EVALUATION OF CLAY

FOR

THE CORPORATION OF THE TOWNSHIP OF ATIKOKAN

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DEPARTMENT OF MATERIALS CHEMISTRY
Glass and Ceramics Division

Report No.
G&C-64-77-203

EVALUATION OF CLAY

for

The Corporation of the Township
of Atikokan,
Box 460,
Atikokan, Ontario POT 1C0

Attn: Mr. J.M. Kemp

May 10, 1977

Dr. J.A. Topping
Mr. P. McKenzie
Miss J. Liem

About 14 - 45 gallon drums needed to send out 5 ton sample.

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SUMMARY

1. CHARACTERIZATION

The Atikokan clay was characterized as being an illite based clay containing some free silica (quartz) and unweathered feldspar; the particle size distribution is finer than the Southern Ontario illite based clays but coarser than kaolin and ball clays; the Atikokan clay contains a lot of additional chemical constituents, particularly high iron, also some calcium, magnesium, sodium and potassium.

2. SUITABILITY FOR BRICK MANUFACTURE

The Atikokan clay can be easily extruded but requires a high moisture content (>19%). It dries to a strong material (MOR = 750 psi) and it fires to a strong, smooth material (compressive strength 4,000 psi). The total drying plus firing shrinkages of 14% is high and may give cracking problems. Water absorption by 5 hour boil test is satisfactory (14%) but saturation coefficient (0.9) is high for top grade brick (S.W. grade). To waive this, freeze-thaw tests on full size brick samples should be done.

3. ALTERNATIVE HEAVY CLAY PRODUCTS

The Atikokan clay may be suitable for other products such as sewer pipe, facing tile, drainage tile, and flower pots.

4. SUITABILITY FOR POTTERY MANUFACTURE

The colour of the Atikokan clay precludes its use for tableware; thus the most likely pottery use would be art ware. The clay is not suitable for slip-casting but it would be suitable for ram-pressing and for hand throwing and possibly jiggering and jollying.

5. SUITABILITY FOR FLOOR COMPOUND INGREDIENT

The Atikokan clay does not have the same chemistry, brightness or particle size as clay used in floor compounds.

J. Topping

J.A. Topping
Senior Research Scientist
Glass and Ceramics Division
Dept. of Materials Chemistry

JAT/ltd

1. INTRODUCTION

A 50 lb. sample of clay was submitted to the Glass and Ceramics Division of ORF for an evaluation of its suitability for the manufacture of bricks, pottery and as an ingredient for floor compound. The samples were in three sections and were identified as follows:

(a) Hanging wall - Hogarth Pit (2 packages)

(b) Hanging wall - South Roberts (3 packages)

(c) Unidentified (4 packages)

Sections (a) and (b) were medium dry and section (c) was extremely wet. The three sections were blended together to provide a suitable working sample.

2. CHARACTERIZATION OF CLAY

2.1 X-Ray Analysis

The x-ray analysis indicates the sample consists of illite and silica and some unweathered feldspathic mineral and possibly a trace of montmorillonite types of clay; a copy of the x-ray diffraction pattern is included in Figure 1; Table I lists the peaks and the assignment of them to the various mineral phases.

2.2 Differential Thermal Analysis (DTA)

A DTA experiment was conducted at 10°C/min. using calcined kaolin clay as the reference. A trace of the DTA curve is included in Figure 2 and details of the results in Table II.

2.3 Pyrometric Cone Equivalent (PCE) (ASTM C-24)

The end point of the clay tested using large Orton cones is between cone 3 and 4, i.e. 1168°C (2134°F) and 1186°C (2167°F).

2.4 Particle Size Distribution

The particle size distribution was done according to the Andreasen Pipette Method (British Standards 3406 Part 2). 10 g of dry material was dispersed in 600 cc of distilled water with 1 wt.% (of solids) sodium pyrophosphate as a deflocculant. The material settled out quickly after a two minute 'standing time'. Based on visual observation, this material seemed fine enough to have better suspension properties than this, indicating that a more suitable deflocculant is required. Therefore, a new sample of 10 g clay was dispersed in water again using 1 wt.% sodium citrate. This gave a proper dispersion and the particle size distribution was determined at an ambient temperature of 25°C.

The results are listed in Figure 3 and Table III.

2.5 Chemical Analysis

The loss on ignition of the clay was determined by heating a sample to 1000°C. The chemical analysis was done by the Technical Service Labs*. The results are listed in Table IV.

3. EVALUATION OF CLAY FOR BRICK MANUFACTURE I (FIRST TEST)

3.1 Crushing and Grinding

No crushing and grinding was necessary.

3.2 Addition of Water and Extrusion

The samples were mixed while being extruded in a Rowdon Auger type laboratory size de-airing extruder (serial No. 1322). Small portions of the wet sample were added to the dry sample during the first extrusion. During the second pass through the extruder, a small amount of water (about 500 cc) was required to be added to the 50 lb. sample of clay to achieve a suitable workability for the extruder. Specimens 3" x 3/16" x 24" were extruded.

3.3 Drying and Measurement of Drying Shrinkage (ASTM C-179)

Moisture determinations were carried out on specimens of the extruded sample. Six 4" marks were made using the out-turned points of a Vernier caliper. After 24 hours drying at room temperature, measurements were made and the decrease in lengths were recorded. The moisture content, after drying and shrinkage measurements, are listed in Table V.

3.4 Firing and Measurement of Fired Shrinkage (ASTM C-326)

The dried material was subjected to gradient firing temperatures to indicate suitable firing ranges. The firing range covered was from 820°C to 1157°C over an 18" length for a 4 hour soak. In the gradient fired test piece, at temperatures of 812-980°C there was a light brown colour, between 980-1087°C the colour changed to reddish-brown and over 1087°C the material changed to dark brown, it then swelled and melted at about 1150°C. Shrinkage measurements at various temperatures are listed in Table V. A slump test at 3°C/min. was also conducted on the unfired clay and the trace is shown in Figure 4. Both these indicate that the clay fuses readily above 1050°C (1920°F).

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* Their report No. T-01910, 1301 Fewster Dr., Mississauga

3.5 Water Absorption on Fired Samples (ASTM C-373)

Specimens were selected from the gradient firing at various temperature intervals and the apparent porosity and water absorption test was conducted according to ASTM designation C-373. The test required that the specimens be boiled in distilled water for 5 hours and cooled for 24 hours in the water then weighed. In order to establish the saturation coefficient (c/b ratio) a similar test was conducted, but instead the samples were soaked in cold distilled water for 24 hours before weighing. The results of the 5 hour boil test, 24 hour cold test, and the calculated c/b ratio (cold/boiling) are listed in Table VI(a).

3.6 Compressive Strength on Fired Specimens (ASTM C-773)

Previous testing of the fired and unfired clay indicated that a firing temperature of 1035°C was appropriate. One inch cube specimens were moulded for compressive strength tests and fired at 1035°C with a 4 hour soak at temperature. Three of the cubes, fired at 1035°C, were subjected to the 5 hour boil test, 24 hour cold test and the calculated c/b ratio; the latter results are listed in Table VI(b). Nine, one inch cube samples were tested for compressive strength and the results are listed in Table VII. The average shrinkage of the cubes after firing at 1035°C was 2.72%.

3.7 Modulus of Rupture of Unfired Clay (ASTM C-689)

The modulus of rupture was conducted in accordance with ASTM C689-71T. Twenty samples were tested using a table model Instron at a crosshead speed of 0.2 inches per minute, 20 lbs. full scale load, and a chart speed of 10 inches per minute. The results of these modulus of rupture tests are listed in Table VIII.

3.8 Discussion of Results

This first series of tests had shown that the clay could be extruded but a water content of 30% was required for our laboratory extruder. Total shrinkages were all less than 8% (5% drying and <3% firing) which is less than the 10% normally considered to be a comfortable limit in brick manufacture (above this excessive cracking may occur). The 'as-dried' strength of the clay is very satisfactory.

The durability of brick is measured by one of two methods:

Method (i) Combine the compressive strength with the c/b ratio.

Method (ii) Freeze/thaw tests.

