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INFORMAL REPORT

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Author (s) H. B. Rhodes

EVALUATION OF ASBESTOS-VANSIL PRODUCED AT KING CITY AS AN OPACIFYING AGENT FOR PAPER

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SUMMARY AND CONCLUSIONS

Two pilot plant preparations of Asbestos-Vansil have been made at the King City mill. The opacifying power of both of these products has been tested in handsheets at the Niagara Falls laboratories. Chemical composition and repulpability of the Asbestos-Vansil have also been checked. The key results were:

1. The two Asbestos-Vansil products have essentially the same opacifying power.

2. Cost-performance comparison with T-135 (at $290/ton) shows the Asbestos-Vansil products have a value of about $150 per ton. (This is well below the $200 per ton found for a standard Asbestos-Vansil prepared by the R. T. Vanderbilt Co.)

3. The Asbestos-Vansil dry pellets are much more difficult to repulp than standard HPP asbestos.

4. Handsheets made from the King City products had a level of asbestos floccs about the same as T-135 and High Purity pellets. Handsheets made from the standard Asbestos-Vansil prepared by R. T. Vanderbilt had no floccs.

The first pilot plant run was carried out in a circuit where the Asbestos-Vansil product was recycled through the active precipitation zone. The R. T. Vanderbilt Company feels that this is likely to alter the form of the Vansil precipitate and cause the poorer than expected optical properties found in this batch of product.

In the second pilot plant run, the circuit was modified to avoid the recycle. Although the control and operation of the new circuit went very well, an excess of silicate was used. It appears

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that this excess resulted in an Asbestos-Vansil product with at least a partial coating of silica. The coating could cause the lower opacifying ability and the repulping difficulties found in this product.

Although the foregoing operating problems could possibly account for the lower quality of the products, the difference in the amount of floccs in the handsheets suggests that the starting asbestos used by R. T. Vanderbilt for the preparation of the standard Asbestos-Vansil was more open than that used for the King City product. It is well known that the degree of opening can have a significant effect on optical properties. Since all of those materials are now Vansil coated, there is no way to check how the degree of opening of the starting asbestos may have affected the repulpability and optical properties of the final products.

These operating problems and other uncertainties lead to the conclusion that we have not yet made an Asbestos-Vansil product that is well enough defined to serve as a sound basis to evaluate this project. We have now acquired enough experience to make such a product. The present results, although somewhat poorer than anticipated, are sufficiently encouraging to justify an additional run at King City.

RECOMMENDATIONS

It is recommended that a two-part run be made at King City using the following conditions:

Part I

1. One-pass precipitation and neutralization circuit (Same as the last run.)

2. Aim for a Vansil level of 10-11 per cent; final pH after neutralization of 7.

3. Adjust feed flows to maintain a slight excess of Ca^{++} throughout the precipitation step.

4. Use 100% COR from the higher purity circuit as asbestos feed to the precipitation. (No HPO)

Part II

1. Prepare a second lot of Asbestos-Vansil under the same conditions as Part I except that the asbestos feed is 100% COR from the R-G244 circuit, i.e., the same well-opened asbestos that is used as a starting material for R-G244.

A complete set of samples will be taken during both Part I and Part II to permit us to follow the preparation in detail. The R-G244 feed material is obviously too expensive for a paper industry product. The recommended approach, however, is a quick and relatively inexpensive way to separate the opacifying power of the Vansil precipitate from the gain in opacity due to better opening of the asbestos. It will then allow us to make a realistic evaluation of the product performance that can be attained at any specified price.

BACKGROUND

During the latter part of 1966 and early 1967, the Asbestos Group studied the feasibility of preparing an opacifying agent for paper which did not contain TiO_2. Preliminary results on several co-precipitates on highly opened (essentially colloidal) asbestos looked fairly promising.*

At about that time, UCC was approached by the R.T. Vanderbilt Company who had developed a version of their proprietary Vansil (calcium silicate) opacifying agent precipitated on High Purity Asbestos. Although initial claims that the Asbestos-Vansil was as good as T-135 were not borne out, subsequent testing showed that Asbestos-Vansil selling at $200 per ton was equivalent on a cost-performance basis to T-135 at $290 per ton. At these prices, the Asbestos-Vansil would yield a significantly better gross margin than T-135.

The Asbestos-Vansil, as described by R. T. Vanderbilt, was made from the relatively inexpensive High Purity Asbestos, whereas the UCC products used the expensive colloidal material. It was apparently ready to be moved simply and rapidly to commercial production. On this basis, the decision was made to proceed to a pilot plant production test at the King City mill. Further work on the UCC co-precipitated opacifying agent would be delayed until the Asbestos-Vansil tests were completed. (This also had the advantage that it permitted UCC to concentrate its efforts on the production of the potentially very profitable R-G244.)

In accordance with this program, two lots of Asbestos-Vansil have been prepared at the King City mill. This report touches briefly on the King City runs as they relate to the properties of the materials produced. Chemical analyses of the Asbestos-Vansil products, results of the repulpability tests, and measurements of the optical properties are presented. Finally, a cost-performance comparison of these Asbestos-Vansil opacifiers and T-135 is made.

*See Interim Report: "Modified High Purity Asbestos" by G. L. Dickson, March 21, 1967

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KING CITY PILOT PLANT RUNS

The operating conditions for the King City runs have been fully described by Mr. J. L. Myers.* It is convenient for the discussion of product test results, however, to include here the following brief listing of the main conditions:

TABLE I

KING CITY OPERATING CONDITIONS: ASBESTOS-VANSIL

	Run No. 1	Run No. 2
Preparation Circuit		
1. Precipitation Step	Recycle	One-pass
2. pH Adjustment Step	Recycle	One-pass
Asbestos Feed	HPO	Mostly COR with some HPO
Desired Vansil Level (Wt. % Asbestos)	10%	11-14 (12-1/2 preferred)
Overall SiO_2/CaO Ratio	4/1	7.65/1
Final pH	9	7
Pellet Workup	Extruded and tray dried	Extruded and tray dried

The key question with Run No. 1 was the recycle of the asbestos that already contained the Vansil precipitate back through the mixing pump where it was again contacted with fresh silicate solution. This procedure and the properties of the Asbestos-Vansil product were discussed with R. T. Vanderbilt. They felt that this recycle could have a significant effect on optical properties and recommended the one-pass approach that was adopted for the second run.

In the second run, the operation and control went very smoothly. The SiO_2/CaO ratio used, however, gave an excess of silicate over that needed for Vansil. Results to be presented in subsequent sections indicate that this gave a deposit that was not pure Vansil but a mixture of Vansil and SiO_2.

*See letters J. L. Myers to G. L. Dickson (Sept. 7, 1967)
J. L. Myers to R. G. Woolery (Nov. 22, 1967)

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EXPERIMENTAL PROCEDURES

Chemical Analyses

The "green" and dry pellets, as received in plastic bags from King City, were submitted in duplicate for the following analyses:

1. Per cent Moisture:

   Weight loss after one hour in an oven at 105°C.

2. Loss on Ignition:

   Weight loss after one hour in an oven at 800°C.

3. Per cent Calcium and Magnesium:

   Dry sample dissolved in mixture of hydrofluoric, nitric, and perchloric acids. Double ammonia separation followed by EDTA titration.

Repulpability

Our standard asbestos repulpability test was used for both the green and dry pellets. In this test a weighed sample of pellets is opened at a two per cent solids concentration in a Hermann Disintegrator. Small samples of a predetermined size are removed at several successive time intervals. These samples are diluted and screened. The per cent "retained" after three passes through a 65-mesh screen is taken as the measure of the repulpability.

