DESCRIBING THE EFFECTS OF VARYING ADHESIVE COVERAGE ON CORRUGATED GLUE LAP JOINT STRENGTH

(By Edward N. Kill, Owens-Illinois, Inc., in the course of an address to the recent 19th Corrugated Containers Conference, at Pittsburgh)

PURPOSE

The purpose of this work initiated by the Fibre Box Association Technical Committee was to:

(1) Determine the amount of manufacturer's joint adhesive coverage of the glue lap tab required for satisfactory corrugated box performance.
(2) To compare the performance of hot melt adhesives with that of regular aqueous adhesives used in the fabrication of manufacturer's joints for corrugated boxes.

SAMPLE VARIABLES

The following variables were investigated:

(1) Manufacturer's joints formed with:
   (a) A continuous film application of adhesives with approximately 100, 75, 50 and 25 per cent. aqueous adhesive coverage.
   (b) A striped adhesive pattern with 100, 75, 50 and 25 per cent. aqueous adhesive coverage.
   (c) Hot melt adhesive using 2, 3 and 4 bead adhesive application.

For each of the above variables, two commercially available adhesives were used.

In addition to the glued manufacturer's joint variables, taped and stitched manufacturer's joints were fabricated in accordance with Rule 41, Section 11, requirements of the Uniform Freight Classification 9 and included in the experiment. Two types of commercially available, reinforced manufacturer's joint tape and a standard 0.103 in. wide × 0.20 in. thick stitching wire were used for these samples.

PLANT TRIAL AND SAMPLE PROCEDURES

Seven thousand five hundred B-flute boxes with 1½ in. inside manufacturer's glue lap tab were fabricated to these specifications:

Style—RSC.
Size—16¼ in. × 12 3/16 in. × 9⅜ in. deep.
Test—200 p.s.i. bursting strength.

Components—outer facing, 42 lb. kraft linerboard; corrugating medium, 26 lb. semi-chem.; inner facing, 42 lb. kraft linerboard.

All boxes were manufactured on the same commercial corrugating equipment with identical liner and medium materials throughout the run. Box blanks were taken three-off across the corrugator and were randomised prior to being sorted into lots of 300 blanks for each of the 25 variables investigated.

Box blanks were then fed through a standard printer-slotter and identified with appropriate sample codes.

GLUE LAP CLOSING PROCEDURES

Water base adhesives

Two methods of applying water-based adhesives were used:

(1) *Solid adhesive pattern* applicator rolls were machined for use on automatic folder gluer. Applicator rolls were machined 1¼ in., 15/16 in., ⅝ in. and 5/16 in. wide in order to obtain approximately 100, 75, 50 and 25 per cent. adhesive coverage based on the 1¼ in. required. This method allowed placement of the adhesive film in the centre of the 1½ in. wide glue tab regardless of the amount of adhesive applied. Two adhesives were used for each coverage variable.
(2) *Striped adhesive pattern* application was performed by another Fibre Box Association member* on a commercial folder gluer machine which uses grooved adhesive applicator rolls. In order to minimise variables, adhesives taken from the same drums as used in manufacturing solid adhesive pattern variables were also used for the striped pattern adhesive application.

With this type of adhesive applicator roll-adhesive fills the grooves with the lands wiped clean. Affinity of the

* *Weyerhaeuser Co., Baltimore plant.*

(This article is continued overleaf)

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substrate for the adhesive transfers the adhesive from the grooves to the substrate. The amount of adhesive carried in each groove is sufficient to flow together under pressure to provide essentially 100 per cent. glue tab coverage if effective adhesive transfer is made. This can be effected by the viscosity of the adhesive used. In this particular instance, 100 per cent. glue lap coverage occurred.

It was originally intended to vary the amount of adhesive coverage by backing the adhesive applicator roll away from the substrate. This was not possible. In order to vary the percentage of adhesive coverage only, a portion of the glue tab was presented to the applicator roll. For example, the manufacturer's joint glue tab received $\frac{5}{16}$ in. adhesive application on the outside tab edge for 25 per cent. coverage.