CSA specification A82.1* states limits for these as follows:

Designation	Minimum Compressive Strength (brick flatwise) psi, gross area		Maximum Water Absorption by 5-hour Boiling per cent		Maximum Saturation Coefficient*	
	Average of 5 Brick	Individual	Average of 5 Brick	Individual	Average of 5 Brick	Individual
Grade SW	3000	2500	17.0	20.0	0.78	0.80
Grade MW	2500	2200	22.00	25.0	0.88	0.90
Grade NW	1500	1250	no limit	no limit	no limit	no limit

* *The saturation coefficient is the ratio of absorption by 24-hour submersion in cold water to that after 5-hour submersion in boiling water.*

The various grades of brick are as follows:

Grade SW: Brick intended for use where a high degree of resistance to frost action is desired and the exposure is such that the brick may be frozen when permeated with water.

Grade MW: Brick intended for use where exposed to temperatures below freezing but unlikely to be permeated with water; or where a moderate and somewhat nonuniform degree of resistance to frost action is permissible.

Grade NW: Brick intended for use as back-up or interior masonry.

The samples made from Atikokan clay had compressive strengths of 4,000 psi, exceeding the specifications; the 5 hour boil absorption of 14% also meets the specifications; however, the saturation coefficient of 0.9 meets the specification only for the NW grade brick and not the MW and SW. This means that the cold absorption is too high. It was felt that this may have been due to the high water content (30%) needed for the laboratory extruder. Thus, steps were taken to test the remaining sample in an alternative extruder with direct drive and thus higher power, and thus would need less water. This extruder belongs to a local brick manufacturer. This second series of tests is described in section 4.

3.9 Other Heavy Clay Products

The fired samples of clay have a very nice, smooth appearance and it is likely that other clay products could be made from this material. Some such products being:

- sewer pipe
- facing tile
- flower pots
- drainage tile

* A copy of this is attached.

4. EVALUATION OF CLAY FOR BRICK MANUFACTURE II (SECOND TEST)

4.1 Procedure

A second attempt was made to evaluate the clay for brick manufacture. A local brick manufacturer was consulted and their testing apparatus was made available to ORF. The clay was first passed through a pug mill which gives an indication of the amount of water required for efficient extrusion. The material from the pug mill was then extruded once and about three specimens, 1 3/4" x 1 3/4" x 6", were obtained. Raw material from the brick manufacturer was also processed (pug milled and extruded) and the following tests were conducted on both sets of specimens: percent moisture after extrusion; percent shrinkage after drying, and after firing at 1035°C; water absorption and c/b ratio; and efflorescence. The results are also listed in Table IX.

4.2 Discussion of Results

The Atikokan clay could be extruded with lower water content (19%); however, this was still higher than the Southern Ontario clay which had only 12%. The shrinkage of the clay, with this lower water content, increased to a total of 14% compared to 7-8% for the Southern Ontario clay. This shrinkage value is high and may lead to cracking problems in the manufacture of brick. However, these problems can probably be reduced by incorporating "grog"* into the mix; alternatively, a mineral filler such as nepheline syenite or possibly sand could be used.

The 5 hour boil water absorption characteristics of these samples (13.6%) were almost the same as the first lot of samples (14.3%) but significantly less than the Southern Ontario clay (9%). However, the cold absorption showed similar behaviour, i.e. 12.2% for the second samples compared with 13.1% for the first ones and 7.1% for the Southern Ontario clay. Thus, the saturation coefficient remained at 0.9.

It must be stressed here that the requirements for saturation coefficient can be waived if the brick passes the freeze/thaw test. Since the Atikokan clay has saturation coefficient very close to the specification but its compressive strength is 25% higher than the specifications, there is a good chance that bricks made from this clay would meet the freeze/thaw test.

The fired samples were fired in a 16 hour cold-to-cold cycle, this was too fast for both materials, the Southern Ontario clay developed black hearts but the Atikokan clay had only a slightly reduced centre. This indicates that bricks made from the Atikokan clay can probably be fired faster than the 40 hour cold-to-cold cycle required by the Southern Ontario clay.

In the efflorescence test, where fired samples are allowed to sit in 1/4" of water for several days, the samples made from Atikokan clay did not show efflorescence after 7 days, whereas the samples made from Southern Ontario clay did show some efflorescence after 7 days.

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* "Grog" is ground-up fired brick - generally rejects and scrap from the process.

5. EVALUATION OF CLAY FOR POTTERY

In evaluating the Atikokan clay for pottery the various areas of pottery manufacture must be considered. Firstly, the strong red colour of the fired Atikokan clay precludes its use for tableware which requires a white-firing clay. The other main pottery area is artware, and in Canada red-burning clays are used extensively for this.

Pottery manufacture consists of the following:

- forming
- drying
- bisque firing
- glazing
- gloss firing

From the results seen to-date on the drying and firing properties of Atikokan clay it can be seen that it is quite suitable for these aspects of pottery manufacture. In fact the dilatometric curve (Figure 4) shows a firing range of 150°C and this is larger than the Southern Ontario pottery clays. Also it will be readily possible to formulate glazes to fit this clay.

The outstanding question is the forming process. The processes used for this are as follows:

i) Hand throwing on a pottery wheel:

- this is the hobbyists process and the Atikokan clay would be suitable for this.

ii) Ram pressing:

- this is a production process useful for flat articles like trays, plates, ash-trays, etc., (also cup handles); the Atikokan clay would be suitable for this.

iii) Jiggering and jollying:

- these are production processes for making cup bodies and plates and saucers. The process is similar to an automated potters wheel but the forming is done mechanically. The Atikokan clay would probably be suitable for this.

iv) Slip-Casting:

- this is a production process for ornaments, cups, mugs and all irregularly shaped items. This process depends on the ability of the clay to form a castable slip of viscosity of typically 150 cp, and zero or very little thixotropy. To achieve this, clays must be deflocculated by the addition of electrolytic deflocculating agents. To test the Atikokan clay for this the following tests were done:

A suitable amount of the extruded material from section 3 was dried at 35°C. The dry clay was ground in a mortar and pestle and passed through a 60 mesh Endecott sieve. The following flocculating experiments were carried out.

Sodium Silicate and Soda Ash (ratio 1:2) as Deflocculant

300 g of dry clay was mixed with 115 ml water. The mixture was extremely thick and could barely be stirred. The pH of this mixture was 6.4. Sodium silicate and soda ash were gradually added in 0.05 wt.% (of solids) increments. The mixture gradually thickened until it was almost impossible to stir. The maximum addition of deflocculants used was 0.04 wt.%.

Calgon 'T' and NaOH (5 parts to 1 part by wt.) as Deflocculant

300 g of dry clay was mixed with 174 ml water. The mixture was not as thick as in section 5.1 and could be stirred easier. The initial pH measured was 6.3. Calgon'T' and NaOH were gradually added in 0.05 wt.% (of solids) increments. After the first addition of deflocculant the mixture thinned considerably. The viscosity went from 710 CP to 566 CP. This viscosity was measured with a Fann Viscometer Model 35 which measures the shear rate or a certain shear stress. However, further additions of deflocculant thickened the mixture to such an extent that it was impossible to take further readings.

Darvan C as a Deflocculant

Darvan C from R.T. Vanderbilt Company is the ammonium salt of a polyelectrolyte. 350 g of clay was stirred into 200 ml of water. The pH of the mix was brought to ~9 (pH paper) with 10 ml 5N NaOH. The initial viscosity was too thick to measure. 1 ml additions of Darvan C were added and the viscosity measured after each addition of deflocculant. The results are in Table XI and Figure 5. The flow curve is shown in Figure 6.

Comments

(i) All the above mixtures were extremely thixotropic and thus unsuitable as a casting slip (flow curve in Figure 6).

(ii) The clay 'as is' is unsuitable for slip-casting. Pottery shops normally require approximatley 35-40 ml water for every 100 g solids content. The experiments show that the amount of water required will be two times and even three times more, which will cause high shrinkages on drying and firing. The high sodium content in the chemical analysis of the clay indicates that the clay is already over-deflocculated in itself. Small amounts of a sodium electrolyte aid in dispersing a well-weathered clay in water. The chemical analysis also shows 0.33% sulphur, which when present as soluble sulphates, is sufficient to cause problems in deflocculating casting slips. In order to make the clay a suitable ingredient for pottery, it should be washed by way of filter-pressing. The filter cake can then be utilized as a component for ram-pressed, or hand-moulded bodies rather than slip-cast bodies.

6. EVALUATION AS AN INGREDIENT IN FLOOR COMPOUND

The evaluation of the Atikokan clay as an ingredient in floor compound, consisted of comparing the measured characteristic against the characteristics of a typical clay used in floor compounds. The information on the latter is given in Table XII. The three key areas are the chemistry, brightness, and particle size of the clays. The clays used in floor compounds are kaolin-based and they have very low iron content (and thus colour), namely, 0.6% compared to the Atikokan clay which is illite based and has a very high iron content (7.4%). This high iron content will also decrease the brightness of the clay way below the values quoted for the clays used in floor compounds. Finally, the particle size of the floor compound clay is extremely fine (96%<10μ) compared to the Atikokan clay (~60%<10μ).