When it became evident that the dry product would not repulp to a satisfactory level in a reasonable time in the Hermann Disintegrator, a test series was run at high speed in a Waring Blendor. The pulp concentration and screening procedure were kept the same as for the tests in the Hermann Disintegrator.

It was also noticed that there was a very considerable difference in repulpability between the green and dry pellets. In order to get a qualitative picture of the effect of pellet moisture level, a single layer of green pellets was oven dried at 105°C. in a 15" x 22" flat pan. Although the drying was obviously more rapid along the edges of the pan, it was possible to remove samples at intervals which visually, at least, were homogeneous. These samples were stored overnight in polyethylene bags at ambient conditions and were then subjected to the standard repulpability test in the Hermann Disintegrator.

Optical Properties

The optical properties of the Asbestos-Vansil fillers were measured in handsheets prepared in accordance with TAPPI Standards

T-205M-58. Specific equipment and procedures are summarized in Table II. Deionized water (pH ~5.0) was used exclusively for all pulp, filler, and sheet preparation. The pH was controlled with alum.

Quality control during the several days required for the handsheet work was monitored by the preparation of unfilled sheets interspersed at intervals between the test samples. A series of sheets containing different loadings of standard T-135 (King City mill preparation of 3/15/67) was also made up for each Asbestos-Vansil product test sequence to serve as a standard of comparison.

All handsheets were conditioned at 72°F., 50% relative humidity for at least 24 hours prior to testing. Values for the light refracted from the sheet when backed by a black body, (R_o), and when backed by a standard white body (R_w), were measured in a Bausch & Lomb opacimeter equipped with a digital readout. A minimum of five readings each on three sheets per set were made. The sheets were then oven dried and individually weighted to the nearest milligram. A representative cross section of the three sheets (in each set) weighing a total of one gram was submitted for chemical analysis.

TABLE II

SUMMARY OF HANDSHEET PREPARATION PROCEDURES

Filler	King City Run 1 Asbestos-Vansil	King City Run 2 Asbestos-Vansil
Filler Preparation		
Green pellets	8 min. Hermann Disintegrator, 1% Slurry	8 min. Hermann Disintegrator, 1% Slurry
Dry pellets	12 min. Hermann Disintegrator, 1% Slurry	0.5 min. High Speed Waring Blendor, 1% Slurry
Pulp	100% Bleached Hardwood Kraft	100% Bleached Hardwood Kraft
Pulp Preparation		
Beater	Valley	Valley
Canadian Standard freeness (mm)	300	300
Handsheet Preparation		
Sheet Mold	Noble and Wood	British
Basis Weight (g/m²)	60	90
Alum Added (wt. % of fiber)	2.5	2.0
pH	5.3-5.9	5.5-5.7

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Flocc Testing

The test recently developed by Mr. F. H. Thompson* was used to examine the various handsheets for floccs of poorly opened asbestos. In this test the surface of the paper is coated with a solution of VYHH - vinyl chloride, vinyl acetate polymer dissolved in MEK. The treated sheets are air dried and then heated on a hot plate at 200-300°C. for one minute. Any poorly-opened asbestos particles (floccs) appear as black specks in the surface of the sheet.

RESULTS AND DISCUSSION

Chemical Analyses

The results of the chemical analyses on the two Asbestos-Vansil products are summarized in Table III.

TABLE III

CHEMICAL ANALYSES

ASBESTOS-VANSIL DRY PELLETS - KING CITY PILOT PLANT RUNS

Sample Designation	% Mg	% Ca	% Moisture	% LOI
Run 1				
1A	22.67	0.96	1.91	14.10
1B	22.67	0.96	1.92	13.90
Run 2				
1A	20.71	0.64	1.70	12.07
1B	21.09	0.65	1.91	12.78
2A	20.63	0.45	1.92	12.65
2B	21.18	0.51	1.93	12.52
Average	20.90	0.56	1.87	12.50

Note: Samples submitted as received from King City.

Mg, Ca, and LOI results are on a dry basis corrected for per cent moisture.

*See letter F. H. Thompson to R. G. Woolery, October 27, 1967

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The amount and composition of the Vansil deposited on the asbestos was calculated from these chemical analyses. In this calculation it is assumed that the magnesium in the deposit comes entirely from the asbestos and, on the average, asbestos contains 25% magnesium. With these assumptions, the Asbestos-Vansil made in Run 1 has a composition of:

$$\frac{(\%\ \text{Mg in Asbestos-Vansil})}{(\%\ \text{Mg in Asbestos})}(100) = \frac{22.67}{25.00}(100) = 90.68\%\ \text{Asbestos}$$

$$100 - 90.68 = 9.32\%\ \text{Vansil}$$

The figures can be cross-checked independently by means of the calcium analysis. Thus, the R. T. Vanderbilt literature gives the approximate formula for Vansil as:

$$1(CaO)\cdot 4(SiO_2)\cdot 3(H_2O)$$

$$MW = 40 + 16 + 240 + 54 = 350$$

The per cent calcium will be:

$$100\ (40/350) = 11.42\%$$

Applying this percentage to the average calcium content of the Run 1 product gives:

$$\frac{(0.96\ )}{(11.42)}(100) = 8.4\%\ \text{Vansil}$$

This is considered to be an excellent check with the 9.32% value calculated from the magnesium determination.

When the same procedure is applied to Run 2, the results are considerably poorer. Thus, from the magnesium analysis:

$$\frac{(20.9)}{(25.0)}(100) = 83.6\%\ \text{Asbestos}$$

$$100 - 83.6 = 16.4\%\ \text{Vansil}$$

While from the calcium results:

$$\frac{(0.56\ )}{(11.42)}(100) = 4.9\%\ \text{Vansil}$$

A partial explanation for this discrepancy can be found in the procedure that was used in the precipitation. In essence the following quantities of reactants were used:

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	Pounds	Pound Mols
Asbestos	90	-
$CaCl_2$ (100% basis)	2.02	0.0254
SiO_2	11.63	0.194

These figures show that the mol ratio of SiO_2/CaO is (0.194/0.0254) = 7.65/1 which is considerably in excess of the 4/1 ratio given in the Vansil formula. If it is assumed that all of the calcium fed is used to produce Vansil and that all of the excess silicate was precipitated on the asbestos when the pH was reduced to 7, the total deposit would be:

	Pounds	Weight Per cent
Vansil	8.93	(13.8
SiO_2	5.52	(
Asbestos	90.0	86.2
	104.45	100

Based on the formula for Vansil, this deposit should have a calcium content of:

$$\frac{(8.93)\ (0.1142)}{104.45}\ (100) = 0.9\%$$

Considering the various assumptions involved, the agreement between 13.8 and 16.4% for the total deposit seems reasonably good. Nearly half of the calcium fed, however, appears to be missing. Four possibilities for this are:

1. Loss of soluble calcium salts to the filtrate solution.

2. Systematic analytical bias.

3. Non-uniform dispersion of the small amount (one gallon) of starch-$CaCl_2$ complex in the 600 gallons of slurry

4. Incorrect quantity of $CaCl_2$ used in the preparation.

At the present time, there is no basis to choose among the alternates. It seems safe to conclude, however, that this deposit is something other than pure Vansil. A careful check on the calcium balance and the uniformity of the Vansil deposit will be made on the next run.