HOT MELT ADHESIVES

Standard hot melt application equipment mounted on a converted semi-automatic folder taper was used to apply 2, 3 and 4 beads of hot melt adhesive to the manufacturer's joint glue tab. Maintaining a constant amount of adhesive presented some problems.

Stitching wire

Box blanks were closed over a standard semi-automatic stitcher. No problems were encountered.

Reinforced tape

A semi-automatic folder taper was used to close box blanks with two types of 2 in. reinforced tape.

TESTS PERFORMED AND PROCEDURES

Conditioning

All specimens were preconditioned for 24 hours at 80 deg. F.—30 per cent. RH.

All specimens were tested in a 72 deg. F.—50 per cent. RH atmosphere after conditionong at one of the following:

(1) 24 hours at 72 deg. F.—50 per cent. RH.
(2) 24 hours at 0 deg. F. ±10 deg. F.
(3) 72 hours at 85 deg. F.—85 per cent. RH.
(4) 72 hours at 100 deg. F.—92 per cent. RH.

High humidity and cold conditioned specimens were removed one at a time from adjacent conditioning cabinets and tested immediately. Box compression samples were enclosed in a poly bag during test.

Tensile test

Specimens 12 in. long by 2 in. wide were tested across the manufacturer's joint.

Tests were performed using a pendulum type, hydraulically operated instrument. Crosshead speed was approximately 8 in./min. Specimen size was large enough to accommodate two stitches $\frac{1}{2}$ in. from the edge of the specimen strip. Tensile tests were performed after 24 hour conditioning at 72 deg. F.—50 per cent. RH, 0 deg. F. and 72 hour conditioning at 100 deg. F. —92 per cent. RH. Origin of failure was noted and test results were reported in lb./in. of sample width.

Bathurst joint test

This test equipment exerts pressure from the inside of the manufacturer's joint which has been formed at a 90 deg. angle. Pressure is applied along the length of the manufacturer's joint tab score. Force is applied by a compression machine using a 0.5 in./min. crosshead speed.

A 4 in. length of manufacturer's joint was tested—origin of failure noted—and test results reported in lb./in. Sample size was large enough to accommodate three formed stitches in the case of the stitched joint variable. Bathurst tests were performed after 24 hours conditioning at 72 deg. F.—50 per cent. RH, 0 deg. F. and 72 hours conditioning at 100 deg. F.—92 per cent. RH.

Heat resistance

One-inch wide segments of manufacturer's joints, cut across the manufacturer's joint similar to tensile samples, were suspended in a circulating air oven with a 100 gram dead weight load for 24 hours. Heat resistance tests were started at 150 deg. F. and with each succeeding test, increased in 10 deg. F. increments until sample failure. New samples were prepared for each increasing temperature increment. Test method used conforms to Mil-A-101A, paragraph 4.4.1.4.

Compression tests

Top-to-bottom compression tests were performed on all samples in accordance with T.A.P.P.I. T804-m45. Tests were performed after conditioning at 72 deg. F.—50 per cent. RH and 85 deg. F.—85 per cent. RH.

In addition, dead load top-to-bottom compression tests were performed at 72 deg. F.—50 per cent. RH. Static load applied was approximately 80 per cent. of the dynamic compression values obtained at 72 deg. F. —50 per cent. RH.

Drop test

Drop tests were performed on boxes filled to gross weights of 40 lb. and 55 lb. with loose, free-flowing product. A constant drop height of 36 in. was used. Boxes were dropped on the four top and bottom edges

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radiating from the manufacturer's joint until failure.

Drop sequence used was the 1-5, 1-2, 3-5 and 2-3 edges.

Note:

(1) Test boxes were filled with low density polyethylene beads for 40 lb. gross weight and soybeans for 55 lb. gross weight.

(2) Failure was defined as any box wall, score, manufacturer's joint or other rupture which allowed product loss.