Thus it appears as if the Atikokan clay is not appropriate for floor compounds.

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TABLE I

X-RAY ANALYSIS OF ATIKOKAN CLAY

2θ	'd' Spacing	Allocation
6.2	14.2	M
12.50	7.08	U
18.75	5.00	U
20.80	4.27	I, S
22.10	4.02	F
23.60	3.77	U
24.00	3.70	U
24.40	3.64	U
25.30	3.52	U
25.50	3.49	U
26.60	3.35	I, S
28.00	3.18	F
35.20	2.55	F
36.50	2.46	S
39.50	2.28	S
40.30	2.24	S
42.40	2.13	S
45.75	1.98	S
50.10	1.62	I, S
54.80	1.67	S
60.00	1.54	

U = undetermined, possibly hydrated minerals such as chlorites or kaolinites.
I = illite
S = silica (α quartz)
F = feldspar (maybe anorthite $CaAl_2\ SiO_2$)
M = montmorillonite type clay

TABLE II

DIFFERENTIAL THERMAL ANALYSIS OF ATIKOKAN CLAY

Heating:	endothermic	155°C	water
"	"	585°C	α–β quartz
"	"	620°C	dehydroxylation of clay
Heating:	exothermic	925°C	mullitization of clay
Cooling:	exothermic	575°C	β–α quartz

TABLE III

DATE: March 29/77

MATERIAL: Atikokan Clay 10 g + 1 wt.% Na citrate   DENSITY: 2.77

$$C = \left(\frac{18\ M\ h}{g(P_s - P_1)}\right)^{1/2} = 0.043028 \qquad d = ct^{-1/2}$$

M = 0.00893
g = 981

Time	Mins.	Sample No.	Wt. pan + Mat.	Wt. Pan	Wt. Material	Time (sec.)	$\sqrt{t}$	d (μ)	B	d corr.	% Undersize
	0	1	1.5621	1.3949	0.1672) 0.1676						
1:35	0	2	1.5582	1.3902	0.1680)						
	1	3	1.5560	1.3880	0.1680	60	7.75	55.52	0.98	54.41	100.24
	2	4	1.5618	1.3953	0.1665	120	10.95	39.29	0.97	38.11	99.34
	3	5	1.5571	1.3913	0.1658	180	13.42	32.06	0.96	30.78	98.93
1:55	20	6	1.5422	1.3869	0.1553	1200	34.64	12.42	0.95	11.80	92.66
2:15	40	7	1.4982	1.3868	0.1114	2400	48.99	8.78	0.93	8.17	66.47
2:45	55	8	1.4069	1.3881	0.0188	3300	57.45	7.49	0.92	6.89	11.22
3:18	88	9	1.4001	1.3888	0.0113	5280	72.66	5.92	0.91	5.39	6.74
3:45	115	10	1.4036	1.3944	0.0092	6900	83.07	5.18	0.90	4.66	5.49
4:15	145	11	1.3950	1.3870	0.0080	8700	93.27	4.61	0.89	4.10	4.77
8:20 30/3	1110	12	1.3903	1.3850	0.0053	66600	258.07	1.67	0.88	1.47	3.16

TABLE IV

CHEMICAL ANALYSIS OF CLAYS

		Atikokan Clay	Weathered Queenston (S. Ontario Clay*)
Loss on ignition	(LOI) %	4.06	-
Silica	(SiO_2) %	61.02	56.0
Alumina	(Al_2O_3) %	14.74	16.0
Iron Oxide	(Fe_2O_3) %	7.36	6.8
Titanium Oxide	(TiO_2) %	0.12	-
Calcium Oxide	(CaO) %	4.20	4.7
Magnesium Oxide	(MgO) %	3.45	2.6
Sodium Oxide	(Na_2O) %	2.31	0.7
Potassium Oxide	(K_2O) %	2.35	3.9
Chloride	(CL^-) %	0.02	-
Sulphur	(S) %	0.33	-
Carbon Dioxide	(CO_2) %	0.18	3.8
	TOTAL	100.14	

* This analysis had been done in 1975 in an ORF internal project and the data is presented here for comparative purposes.

TABLE V

MOISTURE DETERMINATION %

Specimen 1	30.12
Specimen 2	30.67
Average	30.40

SHRINKAGE AT ROOM TEMPERATURE (AFTER 24 HRS.)

	Measurements Immediately After Extrusion (ins.)	Measurements After 24 hrs. (ins.)	Shrinkage %
Specimen 1	4.000	3.799	5.03
Specimen 2	4.000	3.799	5.03
Specimen 3	4.000	3.799	5.03
Specimen 4	4.000	3.799	5.03
Specimen 5	4.000	3.799	5.03
Specimen 6	4.000	3.799	5.03
Average			5.03

SHRINKAGE MEASUREMENTS ON FIRED CLAY

Temperature °C	Temperature °F	Shrinkage at width (%)	Shrinkage at thickness (%)
1072	1962	3.86	6.21
1060	1940	3.37	3.45
1040	1904	1.84	1.36
1020	1868	1.51	1.22
1000	1832	1.51	1.36

TABLE VI

(a) Samples from Gradient - Fired Bar

Sample Temperature °C	5 Hr. Boil Test Water Absorption %(b)	24 Hr. Cold Soak Test Water Absorption %(c)	c/b Ratio
1000	18.99	16.88	0.89
1020	18.22	16.32	0.89
1040	18.22	15.37	0.84
1060	14.53	12.37	0.85
1072	10.45	9.53	0.91

(b) Fired Samples

1035			
1" cubes: Specimen 1	14.17	12.83	-
Specimen 2	14.57	13.28	-
Specimen 3	14.12	-	-
Average	14.29	13.06	0.91

TABLE VII

COMPRESSIVE STRENGTH AFTER FIRING AT 1035°C

Specimen	Compressive Strength (psi)
1	4250
2	2500
3	2400
4	2400
5	6125
6	2600
7	4900
8	4900
9	5000
Average	3897
Standard Deviation	1433

∴ Compressive Strength = 4000 ± 1400 psi

TABLE VIII

MODULUS OF RUPTURE ON ATIKOKAN CLAY

Specimen No.	Breaking Load (lbs.)	Modulus of Rupture (psi)
1	1.50	835
2	0.95	529
3	1.50	835
4	1.60	882
5	1.60	882
6	1.10	770
7	1.30	709
8	1.50	818
9	0.80	436
10	1.30	724
11	1.20	668
12	1.60	873
13	1.30	709
14	1.40	780
15	1.60	891
16	1.20	655
17	1.00	545
18	1.40	764
19	1.60	873
20	1.60	906
Average		754
Standard Deviation		125

∴ MOR = 750 ± 125 psi

TABLE IX

EVALUATION FOR BRICK MANUFACTURE USING INDEPENDENT MANUFACTURERS' APPARATUS

TEST	ATIKOKAN CLAY	INDEPENDENT MANUFACTURER
% Moisture	18.9	12.2
% Shrinkage at Room Temperature	6.0	3.0
% Shrinkage after firing at 1035°C	8.4	4.6
Total Shrinkage	14.4	7.6
5 Hour Boil Test Water Absorption % (b)	13.6	8.9
24 Hour Soak Test Water absorption % (c)	12.2	7.1
c/b Ratio	0.90	0.80

TABLE X

CSA SPECIFICATION A82.1

		Physical Requirements (Grade)			Atikokan Clay	Rating of Atikokan Clay
		SW	MV	NW		
Minimum Compressive Strength psi	Average	3000	2500	1500	4000	SW
	Individual	2500	2200	1250	2400	SW
Maximum 5 hr. Boil	Average	17	22	no limit	14	SW
	Individual	20	25	no limit	14	SW
Maximum Saturation Coefficient	Average	0.78	0.88	no limit	0.9	NW
	Individual	0.80	0.90	no limit	0.9	NW