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Repulpability

The results of the repulpability study are shown in Table IV and Figure 1. The ordinate gives the per cent of material retained on 65 mesh as a function of opening time in the Hermann Disintegrator. It is immediately evident from the figure that the Asbestos-Vansil dry pellets from Run 2 are much more difficult to repulp than either the dry pellets from Run 1 or typical High Purity pellets. This could well be due to the postulated silicate coating acting as a binder.

The more important point, however, is the large difference between the green and dry pellets. Some change is apparently taking place during the drying that makes the pellets much harder to repulp. This is of particular concern because both of these Asbestos-Vansil products were tray dried. Past experience with other products has indicated that the usual rotary kiln drying used for commercial production will, if anything, make this problem worse. In any case, this question will be examined in detail during the next run.

Optical Properties

The optical properties of the handsheets have been expressed in terms of the Kubelka-Munk parameters, Brightness (R_∞), TAPPI Opacity ($R_0/R_{0.89}$), and Scattering Coefficient of the filler (s_p). A detailed discussion of the bases for these parameters is beyond the scope of this report. The following brief descriptions show how they relate to the present study.

The brightness, as the name implies, is a measure of the amount of incident light that is scattered back from the sheet. This property is important in many grades of paper so an opacifying additive should not be a material that reduces brightness.

The opacity is basically the proportion of incident light which is not transmitted through the sheet. TAPPI Opacity ($R_0/R_{0.89}$) is a widely used measure of this property. Accordingly, our cost-performance comparison will be based on TAPPI Opacity.

It is also noteworthy in this connection that fillers such as T-135 and Asbestos-Vansil obtain opaqueness largely by light scattering rather than direct absorption. The Asbestos-Vansil is intended to achieve opacity without reducing brightness and without the use of the relatively expensive TiO_2.

TAPPI Opacity has one inherent drawback, i.e., it represents the combined opacity of both the pulp and of any fillers that have been added. The Kubelka-Munk theory makes it possible, however, to

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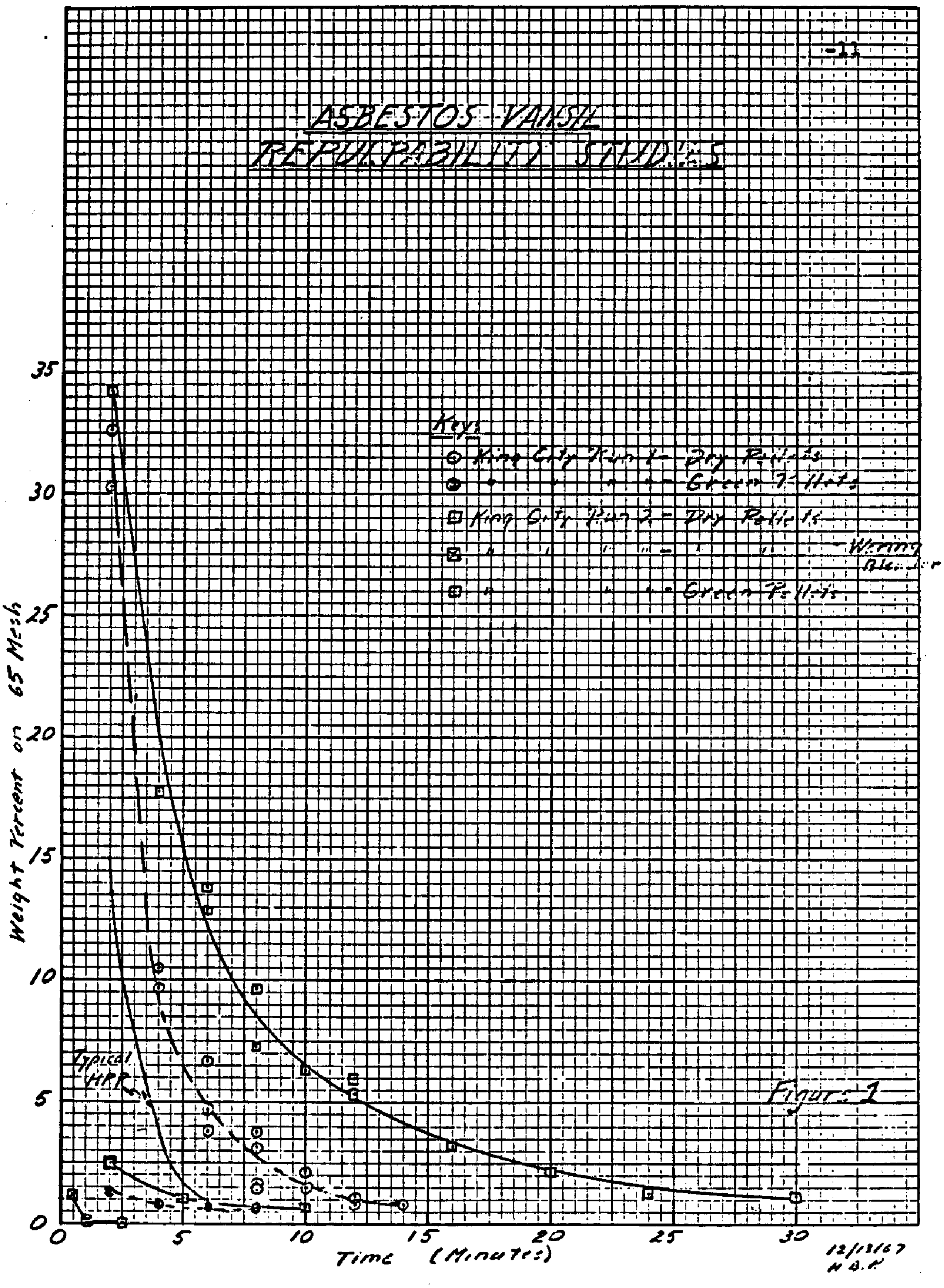

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TABLE IV

ASBESTOS-VANSIL REPULPABILITY STUDIES

Material	Run Designation	pH in 2% slurry	Time in Disintegrator (2) (Minutes)	Per cent on 65 mesh
King City Run No. 1 Dry Pellets) (98.1% Solids)	1	9.1	2	30.3
	1	-	4	9.6
	1	-	6	4.6
	1	-	8	1.6
	2	-	6	6.6
	2	-	8	3.1
	2	-	10	1.5
	2	-	12	0.8
	1R	-	2	32.6
	1R	-	4	10.5
	1R	-	6	3.7
	1R	-	8	1.4
	2R	-	8	3.8
	2R	-	10	2.3
	2R	-	12	1.1
	2R	-	14	0.8
King City Run No. 1 Green Pellets (14.8% Solids)	1	4.2	2	1.3
	1	-	4	0.8
	1	-	6	0.7
	1	-	8	0.6
King City Run No. 2 Dry Pellets (98.1% Solids)	1	8.7	2	34.2
	1	-	4	17.8
	1	-	6	12.9
	1	-	8	7.3
	2	-	6	13.9
	2	-	8	9.6
	2	-	10	6.4
	2	-	12	5.4
	3	-	12	6.0
	3	-	16	3.1
	3	-	20	2.1
	3	-	24	1.2
	4	-	30	1.1

(1) Distilled water used to make slurry

(2) All repulping in Herman Disintegrator unless otherwise noted

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TABLE IV (CONTD.)

