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Comparison of 60# white converter kraft to 60# white Velumina kraft for use in multi-wall paper bags

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Comparison of 60# white converter kraft to 60# white Velumina® kraft for use in multi-wall paper bags

By

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ABSTRACT

This study was designed to analyze the change from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft on the outer ply of multi-wall paper bags. Logisitical issues were driving the change but Good Manufacturing Practices had to be observed as the bags were being used for Food and Drug Administration registered medicated animal feed products. The papers were tested for physical strength and print quality. Results showed that the 60# Georgia-Pacific white Velumina® kraft was equal to the 60# Gilman white converter kraft in physical strength and slightly better in print quality. Both papers met the performance standards of the current application and either paper could be used with confidence that bag performance would not suffer.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

This study was designed to analyze the change from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft on the outer paper ply of multi-wall paper bags. The hypothesis was that 60# Georgia-Pacific white Velumina® kraft was equal to or better than 60# Gilman white converter kraft in physical performance, print performance and logistical issues. The proposal to switch from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft originated from the Bemis Company Peoria bag plant and was submitted to the author, an Elanco Packaging Engineer. The engineer was to assess if a change in specification was needed and if the paper change would affect the bags physical and print performance.

There were several reasons to make the change from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft. Bemis had logistical problems with the Gilman converter sheet. Elanco, being a Federal Drug Administration(FDA)Good Manufacturing Practices(GMP's) regulated industry, needed to ensure changes in package materials would not affect the safety, identity, strength, purity and quality (SISPQ) of the registered products (Code of Federal Regulations Section 21 Part 211.122).

1.1 LOGISTIC ISSUES

Bemis Peoria had several logistical problems with the 60# Gilman white converter kraft. Elanco was the only customer they had that required the 60# white converter. Elanco had two different size bags that required the converter kraft and the different bag sizes meant Bemis Peoria had to order two different roll sizes 43 ¾" wide and 45 ¾" wide. The Elanco bags were for two different product lines thus the different bag sizes. The paper volumes that Elanco required for the two bags were very low at approximately 75,000 pounds per year. The 60# white converter supplier, Gilman Paper Company, required Bemis to purchase a minimum of 180,000 pounds or well over a two year supply of the paper Elanco had specified (Wagner,1998). Bemis Peoria was not equipped to store paper for that long and would have had to use the more expensive paper on bags that did not require it to move the inventory to an acceptable level. Bemis would have had to absorb the cost of putting better paper into bags or would need to pass some of the "extra" costs onto Elanco. Elanco only wanted to pay for better paper on their two bags and did not want to be charged for the storage and "extra" expenses. Bemis procurement also realized that the only paper they were buying from Gilman Paper Company was the 60# white converter kraft. Eliminating a supplier would help simplify their procurement processes. Bemis is a non-integrated bag manufacturer and because of this they have formed several strong alliances with paper suppliers.

As Bemis looked to replace the converter kraft, they turned to Georgia-Pacific. Georgia-Pacific was one of the Bemis preferred paper suppliers and had a new paper, Velumina®, that matched up well with the converter kraft in terms of print quality and strength. Paper specifications are in APPENDIX B. Georgia-Pacific was contacted and arrangements made to evaluate the Velumina® as a replacement for the Gilman converter kraft. Georgia-Pacific did not require Bemis Peoria to order a minimum amount of 60# white Velumina® kraft and offered it at a competitive price (Larson,1998). After successful test runs at Peoria, Bemis procurement approved the change from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft. This change took place at the start of 1998 along with the approval of Elanco Package Engineering. Both Bemis and Elanco Package Engineering agreed to continue to gather data on the 60# Georgia-Pacific white Velumina® kraft versus 60# Gilman white converter kraft.

1.2 GMP ISSUES

It is critical that the medicated animal feed made by Elanco be properly used by the Elanco customers. Elanco is responsible to insure that product, package and usage instructions are correct and applicable. This is regulated by the FDA through the GMP core values referred to as SISPQ. By evaluating the paper change versus each of the core GMP values, the areas of testing were identified. TABLE 1 lists the core values and their definitions as interpreted by Eli Lilly Quality Assurance (Lilly,1995).

TABLE 1 GMP CORE VALUES

Value	Definition
Safety	All products remain free of unexpected side effects when taken by the patient
Identity	Maintain product identity so that product contains exactly what labeling says it contains.
Strength	Assure that product's strength is always as specified, and that it contains the correct dosage and potency.
Purity	Preserving product purity by protecting it from contamination.
Quality	Assure that products meet the standards and expectations of medical professionals and regulatory agencies around the world and the products perform as claimed.

Based on the GMP core value definitions and paper change details, the core values of Safety, Strength and Purity were deemed to be unaffected. The multi-wall bag used in this study has a 2.5 MIL Linear Low Density Polyethylene film inner liner. The polyethylene liner is the contact surface with the product and provides the package barrier against moisture, gas, or grease. As Scott stated, the paper plies of the bag provide the support and structure for the bag, but no moisture, gas, or grease barrier (1995). Thus, the change to the outer paper ply will not affect the packages performance to keep the product at the proper potency.

Identity is a very important GMP core value and the paper change could affect the text on the bag. The bags in this study require better print quality paper than just regular white bleached kraft. Instructions for mixing the medicated feed are printed on the bags making it important that all of the FDA approved text be legible on the bag. A comparison test needs to be completed to assure that the 60# Georgia-Pacific white Velumina® sheet has acceptable print quality. The 60# Gilman white converter sheet has not had print quality issues so if the Velumina® sheet can be found equal to the Gilman converter sheet, it can be granted acceptable print quality. Since, the filled bags are not sold in a retail environment the print quality issues focus on legibility more than color brightness or dot gain.

The last core value, Quality, tends to cover the broad category of package and product performance. The change in outer ply could affect the bag's strength or ability to withstand shipping stresses. Though the basis weight of the converter and Velumina® are both 60#, testing should be done to assure that the change will not weaken the bag.

In summary, the study to analyze the change from 60# Gilman white converter kraft to 60# Georgia-Pacific white Velumina® kraft will need to include tests that assure the bag's print and physical performance will not suffer. For business reasons, the logistical issues favored the 60# Georgia-Pacific white Velumina® kraft or the change would not have been proposed.

CHAPTER 2 LITERATURE REVIEW AND BACKGROUND

CHAPTER 2 will cover details on the companies, papers and bags involved in this study. Please refer to APPENDIX B for complete paper and bag specifications.

2.1 COMPANIES

For this study, the customer or user of the multi-wall paper bags is Elanco Animal Health, a division of Eli Lilly and Co. Elanco manufactures medicated animal feed products. Though they manufacture and sell their products all over the world, the filling operation at Clinton Laboratories in Clinton, Indiana is the site that buys and fills the bags that were using converter kraft outer plies on Pinch Bottom Open Mouth(PBOM)bags. Elanco's customers receive the medicated feed products and blend them into animal feed rations for poultry, swine and cattle. FIGURE 1 shows the flow of critical materials and products for the bags used in this study.

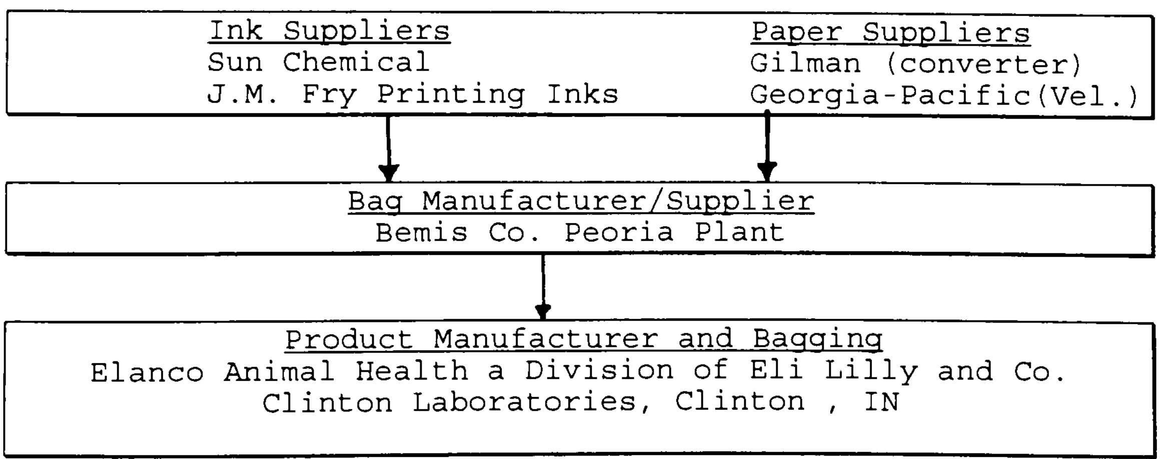


FIGURE 1 MATERIAL AND SUPPLIER FLOWCHART

2.2 PAPER

Several companies manufacture the converter quality grade of paper (Larson,1998). A list of the companies and their mill locations is in TABLE 2. For this study, Gilman and Georgia-Pacific were the focus.

TABLE 2 CONVERTER GRADE MANUFACTURERS AND MILLS

Manufacturer	Mill
Gilman	St. Marys, GA
Georgia-Pacific	Palatka, FL
International Paper	Mobile, AL
Simpson	Tacoma, WA
Longview Fiber	Longview,WA

Converter kraft has been available for a long time and is used in many bag and print operations as a step up from regular bleached white kraft. Gilman has been making this soft calendered grade of paper since the mid-to-late 1980's (Larson,1998). Both Georgia-Pacific and Gilman manufacture various basis weights of the converter/Velumina® grade. Velumina® was developed as an alternative sheet for clay coated paper customers in 1996 (Arendsen, 1997). Velumina® provides the print quality that customers want, but is cheaper than clay coated paper. Because Velumina® supplies more strength to the bag (Walker,1998) customers were able to reduce the basis weight of their plies and save money (Wells,1998). Elanco is not changing from a clay coated sheet so Velumina® does not offer the advantage of dropping basis weight.

Both the Georgia-Pacific Velumina® and the Gilman converter are kraft papers made using the kraft process. The word kraft is from the German word for "strong" (American Forest Paper Association,1998) and kraft papers are meant to do work. According to Soroka, "The kraft process, when used with long-fiber softwoods, yields the strongest of the wood-based papers"(1995). Unfortunately, bleaching the natural kraft to get white kraft paper does weaken some of the fibers (Kline,1991). Regular natural kraft or bleached white kraft does not have a nice smooth surface to hold the ink up and will tend to absorb the ink into its surface causing the printing to lose its crisp appearance. Converter kraft and Velumina® kraft are specially processed to give them a better surface for printing. Also, converter kraft has many industry interpretations. Although each supplier's converter kraft may be slightly different, it was agreed that converter kraft does mean a soft calendered kraft (Hodges,1998). For reference, FIGURE 2 shows the paper making process and the calender section is identified. The Velumina® kraft is processed with a soft-nip calender and a special calender steam shower (Arendsen, 1997). Scott describes the soft calender as the part of the press section whose role is to decrease the water in the sheet, and decrease the surface roughness (1995). Soroka added that heat, pressure and time are controlled conditions that affect the paper during calendering (1995).

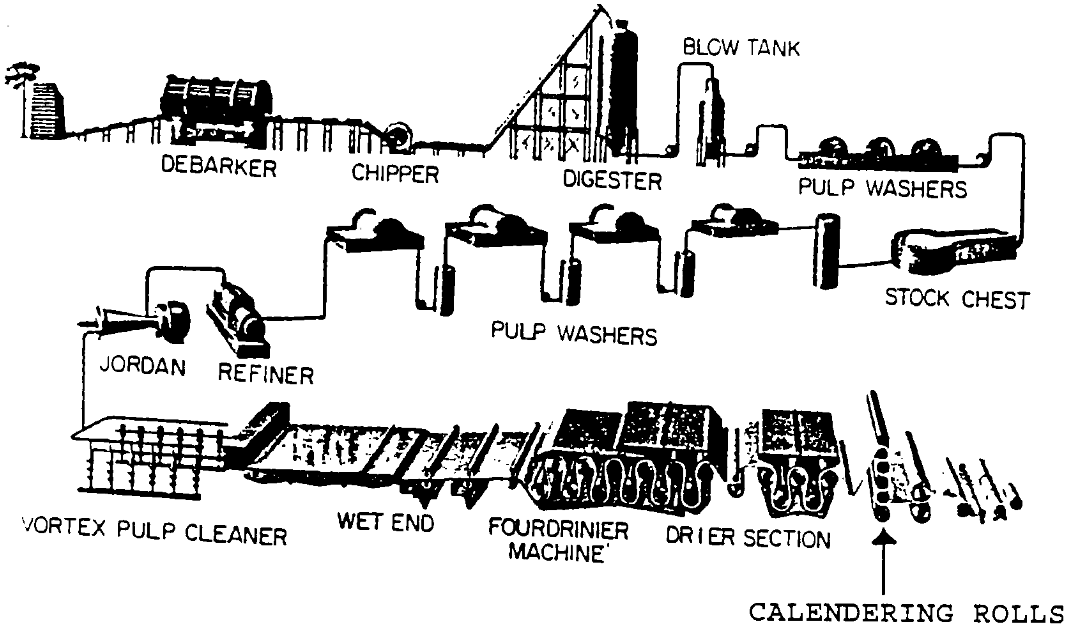


FIGURE 2 PAPERMAKING PROCESS

To improve the paper's surface, a soft calender is rolled over a steel calender and in the process pulls up the valleys in the paper surface and pushes down the peaks without causing too much water pressure to build up and disrupt the web structure (Scott,1995),(Cutrer,1998). Due to proprietary information, the Gilman and Georgia-Pacific calendering processes can not be compared head to head. It can be assured that the calendering step is vital to creating the higher print quality bleached white kraft sheet.

