BC: J. L. Myers
J. W. Rawlings
F. H. Larrison
N.F. - File

Calidria ASBESTOS

UNION CARBIDE

THE DISCOVERY COMPANY

UNION CARBIDE CORPORATION • MINING & METALS DIVISION • P.O. BOX 579 • NIAGARA FALLS, N.Y. 14302 • TEL: 716-285-3311

March 16, 1972

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PLAINTIFF'S EXHIBIT
UC-1365

Mr. Hans Lundgren
The Permutit Company
East 49 and Midland Avenue
Paramus, New Jersey 07652

Dear Hans:

Two copies of the report covering our recent asbestos slurry mixing tests are enclosed. Please pass one on to Fred. I hope your work on the level of asbestos opening needed and the use of anionic surfactant is progressing satisfactorily. As we discussed, we are sitting tight until we hear from you.

Thank you for the newspaper clippings. They are typical of the kind of sensationalism and half truths that sell newspapers. The OSHA hearings are taking place in Washington this week with senior representatives from fifteen asbestos producers or users among those testifying. Hopefully, this will bring some reason into the picture.

A Material Data Sheet conforming to the present OSHA regulations is also enclosed. Let me know if you need any more copies of this or of the report.

Very truly yours,

Harry

H. B. Rhodes
Area Manager
Marketing & Technology

HBR:cjb
Enclosures

A10702

Technical Service Report

for

The Permutit Company, Inc.
Paramus, New Jersey

by

H. B. Rhodes

March 15, 1972

UNION CARBIDE CORPORATION
Mining and Metals Division
Niagara Falls, New York

A10703

SUMMARY

The Permutit Company has developed a new process to remove oil from industrial waste water. CALIDRIA High Purity asbestos is a key ingredient in this process. A reliable feed system for asbestos slurry that can be "serviced" only once a day is now needed in order to fit into general operating practices in the water treating industry.

The most attractive of the proposed feed systems requires that a 5% slurry of asbestos be held for as long as 24 hours in a tank with sufficient agitation to keep it uniformly mixed. During this period, the slurry must stay at a fairly constant viscosity and not become too thick to handle.

Definitive data on the effect of long-term, moderate-shear agitation were not available so two 24-hour mixing tests to provide the information needed have been run. A simple pump-constriction shearing device has also been tested. The latter test provided the data on shear levels that will be needed subsequently for the selection of the asbestos opening equipment.

The test results showed that the 24 hour holding tank approach is technically feasible and either HPO or HPP works satisfactorily. The shear device gave an asbestos opening about equivalent to a Multimixer but well below that of a high shear Waring Blender.

The information obtained has been transmitted informally to Permutit. They are now examining the level of asbestos opening needed for their treating process. The possible use of surfactants to reduce viscosity is also being checked. No further work by Union Carbide is planned until these important variables are defined.

A10704

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A10705

INTRODUCTION

The Permutit Company has developed a new proprietary system to remove oil from industrial waste water that uses CALIDRIA High Purity asbestos as a key ingredient. In order to fit into conventional water treating practices, it is necessary to devise a method to feed the asbestos that is simple, reliable, and most important, is suitable for servicing only once a day.

One approach that has been proposed makes use of a tank large enough to hold a day's supply of asbestos as a 5% aqueous slurry. The tank must be provided with sufficient agitation to keep the slurry uniformly mixed. Slurry is withdrawn either continuously or in batch increments to a shearing circuit where it is diluted and opened.

A key question regarding the technical feasibility of this approach is whether agitation sufficient to keep the holding tank uniformly mixed will also open the asbestos enough to make it too thick to handle. Since the Union Carbide experience did not provide a definitive answer, it was necessary to run two tests in the pilot-plant scale equipment at the Niagara Falls laboratory. One test used High Purity Opened asbestos and the other used High Purity pellets.

The existing test equipment was piped so that the slurry could be circulated through a constriction to open the asbestos. Since the selection of opening equipment is the next step in the design of the feed system, it was expeditious to check the level of opening that could be obtained with this very simple system.

OBJECTIVES

The main objectives of this study were thus:

1. To determine the change of viscosity with time when a slurry containing ~5% of CALIDRIA HPO asbestos is subjected to moderate shearing for 24 hours.

2. To determine the extent of opening that can be attained by circulating the HPO slurry with an open-impeller centrifugal pump through a constriction.

