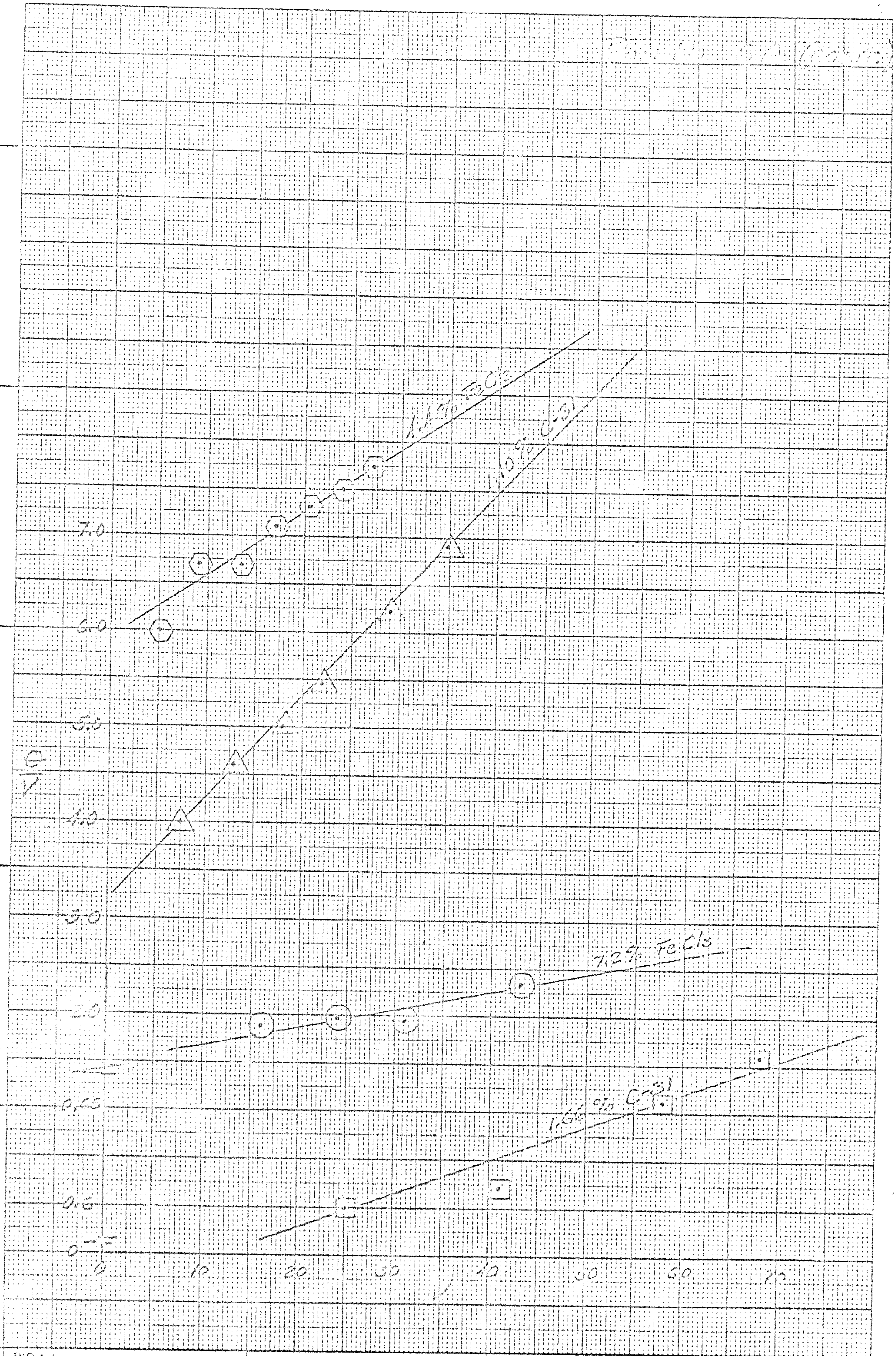
Run No. 5A (continued)