(3) Top and bottom flaps were sealed with adhesive. Additionally, 3 in. reinforced tape was centered on box top and bottom faces covering flap edges. Tape extended over box horizontal scores 3 in. to 4 in. into end panels. This was necessary to prevent product loss due to flap gap openings or flap adhesion failures.

Adhesive evaluation tests

Regular (water base) adhesives were evaluated in accordance with procedures outlined in T.A.P.P.I. Monograph No. 26.

Adhesive coverage determination

Adhesive coverage was estimated by delaminating tested tensile samples using an alkaline solution or in the case of hot melt adhesives—cutting the glue line.

Regular adhesive samples were then stained with iodine solution. A cross-hatched plastic rule placed over the glue tab facilitated adhesive coverage estimates.

DISCUSSION AND COMMENTS—TENSILE TESTS

(1) *Test method*

The machine direction tensile of the single face and double face liners was determined from materials

(Continued overleaf)

TABLE I.
MANUFACTURER'S JOINT TENSILE TEST RESULTS

IDENTIFICATION			TEST RESULTS[1]					
Adhesive and Application	Coverage[2]		72° F-50% RH		100° F-92% RH		0° F	
	Goal	Actual	#/in.	Type[3] Fail	#/in.	Type[3] Fail	#/in.	Type[3] Fail
Aqueous #1	100%	113%	122	A	80	A	91	A
Solid Strip	75%	91%	121	A	76	A	—	—
	50%	62%	104	A	75	B	—	—
	25%	31%	77	C	44	C	—	—
Aqueous #1	100%	106%	127	A	83	A	93	A
Striped Pattern	75%	91%	133	A	82	A	—	—
	50%	68%	126	A	85	A	—	—
	25%	42%	115	B	74	B-C	—	—
Aqueous #2	100%	109%	130	A	85	A	96	A
Solid Strip	75%	93%	104	A	80	A	—	—
	50%	59%	92	C	48	C	—	—
	25%	27%	30	C	19	C	—	—
Aqueous #2	100%	114%	131	A	86	A	93	A
Striped Pattern	75%	86%	127	A	83	A	—	—
	50%	70%	123	A	80	A	—	—
	25%	41%	113	B	66	B	—	—
Hot Melt #1 4 Bead ...	—	106%	109	A	72	A	88	A
3 Bead ...	—	84%	102	A	67	A	—	—
2 Bead ...	—	67%	101	A	71	A	—	—
Hot Melt #2 4 Bead ...	—	86%	117	A	84	A	82	A
3 Bead ...	—	58%	113	A	80	A	—	—
2 Bead ...	—	49%	105	A	69	A	—	—
Tape #1	—	—	53	D	39	D	51	D
Tape #2	—	—	64	D	49	D	—	—
Stitch	—	—	26	E	26	E	27	E

[1] Average based on N = 5
[2] 1¼ in. tab coverage considered as 100%
[3] (A) Paper failure—complete rupture away from manufacturer's joint
(B) Paper failure—shear failure *in* manufacturer's joint—generally a failure of the secondary surface fibres
(C) Adhesive (manufacturer's joint) failure
(D) Tape failure
(E) Stitch pull out—paper tear failure

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obtained prior to and after corrugator trial. Our test results indicate no appreciable difference in the machine direction tensile strength between the single face and double face liner. Average tensile values (N = 20) were approximately 94 lb./in. Range of test values obtained for materials tensile strength was from 104 to 87 lb./in. Tensile tests performed across the manufacturer's joint in many cases resulted in paper failure; i.e., failure of the sample with complete rupture occurring away from the manufacturer's joint, or failure which was not attributable to adhesive or fibre shear. Test results obtained on combined board tensile with complete rupture of either the single face or double face liner produced test results which were higher than the tensile value obtained for the liner materials alone. It is our belief that this was due to the reinforcing action of the corrugator adhesive lines which created many small segments of liner material under tension whereas for the uncombined liner materials—tension was spread over an unsupported 8 in. span.