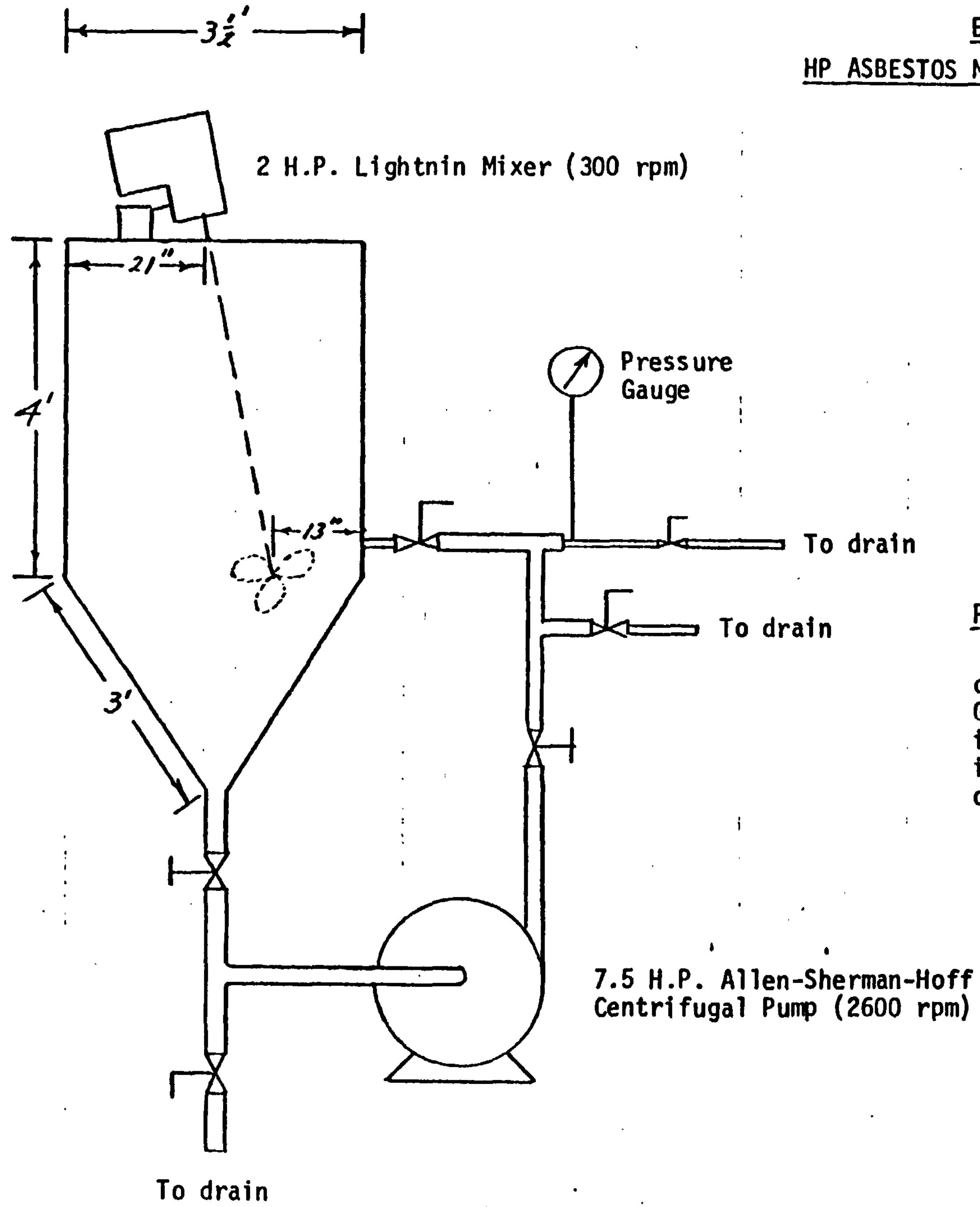
3. To obtain comparable data on both mixing and shearing for CALIDRIA High Purity asbestos pellets.

APPARATUS

A schematic diagram of the apparatus used is shown in Figure 1. Basically, the equipment consisted of a 3-1/2 foot diameter cone-bottom tank that held 250 gallons with about 8 inches of freeboard. It was equipped with a 2 H.P. Lightening Mixer driving a 12 inch diameter, 3 blade marine propeller at about 300 rpm. The mixer label was partially obliterated but it appeared to be a Model ND-34 or MD-14, Type CIXC. Motor rating was 6.1 amps at 208 v. This mixer stirring the tank at what can be described qualitatively as a "rolling boil."

<u>EQUIPMENT LAYOUT</u>

<u>HP ASBESTOS MIXING AND SHEARING TESTS</u>



<u>Pump Circulation Loop</u>

~9 ft. of 2 in. Schedule 40 Steel Pipe containing two 125 lb. Standard Walworth Gate Valves (2 in. opening) and one 1-1/2 in. NRC Equipment Corp. Ball Valve (1-1/4 in. opening). Tank entry is 6 in. nozzle of 1 in. I.D. S.S. pipe.

Figure 1

A 10707

The pump used was an Allen-Sherman-Hoff Model AA-6-5 Hydroseal, rubber lined, with a lantern ring seal. It was belt driven at 2600 rpm with a 7-1/2 H.P. induction motor. Circulation rate at 50 psig head pressure was about 35 gpm.

Laboratory samples for comparison of shear level were prepared in either a Sterling Multiproducts Inc. Model 9B Multimixer or an industrial Waring Blender Model 5011G.

MATERIALS

The pilot scale mixing and shearing tests were ran in tap water. Laboratory comparisons were run in distilled water.

The High Purity Opened and High Purity Pellet asbestos used were regular production lots. Percent moisture was 1.3 and 1.4, respectively.

TEST PROCEDURES

In the mixing portion of the tests, the tank was filled to a 250 gallon mark with tap water at ~6 °C. (As the run progressed, the temperature rose to ambient level of ~22°C.) One hundred four and a half pounds of asbestos was then added over a period of about five minutes with the mixer running and all line valves closed. Agitation was continued for 24 hours. Samples for analysis were scooped out of the top of the tank at intervals while the agitator continued running. One sample was also removed through the tap at the bottom of the tank at the end of the open asbestos mixing cycle.

The pellet mixing tests were run in the same way except that the slurry was circulated through the pump for five seconds on the hour for the first four hours. This was to prevent buildup of unopened pellets or chips in the line between the tank bottom and the first valve.

