

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

DEVELOPMENT OF AN IMPROVED DIFFUSION BOARD MATERIAL

Project 2256

Contract No. DA18-108-405-CML-941

DA18-108-CML-6561

Order No. CP 1-405-4519

Report Nine

Monthly Progress Report

to

U. S. ARMY CHEMICAL CENTER PROCUREMENT AGENCY

Report Period: May 29, 1961 to June 28, 1961

July 28, 1961

Distribution:

Contract Project Officer  
U. S. Army Chemical Research and Development Laboratories  
Army Chemical Center, Maryland  
Att. of Mr. Grover C. Condon (22 copies)

Contracting Officer  
U. S. Army Chemical Center Procurement Agency  
Army Chemical Center, Maryland  
Att. of Mr. W. E. Bankert (1 copy)

Commander, Armed Services Technical Information Agency (10 copies)  
Arlington Hall Station  
Arlington 12, Virginia  
Attention: TIPDR

The Institute of Paper Chemistry .

✓  
Central Files - 2 copies  
T. A. Howells  
E. J. Jones  
L. E. Leporte

## TABLE OF CONTENTS

	Page
SUMMARY	1
LABORATORY WORK	3
Test and Procedures	3
Ignition Temperature	3
Flame Resistance	3
Strength Tests	4
Pulps Evaluated	5
Minnesota and Ontario Groundwood	5
Armstrong Cork Company Pulps	5
Effect of Aquapel 486 on Gas Life	6
Drying Studies	8
PILOT RUNS	13
Flammability	18
APPENDIX	20

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

DEVELOPMENT OF AN IMPROVED DIFFUSION BOARD MATERIAL

SUMMARY

Gas life evaluations of board containing additions of Aquapel 486 and Cato 8 were found to be somewhat lower than previous work with Aquapel 486 would indicate. The boards tested had been aged under room conditions for nearly two months before testing; it is possible that the poor gas life is the result of deterioration through aging.

Boards made from spruce, pine and willow were formed and are being tested. The spruce groundwood formed a dense (27 lb./cu. ft.) and very tough board, while the boards formed from the pine and willow were less dense than would be desirable and formed poorly. Gas life tests on these boards were not complete at the end of this reporting period.

Drying studies were carried out on newly formed boards by attaching thermocouples to the wet boards in a circulating oven under various drying conditions. It was found that the boards would dry to constant weight in 125 minutes at 230°F. and in 75 minutes at 310°F. Gas life tests are being run on these boards to determine effect of drying temperature on gas life.

Water absorption, gas life, ash, and inclined panel flame tests were run on samples of board and pulp obtained from the series of pilot runs at the Bauer Bros. Co. Water absorption was slightly less on sized board produced on the pilot machine than comparable board produced in the laboratory and the gas life was slightly better. Tensile strength of the board was around 400 p.s.i. for all board except the unsized board and the board containing Cyron; the addition of sizing materials improved the wet strength from less than 20 p.s.i.

tensile for unsized board soaked for 2 hours to 21<sup>4</sup> p.s.i. for board treated with 0.5% Aquapel 360 and 0.2% Kymene 557. The board treated with the Aquapel-Kymene system seemed to have the best properties, 2-hour water absorption was 6% and cyanogen chloride gas life was 42 minutes. Ash contents of the board specimens and the pulp were high (4.16% ash in pulp against 1% or less for other Wood Conversion Company pulps). It is thought that the pulp used in these runs was contaminated with mineral fiber.

## LABORATORY WORK

### TESTS AND PROCEDURES

#### Ignition Temperature

A thermocouple was inserted into a specimen, thermocouples were attached to both surfaces of the specimen, and the specimen was placed in a circulating air oven. The temperature of the oven was increased in increments of ten degrees, increasing the oven temperature after the specimen had become equilibrated to the oven temperature. The ignition temperature was considered to be the internal temperature of a specimen at the moment that the temperature of the surface of the specimen exceeded the temperature of the air surrounding the specimen. Temperatures were recorded on a recording potentiometer.

#### Flame Resistance

This test was carried out in accordance with the specifications for the Inclined Panel Flame Test as outlined in the ASTM Specification C-209-60. In this test, a 12 by 12-inch specimen is supported at an angle of 45° and ignited by burning 1 ml. of anhydrous ethyl alcohol at a point one inch below the bottom surface of the supported specimen and 3 inches in, centered, from the lower edge measured along the bottom surface of the specimen. The specimens were supported on four 1/2-inch dowels tapered to 1/8-inch points in order to provide maximum access of air for combustion.

The test was carried out under ambient conditions in a draft-free hood. Burning or glowing boards were extinguished one minute after exhaustion of the fuel by placing them in a container holding an atmosphere of carbon dioxide. Results of the tests were reported as the area of char computed as the area of an ellipse having major and minor axes equal to the maximum length and width of the charred area.

## Strength Tests

Tensile and transverse strength tests were run according to ASTM C-209-60. Three specimens cut in the machine direction and three specimens cut in the cross-machine direction of each sample were used for each test. All of the specimens were conditioned to  $50 \pm 5\%$  relative humidity,  $72 \pm 2^\circ\text{F.}$ , with exception of the wet tensile specimens. Wet tensile tests were run on specimens after soaking for 2 hours under 1 inch of distilled water at  $72 \pm 2^\circ\text{F.}$ , and after 24-hour soaking. Dry tensile tests were run on conditioned samples and samples reconditioned after 24-hour soaking.

Tensile tests were run on dumbbell-shaped specimens 10 inches in over-length, 2 inches maximum width, necked down to 1-1/2 inches minimum width along a 2-inch flat in the center. Rate of jaw separation was set at 0.5 in./min. (ASTM specifies 2 in./min. which was too rapid for the response of the machine). Specimens breaking within 1/2-inch of the jaws were discarded. Cross-sectional area at the point of break was determined and maximum tensile strength was reported in p.s.i.

Transverse strength tests were run on 3-inch by 15-inch specimens loaded at midspan on bearings 12 inches apart. All bearing edges were 3/8 inch radius. Loading was applied at a rate of 5 in./min. until failure. Results were reported as maximum load, deflection at breaking point, and modulus of rupture. The modulus of rupture was computed by the formula given in TAPPI Standard T 1003 sm-55, "Flexural Resistance and Deflection of Insulating Fiberboard":

$$R = \frac{1.5 PL}{W (t)^2}$$

Where:

$\underline{R}$  = modulus of rupture in p.s.i.

$\underline{P}$  = loading in lb.

$\underline{L}$  = span length in inches

$\underline{W}$  = width in inches

$\underline{t}$  = thickness in inches.