TABLE XI

CHANGE IN VISCOSITY OF CLAY WITH DARVAN C ADDITION

Rotor Speed →	3	6	100	200	300	600	300	200	100	6	3
Darvan C: 0 wt.%											
Shear rate	5.112	10.22	170.4	340.8	511.2	1022	511.2	340.8	170.4	10.22	5.112
Shear stress	1269	1218	5839	7362	–	–	–	–	–	–	–
Viscosity CP	24824	11918	3427	2160							
Darvan C: 0.32 wt.%											
Shear stress	1015	1269	2945	3554	4062	6143	–	6245	7108	2386	1980
Viscosity CP	19855	12417	1728	1043	795	601		1832	4171	23346	38732
Darvan C: 0.94 wt.%											
Shear stress	762	1117	1980	2082	2386	2691	3554	3554	3655	2132	1269
Viscosity CP	14906	10930	1162	611	467	263	695	1043	2145	20861	24824
Darvan C: 1.25 wt.%											
Shear stress	660	762	1015	1117	1625	2031	2285	2640	2539	1929	1218
Viscosity CP	12910	7456	596	328	318	199	447	775	1490	18875	23826
Darvan C: 2.02 wt.%											
Shear stress	609	635	670	965	1005	1472	–	–	–	–	–
Viscosity CP	11913	6213	393	283	197	144					
Darvan C: 2.78 wt.%											
Shear stress	228	406	518	533	584	1066	965	1031	944	1066	1041
Viscosity CP	446	3973	304	156	114	104	189	303	554	10431	20364
Darvan C: 3.37 wt.%											
Shear stress	264	279	432	437	457	685	640	604	599	–	–
Viscosity CP	5164	2730	254	128	89	67	125	177	352		
Darvan C: 3.67 wt.%											
Shear stress	223	228	368	371	381	635	624	594	589	609	645
Viscosity CP	4362	2231	216	109	75	62	122	174	346	5959	12617
Darvan C: 4.54 wt.%											
Shear stress	330	335	432	457	538	812	609	558	523	548	579
Viscosity CP	6455	3278	254	134	105	79	119	164	307	5362	11326
Darvan C: 4.83 wt.%											
Shear stress	152	168	406	432	482	482	599	594	538	–	–
Viscosity CP	2973	1644	238	127	94	47	117	174	316		
Darvan C: 5.12 wt.%											
Shear stress	305	315	467	487	518	817	746	619	604	–	–
Viscosity CP	5966	3082	274	143	101	80	146	182	354		

NOTE: Darvan C addition is wt.% of solids (= clay)

TABLE XII

Thompson, Weinman and Company

Sales Offices
CARTERSVILLE, GA. 30120
EAST ORANGE, N. J. 07018

Research Laboratory
92 GREENWOOD AVENUE
MONTCLAIR, N. J. 07042

PRODUCT BULLETIN

SNOBRITE CLAY - APEX CLAY

SNOBRITE and APEX are two grades of clay produced and sold in large volume by Thompson, Weinman and Company. Both of these grades of kaolin display the high absorption properties and/or "hard clay" characteristics. The principal difference between them is that SNOBRITE has consistently a very high pigment brightness for this type of product, whereas APEX Clay has a more ordinary color and thus is used where maximum economy is needed and/or where color characteristics are not too critical. It is well known that some large volume uses of "hard clay" do not need the best brightness. Thus in such products APEX serves as a most valuable extender pigment

The principal end uses where these clays are particularly beneficial are 1) in rubber soles and heels, 2) in rubber and vinyl flooring, 3) in mechanical rubber goods, 4) in metal undercoaters, primers, emulsion and latex paints, 5) in resin base mastics, 6) in rug backing, 7) in polyester "gunks" and 8) as a filler clay for the paper industry. As previously stated these clays can be recommended for use in high tensile, high modulus and high hardness rubber compounds. However, if "soft clay" characteristics are desired in a rubber stock a blend of one of these "hard clays" with a finely ground grade of calcium carbonate, such as DRIKALITE, is to be recommended.

The following typical chemical composition and typical physical constants are given to show the similarities and differences in these two kaolin pigments.

Typical Chemical Composition

Ingredients	SNOBRITE	APEX
Al_2O_3	39.5 ± 1%	39.5 ± 1%
SiO_2	44.5 ± 1%	44.5 ± 1%
TiO_2	0.5 ± .25%	0.5 ± .5%
Fe_2O_3	0.4 ± .25%	0.6 ± .5%
CaO	0.25± .25%	0.25± .25%
Cu	None	None
Mn	None	None
Moisture	1.0%	1.0%
Loss on ignition	14 ± .5%	14 ± .5%

Typical Physical Constants

	SNOBRITE	APEX
Dry Pigment Brightness (Green filter)	87.0 ± 1%	84.5 ± 1.5%
Screen Fineness (Min. thru 325 mesh)	99.5%	99.5%
Typical Particle Size Distribution:		
% -44 microns	99.85%	99.85%
% -10 microns	96%	96%
% -2 microns	83%	83%
% -1 micron	75%	75%
pH	6.0 ± .5	6.0 ± .5
Bulking Value (gals./lb.)	.0465	.0465
Dry Bulk (loose)	30 lbs./cu.ft.	30 lbs./cu.ft.