Material	Run Desig-nation	pH in 2%[1] slurry	Time in Disintegrator[2] (Minutes)	Per cent on 65 mesh
King City Run No. 2				
Dry Pellets in Waring Blendor (98.1% Solids)	1	-	0.5	1.07
	1	-	1.0	0.09
	1	-	2.5	0.07
	2	-	1.0	0.07
Green Pellets (27.2% Solids)	1	8.7	2	2.5
	1	-	5	1.0
	1	-	10	0.7
Green Pellets Dried to 41% Solids	1	-	8	1.2
Green Pellets Dried to 52% Solids	1	-	8	5.3

Date Book References
1748-41, 42, 91, 92

(1) Distilled water used to make slurry

(2) All repulping in Hermann Disintegrator unless otherwise noted

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separate out the contributions of the pulp and of the filler(s) and express them as individual scattering coefficient.. The resulting scattering coefficient of a particular filler is theoretically an intrinsic property of the filler and can be used directly to compare the effectiveness of different fillers. Paper, unfortunately, deviates considerably from the Kubelka-Munk ideal system so that the individual scattering coefficient is really only useful to relate the relative performance of different fillers in the same basic pulp system. It will be utilized in this way here.

The optical properties of Asbestos-Vansil and T-135 are shown graphically in terms of the foregoing three parameters in Figures 2, 3, and 4. As noted previously, the handsheets for Run 1 were prepared on a Noble and Wood Machine, while those for Run 2 were made on a British sheet mold. Since the results are not directly comparable, only the more complete data from the second run are included in the figures. A listing of all of the results for both runs is given in Tables V and VI.

Consider first, Figure 2, where the brightness, R_∞, is shown as a function of the weight per cent filler in the sheet. Both the "green" and "dry" pellets have the same brightness so it can be concluded that the repulping of the dry pellets was adequate.

The Asbestos-Vansil products had little effect on the brightness of the sheet, while the T-135 gave a substantial increase for loadings beyond about 5%. This pattern is entirely consistent with the properties of the two fillers.

For the Asbestos-Vansil system, both the pulp used and the Asbestos-Vansil had a brightness of about 0.82. It is quite reasonable to expect that a mixture of the two would also show a brightness of approximately 0.82.

The T-135 had a brightness of about 0.86. At low levels of T-135 addition to handsheets, the retention of asbestos is considerably better than that of the TiO_2 (see Table VII). As the loading increases, the TiO_2 retention improves until at about the 5% level, the ratio of asbestos to TiO_2 reaches the input value of 2/1. This retention pattern would give little or no increase in brightness up to roughly the 5% addition level and then the influence of the 0.86 brightness T-135 would increase the brightness of the sheet.

It should be made clear that the Asbestos-Vansil product is intended as an opacifying agent not a brightness improver. However, if at a given opacity level a filler also provides a "fringe" benefit in increased brightness, it could be at a significant advantage in many applications. This factor is not considered further here but should be taken into account in any final evaluation of this project.

Figure 3 shows the opacifying performance in terms of TAPPI Opacity ($C_{0.89}$) as a function of weight per cent filler in the sheet. As noted previously, this is the key property desired in the Asbestos-Vansil and this figure will serve as the basis for the cost-performance comparison of Asbestos-Vansil and T-135 given in the next section. It will thus only be noted here that:

1. The green and dry pellets give the same opacities.

2. At a given loading in the sheet, the T-135 produces considerably higher opacities than the Asbestos-Vansil.

3. The two curves are not parallel but spread gradually as the loading increases.

Figure 4 shows the individual scattering coefficient of the respective fillers as a function of the weight per cent filler in the sheet. It is immediately evident from the figure that neither of the fillers has a constant scattering coefficient For T-135 this is in part due to the varying retention of the co-flocculated components and in part due to non-uniform distribution of the filler in the sheet. The much smaller variation for the Asbestos-Vansil is probably largely due to sheet non-uniformities, but some variation in retention between the Vansil precipitate and the asbestos is also quite possible. Analytical problems (see Section on "Retention") prevented a check on this latter question.

In the commercial papermaking operation, there is a substantial recycle of water that will largely eliminate the differences in retention of individual filler components. It is thus best to compare the fillers in terms of the essentially constant scattering co-efficients attained at high sheet loadings. On this basis the Asbestos-Vansil can be characterized by a value of 1520 cm.^{2}/g. while T-135 shows a value of about 2850 cm.^{2}/g. This suggests that the T-135 is almost twice as effective as an opacifying additive as the present batches of Asbestos-Vansil.

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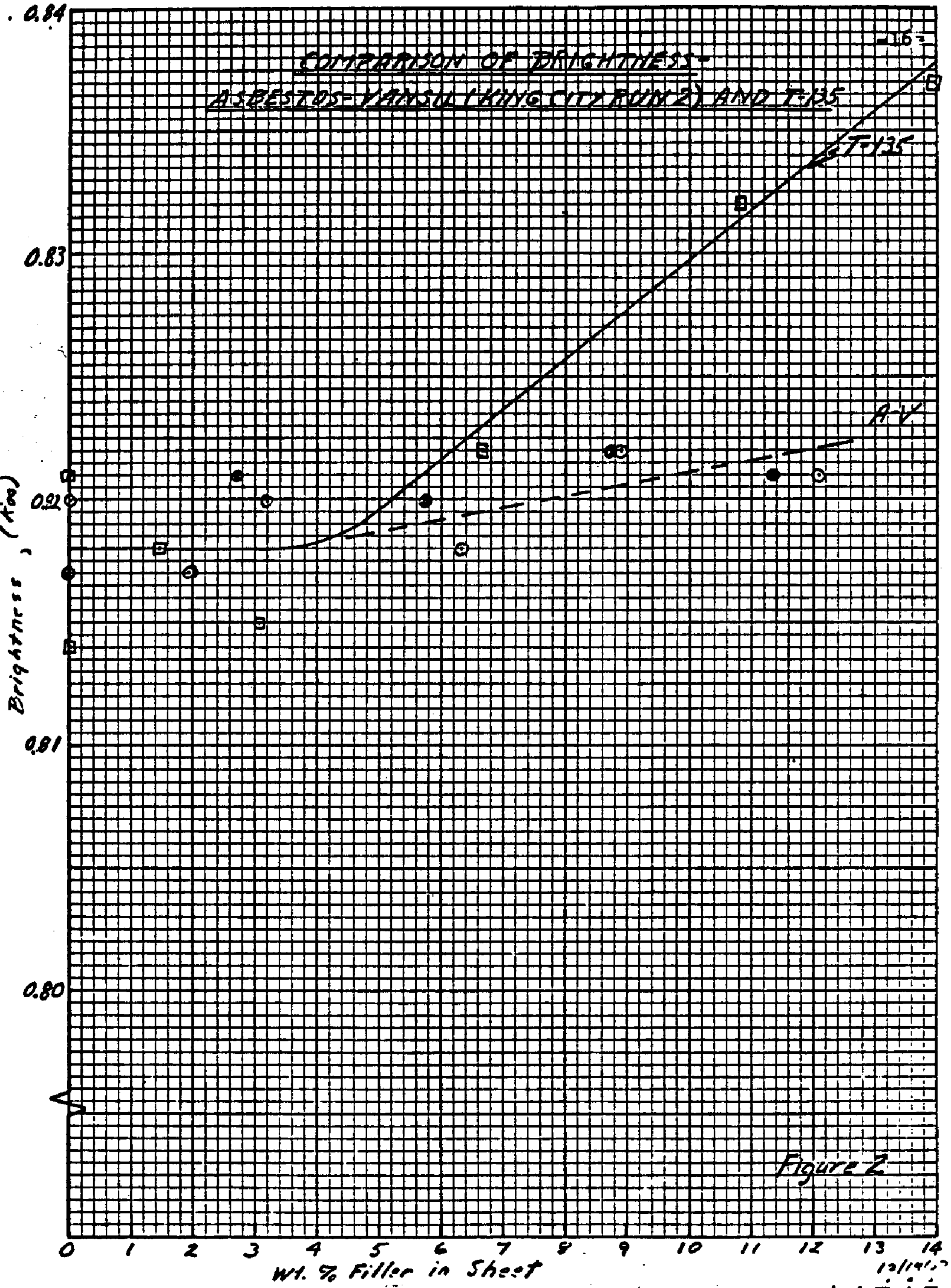
COMPARISON OF BRIGHTNESS -
ASBESTOS-VANSIL (KING CITY RUN 2) AND T-135
-16-
T-135
A-V
0.84
0.83
0.82
0.81
0.80
Brightness, (R∞)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Wt. % Filler in Sheet
Figure 2