#### PULPS EVALUATED

##### Minnesota and Ontario Groundwood

The paper mill groundwood pulp was primarily intended for use with other pulps in order to increase density. A test was made also to check the effect of wood species (spruce) on gas life. Board produced by standard laboratory methods was relatively dense (27.3 lb./ft.<sup>3</sup> wet-pressed for 10 minutes at 150 p.s.i.) and tough. Pressure drop through a 0.25-inch thick specimen of this board was very high, over 320 mm. H<sub>2</sub>O (the maximum reading on the monometer) at 1 liter/min. air flow, and the carbon dioxide diffusivity was low,  $1.13 \times 10^{-2}$  cm.<sup>2</sup>/sec. Gas life tests on this board are not yet complete.

##### Armstrong Cork Company Pulps

Samples of pine groundwood and willow groundwood pulps received from the Armstrong Cork Company were formed into boards to be evaluated in terms of gas life. Each of the pulps contained a small amount of Dowicide G preservative.

Board formed from the pine pulp was less dense (18.4 lb./cu. ft.) than the density desired in diffusion board. The willow pulp produced slightly denser board (20.2 lb./cu. ft.). Formation was poor in both cases; chips and large fibers were imbedded in the top surfaces of the boards, particularly the boards from the pine groundwood. Board samples of these pulps have not yet been tested for gas life.

#### EFFECT OF AQUAPEL 486 ON GAS LIFE

The use of Aquapel 486 with a mixture of Wood Conversion Company pulps (17% 10-855 and 83% 10-890) was discussed in Report Eight; however, at that time the results of gas life tests were not available. The gas life values of board treated with varying levels of Aquapel were consistent in relation to the level of addition but were lower than was anticipated based on previous experience with Aquapel 486 and Wood Conversion Company pulps. These boards were not tested for gas life until nearly two months after they were produced; it seems possible that the relatively low level of gas life protection could be the result of deterioration through aging.

It can be seen from Table I that the use of increasing amounts of Aquapel consistently results in decreased water absorption and gas life. The water absorption seems to level off at approximately 6 and 15% pickup, 2 and 24-hour soaking, respectively. Increased additions of Cato 8 produces a slight reduction in water absorption; however, the gas life is reduced somewhat. The effects of the Kymene 557 additions seem to lie somewhere between the high and low Cato 8 additions at a given Aquapel addition.

TABLE I  
USE OF AQUAPEL 486 WITH WOOD CONVERSION COMPANY PULP

Sample 2256-	Additions, <sup>a</sup> % of Fiber		Caliper, in.	Density, lb./cu. ft.	Charcoal Loading, 2 g./100 cm. <sup>2</sup>	PS, min.	Gas Life, min. CK, min.	Water Absorption %, Based on Dry Volume	
	Aquapel 486	Kymene 557						2 hr. Submersion	24 hr. Submersion
84-1	0.1	0.2	0.323	19.52	5.07	26.2	17.3	11.05	24.54
84-2	0.5	1.0	0.328	19.81	5.31	12.7	8.4	7.18	19.16
84-3	1.0	2.0	0.322	20.72	5.41	20.7	4.4	6.88	18.31
84-4	2.0	4.0	0.319	21.93	5.68	16.0	2.4	6.66	16.74
84-5	4.0	8.0	0.316	23.53	6.05	12.2	1.8	6.14	15.39
84-6	1.0	0.5	0.332	20.81	5.61	24.1	8.4	7.70	18.78
84-7	2.0	0.5	0.336	20.78	5.67	21.1	4.4	6.48	16.33
84-8	1.0	--	0.341	19.97	5.93	24.8	5.6	7.29	18.69
84-9	2.0	--	0.325	20.07	5.47	22.1	3.7	6.61	15.91

<sup>a</sup> Active material added, based on oven-dry fiber. All additions were made to a 4% slurry of pulp.

<sup>b</sup> Gas life values not corrected to 5 g./100 cm.<sup>2</sup> loading.

## DRYING STUDIES

Drying studies were carried out in order to determine (1) the effect of oven temperature in a circulating air oven on drying time, board temperature, and gas life, and (2) the rate of moisture loss in the drying process. The purpose for obtaining this information was to parallel commercial drying procedures and determine the necessity of restricting or modifying the drying conditions in commercial production. It was anticipated that, other than the thermal restrictions imposed by the flammability of the board, certain restrictions might be imposed through a balance of effects on gas life resulting from temperature, moisture content, and duration of exposure to elevated temperatures.

Boards were formed from the same mixture of Wood Conversion Company stocks used in the pilot runs. Immediately after wet-pressing, a thermocouple was inserted into the board at one edge and thermocouples were attached to each surface of the board; two thermocouples were used to measure the temperature of the oven. Temperatures were recorded on a recording potentiometer. All board samples except Samples 94-3 and 95-4 (see Table II) were dried at one oven temperature setting. This was considered as single-stage drying, not to be confused with the phases encountered in the mechanism of drying. In drying at temperatures in excess of 320°F., it was assumed that the board would scorch at 320°F., and consequently, when the surface of the specimen reached 300 to 320°F., the oven was reset to a lower temperature for the remainder of the drying period; this was considered as two-stage drying. All of the boards were considered dry when the internal temperature of the specimen reached 220°F. or when no change in the weight of the specimen was noted over a fifteen-minute period.

TABLE II  
 EFFECT OF DRYING CONDITIONS ON DRYING TIME AND GAS LIFE

Sample 2256-	Stage I <sup>b</sup>			Oven Temp. Reset			Stage II <sup>b</sup>			Gas Life CK, <sup>e</sup> min.
	Oven-Initial Set Temp., °F.	Time, <sup>a</sup> min.	Board Temp, <sup>c</sup> Surface Internal °F. (max.)	Temp., °F.	Cooling Time, min.	Time, min.	Board Temp., °F. Surface Internal	Moisture Loss, %		
94-1	220	155	220	220	--	--	--	--	--	43.8
94-2	305	76	285	220	--	--	--	151.3	--	44.2
94-3	395	26	300	180	21	79	265	220	140.3	46.1
95-4	425	6	320	170	16	57	295	220	134.9	45.0
96-5 <sup>d</sup>	230	115	230	220	--	--	--	--	134.7	--
97-6 <sup>d</sup>	310	65	265	220	--	--	--	--	144.1	--

<sup>a</sup>Time for temperature of surface to reach 300 to 320°F., at which time the oven temperature was reset, or total drying time if oven was not reset.

<sup>b</sup>Drying was considered complete when internal temperature reached 220°F.

<sup>c</sup>Temperature of hottest surface.

<sup>d</sup>Dried to constant weight; removed from oven and weighed every 15 minutes.

<sup>e</sup>Values not corrected to standard 5 g./100 cm.<sup>2</sup> loading.