(2) *The effects of adhesive coverage with regular (water base) adhesive*

From the tensile data obtained, there appears to be a relationship between the amount of adhesive coverage and the ultimate tensile test results. This data would indicate that as 50 per cent. adhesive coverage is approached, either a shearing failure or adhesive failure. takes place and consequently, a lower tensile test value. However, even with paper failure, the test value on the average drops as the amount of adhesive coverage drops. Granted, the test level drop obtained with paper failure is small when related to the decreases in the percentage of adhesive coverage, but the results are so uniform indicating a slight drop in tensile value as the adhesive coverage drops, that a good reason should be apparent. We were not able to arrive at a conclusion as to why the test level should drop, with paper failure occurring away from the glue tab area.

(3) *Manufacturer's joint fabrication comparison*

Tensile test levels obtained on boxes manufactured using a striped adhesive pattern appear to be slightly higher for a comparable area of adhesive coverage than those obtained on boxes manufactured using a solid strip pattern.

(4) *Hot melt adhesives vs. regular manufacturer's joint adhesives*

We obtained single or double face liner failure on all manufacturer's joints manufactured using 2, 3 or 4 bead hot melt application. Again, there is some confusion in the test results since the type failure we have obtained would indicate that the maximum paper strength has been obtained. However, the maximum tensile test level obtained with complete paper failure was lower than that obtained for regular adhesives also failing on the single face or double face liner. We are at a loss to explain this difference, especially when you consider that boxes were completely randomised for this study, and so the effects of any variation of paper tensile strength should be lost in our comparisons.

(5) *Comparison of hot melt and regular adhesives vs. taped and stitched joints*

Manufacturer's joints were formed using two types of 2 in. reinforced tape conforming to Rule 41 for use in 200 lb. test boxes not exceeding gross weight of 65 lb. Tensile tests performed on manufacturer's joints formed with this tape indicated tape failure in all instances and an ultimate tensile test value lower than that obtained with either hot melt or regular adhesives even at a very low per cent. of adhesive coverage. As might be expected, tensile tests obtained on manufacturer's joints closed with wire stitches were lower than those closed with tape, regular or hot melt adhesives since the stitches, in most instances, pulled through the corrugated during stress.

(6) *The effects of high humidity*

All manufacturer's joint variables were tested after 72 hour exposure at 100 deg. F.—92 per cent. RH atmosphere. Moisture content of the corrugated material was approximately 20 per cent based on oven dry fibre weight. All hot melt and regular adhesive combinations checked tested approximately 65 per cent. ± 5 per cent. of the original tensile values obtained at 72 deg. F.—50 per cent. RH. Tensile tests obtained on stitched joints after high humidity conditioning were 100 per cent. of the original strength obtained at 72 deg. F.—50 per cent. RH and tensile tests obtained on taped samples after exposure to high humidity were approximately 70 per cent. of the original strength obtained at 72 deg. F.—50 per cent. RH. You will note, however, that the regular and hot melt adhesive manufacturer's joints still tested higher than stitched or taped joints.

(7) *The effects of low temperature*

It was suggested that hot melt adhesives might be more susceptible to damage or strength loss after storage at low temperature. In order to determine this, tensile samples were exposed to 0 deg. F. for 24 hours. Tensile test levels obtained were approximately 75 per cent. of original test values obtained at 72 deg. F.—50 per cent.

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RH. This per cent. retention is essentially the same for all adhesive joints, whether hot melt or regular adhesive. Taped and stitched joints were essentially unaffected by low temperature test conditions.

TABLE II.