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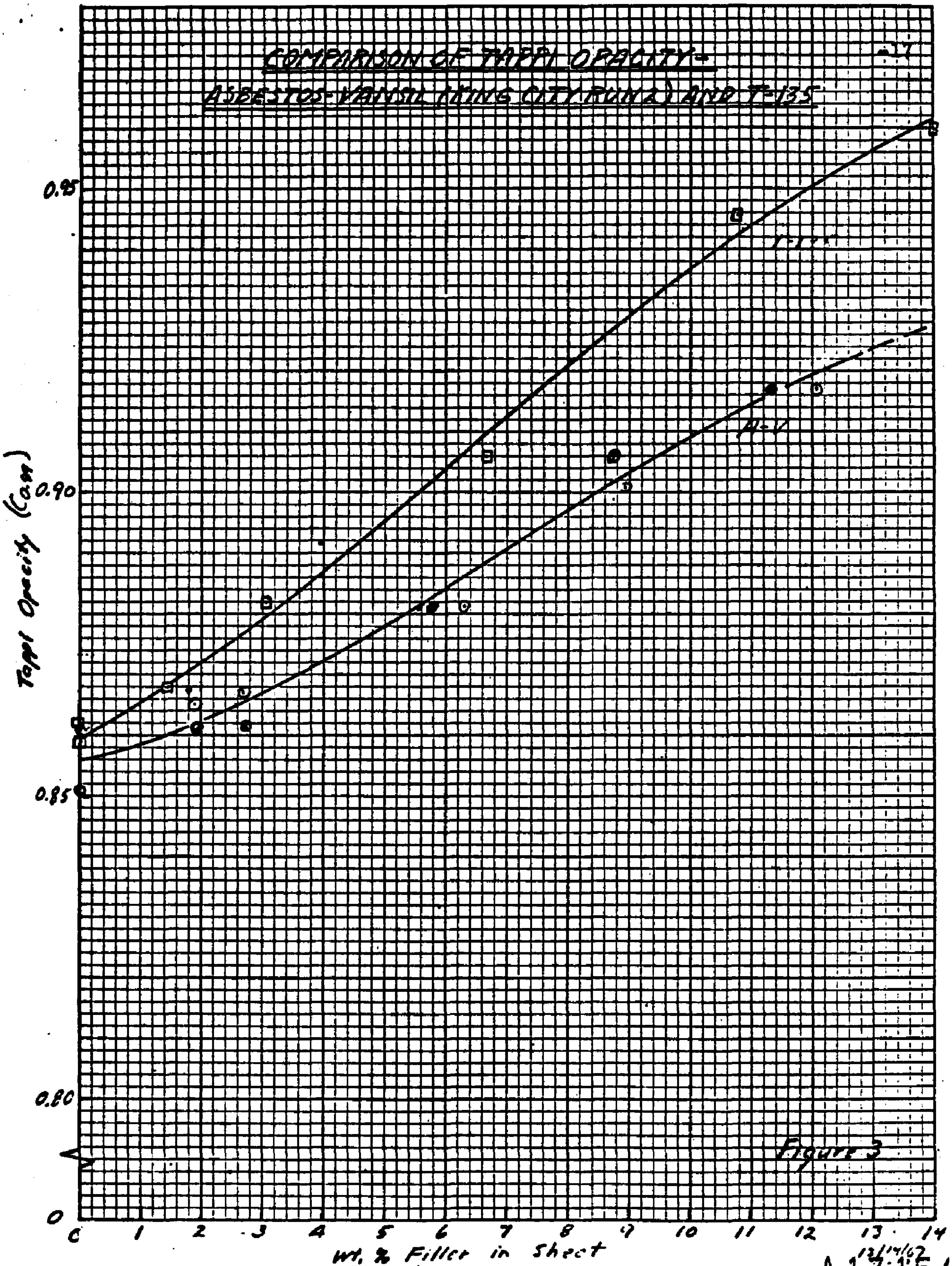

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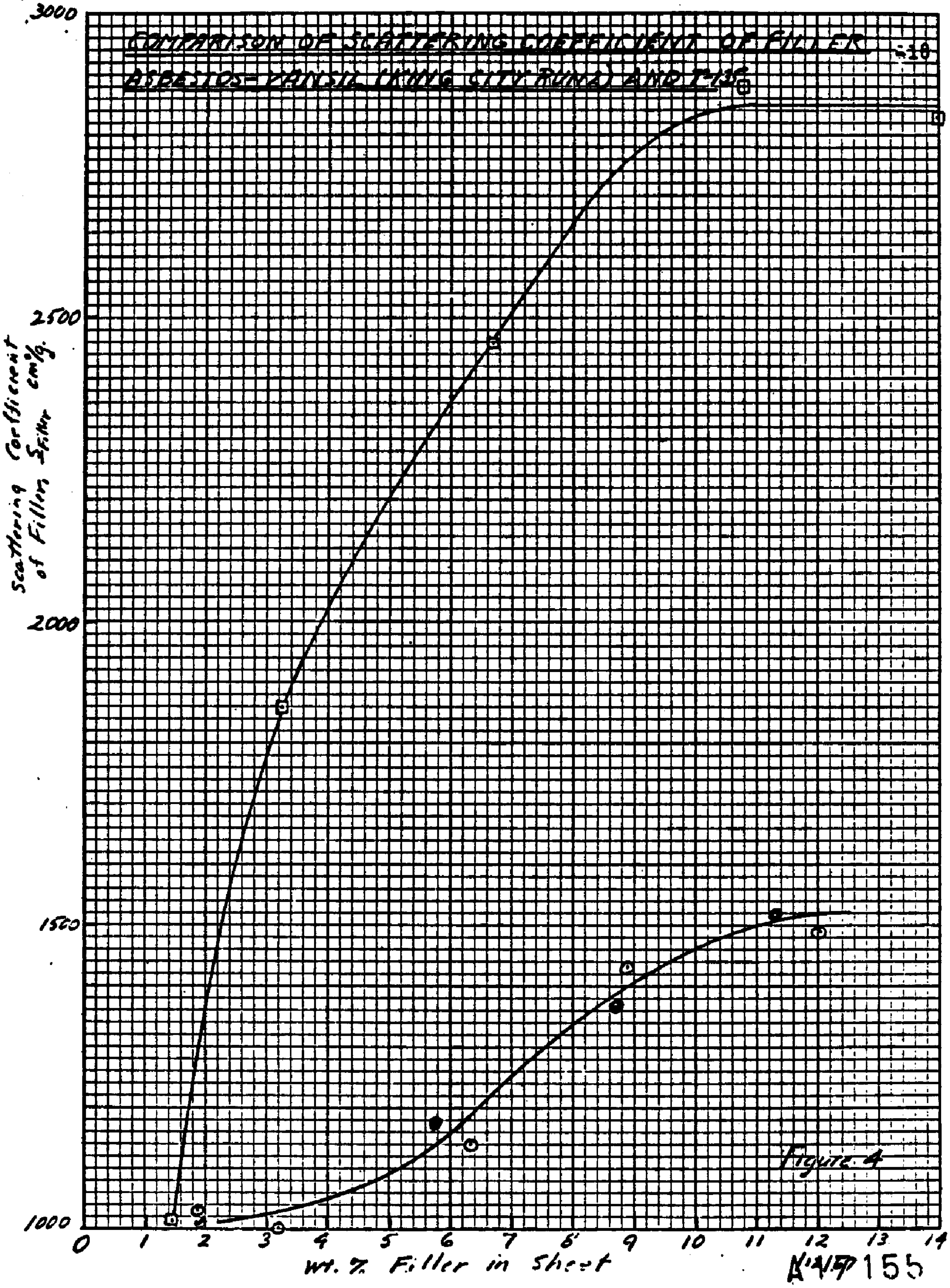
COMPARISON OF SCATTERING COEFFICIENT OF FILLER
Scattering Coefficient of Filler S_{filler} cm²/g.
3000
2500
2000
1500
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Wt. % Filler in Sheet