Velumina® kraft does have a raw material difference from the converter kraft in that it has twenty-two percent hardwood added to the sheet instead of all softwood (Arendsen 1997, Cutrer,1998). Kline warns that the increase in hardwood makes the paper smoother but could have weakened the paper strength (1991). Both papers are made from virgin fibers and are FDA approved (Larson,1998). The paper specification sheets, in APPENDIX B, do not list what sizing agents or filler pigments are used in the calendering for converter or Velumina®. The paper suppliers would not reveal this proprietary information, but the Gilman converter kraft does not feel or appear to be coated like the Georgia-Pacific Velumina® kraft (Wells,1998). Since the outer ply does not touch the product or affect the product purity, defining the sizing and coating ingredients will not be necessary.

Exploring the print quality of the two papers, leads to trying to define print quality. For regulated products the text print quality is very important versus in retail the lot to lot printing of logos and pictures must be consistant. Print quality will focus on text legibility for this study as the end products are not sold in the retail environment and graphic requirements are minimal. In general, if the paper surface is rough, the print will tend to be grainy (Eldred,1993). Also, from Eldred, if the surface is absorbent, ink will tend to soak into the sheets or feather, again causing dot gain and ragged edges(1993). So by testing for how the papers react to moisture, it will show the tendency for the paper to have higher or lower ink holdout. Higher ink holdout is preferred because it gives stronger colors, crisper text (Eldred,1993) and uses less ink. Using less ink increases the ink mileage, area covered by a given volume of ink, and saves the printer money.

2.3 BAGS

The Pinch Bottom Open Mouth(PBOM) multi-wall bags used in this study have three 60# paper plies and an inner ply of 2.5 MIL Linear Low Density Polyethylene(LLDPE). FIGURE 3 shows the basic material characteristics of the PBOM style. PBOM bags are used because they offer several advantages to the sewn or valve style of bag. See TABLE 3 below (Bancroft,1992).

TABLE 3 ADVANTAGES OF PBOM BAGS

Advantages of PBOM Bags
1. Provides sift proof closure
2. Can employ a variety of barrier plies
3. Can be packed on automatic equipment

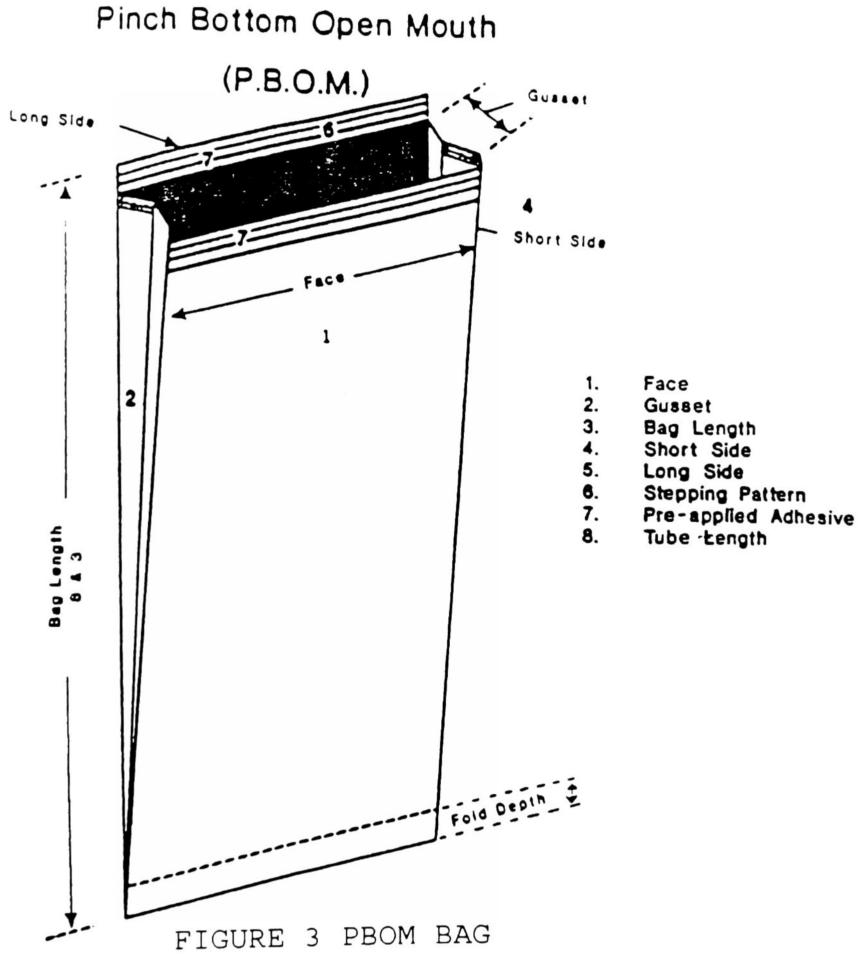


FIGURE 3 PBOM BAG

PBOM bags are generally used to package more expensive or sensitive products than sewn bags(Bancroft,1992). The majority of Elanco bags are PBOM with a regular bleached white kraft outer ply but the bags for this study specify white converter kraft because they need a better print quality paper. They have more colors, more ink coverage and smaller print than the normal Elanco bags. In the GMP section of CHAPTER 1, the significance of the inner ply and paper plies was covered. With specifications, the materials and size of a bag can be compared. The only issue specifications do not cover in detail is the performance criteria for the bag. Each customer will have different shipping conditions, different products and different expectations of what is acceptable quality bags.

In the twenty years that Elanco has used pinch style bags, the distribution and handling of the bags has been documented and criteria for bag performance has been developed. Bags going from the filling operations at Clinton have been shipped via truck, rail, sea and even air to distribution points all over the world. The pallets will be broken down at least once as bags pass through the distribution system. The end customer will have handled the bags prior to opening and mixing them with feed. The expectation has developed that the bags must withstand several movements and drops during their life span prior to being portioned into a mixer by a customer. The bags should not be leaking product from any seal or rip and the bags should be able to protect the product from normal warehouse conditions. Drop testing the bag with four drops on either face from 48" has been the accepted criteria for drop testing. This is written into the bag specifications. Bag specifications are in APPENDIX B. Filled pallets of bagged product are about 48" high and 48" would be the maximum drop height for someone carrying the bag. Thus it was concluded that the four drops from 48" test was acceptable.

CHAPTER 3 METHODOLOGY

The focus of the testing was to check the suitability of the 60# Georgia-Pacific white Velumina® kraft to replace the 60# Gilman white converter kraft in physical strength and printing quality. TABLE 4 is a quick summary of the tests run for this study and the test methods.

TABLE 4 TESTS AND TEST METHODS

Characteristic	Test	Test Method
Physical	Tensile CD	TAPPI T 494
	Tensile MD	TAPPI T 494
	Elmendorf Tear	TAPPI T 414
	Drop Test	ASTM D 959
Printing	Moisture Analysis	
	Water Absorptivity	TAPPI T 441
	Text Comparison	

3.1 PHYSICAL TESTING

The physical testing of the 60# Gilman white converter kraft and the 60# Georgia-Pacific white Velumina® kraft took place at the Bemis Paper and Packaging Testing Laboratory in Omaha, Nebraska. Bemis lab personnel ran the tests with the author, an Elanco Packaging Engineer present. Bemis was chosen to run the tests over the Lilly/Elanco Packaging Laboratory because of the availability of equipment designed for testing bags and because of their experience in testing bags and paper. Elanco's lab does not often run Technical Association of the Pulp & Paper Industry (TAPPI) paper tests and it was thought that there would be greater chance for variability due to operator unfamiliarity with procedures.

After discussions among the Bemis lab personnel and the author, it was decided that three tests would be run to compare the physical performance of the papers: tensile, tear, and drop. The strength of each paper sheet would be tested with the tensile and tear. The sheet's performance in the bag would be tested by the drop test. Tensile testing shows the sheet's ability to absorb energy and indicates the durability of the sheet. As plies in the bag, the sheets are subject to repeated straining and stressing (TAPPI T494 Sec. 3.3). Smook states, "The Elmendorf tear test is recognized as a good measure of fiber strength within the sheet" (1992). The drop test is the accepted customer test of package performance. The customer criteria for the drop test was discussed in CHAPTER 2 in the 2.3 BAG section. The drop test is a good measure of how the change in outer ply affects the whole bag's ability to perform. Here are the specifics on each of the physical tests:

3.1.1 TENSILE TEST

Date: 5/7/98

Tester: David Sanzobrin - Bemis Quality Systems Manager

Test Method: TAPPI T494 Tensile breaking properties of paper and paperboard (using constant rate of elongation apparatus) Method in APPENDIX C.

Samples: 60# Gilman white converter kraft, 60# Georgia-Pacific white Velumina® kraft from Bemis, Peoria paper supply

Sample size: Approx. 7 samples/paper/direction, 1″ wide

Conditioning: The paper samples were not specially conditioned as the testing was for comparison. The Bemis lab is kept at a constant 50% humidity and 73 degrees F. The paper samples were in the lab for over 48 hours under similar conditions.

Testing Apparatus: INSTRON Model 1011

Tests: Tensile Machine Direction and Cross Direction

3.1.2 TEAR TEST

Date: 5/7/98

Tester: David Sanzobrin - Bemis Quality Systems Manager

Test Method: TAPPI Internal tearing resistance of paper (Elmendorf-type method) Method in APPENDIX C.

Samples: 60# Gilman white converter kraft, 60# Georgia-Pacific white Velumina® from Bemis, Peoria paper supply

Sample size: 5 samples/paper/direction, 2 ½ IN X 3 IN

Conditioning: The paper samples were not specially conditioned as the testing was for comparison. The Bemis lab is kept at a constant 50% humidity and 73 degrees F. The paper samples were in the lab for over 48 hours under similar conditions.

Testing Apparatus: TMI- Model 83-11-00 Tearing Tester

Tests: Internal Tear- Machine Direction and Cross Direction

3.1.3 DROP TEST

Date(s): 5/7/98-5/8/98

Tester: Brad Walker Bemis Packaging Engineer

Test Method: The American Society for Testing & Materials

ASTM D 959 Drop Test for Filled Bags. Method in APPENDIX C.

Bags: Six PBOM bags manufactured by Bemis Peoria plant

BAGS 1,2,3

Samples pulled from approved production lots at Clinton Laboratories and were manufactured by Bemis Peoria in March of 1998.

(4-ply inside to outside)
1 2.5 MIL Linear Low Density Polyethylene
2 60# Natural Kraft
1 60# White Velumina® kraft with anti-skid coating
Dimensions: 16 IN X 6 ½ IN X 32 IN
Capacity: 25 KG

BAGS 4,5

Samples pulled from approved production lots at Clinton Laboratories and were manufactured by Bemis Peoria in 1997. Only two of the older run bags, sized like Bags 1-3, were available in May 1998 for testing as the Clinton inventory of those lots had been exhausted.

(4-ply inside to outside)
1 2.5 MIL Linear Low Density Polyethylene
2 60# Natural Kraft
1 60# White Converter kraft with anti-skid coating
Dimensions: 16 IN X 6 ½ IN X 32 IN
Capacity: 25 KG

BAG 6

Sample from a different Elanco product line than Bags 1-5 but of same materials. Bag 6 was slightly smaller in the gussett and shorter in length than Bags 1-5. To assure that Bag 6 was filled to the same level with the same amount of freeboard as Bags 1-5, the bag volumes of Bag 1 and Bag 6 were calculated and Bag 6 needed to be filled at 81.97% of Bag 1 or instead of

25,000 grams, Bag 6 needed 20,493 grams. Bag 6 was filled with the 20,493 grams and tested the same as Bags 1-5.

(4-ply inside to outside)
1 2.5 MIL Linear Low Density Polyethylene
2 60# Natural Kraft
1 60# White Converter kraft with anti-skid coating
Dimensions: 16 IN X 5 ½ IN X 31 IN
Capacity: 25 KG

Testing Fill Material: 2-L-Lysine Monohydrochloride 98.5% Feed Grade, density 38lb./cubic ft. Elanco animal feed products were not used due to regulatory and safety precautions but the density of 38lb./cubic ft. and granulation of the Lysine are very similar to the Elanco products.