For the shearing portion of the tests, the slurry was circulated through the pump loop with the back pressure adjusted to 50 psig by partial closing of the ball valve adjacent to the tank. Flow rate was about 35 gpm. Samples for analysis were scooped from the top of the tank at periodic intervals. The agitator ran continuously during both shearing tests.

ANALYTICAL PROCEDURES

A variety of analytical tests were run to characterize the properties of the slurry samples. The procedures are summarized in this section.

Fann Viscosity

Fann viscosity properties have been used as the primary definition of slurry properties. This is a basic drilling mud test procedure and details of the equipment are attached. In essence, the viscometer consists of a fixed bob enclosed within close clearance rotating sleeve. The bob deflection, θ, is read on a calibrated dial at rotations of 300 and 600 rpm. These θ values can be converted to centipoise readings but it is more common and convenient to calculate three derived properties as follows:

$$\text{Apparent Viscosity (AV)} = \frac{\theta_{600}}{2}$$

$$\text{Plastic Viscosity (PV)} = \theta_{600} - \theta_{300}$$

$$\text{Yield Point (YP)} = \theta_{600} - 2\left(\theta_{600} - \theta_{300}\right) = \theta_{600} - 2(PV)$$

This approach implies that the slurry behaves as a Bingham plastic. The Apparent Viscosity (AV) is a measure of viscosity at high shear. The Plastic Viscosity (PV) measures the shear rate dependence of the viscosity, and the Yield Point (YP) is the zero shear intercept or "viscosity." This method works very well for the dispersed, finely-divided bentonite slurries for which it was developed. It has serious shortcomings, however, for flocculated asbestos slurries and is only used because no simple alternative has been demonstrated.

The main problem with asbestos arises from syneresis effects that yield a water layer next to the measuring surfaces and from the tendency for the fibers to align in the direction of motion of the spindle. Both of these effects tend to give Fann θ readings that drift strongly with time of rotation. In order to minimize this, the readings reported are the first 600 and 300 values for each sample taken as soon as the reading had reached a steady oscillation.

In spite of these shortcomings, it is our judgment that this instrument provides a reasonably reliable and quick way to compare properties within a particular type of asbestos. Comparisons with other types or the use of the absolute values of viscosity (C_p) are not recommended.

Settling

A 250 ml. sample of the slurry is placed in a 250 ml. stoppered graduate and inverted ten times to mix evenly. The amount of clear layer after 1 and 24 hours is read and reported in ml.

Percent Solids

A measured volume of slurry is filtered and the residue dried overnight in a circulating oven at 110°C. Dry solids are weighted and used to calculate the percent solids in the original slurry.

Percent Moisture

A weighted sample of pellets or opened fiber is dried overnight at 110 C in a circulating oven. Weight loss is calculated as a percent moisture based on original wet sample weight.

Dispersed Wet Screening

A measured volume of slurry is taken and dispersed with Tergitol Anionic 7 at low shear with a Lightening mixer. The sample is then transferred to a standard eight inch diameter screen. The screen is hand-jigged in a basin of Tergitol-water mix until the amount on the screen remains unchanged. Residue is dried and weighted. The original charge weight is calculated from the volume of slurry and the measured percent solids. Results are expressed as weight percent retained on the screen. For this work, tests were run at 65 and 325 mesh.

RESULTS AND DISCUSSION

All of the data for the two pilot plant mixing and shearing runs are summarized in Table I. The results for the various laboratory tests made to compare the effect of shear levels are also included.

The best overall picture of the results of this study is given in Figure 2 where the "zero" shear viscosity, i.e., Yield Point (YP), is plotted as a function of mixing time and shearing time. The following reference points are shown for comparison:

1. A representative value of 60 for the 4.5% HPO slurry made in the Multimixer. There is little difference between 5 and 20 minutes mix time in this machine. (See 1857-40-2 and -3 in Table I.)