Figure 4

TABLE V

HANDSHEET RESULTS - KING CITY RUN 1 ASBESTOS-VANSIL

Set No.	Filler	Analysis of Sheet: % Ash	% Mg	% TiO_2	Basis Wt. (g/m^2)	Retention: % Filler in Sheet[1]	% Retention	Measured Optical Properties: (2) R_o	(3) R_w	Calculated Optical Properties, Sheet: TAPPI Opacity $C_{0.89}$	Paper-maker's Bright-ness R_∞	Scatter-ing Coef. Sheet s(cm^2/g)	Filler Only: Scatter-ing Coef. Filler s_p(cm^2/g)
1	None (Control)	0.55	0.01	-	58.30	0	-	0.665	0.848	0.784	0.814	379	-
2	3% A-V Green Pellets	1.74	0.35	-	59.76	1.54	51.3	0.670	0.849	0.789	0.816	379	715
3	5% " " "	2.50	0.55	-	59.14	2.42	48.4	0.674	0.855	0.788	0.825	386	867
4	10% " " "	3.80	0.93	-	59.05	4.10	41.0	0.667	0.849	0.786	0.816	378	983
5	15% " " "	7.25	1.79	-	57.97	7.90	52.6	0.694	0.848	0.818	0.820	445	1280
6	20% " " "	9.89	2.49	-	57.40	10.98	54.9	0.708	0.845	0.838	0.819	485	1386
7	3% A-V Dry Pellets[4]	2.07	0.39	-	57.43	1.72	57.4	0.656	0.847	0.774	0.811	369	58
8	5% " " "	2.54	0.60	-	58.55	2.64	52.9	0.665	0.855	0.778	0.824	372	303
9	10% " " "	5.54	1.35	-	59.72	5.95	59.5	0.674	0.846	0.797	0.813	390	640
10	15% " " "	8.25	2.10	-	59.87	9.26	61.8	0.686	0.842	0.815	0.811	419	862
11	20% " " "	10.61	2.80	-	57.64	12.32	61.1	0.689	0.842	0.818	0.812	442	924
12	3% T-135	1.69	0.27	0.23	60.21	1.31	43.6	0.672	0.855	0.786	0.825	375	458
13	5% "	2.61	0.53	0.44	57.80	2.56	51.2	0.668	0.852	0.784	0.816	394	1172
14	10% "	5.86	1.10	1.57	59.67	5.97	59.7	0.711	0.855	0.832	0.832	458	1772
15	15% "	8.93	1.65	2.85	57.20	9.45	63.0	0.734	0.857	0.856	0.838	556	2300
16	20% "	11.31	2.12	3.46	59.60	11.94	59.6	0.758	0.857	0.884	0.842	624	2460
17	None (Control)	0.42	0.02	-	59.72	-	-	0.667	0.857	0.778	0.827	368	-

Data Reference 1748-50-55

(1) For Asbestos-Vansil: % Filler = $\frac{\%\ Mg}{0.2267}$

For T-135: % Filler = (%Mg) x 4 + (% TiO_2)

(2) R_o = Refracted light of the sheet backed by a black body (%)

(3) R_w = Refracted light of the sheet backed by a white body (%) (White body used had absolute reflectance of 0.89)

(4) Dry pellets had photovolt brightness of 77

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TABLE VI

HANDSHEET RESULTS - KING CITY RUN 2 ASBESTOS-VANSIL

Set No.	Filler	Analysis of Sheet: % Ash	Analysis of Sheet: % Mg	Analysis of Sheet: % TiO_2	Basis Wt. (g/m^2)	Retention: % Filler in Sheet	Retention: % Retention	Measured Optical Properties: R_o(2)	Measured Optical Properties: R_w(3)	TAPPI Opacity $C_{0.89}$	Calculated Optical Properties, Sheet: Paper Maker's Brightness, R_∞	Calculated Optical Properties, Sheet: Scattering Coef. Sheet s (cm^2/g)	Calculated Optical Properties, Sheet: Absorption Coef. Sheet h (cm^2/g)	Calculated Optical Properties, Filler only: Scattering Coef. Filler s_p (cm^2/g)	Calculated Optical Properties, Filler only: Absorption Coef. Filler h_p (cm^2/g)
1	None (Control)	0.54	>0.01	-	86.10	0	-	0.717	0.842	0.852	0.817	348	7.13	-	-
2	3% A-V Green Pellets	2.16	0.41	-	87.50	1.96	65.4	0.725	0.840	0.863	0.817	362	7.42	1028	25.9
3	5% " " "	2.74	0.57	-	89.61	2.72	54.4	0.728	0.843	0.864	0.821	356	6.95	663	31.6
4	10% " " "	5.16	1.21	-	88.15	5.79	57.9	0.740	0.840	0.881	0.820	396	7.83	1175	20.4
5	15% " " "	7.88	1.83	-	88.29	8.75	58.3	0.754	0.839	0.899	0.822	438	7.82	1370	15.9
6	20% " " "	10.43	2.37	-	89.90	11.32	56.6	0.766	0.835	0.917	0.821	481	9.38	1520	27.7
7	None (Control	0.43	0.00	-	90.45	0	-	0.726	0.843	0.861	0.820	349	6.90	-	-
13	3% A-V Dry Pellets(4)	2.09	0.41	-	88.19	1.96	65.4	0.727	0.840	0.865	0.817	363	7.44	1070	26.9
14	5% " " "	3.15	0.67	-	88.12	3.20	64.0	0.730	0.842	0.867	0.820	368	7.27	1000	13.9
15	10% " " "	5.80	1.32	-	86.98	6.31	63.1	0.738	0.838	0.881	0.818	398	8.06	1140	23.0
16	15% " " "	8.30	1.87	-	90.54	8.94	59.5	0.759	0.838	0.906	0.822	445	8.37	1432	21.7
17	20% " " "	10.83	2.52	-	88.94	12.07	60.4	0.766	0.835	0.917	0.821	486	9.48	1490	27.2
18	None (Control)	0.50	>0.01	-	89.42	0	-	0.720	0.838	0.859	0.814	345	7.33	-	-
19	3% T-135	1.64	0.30	0.25	90.65	1.45	48.4	0.729	0.840	0.868	0.818	358	7.25	1034	20.7
20	5% "	3.00	0.59	0.70	87.92	3.06	61.2	0.737	0.836	0.882	0.815	394	8.27	1860	47.0
21	10% "	6.08	1.16	1.99	91.39	6.63	66.3	0.770	0.836	0.916	0.822	487	9.39	2460	42.2
22	15% "	9.75	1.83	3.49	88.95	10.80	72.0	0.796	0.841	0.946	0.832	623	10.57	2880	39.6
23	20% "	12.86	2.30	4.81	91.27	14.01	70.0	0.809	0.843	0.960	0.887	697	11.06	2830	35.7
24	None (Control)	0.34	0.01	-	90.54	0	-	0.727	0.843	0.862	0.821	351	6.85	-	-

Data reference 2273-1-8

(1) For Asbestos-Vansil % Filler = $\frac{\% Mg}{0.209}$

For T-135 % Filler = (%Mg) x 4 + (% TiO_2)

(2) R_o = Refracted light of the sheet backed by a black body (%)

(3) R_w = Refracted light of the sheet backed by a white body (%) (White body used had absolute reflectance.