It can be seen from the data in Table II that the use of high temperatures for initial drying shortens the total drying time required by a considerable amount without impairing the gas life of the board. This method of drying is analogous to the "zone" drying method which is a common commercial operation in the board industry. Zone drying makes use of controlled temperature zones in the drier so designed that a maximum temperature differential can be maintained between the oven air and the interior of the board and yet the surfaces of the board will not reach scorch temperatures. Evidently the scorch temperature will be the limiting factor in drying.

Figure 1 shows the rate of moisture loss expressed as per cent of the dry board weight for drying at 310 and 220°F. oven temperatures. The internal temperatures recorded during the drying process are plotted against time in Fig. 2. Both temperature curves show changes in slope at times corresponding to 25% moisture content on the moisture loss curves, and both temperature curves approach the oven temperature at points corresponding to 1% moisture.

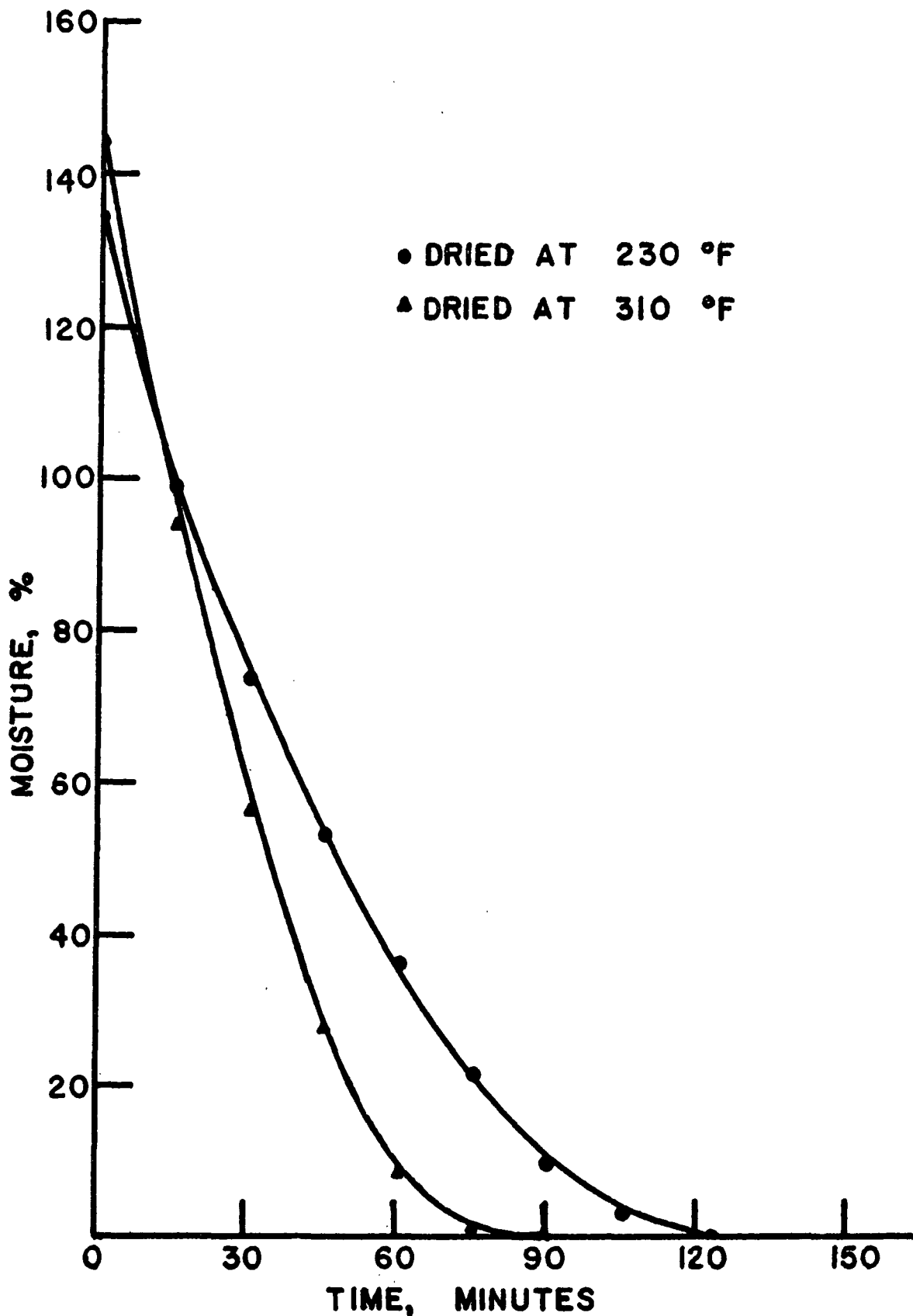


Figure 1. Rate of Moisture Loss in Drying of Diffusion Board

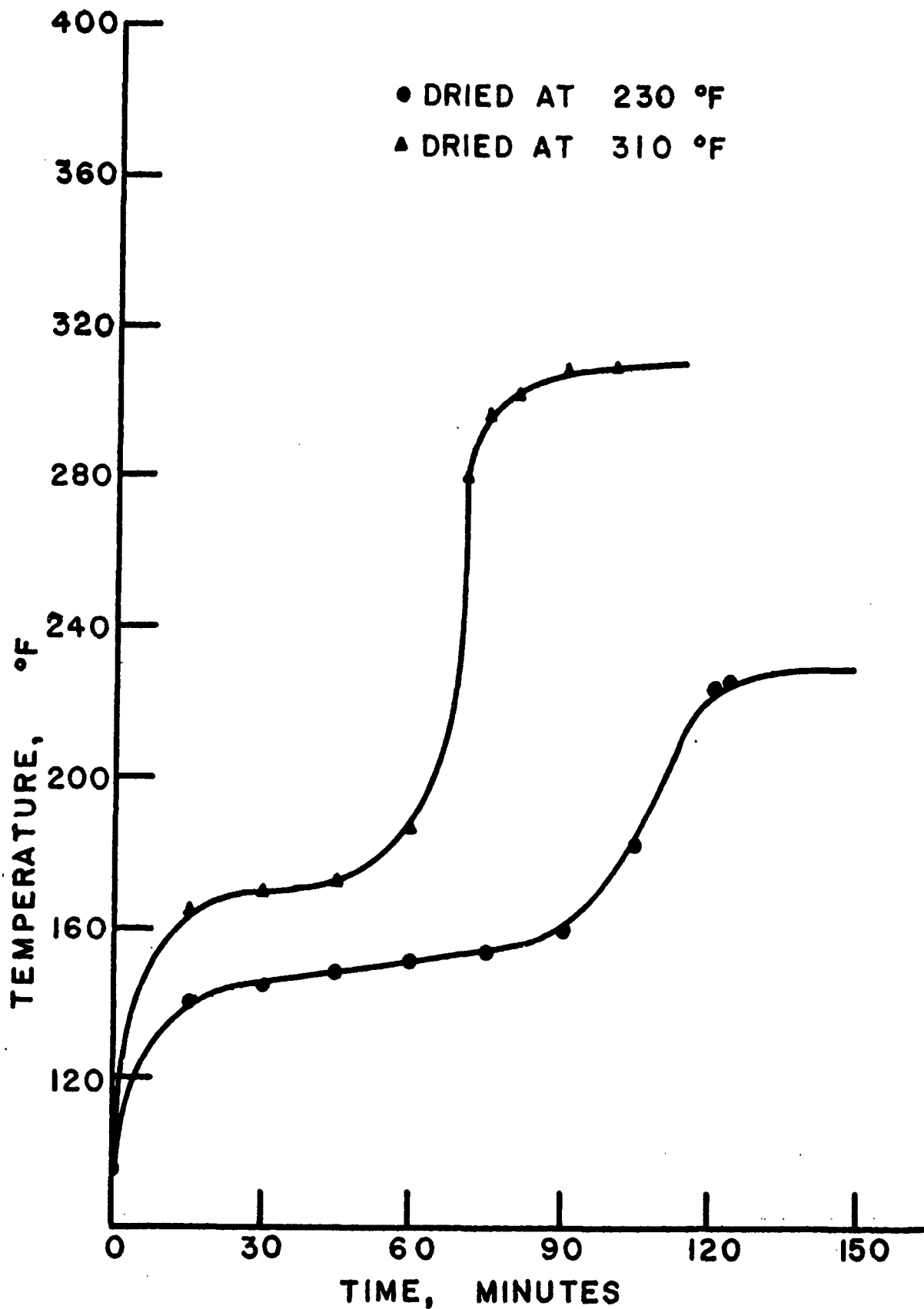


Figure 2. Internal Temperatures Encountered During Drying of Diffusion Board

### PILOT RUNS

Three Institute personnel, Messrs. Howells, Jones, and Leporte, and Mr. Grover Condon of the Army Chemical Center witnessed a series of pilot trials run at Bauer Bros. Co. in Springfield, Ohio on May 15 through May 17, 1961. These trials were mentioned in last months report but not described in detail because the report from Bauer was not received in time.

These runs were made with stock obtained from the Wood Conversion Company designated as a blend of two separately refined stocks containing no broke or defibrator fiber. Part of the stock was refined at Bauer Bros. and blended with the "as received" stock for the runs; stock for the first run contained 50% refined stock and 50% "as received" stock, and subsequent runs were made with a stock blend of 25% refined and 75% "as received" stock. A copy of a report issued by Bauer Bros. contains details of refining and production conditions and is appended to this report.