Sealing: All bags were filled and sealed at the Bemis lab on the Bemis Aero-Sealer Model 4601 at a sealing temperature of 503 degrees F.

Conditioning: The empty bags were not specially conditioned as the testing was for comparison. The Bemis lab is kept at a constant 50% humidity and 73 degrees F. The paper samples were in the lab for over 48 hours under similar conditions.

Testing Apparatus: Gaynes Engineering, Inc. drop tester

Number and Height of Drops: Each bag was dropped four times on either face from a height of 48".

Criteria for Drop Test: Filled bags must withstand the drops and not show visible leaking of product or failure of top or bottom seals. Scuffing or cracking of outer ply is acceptable as long as inner plies continue to contain and protect the product. The drop test and critera is standard for all Elanco multi-wall bags and is written into the bag specifications.

3.2 PRINT QUALITY TESTING

The print quality testing of the two papers was completed at two different locations. The moisture analysis and water absorptivity tests were performed at J.M. Fry Printing Inks and the text comparison texts were completed at Eli Lilly and Co. Printed Packaging Materials department. The moisture tests were designed to show the ink hold out and mileage of the two papers. Since the reason for using converter kraft was improved print quality, it needed to be proven that the Velumina® would not have a lesser print quality. There is no standard test for testing print quality. With the variety of end users and materials, different levels of print quality are acceptable. For the pre-printed bags in this study the critical need was that all the print be legible without missing letters or fill ins. The text comparator allows a more quantitative check for this type of printing quality. If the study bags were going to the retail market, more extensive tests on color and brightness would have been justified. Here are the details on each of the print quality tests:

3.2.1 MOISTURE ANALYZER TEST

Date: 5/26/98

Tester: Frank Mayfield - J.M.Fry Research Associate

Test Method: Heated each sample at 109 deg.C for 20 minutes

Samples: 60# Gilman white converter kraft, 60# Georgia-Pacific white Velumina® kraft from Bemis, Peoria paper supply, same rolls as were sampled for the physical strength tests.

Sample Size: 2 samples/paper, 1" X 1"

Conditioning: The paper samples were not specially conditioned. Both sample rolls from Bemis had been in the J.M.Fry lab conditions for over 48 hours. It could be assumed that the rolls were equally conditioned to the lab environment. The lab is not temperature or moisture controlled.

Testing Apparatus: Metler Toledo H653 Halogen Moisture Analyzer

Test: Moisture Analysis

3.2.2 COBB WATER ABSORPTIVENESS TEST

Date: 5/26/98-5/27/98

Tester: Frank Mayfield - J.M.Fry Research Associate

Test Method: TAPPI T 441 Water absorptiveness of sized (non-bibulous) paper and paperboard (Cobb Test). Method in APPENDIX C.

Samples: 60# Gilman white converter kraft, 60# Georgia-Pacific white Velumina® kraft from Bemis, Peoria paper supply, same rolls as were sampled for the physical strength tests.

Sample Size: Four sets (side in, side out) of 5½" X 5½" samples/paper

Conditioning: The paper samples were not specially conditioned. Both sample rolls from Bemis had been in the J.M.Fry lab conditions for over 48 hours. It could be assumed that the rolls were equally conditioned to the lab environment. The lab is not temperature or moisture controlled.

Testing Apparatus: Teledyne Gurley Cobb Sizing Tester

Tests: Side In, Side Out Water Absorptivity

Timing: Samples were exposed for 60 seconds.

3.2.3 TEXT COMPARATOR

Date: 5/30/98

Tester: Jeff Camp Eli Lilly and Co. Printed Materials Packaging Printing Coordinator

Test Method: Comparator overlays magnified proof copy over original and graphically highlights differences.

Samples: Were taken from full size tear sheets of 60# Gilman white converter kraft and 60# Georgia-Pacific white Velumina® kraft pre-printed with seven color text of actual bag. Both sheets were printed on the same day at Bemis, Peoria plant as an actual Elanco print run was occurring.

Sample Size: Six samples/sheet/paper

Conditioning: Both tear sheets had been shipped and stored in the same shipping tube. No special conditioning of the samples took place prior to the test.

Testing Apparatus: Global Vision Text Verification System

Tests: Comparison to identify if print quality is equal.

CHAPTER 4 DATA AND RESULTS

For this study, several tests were run to confirm physical performance and print quality. Physical performance of the Gilman converter and Georgia-Pacific Velumina® was checked with tensile, tear and drop tests. Ink absorption, a feature related to print quality (Eldred,1993), was tested using moisture analysis and the Cobb Absorptivity tests. The final print check was done using a text comparator to confirm actual print on the Gilman converter sheet versus print on the Georgia-Pacific Velumina® sheet. Complete sets of the test data are located in APPENDIX A.

4.1 TENSILE STRENGTH COMPARISON

TABLE 5 TENSILE CROSS DIRECTION

PAPER 60# white	*MEAN LOAD (lbf)*	*MEAN DISPLACEMENT (in)*
Converter Kraft	19.721	0.203
Velumina® Kraft	18.532	0.259

In TABLE 5 the Georgia-Pacific Velumina® kraft sample stretched more before breaking than the Gilman converter kraft sample but the Georgia-Pacific Velumina® kraft sample broke at a lower load.

TABLE 6 TENSILE MACHINE DIRECTION

PAPER 60# white	*MEAN LOAD (lbf)*	*MEAN DISPLACEMENT (in)*
Converter Kraft	45.069	0.113
Velumina® Kraft	35.661	0.117

TABLE 6 showed a different result than TABLE 5 in that both papers stretched to about the same distance before breaking but again the Georgia-Pacific Velumina® broke at a lower load.

FIGURE 4 is a summary of the test charts for each paper and direction. It is expected that the machine direction be stronger but less flexible than the cross direction as the data show.

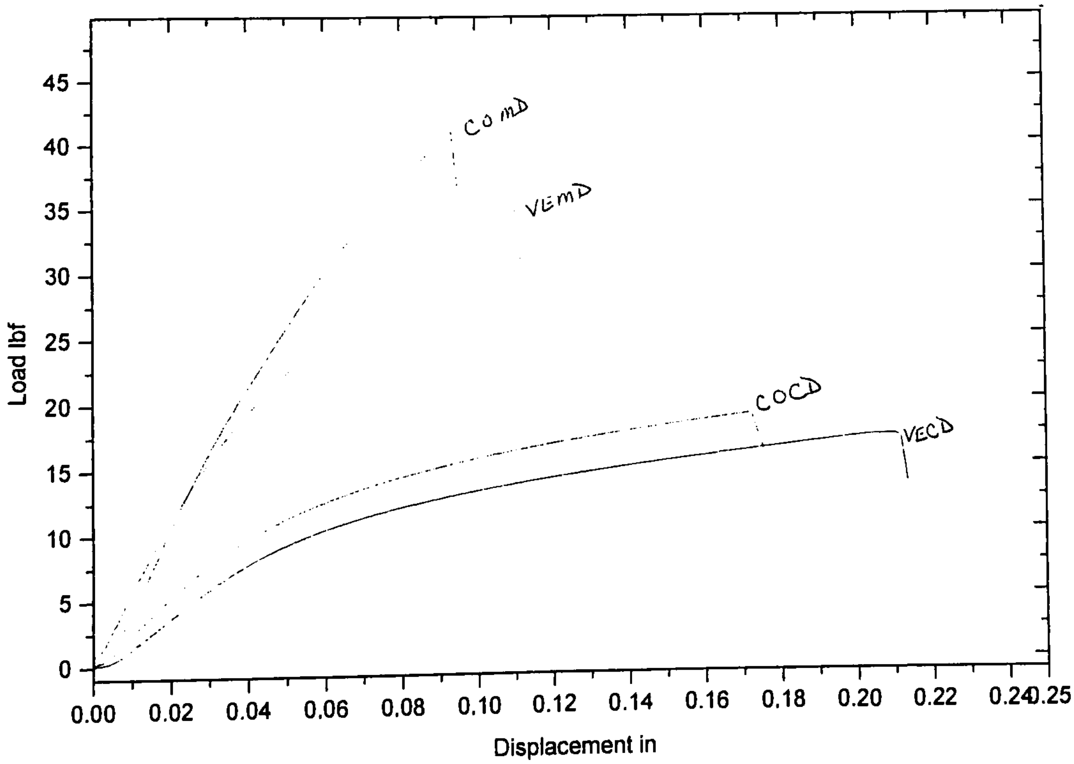


FIGURE 4 TENSILE TEST COMPARISON

4.2 TEAR STRENGTH COMPARISON

TABLE 7 TEAR TEST RESULTS

PAPER 60# white	*Mean Machine Direction (grams) w/Std. Deviation*		*Mean Cross Direction (grams) w/Std. Deviation*	
Converter Kraft	100.3	13	124.6	10
Velumina® Kraft	131.2	21.9	122.1	15.9

In the machine direction, the Velumina® required more force to tear than the converter. The deviation for the Velumina® was high at 21.9 but Walker assured that for paper 10-20% deviation was normal (1998). The two plies were basically equal in the cross direction. The machine direction provides some structural support but it is critical when the sheet is printed and formed into bags as the sheet is pulled in the machine direction. The cross directional strength is important to allow the bag to handle forces when it is dropped.

4.3 DROP TEST

TABLE 8 DROP TEST RESULTS

Bag	*48″ Drops*	*Pass/Fail*	*Comments*
Bag 1-V	4	Pass	
Bag 2-V	4	Pass	
Bag 3-V	4	Pass	
Bag 4-C	4	Pass	
Bag 5-C	4	Pass	
Bag 6-C	4	Pass	Adjusted fill

The drop test is a good physical simulator for the bags real environment. The detailed paper sheet to paper sheet comparison is helpful in identifying potential strength differences but the true test is if in the application, as outer ply in a multi-wall paper bag, the bag's performance is acceptable or not. Since all the bags passed the drop test, it can be assured that the Velumina® physically performs as well as the Gilman converter for this application.

4.4 MOISTURE ANALYSIS

TABLE 9 PERCENT MOISTURE

Paper	Test No. 1	Test No. 2
Converter Kraft	8.91	8.77
Velumina® Kraft	7.77	6.21

The moisture analyzer showed that the Velumina® in an uncontrolled environment absorbs less of the moisture in the air. This sheet characteristic can be related to how the sheet would react to ink. It would be expected that the Velumina® would have better ink holdout since less ink would be absorbed into the sheet.

4.5 COBB ABSORPTIVITY TEST

TABLE 10 ABSORPTIVITY (g/m2)- COBB TEST

	Avg. Side Out	Avg. Side In	Max. Value Side In	Min. Value Side In
Gilman Converter	23.08	22.25	24.60	20.00
Georgia-Pacific Velumina	23.98	21.23	22.50	20.70

Though both the side in (wire side) and side out (felt side) were tested, the side in data were focused on as it is the printing side of the paper sheets.

FIGURE 5 shows that there is no significant difference between the two paper's side in absorptivity at a 95% confidence level. Like with the moisture analysis, the lower the absorptivity the better a paper will print.