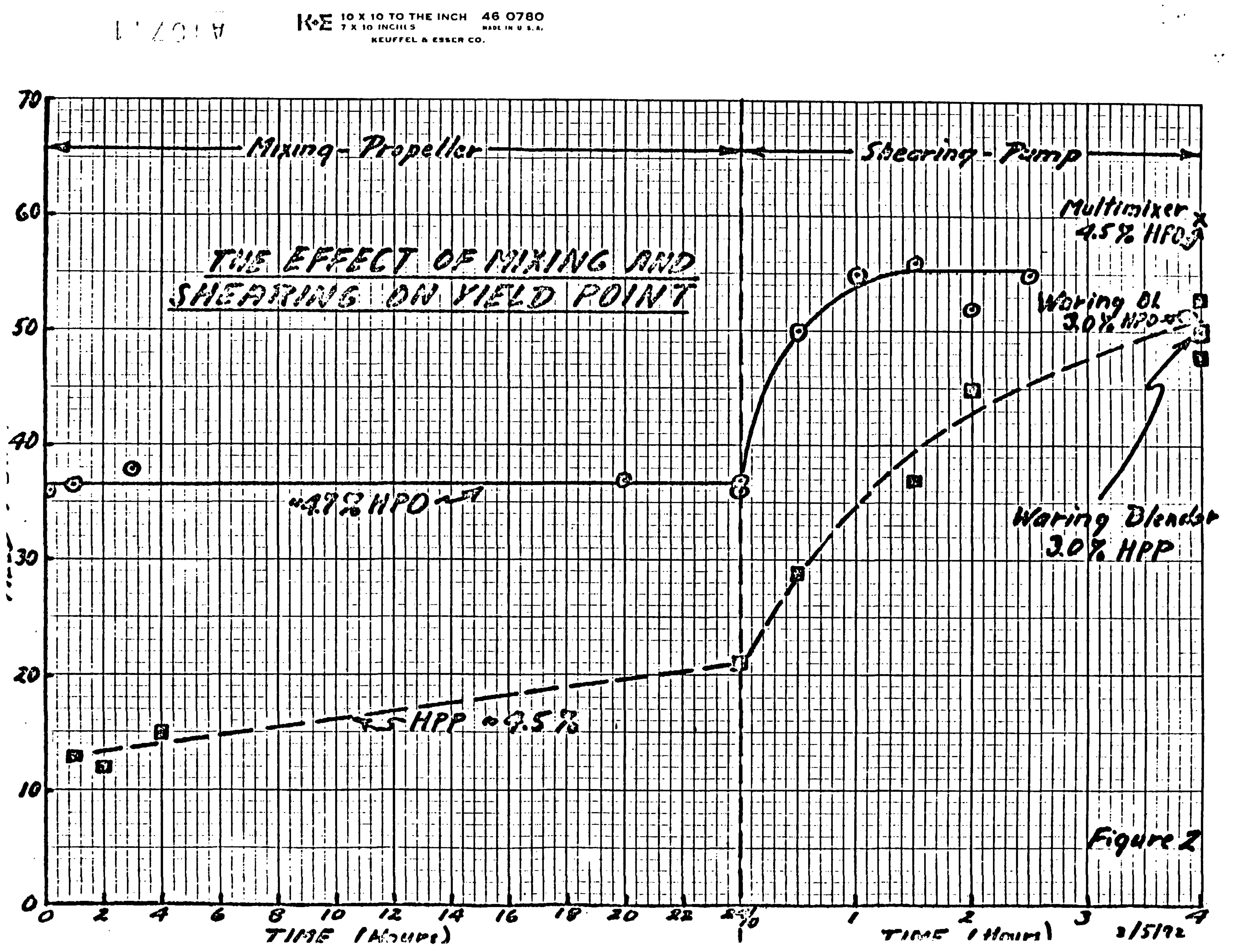
2. A representative value of 51 for 3% HPO slurry. Values for 1 and 2 minute mixing scatter randomly by about ±5 around this point. (See 1857-45-1 and -2; 47-1; and 50-2 in Table I.)

3. A value of 50 for HPP after opening for three minutes in the Waring Blender. The pellets are harder to open and three minutes or more appear to be required. (See 1857-47-2 and -3; 50-3.)

Referring to Figure 2, the Yield Point (YP) for the High Purity Open asbestos (HPO) remained constant at a value of ~36 over the entire mixing period. After the shearing through the valve was started, the YP rose rapidly over about an hour to ~55, and then leveled off at this value. This level of YP is close to that obtained for 4.5% HPO in the Multimixer. It is also about equivalent to that obtained in a Waring blender at 3% solids for both HPO and HPP asbestos.

The High Purity Pellets, as might be expected, gave a much thinner slurry that thickened slowly with time but did not come up to the opened material. When shearing was started, the YP rose gradually over a four hour period to approach the value attained with the HPO.

When the HP pellets were first introduced into the tank, the "slurry" was very watery. In 15 minutes, however, it had begun to thicken up and after an hour it had a soupy consistency. A check of the tank bottom at that time showed no accumulation in the conical section but the line above the valve was plugged with pellets. These were blown clear with compressed air and no further line blockage was experienced. Visual observation of slurry showed a substantial number of small, white unopened "chips" were still present after seven hours of mixing. These had largely disappeared, however, after 24 hours.



K+E 10 X 10 TO THE INCH 46 0780
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.
THE EFFECT OF MIXING AND SHEARING ON YIELD POINT
Mixing - Propeller
Shearing - Pump
Multimixer 4.5% HFO
Waring Bl. 3.0% HPO
Waring Blender 3.0% HPP
4.7% HPO
HPP 4.5%
TIME (Hours)
Figure 2
3/5/72

In connection with the High Purity pellets, it should also be noted that 3 minutes in the Waring Blender was required to bring the YP for the 3% slurry up to the level equivalent to the HPO, YP values around 50 seem to be about the limit for Waring blender shearing of either high purity product.

The three properties calculated from the Fann readings are interdependent so specification of any two define the system. For present purposes, it is most useful to look at the Apparent Viscosity (AV) which represents the system viscosity measured under the high (600 rpm) shearing conditions. These results are shown as a function of mixing and of shearing time in Figure 3.

The overall trends are very similar to the YP data of Figure 2 except that there is a moderate gradual decrease in the AV for the HPO system. This implies that the slurry is getting thinner as opening proceeds. Actually, this is an instrument problem. As the slurry becomes better opened it has more tendency to flow and align with the direction of flow in the Fann Viscometer measuring space. It thus gives progressively lower readings. For the purposes of this experiment, it is sufficient to note that there is a small amount of opening taking place during the mixing but the change in properties are too small to affect the basic consistency of the slurry.