Runs containing charcoal and sizing additions were made according to the following schedule (additions were made on the basis of oven-dry fiber):

Run	Additions
1	25% addition of charcoal
2	25% charcoal followed by a 0.5% addition (active material) of Aquapel 360
3	25% charcoal followed by a 0.5% addition (active material) of Aquapel 360 followed by a 0.2% addition of Kymene 557
4	0.5% (active material) of Aquapel 486 followed by a 25% addition of charcoal, followed by a 1.0% addition of Cato 8
5	25% charcoal followed by a 1.0% addition of Cyron

The board was formed in a continuous web on a 2-ft. diameter, 2-ft. wide Dorr-Oliver drum filter operating with an 8 to 10-inch Hg. vacuum. The wet lap was doctored from the former onto a felt and carried through a Downingtown press and, on removal, was cut into 6-ft. lengths and placed into the drier. The pilot drying facilities consisted of a 60 ft. tunnel drier which was direct-fired with natural gas. All of the board produced from these runs was shipped to the Institute.

At the Institute, samples of the runs were tested for carbon dioxide diffusivity, water absorption, smoke penetration, and physical strength. Samples were sent to the Army Chemical Center for gas life tests. Ashing determinations were run on board samples, the charcoal, and the pulp in order to determine the charcoal loadings of the products. Results of these tests are given in Tables III, IV, and V.

TABLE III  
 CHARCOAL LOADING IN BOARD PRODUCED DURING  
 PILOT RUN AT BAUER BROS. CO.

Sample	% Ash	Caliper, in.	Density, lb./cu. ft.	% Charcoal	Charcoal Loading g./100 cm. <sup>2</sup>
Pulp	4.16	--	--	--	--
Charcoal ASC	24.66	--	--	--	--
1-2	7.31	0.310	19.9	15.37	3.86
1-4	7.29	0.307	16.6	15.28	3.18
2-4	8.32	0.330	19.3	20.32	5.26
2-6	7.80	0.342	18.3	17.75	4.53
3-1	8.04	0.343	17.1	18.93	4.50
3-4	7.95	0.332	17.5	18.50	4.36
3-6	7.87	0.351	17.1	18.11	4.42
4-1	8.02	0.374	18.8	18.82	5.38
4-6	7.85	0.378	19.3	18.00	5.35
5-1	8.04	0.391	17.8	18.93	5.36
5-6	8.10	0.365	16.8	19.22	4.80

TABLE IV  
PHYSICAL CHARACTERISTICS AND TEST RESULTS ON BOARD PRODUCED DURING  
PILOT RUN AT BAUER BROS. CO.