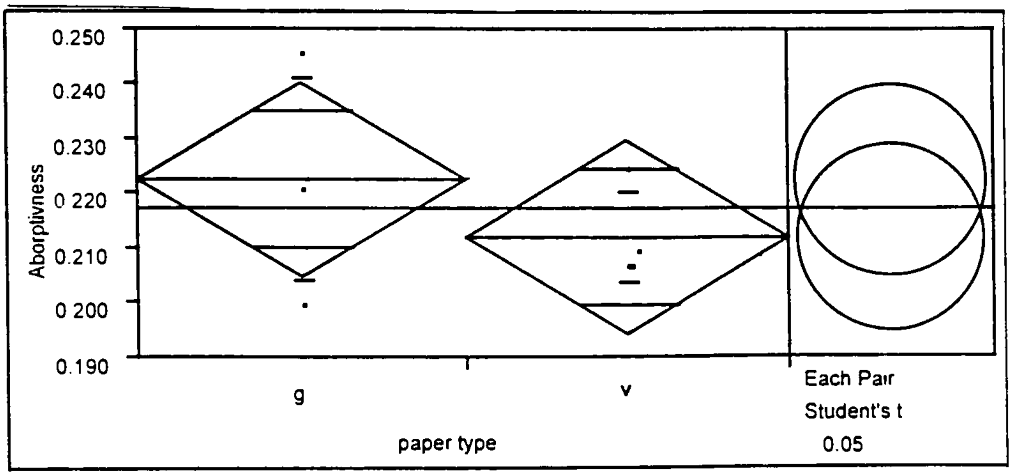
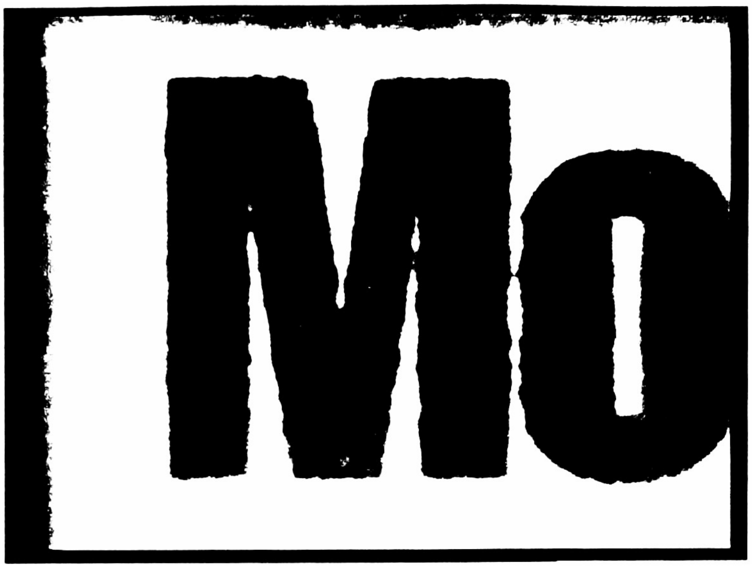


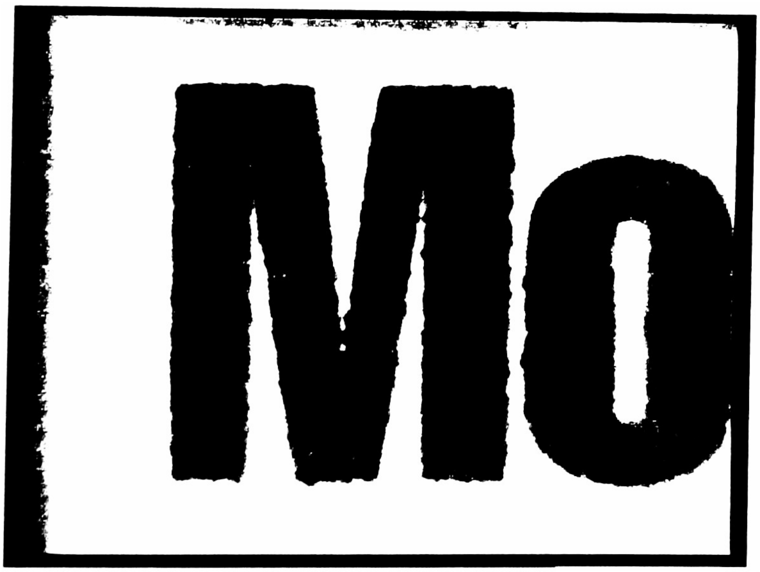
FIGURE 5 ABSORPTIVENESS CHART

4.6 TEXT COMPARISON

FIGURES 6, 7 and 8 are pictures taken with the text verification system. The picture on the top is from the Gilman converter sheet and the picture on the bottom is from the Georgia-Pacific Velumina® sheet. Differences in the print are visible. The Velumina® has better print quality than the Gilman converter as shown by the cleaner lines between letters (Example:FIGURE 7 pe and og) Both the Velumina® and the Gilman converter print quality is acceptable as there are no fill ins or blurring of words.

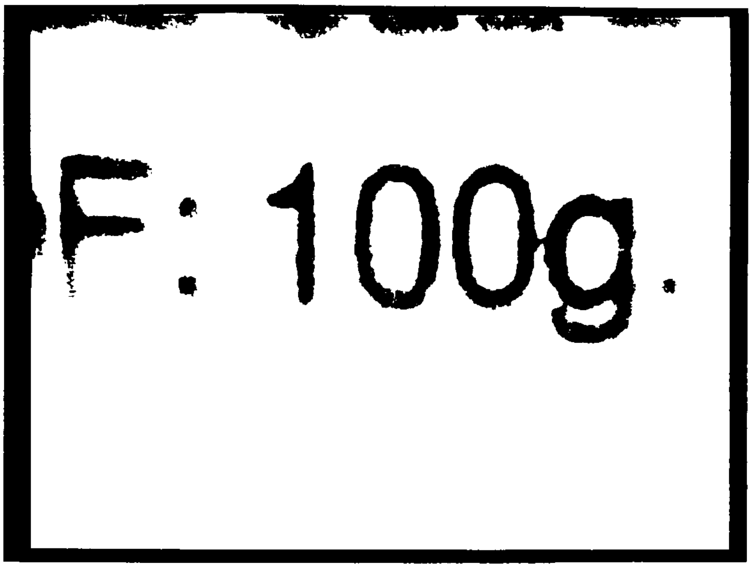


60# Gilman white converter kraft

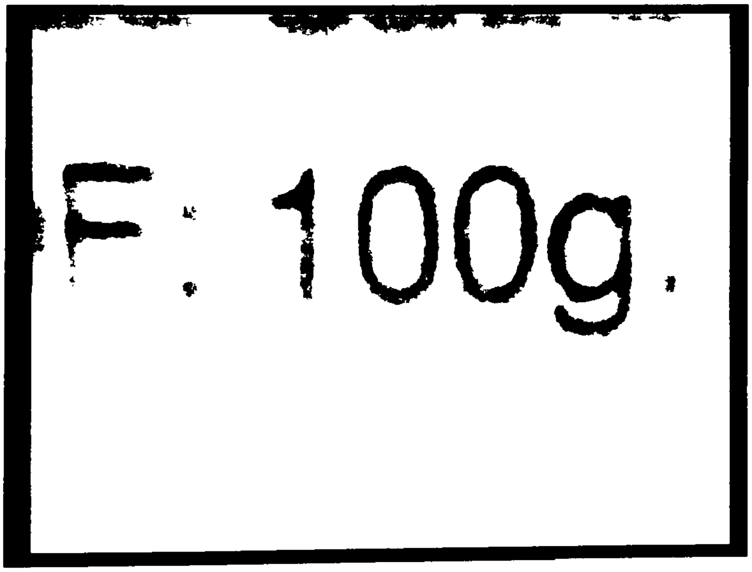


60# Georgia-Pacific white Velumina® kraft

FIGURE 6 TEXT COMPARISON EXAMPLE 1



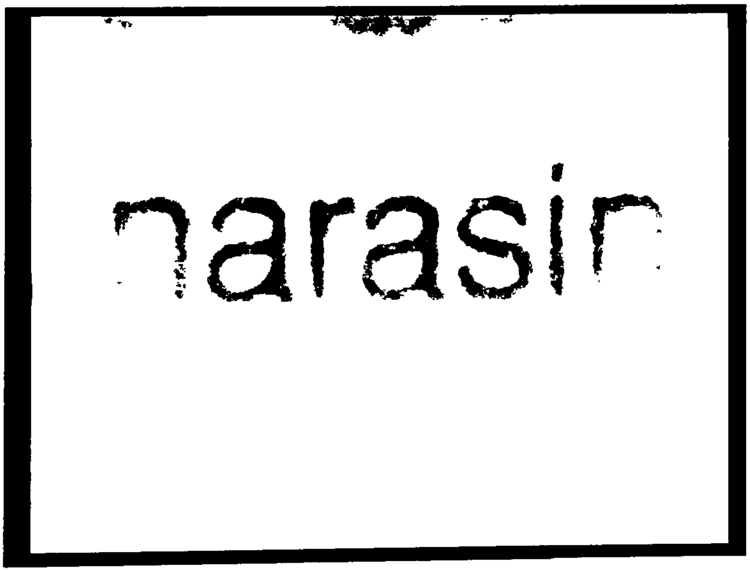
60# Gilman white converter kraft



60# Georgia-Pacific white Velumina® kraft

FIGURE 7 TEXT COMPARISON EXAMPLE 2

60# Gilman white converter kraft



60# Georgia-Pacific white Velumina® kraft

FIGURE 8 TEXT COMPARISON EXAMPLE 3

4.7 DISCUSSION

If the test results could be simplified to greater than (+), less than( ) or equal(=) and all tests were given the same value, TABLE 11 would be the result.

TABLE 11 SUMMARY OF TEST RESULTS

Converter Kraft	Velumina® Kraft	Test
+	-	Tensile Cross Direction
+	-	Tensile Machine Direction
-	+	Tear Machine Direction
=	=	Tear Cross Direction
=	=	Drop Test
	+	Moisture Analysis
=	=	Cobb Absorptivity
-	+	Text Comparison

Based on the customer criteria, the drop test and the text comparison test should be weighed more heavily when setting conclusions. The study hypothesis was that the 60# white Velumina® kraft was equal to or greater than the 60# white converter in logistics, physical performance and print quality. The tests did not have to show that one paper was better than the other just that the Velumina® kraft when compared to the converter kraft would be an equal or better performing sheet.

CHAPTER 5 CONCLUSIONS

Results showed that the 60# white Georgia-Pacific Velumina® kraft was equal to the 60# white Gilman converter kraft in physical strength and slightly better in print quality. Both papers were acceptable for use as an outer ply on multi-wall paper bags. Along with the logisitics of the bag supplier and paper manufacturers, the data supported the switch from converter to Velumina® kraft and met the study hypothesis. Velumina® kraft will be recommended as the paper of choice because of its better print quality.

Since more than one bag manufacturer may be making the bags used in this study, it was decided that the bag specifications of the outer ply would not be changed to read Velumina®. The converter kraft performed acceptably and if another bag supplier wanted to use converter kraft that would meet the customer criteria. Bemis and Elanco have chosen to view the Georgia-Pacific Velumina® as a brand specific converter kraft. Thus, Elanco will not have to register this paper change with the FDA and Bemis has eliminated a costly inventory and paper supplier relationship. Elanco has allowed for future flexibility with bag suppliers by not specifying the Velumina® sheet as the only acceptable sheet. Elanco package engineering will continue to work with the bag suppliers to ensure that any future paper supplier or grade changes will not affect the bag's performance.

CHAPTER 6 OBSERVATIONS AND RECOMMENDATIONS

Choosing the appropriate materials for any package involves meeting requirements from the product, shipping environment, registered materials and text, and manufacturing limits as well as material supply issues. The package buyer/filler and package supplier must work together to find the best combination for themselves as well as the end user. It would be interesting to see if a retail package requiring high print quality, like pet food, would find the Velumina® kraft an acceptable replacement. Future tests could compare clay coated paper versus the Velumina® kraft and converter kraft.

Time, material and cost constraints prevented testing for dot gain or ink holdout on a "live" press run. With the papers so similar, the amount of impressions that would have to be run to overcome the press variability were cost prohibitive. If further substitution of Velumina® is being explored, more detailed print testing should be done. A process color picture could be printed on each paper and evaluated. Dot gain could be measured with halftone screens and different print types could be compared. Measurable resolution targets should also be included.

APPENDIX A

tensile

Test type:	Tensile
Operator name:	Operator
Sample Identification:	ELI1
Interface Type:	1011

Instron Corporation
Series IX Automated Materials Testing System 7.49.00
Test Date: Thursday, May 07, 1998

Sample Rate (pts/secs):	10.0000	
Crosshead Speed:	1.0000	in/min
2nd Crosshead Speed:	0.0000	in/min
Full Scale Load Range:	100.000	lbf

Humidity (%): 50
Temperature: 0 F

TABLE A-1 TENSILE CONVERTER MACHINE DIRECTION

	Load @ Pre-set Point 1 (lbf)	Maximum Displcment (in)
1	42.850	0.108
2	46.900	0.122
3	43.125	0.102
4	47.000	0.118
5	47.950	0.118
6	41.600	0.117
7	41.200	0.095
8	49.925	0.127
Mean	45.069	0.113
S.D.	3.266	0.011

tensile

Test type: Tensile
Operator name. Operator
Sample Identification: ELI2
Interface Type: 1011

Instron Corporation
Series IX Automated Materials Testing System 7.49.00
Test Date: Thursday, May 07, 1998

Sample Rate (pts/secs): 10 0000
Crosshead Speed: 1.0000 in/min
2nd Crosshead Speed. 0 0000 in/min

Full Scale Load Range: 100 000 lbf

Humidity (%): 50
Temperature: 0 F

TABLE A-2 TENSILE CONVERTER CROSS DIRECTION

	Load @ Pre-set Point 1 (lbf)	Maximum Displcment (in)
1	20 250	0.210
2	18.825	0.184
3	18 750	0 176
4	20.150	0.225
5	20 125	0.219
6	20 225	0 202
Mean	19 721	0 203
S.D.	0 725	0 020