FIGURE 1 - X-RAY DIFFRACTION OF ATIKOKAN CLAY PLUS ILLITE AND α-QUARTZ STANDARDS

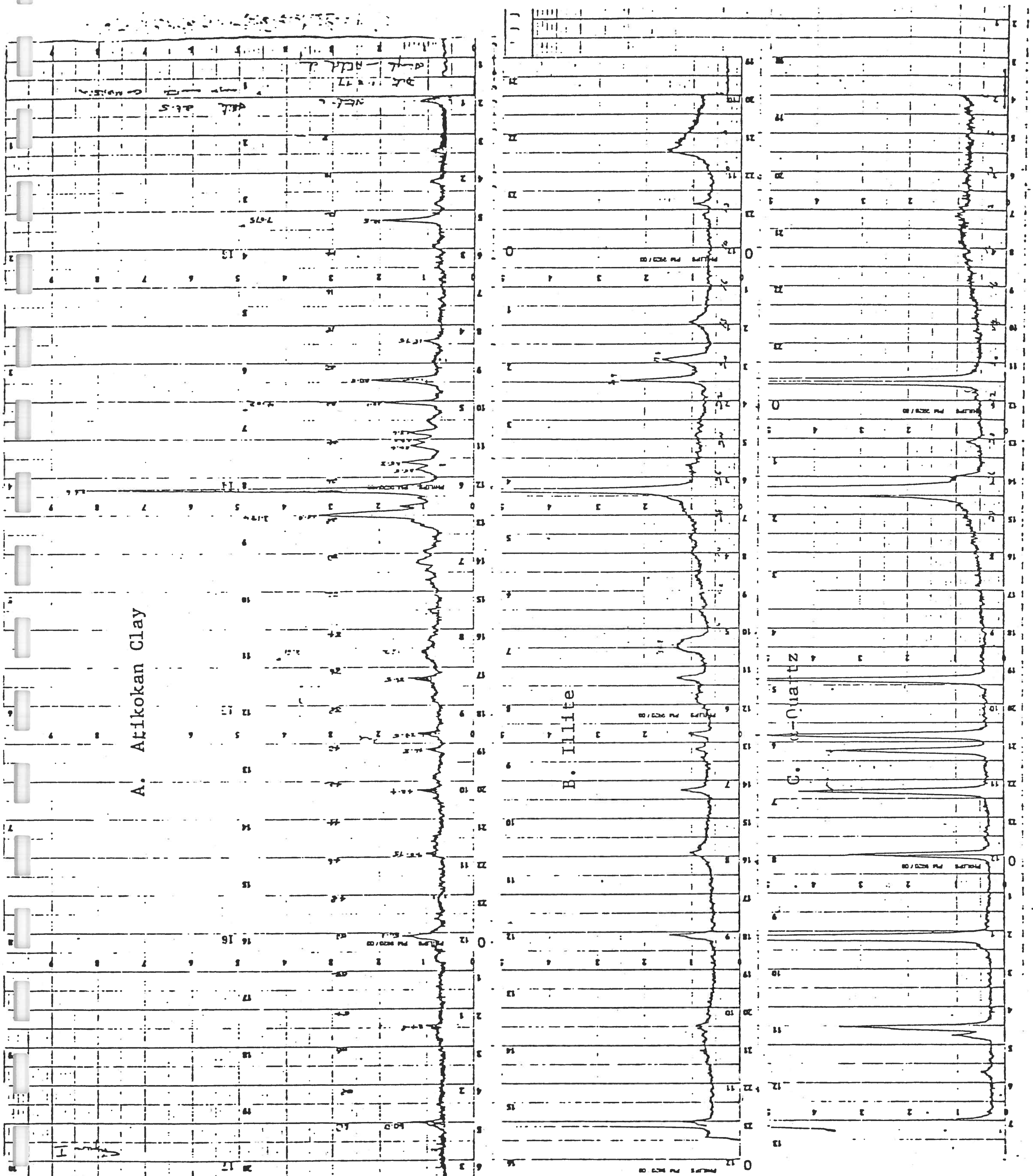


FIGURE 2 - DIFFERENTIAL THERMAL ANALYSIS

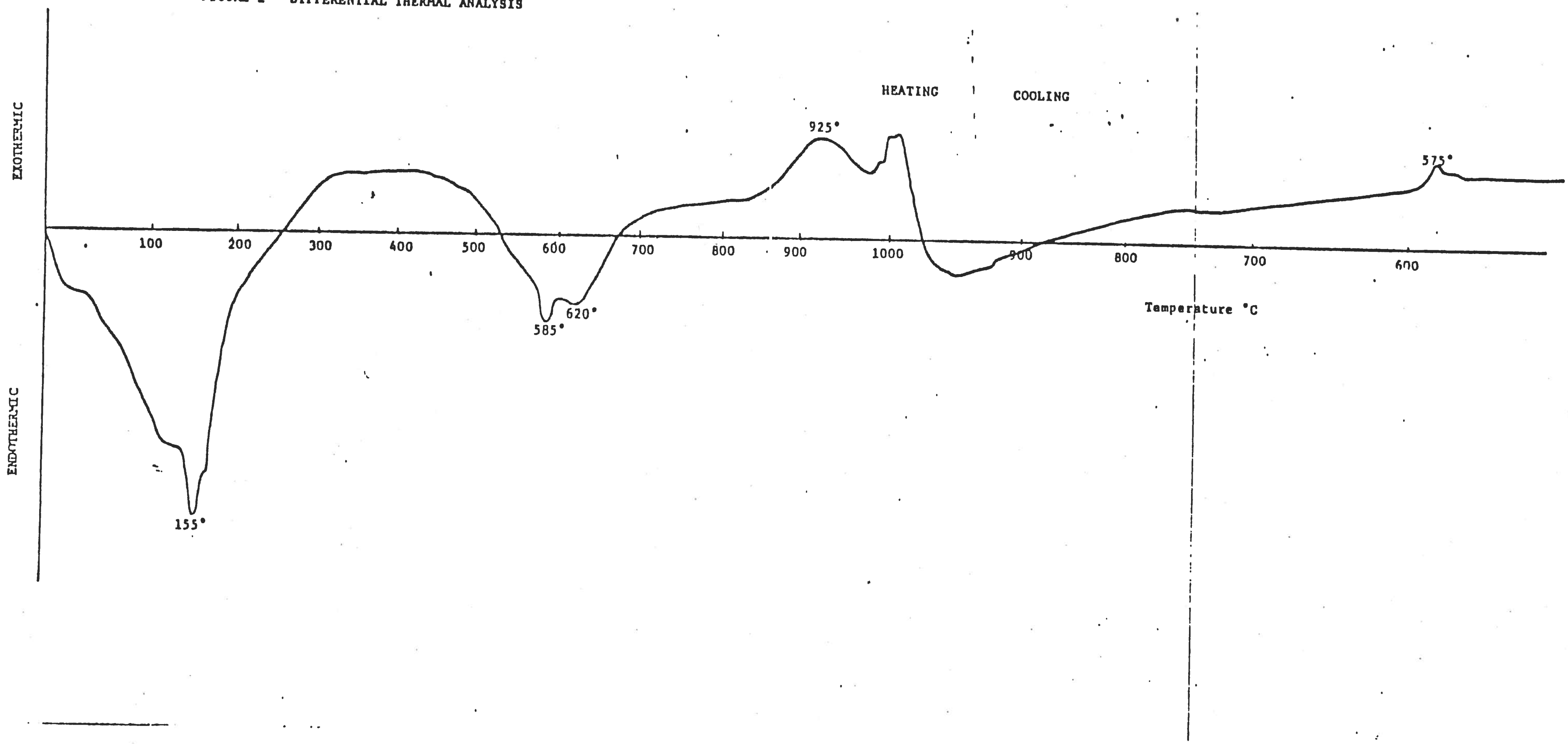


FIGURE 3 - PARTICLE SIZE DISTRIBUTION

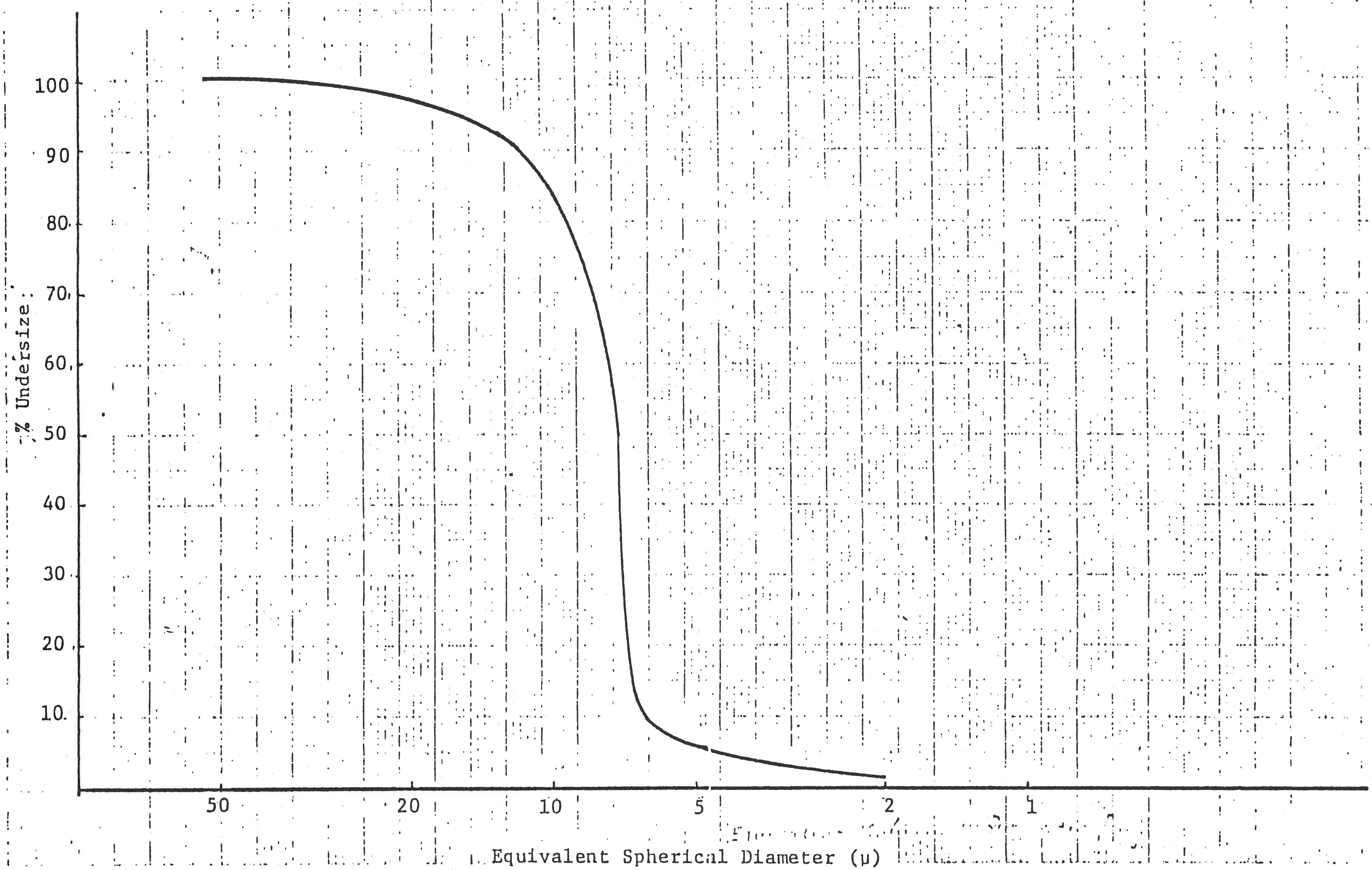
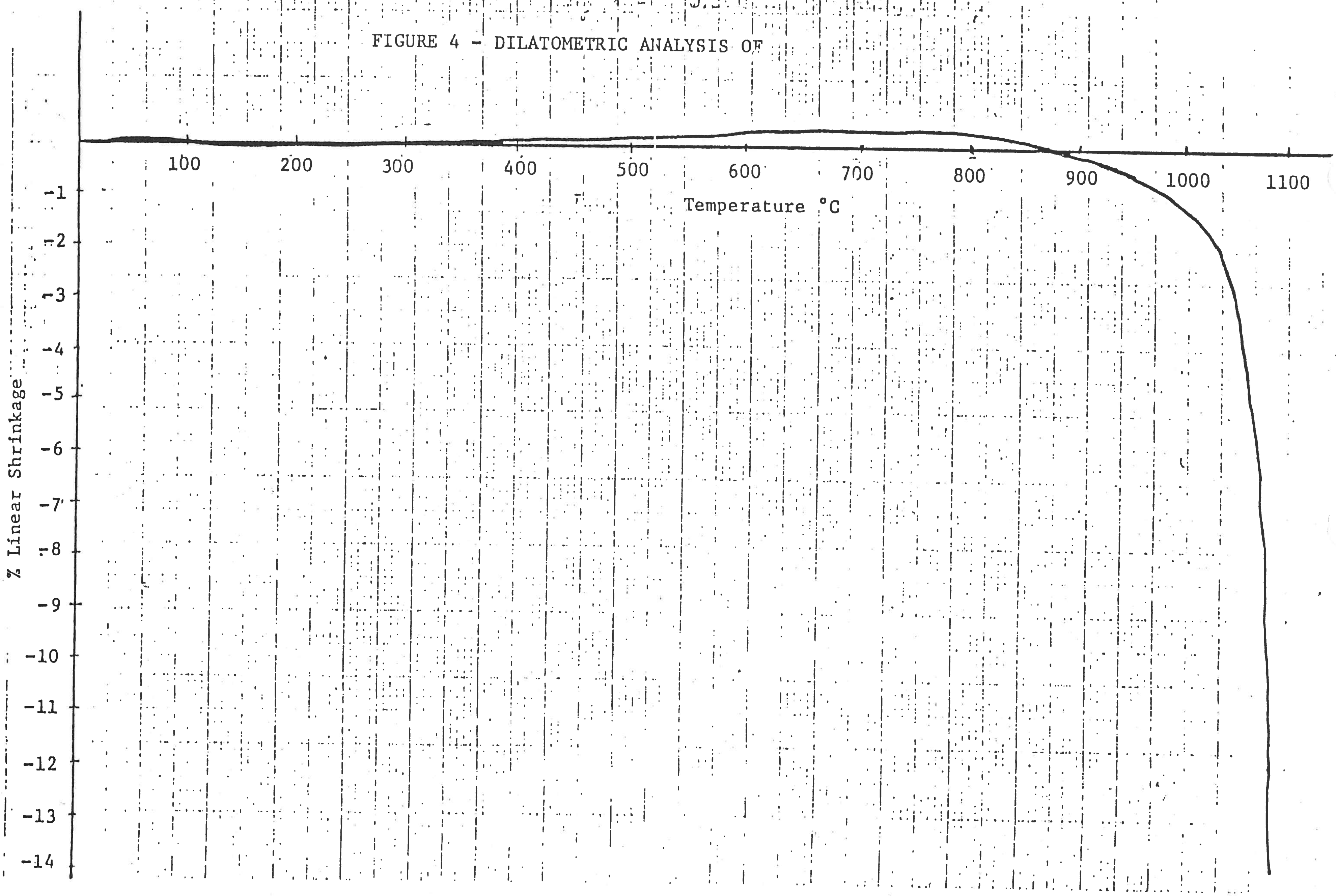