Sample	Material	Additions		Wet Caliper, in.	Dry Caliper, in.	Shrinkage, %	CO <sub>2</sub> Diffusivity, cm. <sup>2</sup> /sec. x 10 <sup>-2</sup>	Water Absorption		Gas Life CK, PS, min. min.	Smoke Penetration at 1 l./min. ΔP, mm. H <sub>2</sub> O	Flow %
		% Based on O.D. Fiber	Order of Addition					% Based on Dry Volume 2 hr.	Submersion Submersion			
1-2	Charcoal, ASC	25.0	--	0.400	0.310	22.5	3.33	20.24	36.87	35.4	16	<0.001
1-4	Charcoal, ASC	25.0	--	0.380	0.307	19.2	3.66	28.88	46.14	23.2	14	<0.001
2-4	Charcoal, ASC	25.0	1	--	--	--	--	--	--	--	--	--
2-6	Aquapel 360	0.5	2	0.380	0.330	13.1	2.95	6.40	13.18	31.5	17	<0.001
	Same as 2-4	--	--	0.390	0.342	12.3	3.36	5.82	12.94	26.5	16	<0.001
3-1	Charcoal, ASC	25.0	1	--	--	--	--	--	--	--	--	--
	Aquapel 360	0.5	2	--	--	--	--	--	--	--	--	--
	Kymene 577	0.2	3	0.400	0.343	14.2	3.15	5.88	13.22	43.4	17.5	<0.001
3-4	Same as 3-1	--	--	0.380	0.332	12.6	--	6.02	12.87	--	18.5	<0.001
3-6	Same as 3-1	--	--	0.410	0.351	14.4	--	5.98	12.18	41.2	19	0.006
4-1	Aquapel 486	0.5	1	--	--	--	--	--	--	--	--	--
	Charcoal, ASC	25.0	2	--	--	--	--	--	--	--	--	--
	Cato 8	1.0	3	0.410	0.374	8.8	3.12	5.67	12.74	26.1	19.5	<0.001
4-6	Same as 4-1	--	--	0.420	0.378	10.0	--	5.74	12.98	34.0	19.5	<0.001
5-1	Charcoal, ASC	25.0	1	--	--	--	--	--	--	--	--	--
	Cyron size	1.0	2	0.400	0.391	2.2	--	5.04	12.44	34.5	16.5	<0.001
5-6	Same as 5-1	--	--	0.400	0.365	8.8	3.30	5.59	14.05	38.5	19.5	<0.001
1-2E <sup>b</sup>	Charcoal, ASC	25.0	--	--	--	--	--	--	--	--	--	--
2-6E <sup>b</sup>	Charcoal, ASC	25.0	1	--	--	--	--	--	--	--	--	--
	Aquapel 360	0.5	2	--	--	--	--	--	--	--	--	--
W-3 <sup>c</sup>	Charcoal, ASC	25.0	--	--	--	--	--	--	--	--	--	--

<sup>a</sup> Active material added

<sup>b</sup> Sample of run dried in a Williams electric oven at 200°F.

<sup>c</sup> Handsheet, formed on TAPPI mold; dried in a Williams electric oven at 200°F.

TABLE V  
RESULTS OF STRENGTH TESTS ON BOARD PRODUCED DURING  
PILOT RUN AT BAUER BROS. CO.

Sample	Material	Additions		Order of Addition	Modulus of Rupture, P.s.i.		Transverse Loading <sup>a</sup> , Breaking Load, lb.		Dry		2 hr. Soak		Tensile--Breaking Load, p.s.i.		24 hr. Soak Redried C.D.	
		% Based on O.D. Fiber			M.D.	C.D.	M.D.	C.D.	M.D.	C.D.	M.D.	C.D.	M.D.	C.D.		M.D.
1-3	Charcoal, ASC	25.0	--	--	416	341	6.35	5.55	233	273	13.2	19.2	10.5	10.1	146	228
1-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2-3	Charcoal, ASC	25.0	--	1	451	402	7.82	5.73	452	345	167.5	132.5	85.0	60.8	370	300
2-4	Aquapel 360	0.5	--	2	--	--	--	--	--	--	--	--	--	--	--	--
2-5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3-5	Charcoal, ASC	25.0	--	1	--	--	--	--	--	--	--	--	--	--	--	--
	Aquapel 360	0.5	--	2	--	--	--	--	--	--	--	--	--	--	--	--
	Kymene 557	0.2	--	3	481	482	8.87	10.10	389	411	214	221	115	130	308	325
3-6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4-1	Aquapel 486	0.5	--	1	--	--	--	--	--	--	--	--	--	--	--	--
	Charcoal, ASC	25.0	--	2	--	--	--	--	--	--	--	--	--	--	--	--
	Cato 8	1.0	--	3	476	458	10.98	10.03	396	371	157	137	60.5	50.9	368	364
4-2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5-1	Charcoal, ASC	25.0	--	1	--	--	--	--	--	--	--	--	--	--	--	--
	Cyron size	1.0	--	2	256	300	6.61	7.72	237	218	111	92.5	69.1	52.9	5	216
5-2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
5-4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

<sup>a</sup>Modulus of rupture calculated from formula:  $R = \frac{1.5 PL}{W(t)^2}$

where: R = Modulus of rupture  
 $\bar{P}$  = Max. load at failure, lb.  
L = Length of span, in.  
W = Width of specimen, in.  
t = Thickness of specimen, in.

<sup>b</sup>All specimens failed at either clamping jaw.

The results of ash determinations on samples of the pulp used in these runs were inordinately high. Other Wood Conversion Company pulps had ash contents in the neighborhood of 1% while this pulp produced 4.16% ash. The ash determinations were rerun with different samplings of the pulp with the same results. Ash determinations of board samples were proportionally high, giving evidence in support of a conclusion that this pulp contained a small amount of foreign material possessing a high ash content. This pulp was produced at Wood Conversion Company after a series of runs using mineral fiber. It is a practice at this mill to clean up and flush all process equipment after a mineral fiber run; however, it seems likely that some mineral fiber remained in various inaccessible places in the equipment and low spots in the piping and became mixed with the pulp as it was produced.

Densities of the board produced were lower than laboratory-produced board due to the difference in wet-pressing conditions available and, consequently, carbon dioxide diffusivities were higher than usual. All of the board samples were acceptable in smoke penetration characteristics and in terms of gas life. The water absorbed by board containing sizing agents was, on the whole, less than laboratory-produced board containing equal additions of the sizing agents. The use of sizing materials increased charcoal retention and strength.

No real comparison is available for estimating magnitudes for the strength tests other than the minimum specifications outlined in Federal Specification LLL-I-535. For Class E (sheathing board), a minimum tensile strength of 150 p.s.i. and a minimum transverse loading 600 lb./sq. ft., which is equivalent to a total load of 12.5 lb. on a 12-inch span, 3 inches wide, are required. The transverse loading requirement in this specification is not actually a valid comparison since it is intended for 1/2-inch board.

The Aquapel 360--Kymene 557 system seemed to produce the best over-all effects. Board treated with this system had the best wet strength and the best gas life. All other properties of this board seemed to be on par with the other boards. On the basis of this data, it is probable that further work will be carried out with an emphasis on an Aquapel 360--Kymene 557 system.

#### Flammability

Tests were made to determine the effects of charcoal on ignition temperature and the burning characteristics of diffusion board. The evaluation was carried out by comparing tests run on charcoal-loaded board with tests run on blank boards formed from the same pulp containing no charcoal. Board samples for these tests were formed in the lab with the same pulp as was used in the pilot run at Bauer Bros.

Charcoal-loaded boards charred badly after a one-minute exposure at 430°F. and after five minutes' exposure at 410°F. The blank board was only scorched after two hours' exposure at 410°F. and charred after three minutes' exposure to a temperature of 500°F. A specimen of charcoal-loaded board was held at 350°F. for two hours, with slight scorching as the result.