BATHURST JOINT TEST RESULTS

IDENTIFICATION			TEST RESULTS[1]					
Adhesive and Application	Coverage[2]		72° F-50% RH		100° F-92% RH		0° F	
	Goal	Actual	#/in.	Type[3] Fail	#/in.	Type[3] Fail	#/in.	Type[3] Fail
Aqueous #1	100%	113%	200	A	152	A	139	A
Solid Strip	75%	91%	233	A	172	A	—	—
	50%	62%	236	A	151	A	—	—
	25%	31%	167	B	92	B	—	—
Aqueous #1	100%	106%	227	A	157	A	162	A
Striped Pattern	75%	91%	184	A	134	A	—	—
	50%	68%	180	A	158	A	—	—
	25%	42%	166	B	102	B	—	—
Aqueous #2	100%	109%	217	A	152	A	149	A
Solid Strip	75%	93%	222	A	146	A	—	—
	50%	59%	184	A	135	B	—	—
	25%	27%	76	C	104	B	—	—
Aqueous #2	100%	114%	230	A	146	A	143	A
Striped Pattern	75%	86%	208	A	145	A	—	—
	50%	70%	198	A	126	B	—	—
	25%	41%	157	B	121	B	—	—
Hot Melt #1 4 Bead ...	—	106%	165	B-A	125	A	136	A
3 Bead ...	—	84%	180	A	137	A	—	—
2 Bead ...	—	67%	147	B-A	115	A	—	—
Hot Melt #2 4 Bead ...	—	86%	199	A	145	A	150	A
3 Bead ...	—	58%	167	B-A	127	B	—	—
2 Bead ...	—	49%	160	B-A	125	B	—	—
Tape #1	—	—	121	D	104	D	110	D
Tape #2	—	—	168	D	135	D	—	—
Stitch	—	—	73	E	51	E	56	E

[1] Averages based on N = 5
[2] 1¼ in. tab coverage considered as 100%
[3] (A) Paper failure—complete rupture *away* from manufacturer's joint
(B) Paper failure—shear failure *in* manufacturer's joint—generally a failure of the secondary surface fibres
(C) Adhesive (manufacturer's joint) failure
(D) Tape failure
(E) Stitch pull out—paper tear failure

TABLE III.

ADHESIVE SOFTENING

DEAD WEIGHT TENSILE

Test Conditions

1 in. wide specimens cut across the manufacturer's joint were suspended in a circulating air oven with a 100 gram dead weight for 24 hours at elevated temperature.

Test Results

1. All tape, stitch and aqueous adhesive, regardless of per cent. of coverage or method of application, passed all 24-hour test cycles from 150° F to and including 190° F where testing was discontinued.

2. Hot melt test results as follows:

		Failure at
Hot Melt #1	4 Bead	180° F
	3 Bead	190° F
	2 Bead	180° F
Hot Melt #2	4 Bead	180° F
	3 Bead	180° F
	2 Bead	170° F

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CORRUGATED GLUE LAP JOINT STRENGTH—*Continued*

SUMMARY

The laboratory tests performed indicate equivalent glued joint tensile, joint Bathurst, box drop and box compression test values for 200 lb. B-flute boxes fabricated with glued manufacturer's joints which varied from approximately 60 to 100 per cent. glue tab adhesive coverage.

From the testing performed it also appears that boxes fabricated with manufacturer's joints adhered with three or four beads of hot melt adhesive are equivalent in strength to boxes fabricated with regular aqueous adhesive glued manufacturer's joints.

While the testing performed would tend to indicate satisfactory box performance for the above conditions —please note the following:

(1) Observations made have validity only in reference to 200 lb. test corrugated boxes and in all probability to lighter test corrugated.

In the case of higher test double wall and triple wall corrugated—the advantage swings to tape and stitch manufacturer's joints which are not as susceptible to glue lap delamination at either the liner and medium glue lines or in the liner facings themselves.

(2) We were unable to devise a realistic test which applies a force to the manufacturer's joint glue line similar to that which is encountered when the box flaps adjacent to the manufacturer's joint are forced in opposite directions. This type of force shears the glued manufacturer's joint from top to bottom.

TABLE IV.