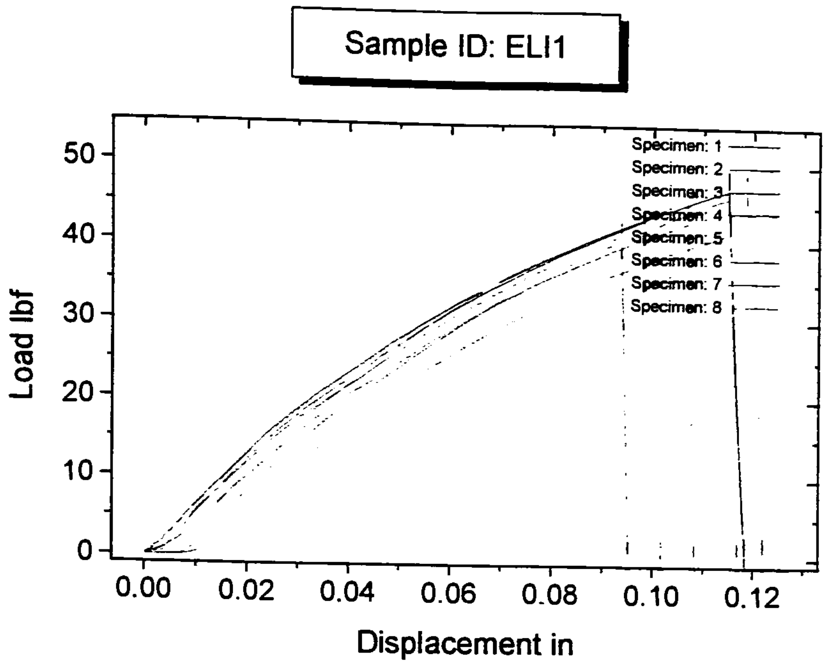


FIGURE A-1 TENSILE GRAPH CONVERTER MACHINE DIRECTION

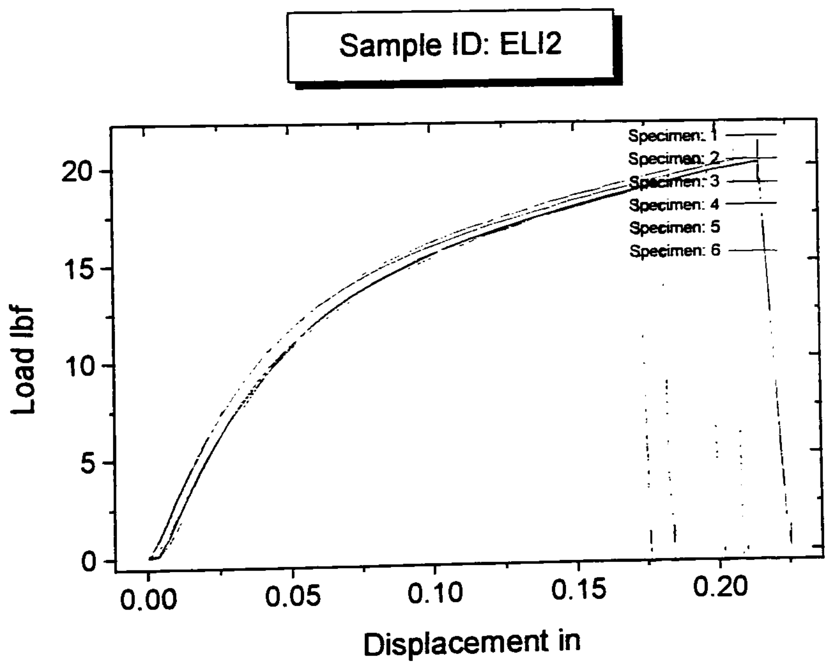


FIGURE A-2 TENSILE GRAPH CONVERTER CROSS DIRECTION

tensile

Test type: Tensile
Operator name: Operator
Sample Identification: ELI3
Interface Type: 1011

Instron Corporation
Series IX Automated Materials Testing System 7 49 00
Test Date: Thursday, May 07, 1998

Sample Rate (pts/secs): 10.0000
Crosshead Speed: 1.0000 in/min
2nd Crosshead Speed: 0.0000 in/min

Full Scale Load Range: 100.000 lbf

Humidity (%): 50
Temperature: 0 F

TABLE A-3 TENSILE VELUMINA® MACHINE DIRECTION

	Load @ Pre-set Point 1 (lbf)	Maximum Displcment (in)
1	36.950	0 125
2	33.425	0 115
3	38 125	0.118
4	35.825	0.117
5	34 800	0 115
6	35.700	0 120
7	34 800	0 112
Mean	35.661	0 117
S.D	1.541	0.004

tensile

Test type: Tensile
Operator name: Operator
Sample Identification: ELI4
Interface Type: 1011

Instron Corporation
Series IX Automated Materials Testing System 7 49 00
Test Date: Thursday, May 07, 1998

Sample Rate (pts/secs): 10.0000
Crosshead Speed: 1.0000 in/min
2nd Crosshead Speed: 0.0000 in/min
Full Scale Load Range: 100.000 lbf

Humidity (%): 50
Temperature 0 F
73

TABLE A-4 TENSILE VELUMINA® CROSS DIRECTION

	Load @ Pre-set Point 1 (lbf)	Maximum Displcment (in)
1	17.475	0.217
2	20.025	0.302
3	16.925	0.213
4	18.950	0.294
5	19.425	0.304
6	19.600	0.267
7	17.325	0.219
Mean	18.532	0.259
S.D	1.258	0.042

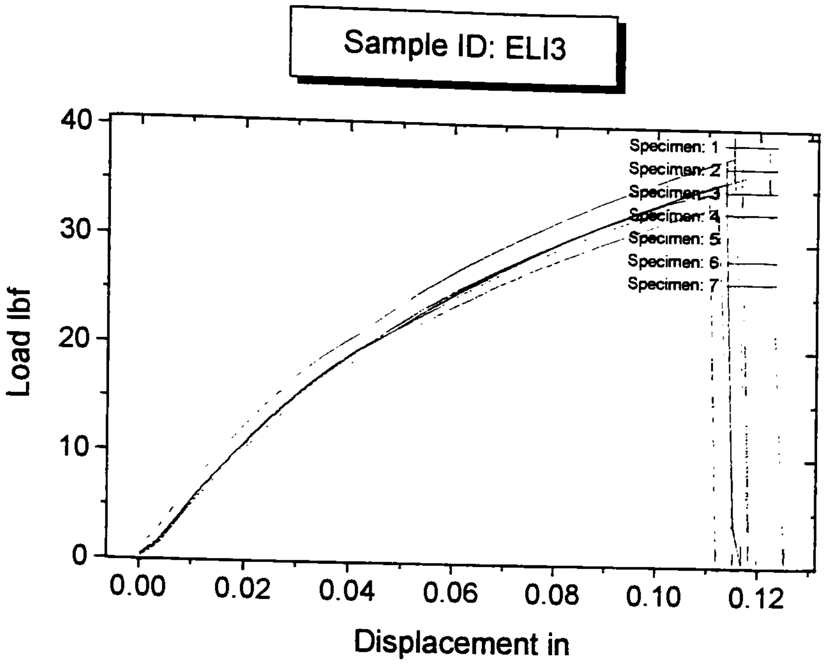


FIGURE A-3 TENSILE VELUMINA® MACHINE DIRECTION

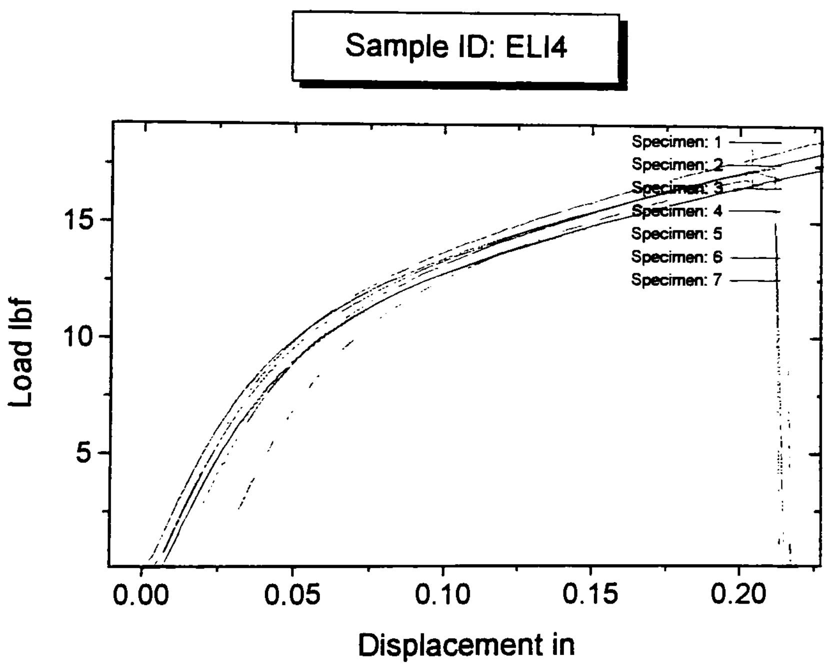


FIGURE A-4 TENSILE VELUMINA® CROSS DIRECTION

TABLE A-5 COBB TEST GILMAN SIDE IN

GILMAN S.I.	INITIAL gms	FINAL gms	CHANGE gms	H2O Gain gms/m2
#1	1.954	2.2OO	0.246	24.6
#2	1.970	2.193	0.223	22.3
#3	1.930	2.130	0.200	20.0
#4	1.992	2.213	0.221	22.1

TABLE A-6 COBB TEST VELUMINA® SIDE IN

VELUMINA® S.I.	INITIAL gms	FINAL gms	CHANGE gms	H2O Gain gms/m2
#1	1.920	2.130	0.21.	21.0
#2	1.898	20123	0.225	22.5
#3	1.936	20143	0.207	20.7
#4	1.940	2.147	0.207	20.7

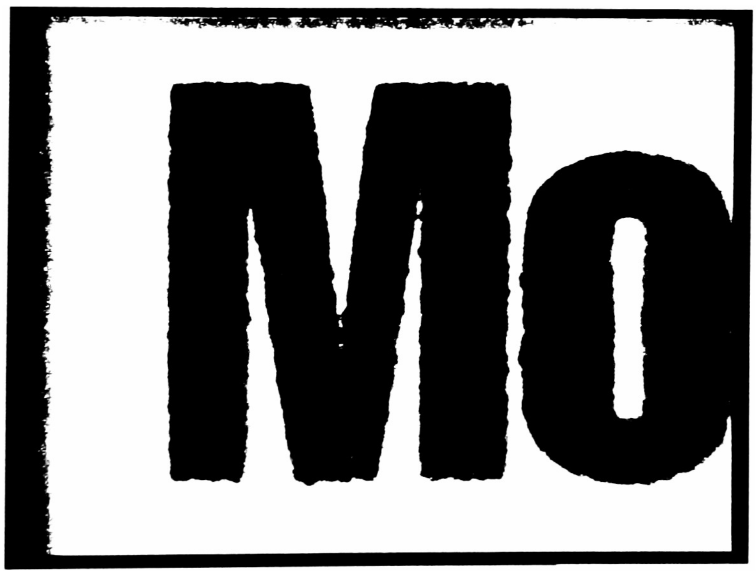
TABLE A-7 COBB TEST GILMAN SIDE OUT

GILMAN S.O.	INITIAL gms	FINAL gms	CHANGE gms	H2O Gain gms/m2
#1	1.958	2.210	0.252	25.2
#2	1.966	2.194	0.228	22.8
#3	1.976	2.191	0.221	22.1
#4	1.982	2.204	0.222	22.2

TABLE A-8 COBB TEST VELUMINA® SIDE OUT

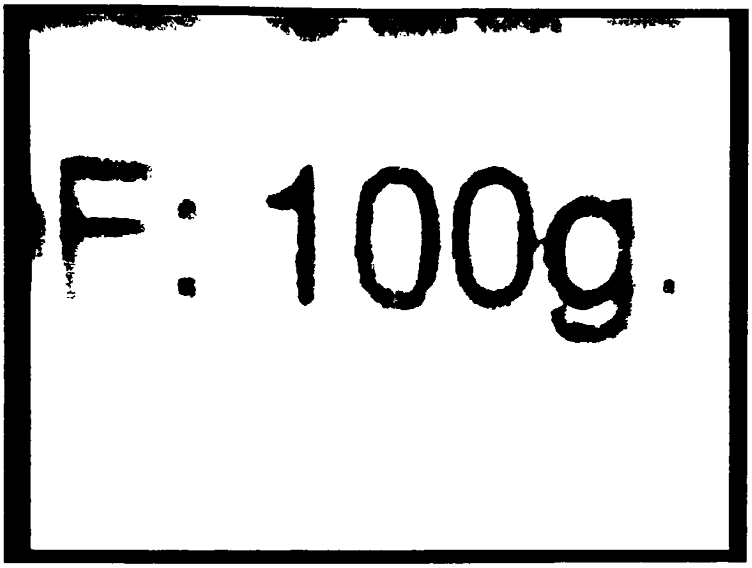
VELUMINA® S.O.	INITIAL gms	FINA L gms	CHANG E gms	H2O Gain gms/m2
#1	1.951	2.209	0.258	25.8
#2	1.914	2.154	0.240	24.0
#3	1.910	2.142	0.232	23.2
#4	1.966	2.195	0.229	22.9