Specimens taken from the pilot run were subjected to the Inclined Panel Flame Test along with a blank specimen. Results of this test are given in Table VI.

TABLE VI  
FLAMMABILITY OF DIFFUSION BOARD BY THE  
INCLINED PANEL FLAME TEST

Sample	Flaming, <sup>a</sup> sec.	Area of Char, in. <sup>2</sup>	Glow
1-4	20	28.4	Persisted at bottom edge of char until extinguished
3-4	24	28.4	Persisted at bottom edge of char until extinguished
5-3	37	31.4	Persisted at bottom edge of char until extinguished
5-2	32	29.4	Persisted at bottom edge of char until extinguished
Blank	Until extinguished (1 min.)	40.5	None

<sup>a</sup>Persistence of flame after exhaustion of the burning alcohol

The charcoal-loaded board tended to glow rather than flame; however, the glow was easily extinguished by a CO<sub>2</sub> atmosphere. The blank board had a greater tendency to propagate a flame as a flash over the surface thereby charring a large area but not to the depth that the charcoal-loaded board was charred. Charcoal was the only additive in Sample 1-4, while Samples 3-4 and 5-3 contained Aquapel 360 and Cyron, respectively, in addition to charcoal. Samples 5-3 and 5-2 tended to flame more, probably as a result of the reduction in density caused by the Cyron.

THE INSTITUTE OF PAPER CHEMISTRY

*L. E. Leporte*

L. E. Leporte, Research Aide

*T. A. Howells*

T. A. Howells, Chief  
Special Processes Section

APPENDIX

# Fiber Products Laboratory

SPRINGFIELD, OHIO

## LABORATORY REPORT

---

TEST No. 3732 CONFIDENTIAL

DATE. June 6, 1961  
Test Run May 15 - 19, 1961

---

CLIENT. The Institute of Paper Chem.  
Appleton, Wisconsin

Witnesses:  
G. C. Condon, Jr.  
Dr. T.A. Howells  
L. E. LePorte  
E. Jones

SUBJECT. Board Forming Demonstration

---

MATERIAL: See Table No. I

OBJECTIVE: To develop Improved Diffusion board for U. S. Army Chemical  
Center Procurement Agency.

### SUMMARY & CONCLUSIONS:

This test was made as directed by the client from fiber which was made by Wood Conversion. Formulations and procedures were determined by the client to enable evaluations of toxic gas absorption properties of the resulting board. Such evaluations were to be made elsewhere since Bauer was not equipped to handle this phase of the work.

Formation of boards was satisfactorily performed, but other conclusions must necessarily be determined by others.

TEST NO: 3732

Page 2

PROCEDURE: The material to be tested was received, marked, and retained in storage until the testing date. The fiber as received was shredded and labeled O1. The material identification and analysis, along with the letter identification, may be found in Table No. I.

Five refiner runs (A-1 through A-5) were made on the O1 material using the Bauer No. 410, 40" double revolving disc refiner with the A-400 X plates. For each run, a refining consistency of 8% was used. The energy applied for each run respectively was 7.32, 7.32, 7.33, 7.33 and 7.21 HPD/ADT. For refiner data, see Table No. II.

A composite, combining the pulp from each refiner run with the O1 material in varying proportions was used as the feed for each board run.

C-1 was a mixture of 50% - O1 and 50% - A1 and was used for board run B-1. Charcoal (25% on O.D. wood) was mixed into the C-1 material for this run. From the B-1 furnish, TAPPI boards W-1, W-2 and W-3 were made with the board formation data listed in Table No. IIIA.

C-2 was a composite of 25% - O1 and 75% - A-2 and was used for board run B-2. The additives mixed with the C-2 stock for this run were 25.0% charcoal and 0.5% Aquapel 360. It was necessary to adjust the pH with NaOH for this particular run.

The third composite (C-3) was a combination of 25% - O1 and 75% - A-3 and was used for board run B-3. The additives for this run, mixed with C-3 stock was 25.0% charcoal, 0.5% Aquapel 360 and 0.2% Kymene 557.

Composite C-4 was a combination of 25% - O1 and 75% - A-4 and was used for board run B-4. The additives for this run was 25.0% charcoal, 0.5% Aquapel 486 and 1.0% Cato - 8.

C-5 was a combination of 25% - O1 and 75% - A-5 and this composite became the feed for board run B-5. The additives mixed with the C-5 stock were 25.0% charcoal and 1.0% Cyron.

Board run B-1 was dried in the Coe dryer at 250°F. Board runs B-2 through B-5 were dried at 350°F.

All board formation data may be found in Table No. III.

Samples were cut from each board run and the board data from these cut samples may be found in Table No. IV.

TEST NO: 3732

Page 3

Insulation boards B-1 through B-5, two drums of Ol pulp, one bag of Cyron, one bag of Cato-8, one drum of Aquapel 486, ten pounds of charcoal and the white water from B-2 was sent prepaid by truck to:

Institute of Paper Chemistry  
Appleton, Wisconsin  
ATTENTION: Dr. T. A. Howells

one pound of Cyron, one pound of Aquapel 486 and two quarts of Aquapel 360 was sent prepaid by express to:

Protective Dev. Div.  
U. S. Army Chem. Res. & Dev. Labs.  
Army Chemical Center, Maryland  
ATTN: Grover C. Condon, Jr.

Oscar Wiegel,  
Assistant Director of Laboratories

Ben W. Perks,  
Director of Laboratories

OW/BWP/lp

CC: T. A. Howells (5)  
Institute of Paper Chemistry  
Appleton, Wisconsin

Grover C. Condon, Jr. (1)  
Protective Dev. Div.  
U. S. Army Chem. Res. & Dev. Labs.  
Army Chemical Center, Md.

J. C. S.  
Goodwin  
Lab  
Library  
Corres.

# APPENDIX

## EXPLANATION OF DATA

### 1. Material Identification

The following is an explanation of the letter identification of material used in this laboratory. The letters are used in combination with numbers which serve to identify various runs, operations, and/or materials produced under a given letter classification.

A: Refiner

B: Insulating Board

C: Composite

D: Structural-Type Board Made on Hand Board Former

E: Machine Made Hardboard

H: Bauer Cleaner

H-F. Feed

H-A. Accepts

H-R. Rejects

L: Laboratory Mill No. 148-1E

M: Mead Mill No. 405-1

N: Biffar Screen

O: Original

P: Pressafiner

R: Research

S: Bark Separation

V: Valley Beater

### 2. Brake Horsepower Days per Air Dry Ton

This figure was chosen because most mills determine capacity in Air Dry Tons per Day, and motors are rated in Brake Horsepower. The BHP Days per Air Dry Ton figure is based on the motor output.

$$\text{BHP Days/Ton} = \frac{\text{KWH used}}{\text{LBS (O.D.) used}} \times F$$

$$F = \frac{\text{Efficiency of Motor} \times 2000 \times 0.90}{0.746 \times 24}$$

F=91.5 when ordinary motors, with 91% mechanical efficiency are used.