TOP-TO-BOTTOM COMPRESSION TEST RESULTS

STANDARD CONDITIONS[1]

IDENTIFICATION			TEST RESULTS[2]					
Adhesive and Application	Coverage		Average		High		Low	
			Load	Defl.[3]	Load	Defl.[3]	Load	Defl.[3]
	Goal	Actual	(#)	(in.)	(#)	(in.)	(#)	(in.)
Aqueous #1	100%	113%	738	.33	780	.34	700	.33
Solid Strip	75%	91%	742	.36	800	.38	705	.33
	50%	62%	763	.38	805	.36	710	.36
	25%	31%	736	.37	780	.40	665	.37
Aqueous #1	100%	106%	786	.37	825	.36	745	.46
Striped Pattern	75%	91%	726	.35	770	.34	670	.34
	50%	68%	767	.38	820	.40	665	.35
	25%	42%	745	.33	790	.45	655	.34
Aqueous #2	100%	109%	774	.36	835	.37	730	.38
Solid Strip	75%	93%	738	.34	770	.33	700	.34
	50%	59%	736	.34	780	.36	685	.35
	25%	27%	758	.41	830	.37	680	.47
Aqueous #2	100%	114%	728	.34	840	.39	665	.32
Striped Pattern	75%	68%	770	.46	835	.48	735	.49
	50%	70%	768	.38	800	.35	705	.34
	25%	41%	732	.38	790	.38	610	.32
Hot Melt 4 Bead ...	—	106%	866	.48	975	.50	760	.32
#1 3 Bead ...	—	84%	778	.38	840	.35	730	.35
2 Bead ...	—	67%	842	.48	885	.52	790	.37
Hot Melt 4 Bead ...	—	86%	757	.39	815	.48	710	.36
#2 3 Bead ...	—	58%	735	.37	780	.37	680	.37
2 Bead ...	—	49%	761	.40	855	.36	685	.38
Tape #1	—	—	808	.37	855	.39	745	.36
Tape #2	—	—	798	.36	860	.35	745	.37
Stitch	—	—	760	.36	790	.35	715	.35

[1] 72° F-50% RH, 24 hr. minimum conditioning
[2] Average based on N = 10
[3] Defl. = deflection

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Similar forces are occasionally encountered in manual box set-up operations. The force required to shear a manufacturer's joint in this direction is believed to be proportional to the area of adhesive coverage. This type of problem frequently encountered with low surface fibre bond strength materials can be remedied by the use of an inside manufacturer's joint with tabs which extend into the top and bottom flaps.

(3) Laboratory test programmes provide only an indication of the likelihood of satisfactory package performance. Successful product protection and package performance under field conditions are the ultimate criteria for determining box performance.

RECOMMENDATIONS

Our test programme was conducted on boxes fabricated with inside glue lap manufacturer's joints. It is possible that boxes fabricated with an outside glue lap joint may be susceptible to strength losses when manufactured with less than 100 per cent. glue lap adhesive coverage. Investigation of this variable would be desirable.

ACKNOWLEDGEMENTS

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(Tables 6, 7 and 8 concerning this article are overleaf)

TABLE V.

TOP-TO-BOTTOM COMPRESSION TEST RESULTS

HIGH HUMIDITY CONDITIONS[1]

IDENTIFICATION		TEST RESULTS[2]			
Adhesive and Application	Coverage		Average		Strength Retention-(%)
	Goal	Actual	Load (#)	Deflection (in.)	
Aqueous #1 Solid Strip	100%	113%	405	.30	54.9
	75%	91%	395	.30	53.2
	50%	62%	388	.31	50.8
	25%	31%	403	.31	54.8
Aqueous #1 Striped Pattern	100%	106%	430	.32	54.7
	75%	91%	415	.29	57.2
	50%	68%	432	.32	56.3
	25%	42%	407	.30	56.4
Aqueous #2 Solid Strip	100%	109%	428	.31	55.3
	75%	93%	427	.30	57.8
	50%	59%	428	.31	58.2
	25%	27%	418	.32	55.1
Aqueous #2 Striped Pattern	100%	114%	440	.32	60.4
	75%	86%	443	.31	57.5
	50%	70%	437	.31	56.9
	25%	41%	402	.29	54.9
Hot Melt #1 4 Bead	—	106%	438	.37	50.6
3 Bead	—	84%	443	.32	56.9
2 Bead	—	67%	423	.29	50.2
Hot Melt #2 4 Bead	—	86%	390	.28	51.5
3 Bead	—	58%	457	.31	62.2
2 Bead	—	49%	443	.31	58.2
Tape #1	—	—	435	.33	53.8
Tape #2	—	—	478	.32	59.9
Stitch	—	—	393	.35	51.7