(4) Dry pellets had photovolt brightness of 82

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Retention

Figure 5 shows the total filler retention as a function of the weight per cent filler in the sheet. The components making up this total have also been calculated for the T-135 data from Table VI and are summarized below.

TABLE VII

COMPONENTS OF T-135 RETENTION

Filler	% Asbestos[1]	% TiO_2	% Filler	Asb./TiO_2 Ratio	Total Per cent Retention
3% T-135	1.20	0.25	1.45	4.8	48.4
5% T-135	2.36	0.70	3.96	3.4	61.2
10% T-135	4.64	1.99	6.63	2.3	66.3
15% T-135	7.31	3.49	10.20	2.1	72.6
20% T-135	9.20	4.81	14.01	1.9	72.0

[1] % Asbestos = (% Mg) x (4)

For the T-135, the retention rises sharply and then levels off at about 70%. This corresponds to a loading in the sheet of 6-8%. This is about the point where the asbestos/TiO_2 ratio in the sheet is equal to the 2/1 ratio in the input T-135.

Neither of the Asbestos-Vansil products have the initial sharp rise. A level of 60 ± 5% has been taken as representative of Asbestos-Vansil retention.

An attempt was also made to check the separate retentions of Vansil and asbestos in the coprecipitated A-V by calcium analysis of the handsheets. A combination of high calcium levels in the unfilled sheets and lack of precision in the analyses made the results too erratic to be useful. This will be explored further in the next run.

It must be considered also that both of the foregoing average retentions are based on handsheet results. Past experience has indicated that a value of 80% is to be expected for T-135 in the actual paper manufacturing. It is reasonable to expect that the Asbestos-Vansil will also improve but probably not to the final level attained

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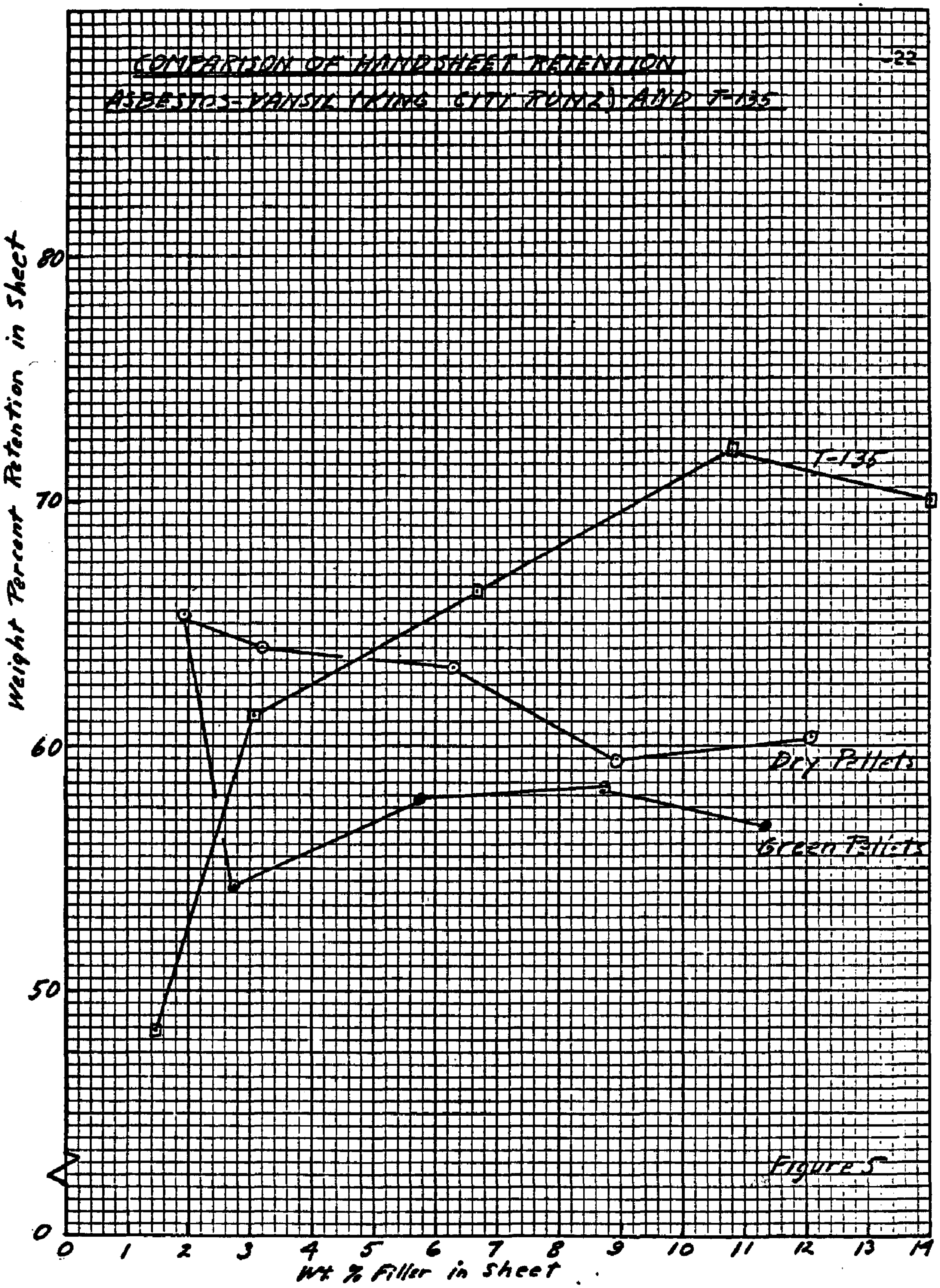

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by T-135. For subsequent cost-performance calculations, therefore, a value of 72% has been assumed for Asbestos-Vansil. This is certainly not in conflict with the present data and is consistent with the value selected by Mr. R. G. Woolery in previous Asbestos-Vansil economic calculations.*

<u>Flocc Testing</u>

Samples of the handsheets treated to make the asbestos floccs visible are shown in Figure 6. While the comparisons are only qualitative, the following observations can be made:

1. The level of floccs in the two A-V materials made at King City appear to be the same.

2. The T-135 is not distinguishable from the King City A-V products.

3. The slurry material prepared by R. T. Vanderbilt Company has a markedly lower level of floccs than any of the other three fillers examined. This level is substantially the same as the blank.

Overall, it appears that the R. T. Vanderbilt material is considerably more open than either of the King City prepared Asbestos-Vansil products. This difference in openness could have a significant effect on the relative optical properties of these materials. There is no way, however, to estimate the size of such an effect from this qualitative test.