F=82.4 when specially wound, multiple speed motors, with a mechanical efficiency of 82%, are used for test.

Where:

2000 equal pounds per ton.

0.900 is conversion factor from oven dry to air dry.

0.746 is conversion factor from KW to HP.

24 equals hours per day.

Brake HP Days per ton x 20 = Metered KWH per Ton (approximate) assuming a motor efficiency of 90%.

### 3. Daily Capacity in Air Dry Tons per Day

This value is derived by dividing the rated capacity (in HP) of the main motors of the refiner by

the HP Days per Air Dry Ton. The figure expressed is the tonnage per day if the refiner were fully loaded at all times. A more practical figure for commercial operations would be 90% of the figures given.

#### 4. Actual Feed Rate

This is the actual feed rate to the refiner. This rate is generally predetermined and controlled by means of a variable speed drive which operates the belt feed of the refiner.

#### 5. Formation of Handsheets

Handsheets, for observation and inspection, are made in the laboratory with an 8" x 8" Williams Sheet Mold. A sufficient amount of slurry, consistent with the weight requirements of the ream, is poured into the mold, and de-watered to form a handsheet. Three blotters are put on the wet sheet which is then couched off. A steel plate is placed on the wire side of the sheet and two additional blotters on the felt side. The sheet is pressed in a hydraulic press for five minutes at 40 psig, then removed and the blotters replaced with one new blotter. The sheet is again pressed, this time for two minutes at 40 psig, after which the sheet is air dried on the steel plate without a covering blotter.

In the Fiber Products Laboratory, handsheets are made in three ream weights: 300 lbs., and 80 lbs., and 40 lbs. per ream (24 x 36-500). A ream weight of 300 lbs. is used when the pulps produced are to be used for insulating board, etc.

A ream weight of 80 lbs. is used for .009 point furnishes.

A ream weight of 40 lbs. is otherwise generally used.

#### 6. Formation of Handsheets for Physical Tests of Pulp

Test sheets are made in accordance with procedures described in TAPPI Standard T205 M-53 in all respects except sheet weight. The above TAPPI Standard calls for a 60g/sq m sheet or, on our basis, a 36.8 lbs/ream (24 x 36-500) sheet. This has been altered to obtain a 40 lb/ream (24 x 36-500) sheet.

#### 7. Physical Testing of Pulp Handsheets

This laboratory tests pulp handsheets for strength and other physical properties, excepting optical properties, in accordance with TAPPI Standard T 220m-53 in all essential details. The breaking width in the tensile test is taken as 0.5 inches rather than 15mm. Basis weight is expressed in lbs/ream (24 x 36-500). The most common strength tests are calculated as follows:

##### a. Mullen Test (Bursting Strength):

$$\% \text{ Mullen} = \frac{\text{Average Burst Reading} \times 100}{\text{Basis Weight (O.D.)}}$$

This value may be converted to the TAPPI burst factor by multiplying the percent Mullen by 0.432.

##### b. Tear Test: The tear strength is determined with an Elmendorf Tear Tester.

$$\% \text{ Tear} = \frac{\text{Total readings} \times 16 \times 100}{\text{Number of tears} \times \text{Basis Weight (O.D.)}}$$

This value may be converted to the TAPPI Tear Factor by multiplying the per cent tear by 0.614.

##### c. Tensile Test: The tensile strength is determined with a Louis Schopper Tensile Tester.

$$\% \text{ Tensile} = \frac{\text{Total of Tensile Readings} \times 2 \times 100}{\text{Number of Strips Tested} \times \text{Basis Weight (O.D.)}}$$

This value may be converted to the TAPPI Breaking Length by multiplying the per cent tensile by 110.

## **8. Freeness Tests**

- a. The freeness of pulp is obtained by following the procedure described in TAPPI Standard T 227m-50. The Canadian Standard Freeness Tester is used.
- b. When desired, the New Green Freeness Tester is used. For a Freeness test, a 3 gram sample is generally used, although a 6 gram sample is used for insulation or hard board.
- c. The freeness of insulation or hard board stock, in seconds, is obtained using an Oliver Freeness Test. For the test, a 150 gram sample is used.

## **9. Handsheets for Optical Tests of Pulp**

The formation of handsheets for optical tests is done in accordance with TAPPI Standard T 218m-48.

## **10. Brightness of Pulp and Paper**

The method used by this laboratory to measure the brightness of paper samples and pulp handsheets is designed to yield results in agreement with TAPPI Standard T 217m-48 and T 452m-48. The Photovolt Reflection Meter, Model 610 is used.

## **11. Yield of Pulp**

At present, two methods are used in this laboratory for the yield determination.

Method No. 1 is followed when an unwashed yield is desired.

When a washed yield is desired, Method No. 2 is employed.

Method 1: The weight of the material (oven dry basis) from the digester is determined. This weight expressed as a per cent of the weight (oven dry basis) of the initial charge to the digester is the unwashed yield.

Method 2: An accurately weighed portion of the cooked material is refined on the Laboratory 8 inch mill, care being exercised not to lose any material. The refined material is washed and then dried to a constant weight. From the per cent solids content thus obtained, the O.D. weight of the washed material from the digester is determined. This weight expressed as a percent of the O.D. weight of the initial charge to the digester is the washed yield.

## **12. Chemical Analysis**

The chemical analysis on various type liquors are performed in accordance with TAPPI Standard procedures. For liquors requiring procedures not listed in TAPPI Standards, generally accepted methods are employed.

## **13. Permanganate Number of Pulp**

The permanganate number of pulp is determined according to TAPPI Standard T 214m-50. For highly lignified pulps the procedure outlined under TAPPI Routine Control Method 242 is followed.

## **14. Chlorine Number**

The chlorine number is determined in this laboratory according to TAPPI Standard T 202m-45.

## **15. Board Test Data**

All test data for hard-pressed, structural fiberboard is obtained following procedures outlined in Federal Specifications LLL-F-311. Insulating fiberboard is tested according to Federal Specifications LLL-F-321b.