FIGURE 4 - DILATOMETRIC ANALYSIS OF



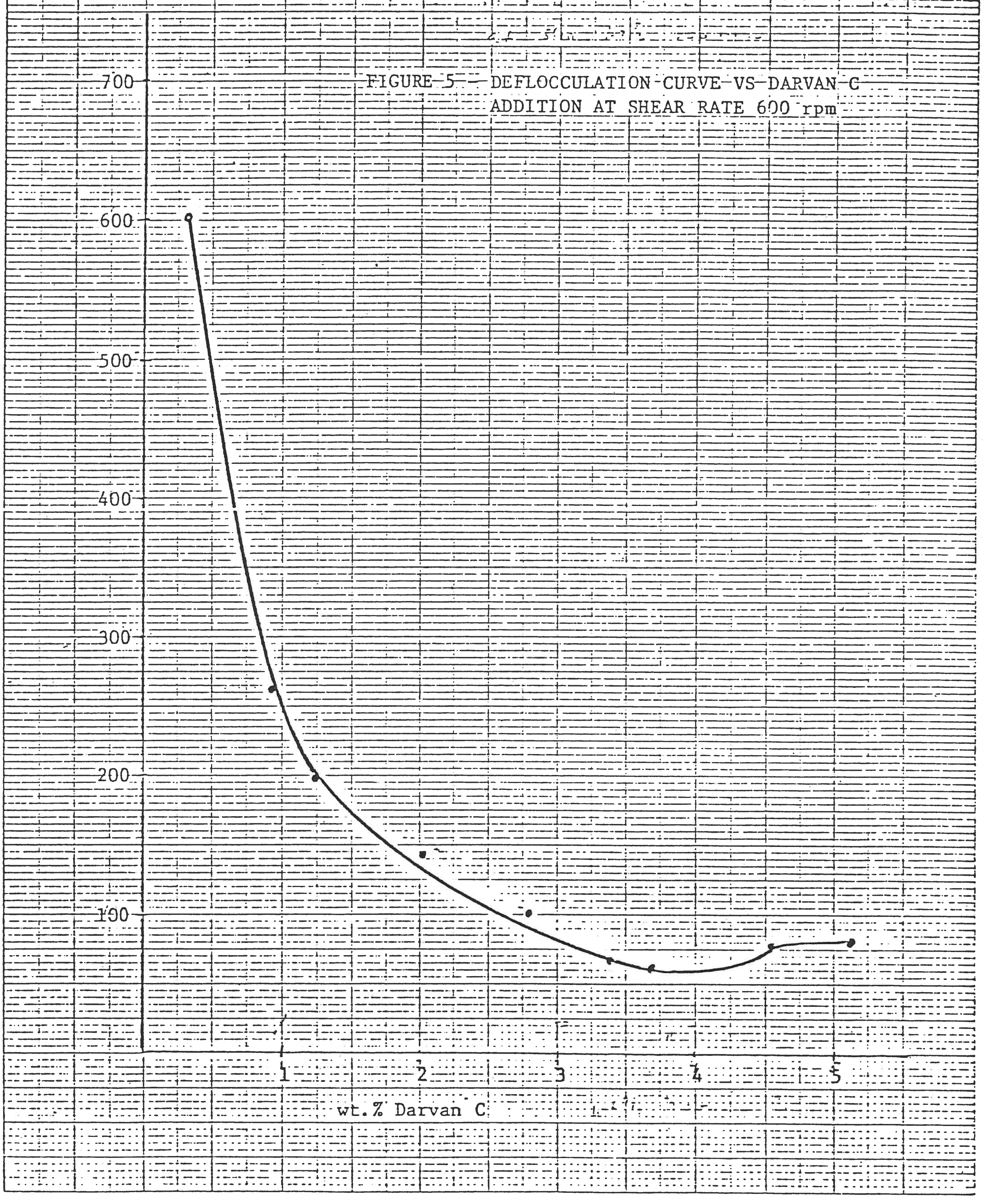


FIGURE 5 – DEFLOCCULATION CURVE VS DARVAN C
ADDITION AT SHEAR RATE 600 rpm
700
600
500
400
300
200
100
1
2
3
4
5
wt.% Darvan C