If fiber liberation is equivalent to the efficiency with which the asbestos performs in the Permutit process, the difference between 3 and 4.5% should be a qualitative measure of the effect of shear level on asbestos feed requirements. In this connection, it should also be noted that adequate mixing was obtained in the Waring Blender up to about 3.25% solids. Beyond this the slurry became so thick it did not flow back into the blades. This may be a useful guide in selecting an appropriate slurry concentration for opening with a bar turbine type impeller.

Next consider the data in Table I for the percent solids measure ments. The pilot plant blends were made by adding 104.5 pounds of asbestos to 250 gallons of water for a target slurry concentration of 5%. Since neither the weight nor the water volume were known exactly, the percent solids was checked on each sample collected. The HPO results (see Table I) were quite consistent and averaged about 4.5% solids. These are on a totally dry basis and must be corrected upward about +0.1% to allow for the 1-2% moisture in the asbestos as fed. In addition to this, the HPO reference runs 1857-40-2,-3, and -4 indicate that there is a bias of about 0.1% in the method. Accordingly, it is recommended that the HPO run be considered as having a true percent solids of ~4.7% and the HPP run as ~4.5%.

Visual observation of the stirred tank during the HPO run indicated that it was turning over rapidly in what can best be described as a "rolling boil." In view of this, only one check was made of a sample withdrawn from the bottom tap. This sample (1857-39-6) is virtually identical with the sample scooped from the top of the tank at the same time (1857-39-5).

The settling tests, shown in the next two columns in Table I, were intended to be another measurement of the degree of opening. It turned out, however, that the amount of settling was generally so small that the test was essentially useless in measuring differences. The only real settling observed was in some qualitative checks (not shown in the Table) over the first few minutes of the pellet run. Even these had largely disappeared after one hour.

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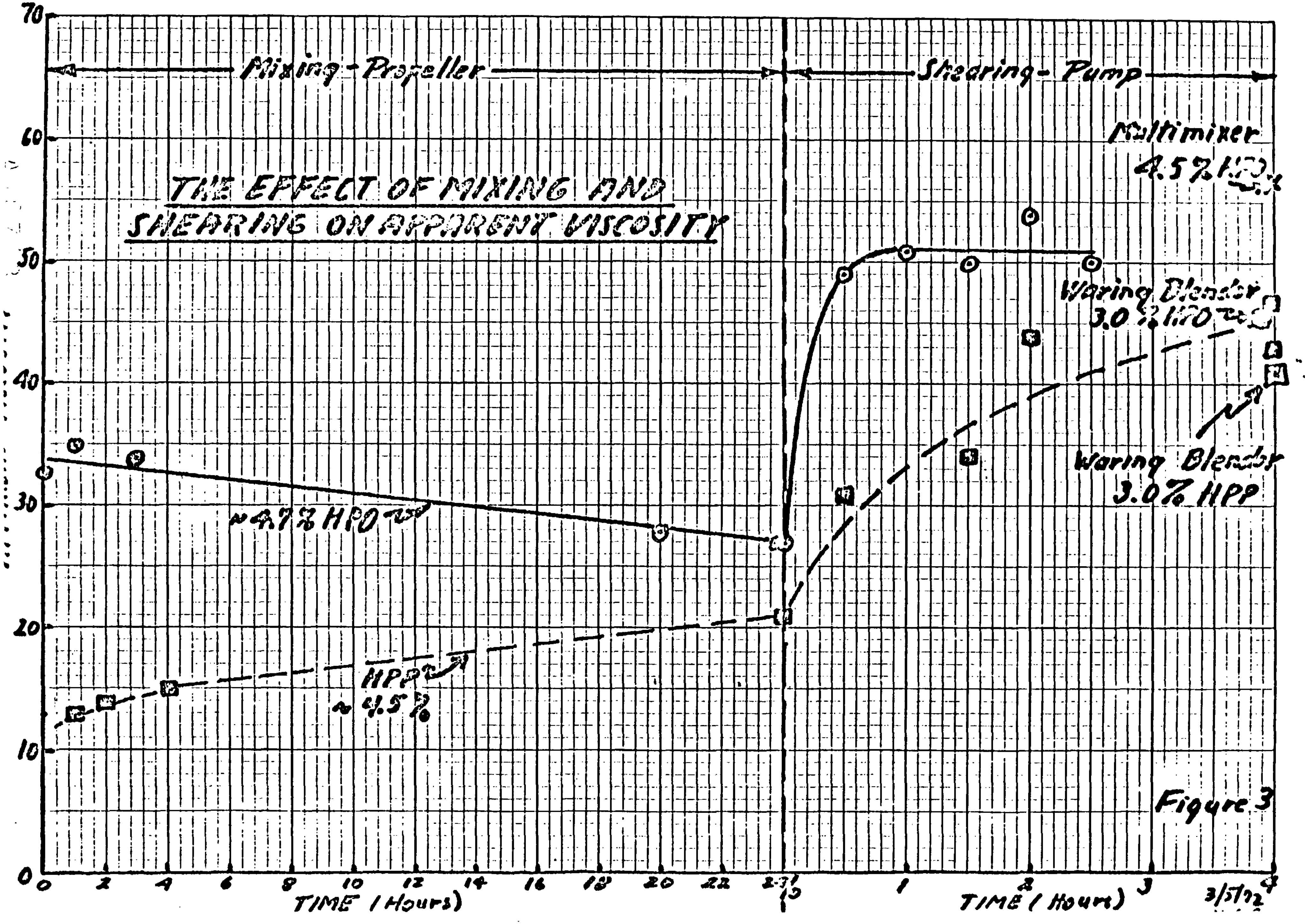


Figure 3

The dispersed wet screening results given in the last two columns of Table I were intended to determine whether a shift in size distribution occurred as the asbestos was mixed and sheared. It appears, however, that the mixing of the Anionic 7 surfactant slurry and the shear imparted in the in the hand jigging during the screening tended to equalize and override the differences that may have been occurring in the tests. Although there may be some trends, the data are too erratic to draw any conclusions. They are included because they were presented in original informal discussions of the tests, because they show the general level of size to be expected, and because the comparisons between the Multimixer and Waring Blender reference samples are probably valid.