GRAPHIC SUMMARY

CHART A

Test No. 3732

Date: June 6, 1961

Material	Refine HPD/ADT	Composite	Board Run No.	ADDITIVES-% ON O.D. WOOD					
				Charcoal	Aquapel 360	Aquapel 486	Kymene 557	Cato-8	Cyron
01 Fiber As Received Thru Shredder	A1 → 7.32	C1 50%-01 50%-A1	B1	25.0	-	-	-	-	-
	A2 → 7.32	C2 25%-01 75%-A2	B2	25.0	0.5	-	-	-	-
	A3 → 7.33	C3 25%-01 75%-A3	B3	25.0	0.5	-	0.2	-	-
	A4 → 7.33	C4 25%-01 75%-A4	B4	25.0	-	0.5	-	1.0	-
	A5 → 7.21	C5 25%-01 75%-A5	B5	25.0	-	-	-	-	1.0

The B1-Furnish Was Used To Make Tappi Boards W1, W2, and W3.

MATERIAL IDENTIFICATION

AND ANALYSIS

TABLE NO. I


Test No. 3732

Date June 6, 1961


Sample No.	Species	% O.D. Solids	Tappi Drainage Time (Sec.)
01	Fiber As Received Thru Shredder	32.0	23.3
02	Guide Sample No. 853	-	19.7
03	Guide Sample No. 855	-	30.7
04	Guide Sample No. 890	-	18.3
C1	50%-01 and 50%-A1	-	31.0
C2	25%-01 and 75%-A2	-	28.3
C3	25%-01 and 75%-A3	-	31.7
C4	25%-01 and 75%-A4	-	28.6
C5	25%-01 and 75%-A5	-	36.0


---

LETTER IDENTIFICATION

A-Refiner Runs

C-Composite

B-Board Run Number

O-Original Material

FIBER PRODUCTS LABORATORY--SPRINGFIELD, OHIO

REFINER DATA

TEST NO. 3732 TABLE NO. II DATE May 25, 1961

Run No.	Material	Refiner Model	Rotation and Type of Plate	Plate Setting (inches Open)	Consistency Between Plates (% O.D.)	Shower Water Temp. °F.	Motor Load Brake H.P.	Actual Feed Rate Air Dry Tons Fiber Per Day	Brake H.P. Days Per Air Dry Tons of Fiber	Daily Capacity Air Dry Tons H. P.	C.S. Freeness Using Gram Sample (M.)	Cumulative Refiner Brake HP/ADT of Fiber	Tappi Drainage Time
A1	01	410	ccv. A400X	.054	8	165	431	58.8	7.32	41.0	300	--	32.0
A2	"	"	"	.052	8	"	430	58.8	7.32	54.6	400	--	29.7
A3	"	"	"	.052	8	"	418	57.2	7.33	54.6	"	--	28.7
A4	"	"	"	.053	8	"	414	56.6	7.33	54.6	"	--	26.3
A5	"	"	"	.050	8	"	419	58.2	7.21	55.4	"	--	29.0

BOARD FORMATION DATA

TABLE NO. III

Test No. 3732

Date June 5, 1961

Run No.	Type of Material	ADDITIVES-% ON O. D. WOOD				FORMING DENSITIES % O. D. SOLIDS				Met Thickness After Oliver (Inches)	Oliver Vacuum (In.)	Forming Speed (r.p.m.)	pH Tank	DRAINAGE TIME		TAPPI	
		Aquapel 360	Aquapel 486	Kymene 557	Cato-8	Cytron	Mixing Tank	Flow Box	After Oliver					Downing- town Press	After		Without Additives
B1	C1	--	--	--	--	--	1.89	0.60	21.0	37.2	0.550	8.0	4.5	8.0	8.0	31.0	25.3
B2	C2	25.0	0.5	--	--	--	1.21	0.27	22.6	33.0	0.470	8.0	3.0	7.9	8.0	28.3	27.3
B3	C3	25.0	0.5	--	0.2	--	1.19	0.35	22.1	32.5	0.720	8.0	3.0	7.8	7.9	31.7	28.3
B4	C4	25.0	--	0.5	--	1.0	1.22	0.37	24.1	34.2	0.680	11.0	3.0	7.9	7.8	28.6	29.0
B5	C5	25.0	--	--	--	1.0	1.26	0.37	21.2	31.7	0.650	11.0	3.0	7.8	7.7	29.6	36.0

The white water from board run no. 2 (% Total Solids) was 0.1001

FIBER PRODUCTS LABORATORY--SPRINGFIELD, OHIO

BOARD FORMATION DATA

TEST NO. 3732

TABLE NO. IIIA

DATE June 9, 1961

Run No.	Furnish	PRESSING		Solids Content From Press	Wet Thickness After Press (Inches)	Dry Thickness (Inches)	% Shrinkage
		Time (Sec.)	PSI on Board				
W1	B1	60	40	29.5	0.460	0.390	15.2
W2	"	"	60	--	0.400	--	--
W3	"	"	120	--	0.340	--	--

## BOARD DATA

TABLE NO. IV

Test No. 3732

Date June 5, 1961

Board Run No.	Sample No.	Wet Thickness From Press	Dry Thickness From Dryer	Shrinkage, %	Lb. Per Cu. Ft.
1	1	--	0.350	--	18.3
	2	0.400	0.275	31.2	19.9
	3	0.360	0.280	22.3	17.8
	4	0.380	0.310	18.4	16.6
	5	0.320	0.260	18.7	18.3
	6	0.360	0.280	22.3	17.4
	7	0.220	0.170	22.7	16.8
2	1	0.300	0.240	20.0	16.8
	2	0.280	0.235	16.1	16.9
	3	0.340	0.280	17.7	19.0
	4	0.380	0.305	19.7	19.3
	5	0.410	0.310	24.4	18.3
	6	0.390	0.340	12.8	18.3
3	1	0.400	0.350	12.5	17.1
	2	0.420	0.320	23.8	19.4
	3	0.400	0.325	18.7	18.7
	4	0.400	0.360	10.0	17.5
	5	0.370	0.335	9.5	17.3
	6	0.410	0.340	17.1	17.1
4	1	0.410	0.350	14.7	18.8
	2	0.400	0.380	5.0	16.8
	3	0.430	0.390	9.3	16.9
	4	0.420	0.360	14.3	18.9
	5	0.420	0.340	19.0	19.1
	6	0.420	0.355	15.5	19.3
	7	0.670	0.600	10.4	18.1
	8	0.750	0.675	10.0	18.0
	9	0.810	0.685	15.4	17.0
	10	0.750	0.620	17.3	16.7
5	1	0.400	0.360	10.0	17.8
	2	0.430	0.350	18.6	17.6
	3	0.420	0.380	9.5	18.0
	4	0.440	0.345	21.6	18.0
	5	0.430	0.405	5.8	16.7
	6	0.400	0.350	12.5	16.8
	7	0.460	0.400	13.0	16.5
	8	0.600	0.490	18.4	17.7
	9	0.690	0.570	17.5	17.7
	10	0.640	0.610	4.7	16.4
	11	0.720	0.580	19.5	17.9