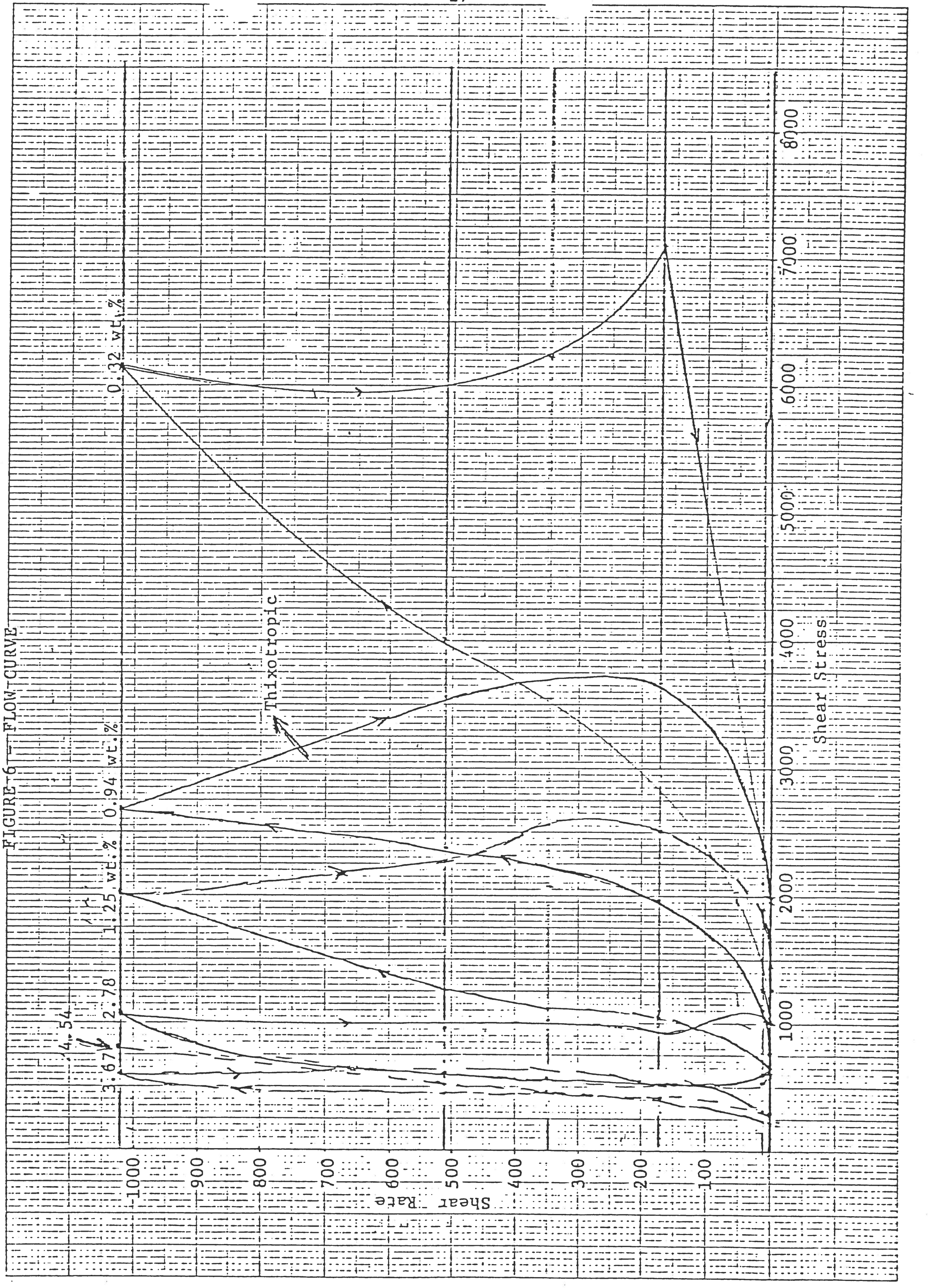


FIGURE 6 — FLOW CURVE
0.32 wt.%
0.94 wt.%
1.25 wt.%
2.78
4.54
3.67
Thixotropic
Shear Stress
1000
2000
3000
4000
5000
6000
7000
8000
Shear Rate
100
200
300
400
500
600
700
800
900
1000

CSA
A82.1—1954

CANADIAN STANDARDS ASSOCIATION

(INCORPORATED 1919)

A82.1—1954

SPECIFICATION
FOR
BUILDING BRICK (MADE FROM CLAY OR SHALE)

(SECOND EDITION)

CSA STANDARD
1954

PUBLISHED, OTTAWA, MAY, 1954

PRICE 50 CENTS

PRINTED IN CANADA

CONTENTS

REFERENCE SPECIFICATIONS

This Specification makes reference to the latest issue of the following Specification:
CSA Specification A82.2 — Standard Methods of Sampling and Testing Brick.

CANADIAN STANDARDS ASSOCIATION
NATIONAL RESEARCH BUILDING
OTTAWA

NOTE: *The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the article herein referred to, but does not comprise all the necessary provisions of a Contract.*

A82.1—1954

CSA SPECIFICATION
FOR
BUILDING BRICK (MADE FROM CLAY OR SHALE)
(SECOND EDITION)

This Specification is in substantial agreement with the latest issue of ASTM Standard C62 "Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)".

NOTE: *In using the following Specification the Purchaser should be guided by the past performance of the brick in the locality in which it has been used. If the performance for a period of 25 years or more has been satisfactory, it is recommended that the purchaser may waive the absorption and saturation coefficient requirements of Table 1, provided that the brick is produced of the same raw material and by the same method of manufacture.*

SCOPE

Scope

1. This Specification covers brick made from clay or shale, burned, and intended for use in brick masonry. Three grades of brick are covered:

Grade SW. Brick intended for use where a high degree of resistance to frost action is desired and the exposure is such that the brick may be frozen when permeated with water;

Grade MW. Brick intended for use where exposed to temperatures below freezing but unlikely to be permeated with water; or where a moderate and somewhat nonuniform degree of resistance to frost action is permissible;

Grade NW. Brick intended for use as back-up or interior masonry.

2. In this Specification the term "brick" shall be understood to mean brick or solid clay masonry unit having not over 25 per cent core space.

PHYSICAL PROPERTIES

Durability

3. The brick shall conform to the physical requirements for the grade specified, as prescribed in Table 1.

TABLE 1

PHYSICAL REQUIREMENTS

Designation	Minimum Compressive Strength (brick flatwise) psi, gross area		Maximum Water Absorption by 5-hour Boiling per cent		Maximum Saturation Coefficient*	
	Average of 5 Brick	Individual	Average of 5 Brick	Individual	Average of 5 Brick	Individual
Grade SW	3000	2500	17.0	20.0	0.78	0.80
Grade MW	2500	2200	22.00	25.0	0.88	0.90
Grade NW	1500	1250	no limit	no limit	no limit	no limit

***** *The saturation coefficient is the ratio of absorption by 24-hour submersion in cold water to that after 5-hour submersion in boiling water.*

4. Unless otherwise specified by the Purchaser, brick of grades SW and MW shall be accepted in lieu of grade NW, and grade SW in lieu of grade MW.

5. If the average compressive strength is greater than 8000 psi or the average water absorption is less than 8.0 per cent after 24-hour submersion in cold water, the requirement for saturation coefficient shall be waived.

Freezing and Thawing

6. The requirements specified in Table 1 for water absorption (5-hour boiling) and saturation coefficient shall be waived, provided a sample of five brick, meeting all other requirements, complies with the following requirements when subjected to 50 cycles of the freezing-and-thawing test*:

Grade SW—No breakage and not greater than 1.0 per cent loss in dry weight of any individual brick;

Grade MW—No breakage and not greater than 3.0 per cent loss in dry weight of any individual brick.

**Brick are not required to conform to the provisions of Clause 6, and these do not apply unless the sample fails to conform to the requirements for absorption and saturation coefficient prescribed in Table 1 as well as the strength and absorption requirements in Clause 5.*

7. A particular lot or shipment shall be given the same grading as a previously tested lot without repeating the freezing-and-thawing test, provided the brick are made by the same Manufacturer from similar raw materials and by the same method of forming; and provided also that a sample of five brick selected from the particular lot has an average and individual minimum strength not less than a previously graded sample, and has average and individual maximum water absorption and saturation coefficient not greater than those of the previously tested sample graded according to the freezing-and-thawing test.

Strength

8. When brick are required having strengths greater than prescribed in Clauses 3 or 6, the Purchaser should specify the desired minimum strength according to the classification given in Table 2.

TABLE 2

CLASSIFICATION BY COMPRESSIVE STRENGTH

Designation	Minimum Compressive Strength (brick flatwise), psi gross area	
	Average of 5 Brick	Individual
2500 pound	2500	2200
4500 pound	4500	4000
8000 pound	8000	7000

Appearance

9. If brick having a particular colour, texture, finish, uniformity, or freedom from cracks, warpage, exposed stones, pebbles, or particles of lime are desired, such brick should be purchased under specifications for facing brick.