This completes the presentation of the basic test data. One additional exploratory test was run, however, which may be potentially quite important.

It was learned during discussions with Permutit that a small amount of anionic surfactant is used in conjunction with the asbestos. It stabilizes the foam during the flotation portion of the water treatment and is eventually largely removed by the asbestos. Since it was known that anionic surfactants act as dispersents for cationic chrysotile asbestos, a run was made where 17.5g of HPP was sheared in 350 ml. of distilled water for one minute in a Waring Blender (5% solids). Actually, the material became too thick to flow after about 15 seconds so it was not well sheared. Fann viscosities were run on the material as mixed and after several incremental additions of sodium dodecyl benzene sulfonate and Tergitol Anionic 7. Results are shown below:

Fann Data - 25°C. - 1 Hour

	θ_{600}	θ_{300}	AV	PV	YP
As Mixed	160	145	80	15	130
+ 0.0175g. NaDBS	135	112	68	23	89
+ 0.10g. NaDBS	80	57	40	23	34
+ 0.10g. NaDBS	65	48	33	17	31
+ 1.0g. Tergitol Anionic 7	40	32	20	12	20

It should be emphasized that the surfactants have been added to a moderately opened 5% slurry so the absolute viscosity levels are not representative of well-opened material. They do serve, however, to illustrate the type of thinning action that can be achieved. Permutit is now checking the effect of adding the surfactant to the asbestos on their overall process. If it is acceptable, some equipment economies on the holding tank and opening circuit may be possible.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from this study:

1. A 4.5 - 5% weight concentration of High Purity Open asbestos can be mixed at a "rolling boil" with a marine propeller type agitator for 24 hours without appreciable thickening.

A 0 7 4

2. The centrifugal pump-constriction shear device used in these tests gave a level of shear comparable to that attained in a Multimixer. This level is considerably below that attainable in a Waring Blender.

3. This type of mixing equipment can be used to open High Purity pellets at 4.5 - 5% by concentration sufficiently to give a uniform slurry. The slurry thickens slowly over a 24 hour mixing period but is always considerably thinner than the comparable HPO slurry.

4. The centrifugal pump-constriction shear device opens the previously mixed HPP slurry nearly as well as it does a comparable HPO slurry.

Overall, the concept of the 24 hour holding tank at 5% solids appears to be technically feasible. The use of High Purity pellets also is feasible provided there is sufficient shear in the mixing operation to break up the pellets.

These results have already been presented informally to Permutit. They are now checking the effect of shear level, i.e., asbestos opening, on their process. The effect of preaddition of anionic surfactant is also being examined. No further work is recommended or planned by Union Carbide until these important process variables are defined.