The fact that both the King City Asbestos-Vansil products and the T-135 show about the same level of floccs is also quite important. These floccs could come from unopened material in the original asbestos used to prepare the respective products. Alternately, they could arise from a processing step such as drying or from inadequate reopening of the final products. We may be faced with an inherent limitation in that the degree of openness of the original R. T. Vanderbilt product cannot be attained in an economic commercial system. It is extremely important, therefore, that the product openness and its corresponding effect on optical properties be carefully checked at the various steps in the Asbestos-Vansil manufacture and use. The two-part run described in the "Recommendations" Section is intended to provide this check.

*Letter of August 10, 1967 Mr. R. G. Woolery to Mr. F. D. Dexter

HANDSHEET SAMPLES TREATED WITH PVC-PVA TO SHOW ASBESTOS FLOCCS

	Standard Material Prepared by R. T. Vanderbilt	King City Run 1	King City Run 2
Blank (No Filler)			
Asbestos-Vansil (Green Pellets)	(90/10 Slurry)		
Asbestos-Vansil (Dry Pellets)			
T-135 (Dry Pellets)			

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COST-PERFORMANCE COMPARISON WITH T-135

In the most basic sense, the user of Asbestos-Vansil or T-135 is purchasing opacity. The unit cost of the opacity actually obtained by the user can be found by combining the values of opacity per unit of loading (Figure 3) with the respective retentions for the two fillers estimated in the previous section. The results of this combination are given in Table VIII and Figure 7. In these calculations, T-135 has been taken at the current market price $290/ton. Values of $140, $170, and $200 have been assumed for Asbestos-Vansil.

The meaning of Figure 7 is perhaps most clear if it is considered to be divided into two parts by the dashed line for T-135. Anything above this line represents a better buy in opacity than T-135; anything below, a poorer buy. Thus, if a user spends $10 per ton of sheet for opacity, he is better off with T-135 unless Asbestos-Vansil sells for about $150 per ton or less. If, however, he spends $20 per ton the break even point for Asbestos-Vansil goes up to $170/ton. The $10/ton level first noted represents a sheet loading of around 5-6 weight per cent which is fairly representative of industry practice. The $20/ton (10 or 12% loading) is on the high side. Based on Figure 7, therefore, the Asbestos-Vansil products so far produced at King City can be characterized as $150-$170 per ton products, depending on the sheet loading. The lower end of the range is probably more representative of industry practice.

H. B. Rhodes/bsn

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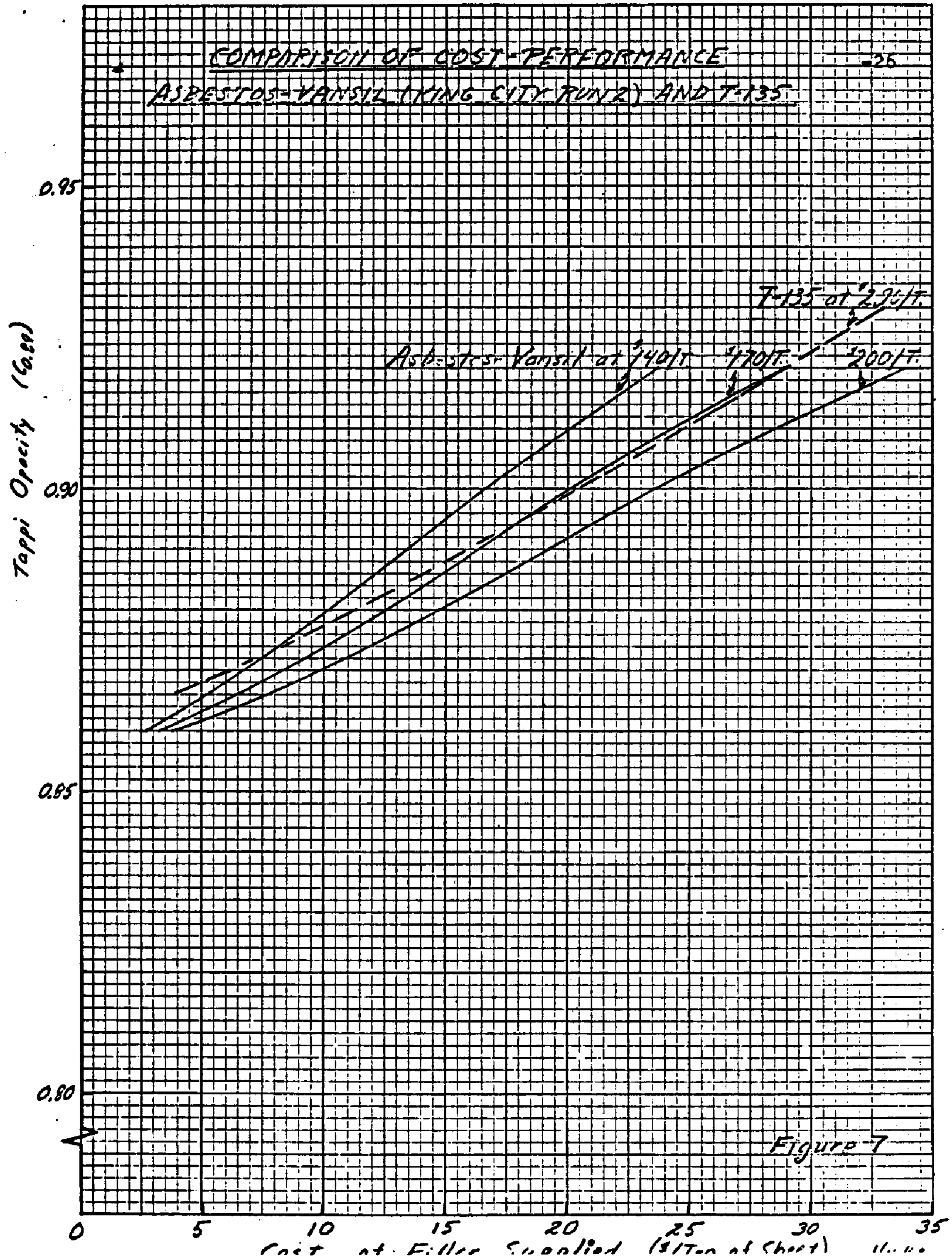

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TABLE VIII

COST-PERFORMANCE COMPARISON - ASBESTOS-VANSIL AND T-135

Filler	TAPPI Opacity ($C_{0.89}$)	Wt. % Filler in Sheet	Lb. Filler per Ton of Sheet: In Sheet	Lb. Filler per Ton of Sheet: Supplied(1)	Cost of Filler Supplied: @$140/T	Cost of Filler Supplied: @$170/T	Cost of Filler Supplied: @$200/T	Cost of Filler Supplied: @$290/T(2)
Asbestos-Vansil	0.86	1.4	28	38.9	2.72	3.31	38.90	-
	~~0.68~~ 0.88	5.3	106	147.3	10.31	12.52	14.73	
	0.90	8.5	170	236.3	16.54	20.09	23.63	-
	0.92	12.2	244	339.2	23.74	28.83	33.92	-
T-135	0.87	1.7	34	42.5	-	-	-	6.16
	0.88	3.1	62	77.5	-	-	-	11.24
	0.90	5.6	112	140.0	-	-	-	20.30
	0.93	9.1	182	227.5	-	-	-	32.99
	0.96	14.0	280	350	-	-	-	50.75

(1) At 80% retention for T-135; 72% retention for A-V

(2) Current f.o.b. price of T-135

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