60# Gilman white converter kraft

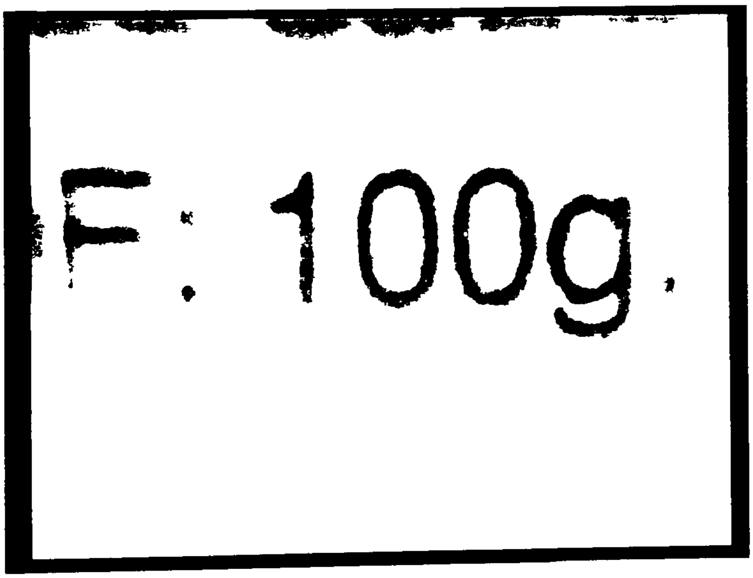


60# Georgia-Pacific white Velumina® kraft

FIGURE A-5 TEXT COMPARISON EXAMPLE 1



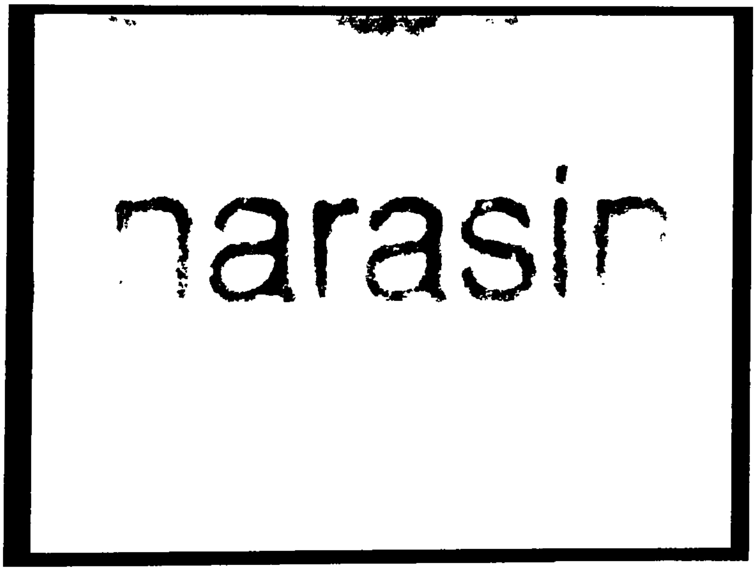
60# Gilman white converter kraft



60# Georgia-Pacific white Velumina® kraft

FIGURE A-6 TEXT COMPARISON EXAMPLE 2

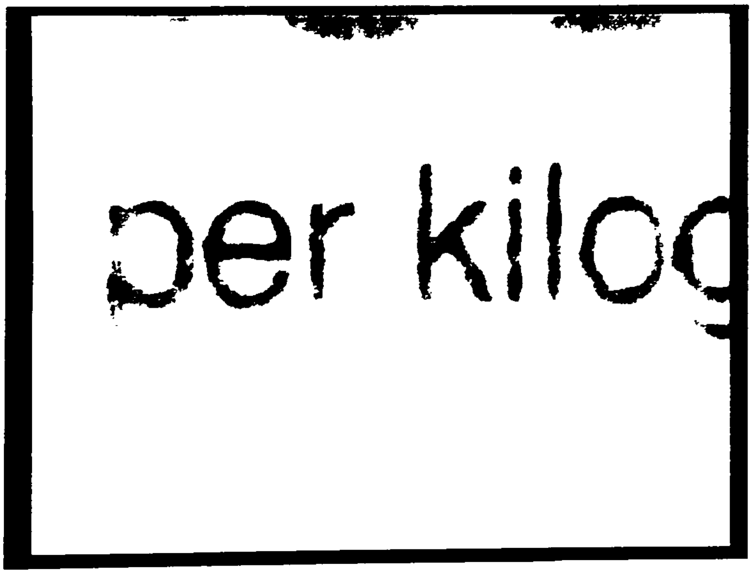
60# Gilman white converter kraft



60# Georgia-Pacific white Velumina® kraft

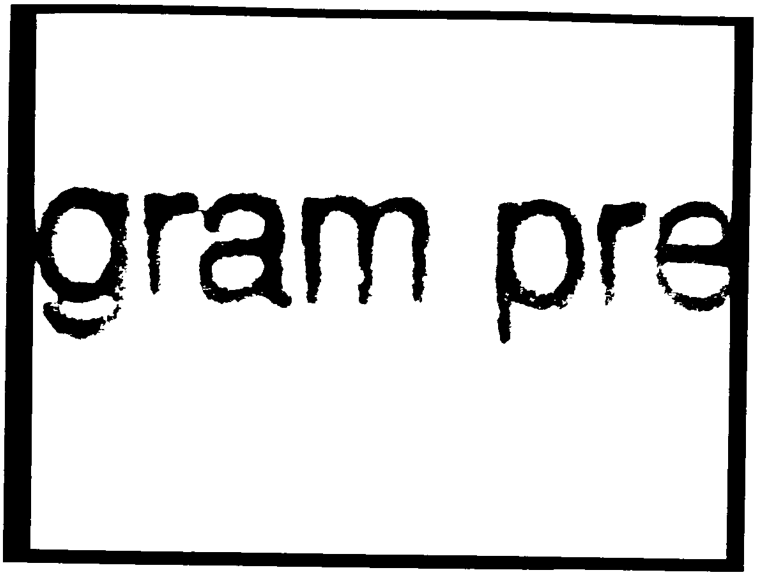
FIGURE A-7 TEXT COMPARISON EXAMPLE 3

60# Gilman white converter kraft

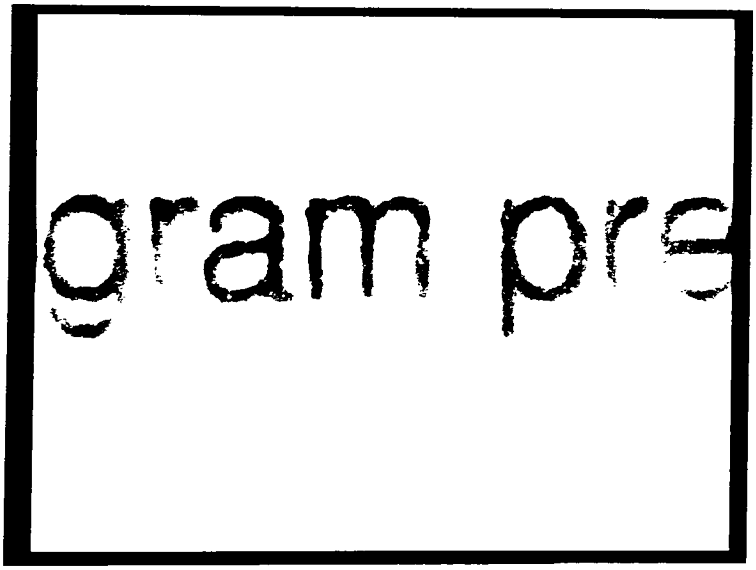


60# Georgia-Pacific white Velumina® kraft

FIGURE A-8 TEXT COMPARISON EXAMPLE 4



60# Gilman white converter kraft



60# Georgia-Pacific white Velumina® kraft

FIGURE A-9 TEXT COMPARISON EXAMPLE 5

60# Gilman white converter kraft

60# Georgia-Pacific white Velumina® kraft

FIGURE A-10 TEXT COMPARISON EXAMPLE 6

APPENDIX B

GILMAN PAPER COMPANY
SPECIFICATIONS
BCV2
Bleached Converting & Wrapping
High Finish

Product Code	Nominal Weight	Basis Weight Aim	Basis Weight Max.	Basis Weight Min.	Tear Min. MD	Tear Min. CD	Mullen Min.	HST WS MIN	Smoothness Aim	Smoothness Max.
BCV2040	40	40	42	38	64	64	21	20	200	250
BCV2050	50	50	52.5	47.5	88	88	28	40	210	260
* BCV2060	60	60	63	57	108	108	34	65	220	275

Notes:
1. Moisture: Aim 5.5, Max. 7.0, Min. 4.0
2. Brightness: Aim 82, Min. 77
3. Caliper: Run & Report
4. Tensile: Run & Report
5. HST is based on 2% Formic Acid

Reference: Submitted To Bernie - Omele on 7/12/96 Initial [signature]

Georgia-Pacific

Palatka, FL Mill

Raw Material Specification

Customer: BEMIS COMPANY 60# VELUMINA WHITE

Physical Properties		Test Method
Basis Weight:	60.0# Target 57.0# min, 63.0 max 24 x 36 - 500	AccuRay Cond. Bs Wt
Moisture, %:	5.7 % Target, 6.7 % max., 4.7 % min.	AccuRay 1160
Air Resistance: (Gurley)	<15 seconds/ 100 cc Target	Gurley Densometer TAPPI T460 om-86
Tensile, Dry:	18.0 lb/in CD Tensile Target, 15.5 lb/in min. 32.0 lb/in MD Tensile Target, 28.0 lb/in min.	CRE Tester (Model EJA) TAPPI T494 om-88 *
Internal Tear: (Elmendorf)	142 grams MD Tear Target, 86 grams min.	Thwing Albert Digitear TAPPI T404 om-87
Caliper (mils):	5.1 Target	L & W Micrometer TAPPI T411 os-76
GE Brightness, %	80.0 % Target, 78.0% minimum	Use MacBeth Color Eye
Hunter "b" Value	1.80 Target, 3.50 maximum and 0.80 minimum	Use MacBeth Color Eye
HST, 85% Refl., 1% FA Ink	200 sec Target, 50 sec min.	Use Hercules Size Tester
Sheffield Smoothness:	250 su Target, 300 su max. - Wire Side	Use Hagerty Tester
Slide Angle	24° Target, 17° min.	ST-1 Slide Angle Tester
Other:	* Rate of Jaw Separation is 4.0 inches/min.	

Non Physical Properties	
Roll Width:	As ordered, + 1/8", - 1/16"
Cores:	Spiral wound, 3" ID, .575" wall thickness
Wrinkles:	Free of wrinkles.
Dirt:	Free of foreign particles.
Roll Wind:	Paper will be wound wire side out.
Splicing:	Overlapping with 3/4" pressure sensitive tape. Maximum of 3 per roll.
Packaging:	Rolls will be completely wrapped in heavy water resistant wrappers and with ends protected adequately to prevent damage. Both ends will be strapped with steel bands.
Marking:	Each roll shall be identified by a printed roll label placed on the round of the wrapped roll. Basis Weight, Roll Width, Grade, Roll Weight, Linear Footage, GP Order Number and GP Roll Number shall appear on this label. GP Roll Number will also be marked near the core on the flat of each roll. Orders run directly for Bemis will also bear their Order Number and Plant location.

APPROVALS:

Bemis Company

[signature]

M M Brelmke [signature]

GEORGIA PACIFIC CORP.

[signature]
C. J. Houk - Supt. Kraft Paper Machines

[signature]
J. A. Cutter - Supt. Customer Service

[signature] 2/4/97
S.E. Jaffe - Supt. Kraft Quality Control

[signature]
T.L. Gould - Manager Kraft Sales

Date: 2/14/97

PACKAGING MATERIAL SPECIFICATIONS

ELANCO ANIMAL HEALTH
A DIVISION OF ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA 46285

ITEM: BAG BG 2581 DATE: 03/20/96

USE: NARASIN - 25 KG APPROVED: BEE

REVISION:

STYLE: DOUBLE PINCH BOTTOM OPEN MOUTH PAPER BAG (DPBOM)

SIZE: 16 (16.000) IN X 5 1/2 (5.500) IN X 31 (31.000) IN
TUBE LENGTH: 33 (33.000) IN

TOLERANCES: FACE WIDTH +/- 1/8 (0.125) IN, GUSSET +/- 1/8 (0.125) IN, TUBE PERIMETER +/- 1/4 (0.250) IN, LENGTH +/- 1/4 (0.250) IN

MATERIAL: (4-PLY INSIDE TO OUTSIDE)
1 2.5 MIL LINEAR LOW DENSITY POLYETHYLENE
2/60# NATURAL KRAFT
1/60# WHITE CONVERTER KRAFT,
WITH ANTI-SKID COATING ON OUTER PLY.