TABLE I

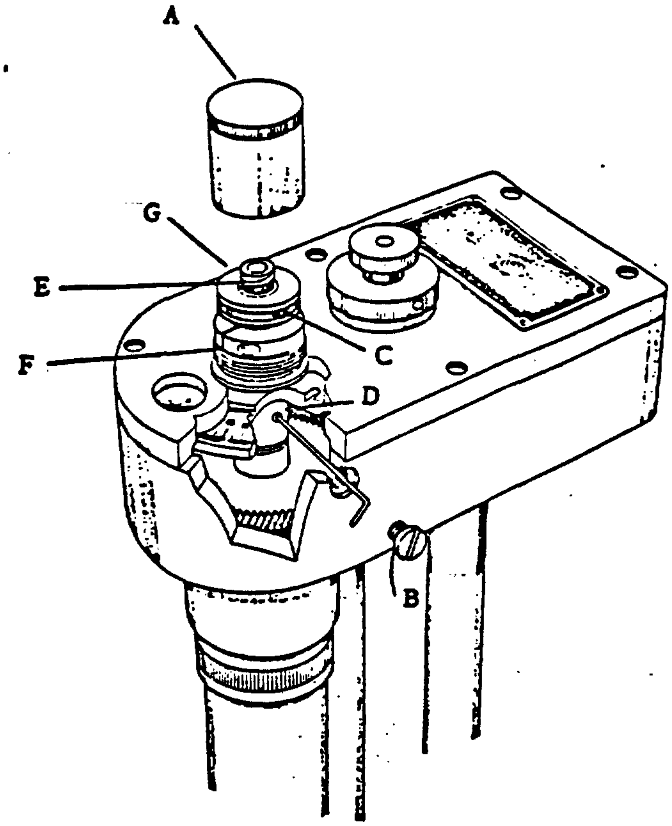
DATA SUMMARY

	Data Reference	Elapsed Time (Hrs.)	Fann Data - 25°C - 1 Hr. θ600	θ300	A.V.	P.V.	Y.P.	Percent Solids	Settling (ml) 1 Hr.	24 Hr.	Dispersed Wet Screen % Retained +65	+325	Notes
High Purity Open (HPO)	1857-39-1	0	66	51	33	15	36	4.34	2	4	0.12	4.88	
	1857-39-2	1	69	53	35	16	37	4.54	2	4	0.42	9.20	
	1857-39-3	3	68	53	34	15	38	4.54	2	4	0.16	9.44	
	1857-39-4	20	55	46	28	9	37	4.45	2	4	0.22	11.82	
	1857-39-5	24	54	45	27	9	36	4.49	2	4	0.24	13.72	
	1857-39-6	24	53	44	27	9	35	4.50	0	2	0.18	11.78	Tank bottom sample.
	Shearing via pump and constriction started.												
	1857-39-7	1/2	98	74	49	24	50	4.54	0	2	0.14	13.28	
	1857-39-8	1	101	78	51	23	55	4.50	2	2	0.16	12.46	
	1857-39-9	1 1/2	100	78	50	22	56	4.48	2	2	0.11	8.60	
	1857-39-10	2	108	80	54	28	52	4.50	2	2	0.10	8.20	
	1857-40-1	2 1/2	100	78	50	22	56	4.60	2	2	0.08	9.48	
High Purity Pellets (HPP)	1857-42-1	1	26	18	13	5	13	4.28	6	8	0.26	6.8	
	1857-42-2	2	28	20	14	8	12	4.28	4	4	0.34	9.3	
	1857-42-3	4	29	22	15	7	15	4.25	4	4	0.24	8.7	
	1857-42-4	24	41	31	21	10	21	4.21	2	2	0.20	10.2	
	Shearing via pump and constriction started.												
	1857-42-5	1/2	61	45	31	16	29	4.33	2	2	0.16	9.8	
	1857-42-6	1 1/2	67	52	34	15	37	4.11	2	2	0.20	9.4	
	1857-42-7	2	87	66	44	21	45	4.19	2	2	0.14	8.9	
	1857-42-8	4	86	67	43	19	48	4.23	2	2	0.08	8.1	
	1857-42-9	4	93	73	47	20	53	4.23	2	2	0.14	10.0	Duplicate retain sample.
Reference HPO	1857-40-2	MM-5 min.(4)	115	87	58	28	59	4.3(1)	2	2	0.22	9.3	Shearing comparison - Multimixer
	1857-40-3	MM-20 min.	112	87	56	25	62	4.4(1)	2	2	0.22	9.4	
	1857-40-4	HSWB-2 min.(5)	61	43	32	18	25	1.8(2)	2	4	0.07	3.6	Shearing comparison - Waring Blender
	1857-45-1	HSWB-1 min.	99	76	50	23	53	3.0(3)	-	-	0.03	5.6	
	1857-50-1	HSWB-1 min.	90	70	45	20	50	3.0(3)	-	-	----	-----	
	1857-45-2	HSWB-2 min.	95	76	48	19	57	3.0(3)	-	-	0.03	4.8	
	1857-50-2	HSWB-2 min.	84	65	42	19	46	3.0(3)	-	-	----	-----	
	1857-47-1	HSWB-1 min.	111	90	56	21	69	3.25(3)	-	-	----	-----	
Reference HPP	1857-44-4	HSWB-2 min.	55	38	28	17	21	2.0(3)	-	-	----	-----	Shearing comparison - Waring Blender
	1857-47-2	HSWB-1 min.	85	63	43	22	41	3.0(3)	-	-	0.1	7.7	Unopened fibers observed.
	1857-47-3	HSWB-2 min.	75	60	38	15	45	3.0(3)	-	-	Trace	6.6	
	1857-50-3	HSWB-3 min.	80	62	40	12	50	3.0(3)	-	-	----	-----	

(1) As measured. Blended at 4.5%
(2) As measured. Blended at 2.0%
(3) As blended. % Solids not analyzed by slurry drying procedure.
(4) MM = Multimixer
(5) HSWB = High speed Waring Blender

APPENDIX

TO CHANGE TORSION SPRINGS IN FANN VISCOMETERS



70% mV

41-42/1000

85

19.800

1. Remove dust cap A and plug screw B.

2. Loosen set screws C and D approximately $\frac{1}{2}$ turn. Spring can then be lifted out.

3. Insert new spring, making sure that it is properly seated. The top of threaded mandrel inside spring should be exactly flush with clamp ring E. Tighten set screws.

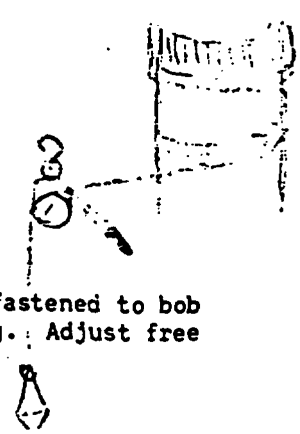
4. Cap screw F can be loosened, permitting knob G to be turned to bring dial "zero" under the index line. Knob G is also movable vertically so that spring can be clamped in a "free" position - neither compressed or stretched.

5. Tighten all screws, replace dust cap and plug screw. For best accuracy check spring constant according to directions given in formula below.

FORMULA FOR CALCULATING K_s:

$$K_s = \frac{G\,g\,R}{\theta}$$

where
K_s = Spring Constant - Dyne cm/deg.
G = Load in grams
g = 981
R = Radius arm - cm
θ = Dial reading.