[1] 85° F-85% RH, 72 hr. conditioning time
[2] Averages based on N = 3
[3] High humidity test average expressed as percentage of compression test average at 72° F-50% RH

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CORRUGATED GLUE LAP JOINT STRENGTH—*Concluded*

TABLE VI

STATIC LOAD COMPRESSION TESTS

610# STATIC LOAD—72° F-50% RH

IDENTIFICATION			TEST RESULTS				
Adhesive and Application		Coverage		Dynamic Comp. Load[1] (lb.)	Static Load[2] %	Static Load Time to Failure	
		Goal	Actual			Lo Test (min.)	Hi Test (min.)
Aqueous #1 Solid Strip		100%	113%	738	82.6	0	.3
		75%	91%	742	82.2	0	1
		50%	62%	763	79.9	6	39
		25%	31%	736	82.8	1	4
Aqueous #1 Striped Pattern		100%	106%	786	77.6	0	532
		75%	91%	726	84.0	0	744
		50%	68%	767	79.5	0	5
		25%	42%	745	84.4	1	7
Aqueous #2 Solid Strip		100%	109%	774	78.8	1	8
		75%	93%	738	82.6	4	147
		50%	59%	736	82.8	12	162
		25%	27%	758	80.4	5	55
Aqueous #2 Striped Pattern		100%	114%	728	83.7	0	21
		75%	86%	770	79.2	0	16
		50%	70%	768	79.4	0	39
		25%	41%	732	83.3	0	2
Hot Melt #1	4 Bead	—	106%	866	70.4	6	4200+
	3 Bead	—	84%	778	78.4	18	216
	2 Bead	—	67%	842	72.4	2	465
Hot Melt #2	4 Bead	—	86%	757	80.5	1	354
	3 Bead	—	58%	735	82.9	0	10
	2 Bead	—	49%	761	80.1	0	189
Tape #1		—	—	808	75.4	2	141
Tape #2		—	—	798	76.4	2	8
Stitch		—	—	760	80.2	0	2

[1] 72° F-50% RH top-to-bottom compression average
[2] Percentage of 72° F-50% RH top-to-bottom compression average

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TABLE VII.

BOX DROP TEST RESULTS

(36 IN. DROP)[1]

IDENTIFICATION			TEST RESULTS[2]					
			40# Product			55# Product		
Adhesive and Application	Coverage Goal	Coverage Actual	Avg. (# Drops)	Hi	Lo	Avg. (# Drops)	Hi	Lo
Aqueous #1 Solid Strip	100%	113%	16.4	20	14	8.0	11	5
	75%	91%	16.0	19	13	8.0	9	7
	50%	62%	16.8	21	13	7.2	10	5
	25%	31%	9.6	16	7	4.6	9	3
Aqueous #1 Striped Pattern	100%	106%	13.2	17	9	7.6	12	6
	75%	91%	13.6	15	12	7.8	10	6
	50%	68%	11.2	12	11	6.6	9	5
	25%	42%	8.6	11	7	4.6	5	3
Aqueous #2 Solid Strip	100%	109%	16.2	19	14	7.4	9	5
	75%	93%	21.6	26	17	7.2	10	5
	50%	59%	18.2	20	16	8.2	11	7
	25%	27%	4.8	11	1	4.0	6	1
Aqueous #2 Striped Pattern	100%	114%	13.6	16	11	6.6	8	5
	75%	86%	15.0	23	11	7.2	9	6
	50%	70%	13.6	17	13	5.8	7	5
	25%	41%	10.2	13	5	3.6	5	2
Hot Melt #1 4 Bead	—	106%	11.0	15	7	4.8	7	2
3 Bead	—	84%	15.4	19	11	6.8	7	6
2 Bead	—	67%	13.4	15	11	6.4	7	5
Hot Melt #2 4 Bead	—	86%	11.8	13	11	5.6	7	5
3 Bead	—	58%	12.2	16	7	5.2	7	4
2 Bead	—	49%	13.2	17	11	6.4	8	5
Tape #1	—	—	2.8	4	2	1.4	2	1
Tape #2	—	—	3.4	4	3	2.2	3	2
Stitch	—	—	2.8	3	2	1.2	1	2