CONSTRUCTION: THIS BAG IS FILLED AND SEALED ON CLINTON LINE IN C47. ALL PLIES TO BE NESTED AND THE ENDS STEPPED FOR PROPER EQUALIZATION OF LOAD-CARRYING CAPACITY AND SEALING. USE STANDARD SUPER PINCH HEAT SEAL STEP SEAM WITH 3/4 (0.750) IN MINIMUM OVERLAP AND INNER MOST PLY TO HAVE P.E. TO P.E. FOLD OVER SEAM WITH LOW TEMPERATURE EVA (FULLER 1535) EXTRUDED SEAM.

OTHER PLIES TO HAVE FLAT SEAMS WITH 3/4 (0.750) IN MINIMUM OVERLAP. ADHESIVE LINE ON OUTSIDE PLY NOT TO EXCEED 1/4 (0.250) IN FROM EDGE OF PAPER. USE LOW TEMPERATURE EVA (FULLER 1535) ON #ONE PLY AND ON OUTSIDE LINEAL SEAM USE A-3 AND MOISTURE PROOF GLUE.

CHECKED BY Michele K. Mitchell 03-20-96

APPROVED BY Brenda E. Covey 03-20-96

NOTE : NO CHANGES TO BE MADE WITHOUT PRIOR APPROVAL OF PACKAGE ENGINEERING

PACKAGING MATERIAL SPECIFICATIONS

ELANCO ANIMAL HEALTH
A DIVISION OF ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA 46285

ITEM: BAG BG 2581 DATE: 03/20/96

USE: NARASIN - 25KG APPROVED: BEE

CONSTRUCTION: THE POLYETHYLENE # ONE PLY IS TO HAVE A P.E. TO P.E. FOLD OVER SEAM. #ONE PLY WILL BE CONTINUOUS LINE LAMINATION TO THE ADJACENT KRAFT USING EMULSIONS AND RESIN ADHESIVE. OUTER PLY IS TO HAVE ONE LINE OF STARCH ADHESIVE AND ONE LINE OF POLYETHYLENE HOT MELT ADHESIVE. MOISTURE RESISTANT WATER-BASED ADHESIVE TO BE USED ON ALL OTHER PAPER PLIES. NATIONAL 6602 OR AB POLYETHYLENE HOT MELT ADHESIVE TO BE USED ON BOTTOM CLOSED END AND TOP PREAPPLIED END. NO ADHESIVE ON SHORT STEP ON CUSTOMER END. BOTTOM CLOSED END TO BE HEAT SEALED BY MANUFACTURER. MANUFACTURER'S END (BOTTOM) IS TO CLOSE ON BACK (SEAM SIDE). FIELD CLOSURE (TOP) IS TO CLOSE ON FACE (NON-SEAM SIDE).

LITERATURE PIECE MEASURING 4 (4.000)IN X 7 1/2 (7.500)IN TO BE INSERTED INTO PRINT PLY SEAM VOID POCKET, FORMED BY SPECIAL SPOT PASTING PATTERN MEASURING 6 (6.000)IN X 10 (10.000)IN. LITERATURE PIECES TO BE SUPPLIED BY ELANCO.

FIELD CLOSURE WILL BE 1 1/2 (1.500) IN MINIMUM FOLD OVER. FILLED BAGS MUST WITHSTAND A MINIMUM OF FOUR DROPS FROM 48 (48.000)IN ON EITHER FACES, SIDES OR BOTTOM WITHOUT FAILURE.

PRINTING: ARTWORK SUPPLIED BY ELANCO. IT WILL INCLUDE A SET OF LINES TO SERVE AS SEAL INDICATORS ON THE CLINTON FINISHING LINE. THE SET OF LINES WILL BE LOCATED 3 1/4 (3.250) IN FROM THE TOP OF THE BAG TO THE BOTTOM OF THE LINES AND WHEN COVERED WILL INDICATE A SATISFACTORY SEAL. LINES WILL BE PRINTED BLACK. MINIMUM SIZE FREIGHT CLASS EMBLEM, LILLY P.O. NUMBER AND LILLY BAG LOT NUMBER TO BE PRINTED ON TOP LEFT GUSSET DIRECTLY BELOW CODE NUMBER. LILLY BAG LOT NUMBER TO BE SUPPLIED BY PURCHASING AT THE CLINTON PLANT WITH EACH ORDER.

CHECKED BY Michele K. Mitchell 03-20-9

APPROVED BY Brenda E. Carey 03-20-96

NOTE: NO CHANGES TO BE MADE WITHOUT PRIOR APPROVAL OF PACKAGE ENGINEERING

PACKAGING MATERIAL SPECIFICATIONS

ELANCO ANIMAL HEALTH
A DIVISION OF ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA 46285

ITEM: BAG BG 2581

DATE: 03/20/96

USE: NARASIN - 25 KG

APPROVED: BEE

PACK FOR SHIPMENT: PACK 800 BAGS PER PALLET BOX. PROVIDE A MONITOR PALLET FOR EACH ORDER AND CLEARLY IDENTIFY IT AS SUCH

ALL SHIPPING CONTAINERS TO BE CLEARLY MARKED AS FOLLOWS:

ELANCO ANIMAL HEALTH
BAG : bag code for printed bags or BG 2581 on blanks
QUANTITY:
P.O. NO. :
LILLY LOT NO.:

CHECKED BY Michele K. Mitchell 03-

APPROVED BY Brenda E. Eavey 03-20-9

NOTE: NO CHANGES TO BE MADE WITHOUT PRIOR APPROVAL OF PACKAGE ENGINEERING

PACKAGING MATERIAL SPECIFICATIONS

ELANCO ANIMAL HEALTH
A DIVISION OF ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA 46285

ITEM BAG BG 2575 DATE. 12/06/96

USE. MONENSIN - 25 KG APPROVED: BEE

REVISION:	REMOVE LOWER SET OF SEAL LINES
STYLE:	DOUBLE PINCH BOTTOM OPEN MOUTH PAPER BAG (DPBOM)
SIZE.	16 (16.000) IN X 6 1/2 (6.500) IN X 32 (32.000) IN
TOLERANCES.	FACE WIDTH +/- 1/8 (0.125) IN, GUSSET +/- 1/8 (0.125) IN, TUBE PERIMETER +/- 1/4 (0.250) IN, LENGTH +/- 1/4 (0.250) IN
MATERIAL.	(4-PLY INSIDE TO OUTSIDE) 1 2.5 MIL LINEAR LOW DENSITY POLYETHYLENE 2/60# NATURAL KRAFT 1/60# WHITE CONVERTER KRAFT WITH ANTI-SKID ON OUTER PLY.
CONSTRUCTION:	THIS BAG IS FILLED AND SEALED ON CLINTON LINE IN C47E. ALL PLIES TO BE NESTED AND THE ENDS STEPPED FOR PROPER EQUALIZATION OF LOAD-CARRYING CAPACITY AND SEALING. USE STANDARD SUPER PINCH HEAT SEAL STEP SEAM WITH 3/4 (0.750) IN MINIMUM OVERLAP AND INNER MOST PLY TO HAVE P.E. TO P.E. FOLD OVER SEAM WITH LOW TEMPERATURE EVA (FULLER 1535) EXTRUDED SEAM. OTHER PLIES TO HAVE FLAT SEAMS WITH 3/4 (0.750) IN MINIMUM OVERLAP. ADHESIVE LINE ON OUTSIDE PLY NOT TO EXCEED 1/4 (0.250) IN FROM EDGE OF PAPER. USE LOW TEMPERATURE EVA (FULLER 1535) ON #ONE PLY AND ON OUTSIDE LINEAL SEAM USE A-3 AND MOISTURE PROOF GLUE.

CHECKED BY Michele K. Mitchell 12/06/96
APPROVED BY Brenda C. Carey 12/06/96

NOTE : NO CHANGES TO BE MADE WITHOUT PRIOR APPROVAL OF PACKAGE ENGINEERING

PACKAGING MATERIAL SPECIFICATIONS

ELANCO ANIMAL HEALTH
A DIVISION OF ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA 46285

ITEM: BAG BG 2575

DATE. 12/06/96

USE. MONENSIN - 25 KG

APPROVED: BEE

CONSTRUCTION: THE POLYETHYLENE # ONE PLY IS TO HAVE A P E. TO P E. FOLD OVER SEAM #ONE PLY WILL BE CONTINUOUS LINE LAMINATION TO THE ADJACENT KRAFT USING EMULSIONS AND RESIN ADHESIVE. OUTER PLY IS TO HAVE ONE LINE OF STARCH ADHESIVE AND ONE LINE OF POLYETHYLENE HOT MELT ADHESIVE, MOISTURE RESISTANT WATER-BASED ADHESIVE TO BE USED ON ALL OTHER PAPER PLIES. NATIONAL 6602 OR A8 POLYETHYLENE HOT MELT ADHESIVE TO BE USED ON BOTTOM CLOSED END AND TOP PREAPPLIED END. NO ADHESIVE ON SHORT STEP ON CUSTOMER END. BOTTOM CLOSED END TO BE HEAT SEALED BY MANUFACTURER. MANUFACTURER'S END (BOTTOM) IS TO CLOSE ON FACE (NON-SEAM SIDE). FIELD CLOSURE (TOP) IS TO CLOSE ON BACK (SEAM SIDE). LITERATURE PIECE MEASURING 4(4.000)IN X 7 ½ (7.500)IN TO BE INSTERTED INTO PRINT PLY SEAM VOID POCKET FORMED BY SPECIAL SPOT PASTING PATTERN MEASURING 6 (6.000) X 10 (10.000)IN. LITERATURE PIECES TO BE SUPPLIED BY ELANCO.

FIELD CLOSURE WILL BE 1 1/2 (1.500) IN MINIMUM FOLD OVER. FILLED BAGS MUST WITHSTAND A MINIMUM OF FOUR DROPS FROM 48 (48.000)INS ON EITHER FACES, SIDES OR BOTTOM WITHOUT FAILURE.

PRINTING. ARTWORK SUPPLIED BY ELANCO. IT WILL INCLUDE ONE SET OF LINES TO SERVE AS SEAL INDICATORS ON THE CLINTON FINISHING LINE. THE SET OF LINES WILL BE LOCATED 3 1/4 (3.250) IN FROM THE TOP OF THE BAG TO THE BOTTOM OF THE LINES AND WHEN COVERED WILL INDICATE A SATISFACTORY SEAL.
LINES WILL BE PRINTED BLACK.
MINIMUM SIZE FREIGHT CLASS EMBLEM, LILLY P O. NUMBER AND LILLY BAG LOT NUMBER TO BE PRINTED ON TOP LEFT GUSSET DIRECTLY BELOW CODE NUMBER. LILLY BAG LOT NUMBER TO BE SUPPLIED BY PURCHASING AT THE CLINTON PLANT WITH EACH ORDER.

PACK FOR SHIPMENT: PACK 800 BAGS PER PALLET BOX.
PROVIDE A MONITOR PALLET FOR EACH ORDER AND CLEARLY IDENTIFY IT AS SUCH

ALL SHIPPING CONTAINERS TO BE CLEARLY MARKED AS FOLLOWS:

ELANCO ANIMAL HEALTH
BAG : bag code for printed bags or BG2575 on blanks
QUANTITY:
P.O. NO. :
LILLY LOT NO.:

CHECKED BY Michele K Mitchell 12/06/96

APPROVED BY Brenda E. Eavey 12/06/96

NOTE: NO CHANGES TO BE MADE WITHOUT PRIOR APPROVAL OF PACKAGE ENGINEERING

APPENDIX C

T 494 om-88

SUGGESTED METHOD — 1964
OFFICIAL STANDARD — 1970
OFFICIAL TEST METHOD — 1981
CORRECTED — 1982
REVISED — 1988

This TAPPI method has been adopted and endorsed by the Tag and Label Manufacturers Institute, Inc. (TLMI).

Tensile breaking properties of paper and paperboard (using constant rate of elongation apparatus)

1. Scope

1.1 This test method describes the procedure, using constant-rate-of-elongation equipment, for determining three tensile breaking properties of paper and paperboard, namely: the force per unit width required to break a specimen (tensile strength), the percentage elongation at break (stretch), and the energy absorbed per unit area of the specimen before breaking (tensile energy absorption).

1.2 This procedure is applicable to all types of paper and paperboard within the limitations of the instruments used, whether the instruments perform horizontal or vertical tests or whether they are manually operated or computer controlled. It may be applicable to handsheets as specified in TAPPI T 220 "Physical Testing of Pulp Handsheets." It does not apply to combined corrugated board.

1.3 TAPPI T 404 "Tensile Breaking Strength and Elongation of Paper and Paperboard (Using Pendulum-Type Tester)" describes a procedure for measuring tensile strength and stretch using pendulum-type instruments. T 494 describes the procedures for determining stretch, tensile energy absorption, and tensile strength.

2. Definitions

2.1 *Tensile strength*, the maximum tensile stress developed in a test specimen before rupture on a tensile test carried to rupture under prescribed conditions. Tensile strength (as used here) is the force per unit width of test specimen.