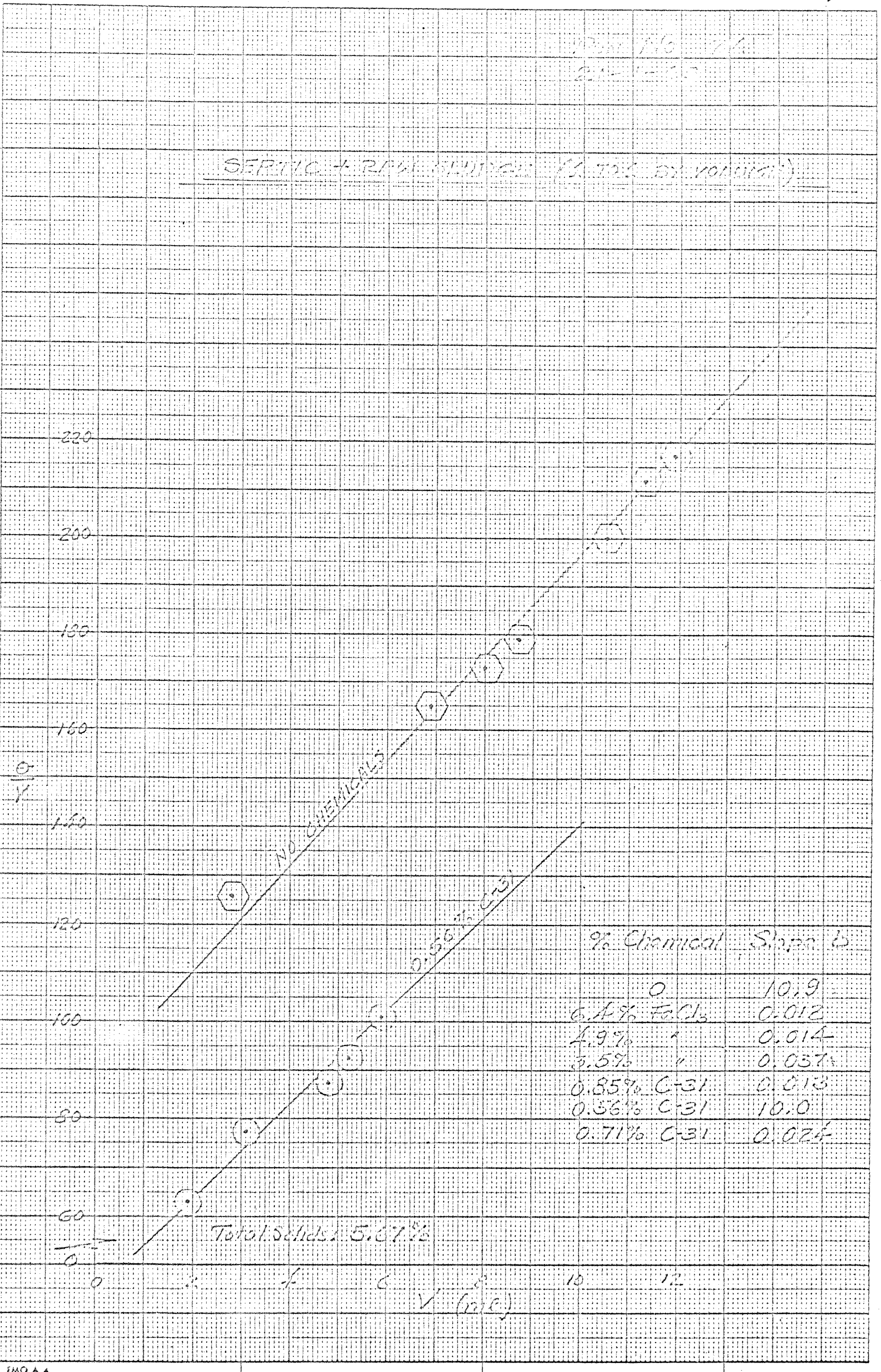
EMO A 4



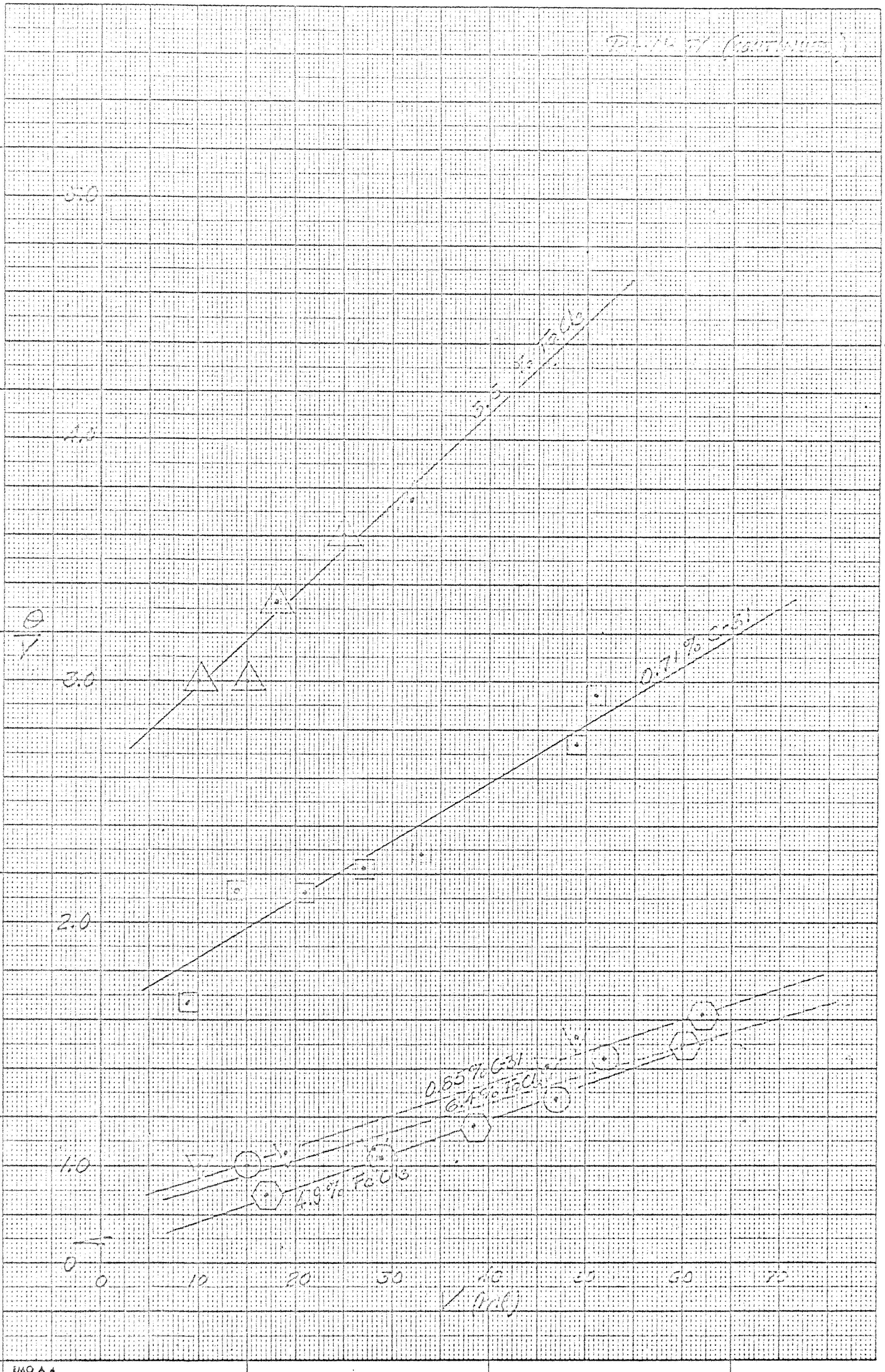
FROZEN POND SLUDGE
%Chemical Slope b
FeCl3 2.2 11.8
" 4.4 0.070
" 7.2 0.020
PURIFLOC C-31 0.55 0.15
1.10 0.106
1.66 0.0017
NO CHEMICAL – 10.8
2.2% FeCl3
NO CHEMICAL
0.55% C-31
Total Solids: 7.25%
θ/V
V (ml)
240
220
200
180
160
140
120
100
20
19
18
17
0
0
2
4
6
8
10
12



EMO A 4


SEPTIC + RAW SLUDGE
NO CHEMICALS
0.56% C-31
% Chemical
0
6.4% $FeCl_3$
4.9%
5.5%
0.85% C-31
0.56% C-31
0.71% C-31
10.9
0.012
0.014
0.057
0.013
10.0
0.024
Total Solids: 5.67%
220
200
180
160
140
120
100
80
60
$\frac{\theta}{V}$
0
2
4
6
8
10
12
V (cc)

EMO A 4



5.5 % FeCl3
0.71 % C-61
0.85 % C-31
6.4 % FeCl3
4.9 % FeCl3
3.0
2.0
1.0
0
10
20
30
50
60
70
EMO A 4