SIZE AND CORING

Size

10. The size of brick varies in the several regions of production in Canada. The Purchaser should ascertain what is available or specify the size desired. The maximum permissible variation in dimensions of individual units shall not exceed those given in the following Table:

Specified Dimension Inches	Maximum Permissible Variations from Specified Dimension, plus or minus, Inch
Up to 3, inclusive	3/32
Over 3 to 4, inclusive	2/16
Over 4 to 6, inclusive	3/16
Over 6 to 8, inclusive	4/16
Over 8 to 12, inclusive	5/16

Coring

11. Unless otherwise specified in the invitation for bids, brick shall be either solid or cored at the option of the Seller. The net cross-sectional area of cored brick in any plane parallel to the bearing surface shall be at least 75 per cent of the gross cross-sectional area measured in the same plane. No part of any hole shall be less than ¾ inch from any edge of the brick.

Frogging

12. Unless otherwise specified in the invitation for bids, one bearing face of each brick may have a recess or panel (frog) not exceeding ⅜ inch in depth, except that in brick containing deep frogs, any cross-section

through the frogs parallel to the bearing surface shall conform to the requirements of Clause 11. No part of the recess shall be less than ¾ inch from any edge of the brick.

VISUAL INSPECTION

Visual Inspection

13. The brick, as delivered to the site, shall, by visual inspection, conform to the requirements specified by the Purchaser, or to the sample or samples approved as the standard of comparison, and to the samples passing the tests for physical requirements. Minor indentations or surface cracks incidental to the usual method of manufacture, or the small chipping resulting from the customary methods of handling in shipment and delivery, should not be deemed grounds for rejection.

14. Unless otherwise agreed upon by the Purchaser and the Seller, a delivery of brick shall contain not less than 95 per cent whole brick.

SAMPLING AND TESTING

Sampling and Testing

15. For purpose of tests, brick that are representative of the commercial product shall be selected by a competent person appointed by the Purchaser, the place or places of selection to be designated when the purchase order is placed. The Manufacturer or the Seller shall furnish specimens for tests without charge.

16. The brick shall be sampled and tested in accordance with the latest issue of CSA Specification A82.2 "Standard Methods of Sampling and Testing Brick".

17. Unless otherwise specified in the purchase order, the cost of tests shall be borne as follows:

(a) If the results of the tests show that the brick do not conform to the requirements of this Specification, the costs shall be borne by the Seller.

(b) If the results of the tests show that the brick do conform to the requirements of this Specification, the costs shall be borne by the Purchaser.

APPENDIX A

EXPLANATORY NOTE

Extensive tests of brick masonry, as well as observations of masonry structures in the field, indicate that the important properties of brick which affect the appearance and performance of masonry in building are size, colour and texture, compressive strength, durability, and suction when laid. Data indicate that a low rate of suction (20 grams per minute or less) is desirable both from the standpoint of bond and watertightness. Since the suction rate of brick that normally have high rates of suction can be reduced to any predetermined value by wetting before laying, this property should not be included in specifications for brick, but may properly be made a part of specifications governing weather protection and heating of the wall under construction during winter conditions.

Other properties of brick such as density, soluble salt content, and homogeneity probably also affect the performance of the masonry. Data are not available, however, from which measures of those properties or their effects upon the masonry may be determined, and consequently there are no bases for controlling these factors through a specification. Their effects may be best judged by the record of performance of similar products.

This Specification provides a basis for specifying the following properties of brick, which, as indicated above, appear to be important.

Colour and Texture—Brick are manufactured in a wide variety of colours and textures, neither of which have been standardized. Both colour and texture are difficult to describe and a complete list of the products now produced, if obtainable, would be too voluminous to include in a specification. These properties are covered in Clause 9 of this Specification, which provides that colour, texture, finish, and uniformity should be specified by the Purchaser. The common practice is to refer to an approved sample.

Compressive Strength—The compressive strength of brick produced in Canada ranges from 1,000 psi or less (under-burned) to over 20,000 psi. Data are available from which the compressive strength of masonry walls may be predicted with reasonable accuracy, if the strength of the brick and the strength of the mortar are known. In the great majority of cases, however, the compressive stresses in masonry walls are relatively low (under 100 psi), and for such structures minimum compressive strengths of brick of from 1,500 to 2,500 psi are ample. These minimum values are included in Clause 3 of this Specification; when brick having higher strengths are desired, the required strength should be specified by the Purchaser as provided in Clause 8.

Durability—Experience has indicated that any well-burned brick will resist the action of freezing and thawing over a long period of time and, from a structural standpoint, may be considered durable. There is a reasonably close correlation between the performance of brick in the freezing-and-thawing test and under the agents of weathering in masonry structures, and at the present time this test appears to be the best measure of the durability of brick. Freezing-and-thawing tests consist of subjecting the brick to alternate cycles (50 or more) of freezing and thawing in the presence of moisture, which requires a period of 10 weeks or more to complete. This makes it impractical as an acceptance test, and for this reason extensive research has been carried on to correlate other physical properties of brick with their resistance to the freezing-and-thawing test.

For brick produced of the same raw material and by the same method of manufacture, either compressive strength or total absorption may be taken as fairly accurate measures of the resistance of such brick to the freezing-and-thawing test. Limits on these properties that apply to one product, however, do not apply to products produced from different raw materials or by different manufacturing processes, and consequently they alone cannot be used as measures of durability in general specifications. A third property known as "saturation coefficient", when used in conjunction with compressive strength and total absorption by 5-hour boiling, has been found to provide a means of predicting the resistance of most types of brick to freezing-and-thawing tests with greater accuracy than any other method developed to date.

The saturation coefficient is the ratio of the absorption by 24-hour submersion in cold water to the absorption after 5-hour submersion in boiling water, and is defined generally as the ratio of easily filled to total fillable pore space. The theory of the saturation coefficient is that if only a part of the total pore space is occupied by water, there is room for expansion on freezing into the remaining pore space without disruption of the material. The data indicate that if the easily fillable pore space, that is, the maximum water that might be absorbed by a brick in a wall subjected to excessive moisture, does not exceed 80 per cent of the total pore space, the remaining space will relieve the pressure due to expansion on freezing.

While this theory seems to be applicable to many types of brick, it has been found that it does not apply to certain types of de-aired products. Strength and absorption are, therefore, used as measures of durability for these products and their acceptance should be based upon Clause 5 of this Specification.

The relationship also does not appear to hold for some brick of very high absorption (exceeding the maximum permitted in this Specification) and the acceptance of these products should be in accordance with Clause 6, which provides for special measures based upon actual freezing-and-thawing tests of the particular product.

In classifying brick according to their resistance to the freezing-and-thawing test, they fell into three general groups as indicated in Table 1 of this Specification:

Grade SW, which are not affected by the test, and whose appearance and structure remain unchanged;

Grade MW, which are for the most part well-burned brick but may include some brick which change materially in appearance when exposed to weathering.

The limits for absorption and saturation coefficient in the grade MW classification have been set to include the average production of those districts which do not grade or classify their kiln output beyond elimination of extremely underburned (salmon) brick. These "kiln run" shipments frequently include a small percentage of brick which, on exposure to weathering, will lose their surfaces by powdering, flaking, or spalling, and thus produce an unsightly appearance of the exposed masonry surface. Data indicate that brick cannot be classified into intermediate durability. Actually, grade MW includes a mixture of durable and non-durable brick. It should be emphasized, however, that disintegration is not necessarily a characteristic of brick in this grade. Certain plants may supply brick under the grading, all of which remain unchanged in appearance even under severe conditions of exposure. The Purchaser is advised to examine the field behaviour of brick in districts where production classifies as grade MW and reach his own decision as to whether the appearance and condition of masonry at the age of 10 or 20 years is satisfactory.

Grade NW intended for use as back-up or interior masonry.

In using this Specification, the Purchaser is urged to consider both the requirements of the structure and the physical properties of the brick available. To a degree at least, brick are a natural product, since such properties as colour, compressive strength, and absorption are more or less inherent in the raw material and frequently can be changed only within narrow limits by different methods of manufacture. While the Committee believes that the Specification, as it now stands, provides the best means available of specifying the desirable properties of brick, it recognizes that the Specification is not perfect and that due to the wide variation in raw materials and methods of manufacture, it is probable that some brick which do not conform to the requirements of grade SW still have satisfactory durability. It may also be true that some products which meet these requirements, particularly of grade MW, do not have satisfactory resistance to weathering. For this reason and because of the lack of data on some properties that may have an important bearing upon the performance of masonry, the Purchaser should be guided to a degree by the record of performance of any particular product.