Wrap light string or thread around bob or other cylinder of known diameter fastened to bob shaft. Run string over a pully and hang weights on string to deflect spring. Adjust free length of spring to get desired deflection.

fann

A .07.8

fann instrument corporation

OPERATING INSTRUCTIONS FOR MODEL 35 FANN V-G METER

GENERAL

1. Connect instrument to 115 volt, 60 cycle, A. C. power source.

2. Speeds, rotor sleeve: CHANGE GEARS ONLY WHEN MOTOR IS RUNNING.

600 rpm	- Gear shift knob down,	motor switch at "high"
300 rpm	- Gear shift knob down,	motor switch at "low"
200 rpm	- Gear shift knob up,	motor switch at "high"
100 rpm	- Gear shift knob up,	motor switch at "low"
6 rpm	- Gear shift knob center,	motor switch at "high"
3 rpm	- Gear shift knob center,	motor switch at "low"

PLASTIC VISCOSITY AND YIELD VALUE

1. Place recently agitated sample in test cup furnished. A line scribed inside the cup at 350 cc level is for barrel equivalent volume. With rotor sleeve running at 600 rpm, wait for dial to come to steady value. Note dial reading.

2. Set motor switch at low and obtain 300 rpm reading in the manner outlined in step one.

3. 600 reading - 300 reading equals plastic viscosity (p. v.) in cps.
   300 reading - (p. v.) equals yield value (y. v.) in lbs. /100 sq. ft.

GEL STRENGTH

1. Stir sample thoroughly at 600 rpm.

2. Change gear shift to center then turn motor off.

3. Allow desired rest time (10 seconds to 10 minutes) then turn switch to low (3 rpm).

4. Read dial at instant of gel break. Reading is in lbs. /100 sq. ft.

CONSISTENCY CURVES AND THIXOTROPIC STUDIES

1. For a more complete consistency curve take readings at 200, 100, and 6 rpm in addition to the above. Plot results, speed vs. dial deflection, and extrapolate straight portion of curve to stress axis to obtain yield value intercept.

2. Thixotropic studies are usually made by taking a series of readings beginning at slow speed on unstirred sample. Measurements are made at successively higher speeds to maximum then the downcurve is run immediately. Plotted, the hysteris loop formed by the upcurve and downcurve is a measure of thixotropy.

Clean instrument by running at high speed with rotor sleeve immersed in water or other solvent. Remove rotor sleeve by twisting slightly to release lock pin. Wipe bob and other parts thoroughly.

$Viscosity = \frac{f}{s}$

RANGE DATA SHEET

SHEAR RATE RANGES

	Rotor-Bob Combinations	Nominal Shear Rate at 1 RPM (sec⁻¹ at bob)	Typical Shear Rate Ranges at Various Rotor Speeds			
			RPM 3 (6, 100)	200 (300)	600	1000
Shear rate, s	R1-B1	1.704	5.112 10.24 170	340.8 511	1,022	1,704
	R1-B2	0.3769	1.130	75.38	226.1	376.9
	R1-B3	0.2683	0.8049	53.66	160.9	268.3
	R1-B4	do.	do.	do.	do.	do.
	R2-B1	5.42	16.26	1,084	3,252	5,420
	R2-B2	0.4084	1.225	81.68	245	408.4
	R2-B3	0.2757	0.827	55.14	165.4	275.7
	R2-B4	do.	do.	do.	do.	do.
	R3-B1	0.3770	1.131	75.4	226.2	377.0
	R3-B2	0.2703	0.810	54.06	162.2	270.3
	R3-B3	0.2358	0.7074	47.16	141.5	235.8
	R3-B4	do.	do.	do.	do.	do.

SHEAR STRESS RANGES

Bob	Shear Stress Factor (Dynes/cm² at bob) F = Spring Factor θ = Dial Deflection	Typical Shear Stress Ranges Using Indicated Range Factor (F) Springs* (F 0.5)					
		F 0.2		F 1		F 10	
		Min. (2.535)	Max. (761.5)	Min.	Max.	Min.	Max.
Stress f B 1	5.077 x F x θ	1.01	304.6	5.077	1,523	50.77	15,231
B 2	10.01 x F x θ	2.002	601	10.01	3,005	100.1	30,054
B 3	20.30 x F x θ	4.058	1,217	20.30	6,092	203	60,925
B 4	43.84 x F x θ	8.766	2,630	43.84	13,152	438.4	131,520

* Min. = 1° Dial Deflection — Max. = 300°.

STANDARD ROTOR-BOB DIMENSIONS

Unit	Radius cm	Length cm
B 1	1.7245	3.80
B 2	1.2276	3.80
B 3	0.86225	3.80
B 4	0.86225	1.89
R 1	1.8415	
R 2	1.7589	
R 3	2.5867	

STANDARD TORSION SPRINGS

F 0.2	F 3
F 0.5	F 4
F 1	F 5
F 2	F 10

$$\frac{5.077 \times Rd \times 100}{N} = cps.$$

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fann instrument corporation

P. O. BOX 66101 3202 ARGONNE ST.
HOUSTON, TEXAS

Example:

Using the R1-B4-F10 Rotor-Bob-Spring Combination dial reads 300° at 3 RPM rotor speed.

$$\frac{131{,}520\ (dyne/cm^2)}{.8049\ (sec^{-1})} = 163{,}399 \text{ poises or } 16{,}339{,}900 \text{ cps}$$