[1] 36 in. drops on box edges radiating from manufacturer's joint
[2] Number of drops prior to product loss.
Averages based on N = 5. All specimens were tested after conditioning 24 hours at 72° F-50% RH.

TABLE VIII

ADHESIVES TESTS

	Aqueous #1	*Aqueous* #2
Rate-of-Set (seconds) (average of 4 tests) TAPPI Monograph 26, p. 74)	Pick = 7.5 Stick=11.5	Pick =6 Stick=9
Heat Resistance Test (TAPPI Monograph 26, p. 71)	Average=105°C	Average=132°C
24 Hour Immersion in Water at 72°F	Softening of the glue line for both adhesives. Pulling the lamination apart revealed no fibre failure.	
Viscosity Brookfield (centipoise) (N=10)	1123	908

Adhesive samples from suppliers had been previously evaluated and were found to be satisfactory for water resistance in accordance with Mil-A-101A which requires 75% fibre pull after 24 hour immersion.

Production samples tested did not freely delaminate after 24 hours immersion; however, no fibre pull was evident.

Paper Exports Up Again

Paper and board exports during the first two months of this year were up 17 per cent. in value and 18 per cent. in volume over the same two months of last year. This was revealed at an export promotion conference organised by the British Paper and Board Makers' Association in London.

Mrs. Gwyneth Dunwoody, Parliamentary Secretary to the Board of Trade, told the conference it was encouraging to note the very substantial increase in the industry's exports since their previous conference—from £33 million in 1967 to £49 million last year, a rise of nearly 50 per cent. in two years. Mrs. Dunwoody said there had been a near comparable increase in exports of manufactures of paper and board from £20 million to £29 million in the same period. "This is no mean achievement by any standards," she said.

Mr. J. Neil Findlay, chairman of the Export Promotion Committee of the Association, expressed the view that the industry would probably not achieve the same high rate of growth in 1970 as in 1969 due to the slowing down of the American economy, the reduction in the E.E.C. rate of growth, new production in Nordic countries of the more exportable grades and other factors. He called on the Government for direct assistance to establish exports and he did not accept the validity of alleged international political impediments on account of GATT and EFTA.

Mr. Geoffrey Pethick, director of the Association, referred to the new responsibilities of the Board of Trade for exports and their effect on the work which a trade association could do. He suggested that possible ways in which a trade association could help its members would be in providing advice through a panel of experts drawn from the industry and in helping to get the market right by providing information too specialised for the Board of Trade to handle.

* * *

Well Designed Machine Hood for Papermakers

A new machine hood, incorporating the Brunnschweiler-Sturtevant Auto-Curtain system, was recently installed on the new papermaking machine at Thos. Tait & Sons Ltd., Inverurie Paper Mills, Aberdeenshire. Sturtevant undertook the complete installation, including the machine hood with exhaust system, underfelt plant and machine house ventilation. The Brunnschweiler-Sturtevant Auto-Curtain features a flexible plastic curtain which is raised to half or fully opened positions in seconds by push-button control, giving all the advantages of a totally enclosed hood, plus rapid access to any part of the machine without obstruction. The cost is little more than that of a conventional canopy hood.

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