2.2 *Stretch*, the maximum tensile strain developed in the test specimen before rupture in a tensile test carried to rupture under prescribed conditions. The stretch (or percentage elongation) is expressed as a percentage, i.e., one hundred times the ratio of the increase in length of the test specimen to the original test length.

2.3 *Tensile energy absorption* (TEA), the work done when a specimen is stressed to rupture in tension under prescribed conditions as measured by the integral of the tensile stress over the range of tensile strain from zero to maximum strain. The TEA is expressed as energy per unit area (test span x width) of test specimen.

2.4 *Breaking length*, the calculated limiting length of a strip of uniform width, beyond which, if such a strip were suspended by one end, it would break of its own weight.

2.5 *Tensile index*, the tensile strength in N/m divided by grammage.

NOTE 1: ISO/TC6 recommends the use of tensile index over breaking length (2.4). See TIS 0800-01 (old number 018-4) "Units of Measurement and Conversion Factors."

3. Significance

3.1 Tensile strength is indicative of the serviceability of many papers, such as wrapping, bag, gummed tape, and cable wrapping, which are subjected to direct tensile stress. The tensile strength of printing papers is indicative of the potential resistance to web breaking during printing and other converting operations and during travel of the web from the roll through the equipment.

3.2 Stretch (sometimes with bending stiffness) is indicative of the ability of paper to conform to a desired contour. It is important for creped paper, towels, napkins, decorative papers, industrially used paper tapes (both creped and pleated), bags, and liners for cans, barrels, or cartons.

3.3 Tensile energy absorption is a measure of the ability of a paper to absorb energy (at the strain rate of the instrument) and indicates the durability of papers which are subjected to repetitive straining and stressing, such as multiwall sack papers.

4. Apparatus

4.1 *Tensile testing machine*, a constant-rate-of-elongation type (*1*), meeting the following requirements:

4.1.1 Two clamping jaws, each with a line contact for gripping the specimen, with the line of contact perpendicular to the direction of the applied load and with means for controlling and adjusting the clamping pressure.

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TAPPI

NOTE 2: "Line contact" describes the clamping zone resulting from gripping the specimen between a cylindrical and a flat surface or between two cylindrical surfaces whose axes are parallel (2).

NOTE 3: For certain grades of paper "line contact" jaws may not be appropriate and it may be necessary to substitute flat gripping surfaces. Certain grades are damaged by the "line contact" loading between cylindrical and flat surfaces.

4.1.2 The clamping surfaces of the two jaws shall be in the same plane and so aligned that they hold the test specimen in that plane throughout the test.

4.1.3 The distance between line contacts at the start of the test shall be adjustable and resettable to ± 0.5 mm (±0.02 in.) for the specified initial test span (6.4).

4.1.4 The rate of separation of jaws shall be 25 ± 5 mm/min (1.0 ± 0.2 in./min), or as otherwise noted (6.5) and once set shall be resettable and constant to ±4%.

4.1.5 Recorder or indicator should be readable to 0.25% of full scale loading force and capable of retaining a calibration accuracy of ±0.5% of full scale.

4.1.6 Recorder speed or indicator shall be adjustable to provide a readability and accuracy of ±0.05% stretch (that is, ±0.09 mm elongation for a test span of 180 mm).

4.2 *Alignment jig* (optional) (2) to facilitate centering and aligning the specimen in the jaws, so that the clamping lines of contact are perpendicular to the direction of the applied force and the center line (long dimension) of the specimen coincides with the direction of applied force.

4.3 *Planimeter* or *integrator*, respectively, to measure the area beneath the load-elongation curve or to compute directly the work to rupture, with an accuracy of ±1%.

4.4 *Specimen cutter*, for cutting specimens of the required width, with straight parallel sides (5.3).

4.5 *Magnifier and scale* or optical comparator, capable of measuring the specimen width to the nearest 0.1mm (0.004 in.).

NOTE 4: Fully automated laboratory management and/or data acquisition systems are available which perform several functions such as: automatic calibration check, pre-setting and storing a variety of test programs, cutting the test strip, acquiring test data, and accurately determining the tensile breaking properties of paper and paperboard. These tests may be performed with the test strip horizontal or vertical by such equipment. Such equipment may be suitable for use in performing this method; however, the user is responsible for making independent assessment of this fact on the basis of data generated using specific equipment.

5. Sampling and test specimens

5.1 Obtain a sample of the paper in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product."

5.2 Precondition, then condition the sample in accordance with TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products" prior to cutting the specimens.

NOTE 5: The exposure of the paper to a high relative humidity before preconditioning and conditioning can lead to erratic results varying from a decrease in stretch and tensile to a substantial increase (30% increase in stretch not uncommon) in these properties. Consequently, TEA is similarly affected. Careful protection of the sample from the time of sampling until testing is therefore very important.

5.3 Cut 10 test specimens from each test unit of the sample in each principal direction of the paper 25 ± 1 mm (0.98 ± 0.04 in.) wide with sides parallel within 0.1 mm (0.004 in.) and long enough to be clamped in the jaws when the test span is 180 ± 5 mm (7.1 ± 0.2 in.), leaving enough length so that any slack can be removed from the strip before clamping. Insure that strips are free from abnormalities, creases, or wrinkles. When the test span is less than 180 ± 5 mm (7.1 ± 0.2 in.), see Appendix A.3.1.2. In some cases, it may be impossible or impractical to obtain a test specimen having a length long enough to be clamped in the jaws having the test span specified here. In such cases, see Appendix A.3.1 for special considerations and procedures required for testing samples at smaller test spans.

6. Procedures

6.1 Perform the test in the testing atmosphere specified in T 402.

6.2 If the test specimen width is not known to 0.1 mm (0.004 in.) (i.e., if a previously evaluated precision cutter is not used), determine width and parallelism using magnifier and scale. Lack of parallelism is indicated by a difference in width of the two ends of the specimen.

6.3 The testing machine shall be calibrated and adjusted as described in Appendixes A.1 and A.2.

6.4 Set the clamps to an initial test span (distance between line contacts) of 180 ± 5 mm (7.1 ± 0.2 in.). Determine and always reset this distance within ±0.5 mm (0.02 in.) (see Appendix A.1.3).

6.5 Set the controls for rate of separation of the jaws to 25 ± 5 mm/min (1.0 ± 0.2 in./min). In cases where time required to break a single strip exceeds 30 s, a more rapid rate of jaw separation shall be used, such that time to break a single strip will be between 15 and 30 s. In such cases, the speed of the instrument must be reported along with the test data.

NOTE 6: For purposes of determining shipping sack and ship... sack paper TEA compliance with Carrier and F... requirements, Uniform Freight Classification Rule ..., National Motor Freight Classification, Item 200, U.S. and Department of Transportation (78.236, 4.8 in. ... mm) between the jaws and 1 in. (25 mm) per minute separation should be used.

6.6 Select recorder speed or indicator to give readability equivalent to 0.05% stretch.

6.7 Select the full scale reading, if possible, so breaking force can be read in the upper three-fourths of the scale. Make preliminary trial tests if necessary to determine full scale load.

NOTE 7: If, for any reason, any of the testing conditions specified above (specimen length, rate of jaw separation, sample width, etc.) cannot be followed because of the small sample size or other reason, the method variance *must* be stated in the report.

6.8 Align and clamp the specimen first in one jaw and then, after carefully removing any noticeable slack, in the second jaw. While handling the test specimen, avoid touching the test area between the jaws with the fingers. Use a clamping pressure determined to be satisfactory (Appendix A.1.4), i.e., so that neither slippage nor damage to the specimen occurs.

6.9 Test 10 specimens in each principal direction for each test unit.

6.10 Reject any value in which the test specimen slips in the jaws, breaks within the clamping area, or shows evidence of uneven stretching across its width. Also reject any values for test specimens which break within 5 mm of the clamp area if further inspection indicates the break location is due to improper clamping conditions or misalignment. If more than 20% of the specimens for a given sample are rejected, reject all readings obtained for that sample, inspect the apparatus for conformance with specifications, and take any steps necessary to correct the trouble.

6.11 Read and record the breaking force to 0.5% of full scale and the elongation at break to the equivalent of 0.05% stretch. Record the integrator reading or use the planimeter to determine the area under the load-elongation curve from zero load to the breaking load.

NOTE 8: For the purpose of terminating integration, the specimen will be deemed broken when maximum tensile load has been reached and the tensile load has dropped no more than 0.25% of the full-scale load below the maximum load. This procedure is applicable in the determination of TEA as long as maximum strain occurs at rupture, which is usually the case.

7. Calculations

7.1 For each test unit and in each principal direction, calculate from the recorded values the average breaking force, average elongation at break, and the average integrator or planimeter value as required. Correct the instrumental results, if necessary, according to the correction curve described in the Appendix (A.2.2). Corrections for instrumental deflection need to be applied to both the elongation and energy measurements. Determine the range or standard deviation in each case.

7.2 Divide the average breaking force by the specimen width to obtain the tensile strength. If this has been measured in pounds and inches, convert to kN/m by multiplying by 0.1751. If this has been measured in kg/mm, convert to kN/m by multiplying by 9.807.

NOTE 9: To calculate the breaking length (air dry) in meters use the following formula:

$$BL = 102{,}000\ (T/R) = 3658\ (T'/R')$$

To calculate the tensile index in newton meters per gram use the following formulas:

$$TI = 1000\ (T/R) = 36.87\ (T'/R')$$

where

- TI = tensile index, N·m/g
- BL = breaking length, m
- T = tensile strength, kN/m
- T' = tensile strength, lbf/in.
- R = grammage (air dry), g/m^2
- R' = mass per unit area (air dry), lb/1000 ft^2

7.3 To calculate the percentage stretch, divide the average elongation at break by the test span and multiply by 100.

7.4 Multiply the average integrator or planimeter value by the appropriate factor for the equipment and settings used to obtain the area under the load-elongation curve (Note 6) in energy units, joules (preferred) or inch-pound force. Then calculate the tensile energy absorption, according to one of the following formulas:

$$TEA = 10{,}000\ A/LW \text{ or } 980.7\ A'/LW \text{ or } 175.2\ a/lw$$
$$tea = 12\ a/lw$$

where

- TEA = tensile energy absorption, J/m^2
- L = initial test span, cm
- W = specimen width, cm
- A = area under load-elongation curve, J
- A' = area under load-elongation curve kgf·cm
- tea = tensile energy absorption, ft·lbf/ft^2
- a = area under load elongation curve, lbf·in.
- l = inital test span, in.
- w = specimen width, in.

To convert tensile energy absorption in ft·lbf/ft^2 to J/m^2, multiply by 14.60.

NOTE 10: The "area under the load-elongation curve" is the area between the curve and the elongation axis.

7.5 Determine the corresponding ranges or standard deviations from the ranges or standard deviations of the measured values (7.1).

NOTE 11: Hardware/softwear systems are available that will perform all calculations required in the desired units of measurements.

8. Report

8.1 Report for each test unit and in each direction to three significant figures:

8.1.1 The average tensile strength and the range or standard deviation in kN/m and (if desired) in lbf/in.

8.1.2 The average stretch and the range or standard deviation as a percentage.

8.1.3 The average tensile energy absorption and the range or standard deviation in J/m^2 and (if desired) in ft·lbf/ft^2.

8.2 Report, in each case, the number of tests rejected and the reasons for rejection.

8.3 Report any deviation in test procedure, as when a short specimen must be used, alternate clamping configurations are used, a wide or narrow strip was tested, or when the rate of jaw separation was varied from 25 ± 5 mm/min (1.0 ± 0.2 in./min) as described in 6.5.

9. Precision

9.1 On the basis of studies (3) made in accordance with TAPPI T 1200 "Interlaboratory Evaluation of Test Methods," two test results, each representing an average of 10 determinations, from the same or different samples as noted, are expected to agree within the amounts shown in Table 1

Table 1. 95% probability limits

	Tensile strength*, %	Stretch*, %	TEA*, %
Repeatability (same sample, operator and apparatus)	5	9	10–16
Comparability (samples markedly different in other properties, but not in designated property, same operator and apparatus)	9	16	15–26
Reproducibility (same sample, different laboratories)	10	25	22–36

*Percentage of the average of the two results.

9.2 In each case, the coefficient of variation of a test result (average of 10 determinations) is expected to be about 0.36 times the value shown in Table 1.

10. Additional information

10.1 Effective date of issue: January 29, 1988.

10.2 This test method may be used in place of the similar method for tensile strength and stretch (T 404) which uses a different type tensile testing machine. These methods are not strictly comparable in that different instrument types are used, but when similar testing conditions are used, they may give similar results. This test method permits three tests (tensile breaking strength, tensile energy absorption, and elongation at break) to be run simultaneously on the same test specimen. This test method also gives more detailed requirements for the apparatus (standardizing on the constant-rate-of-elongation apparatus) and more detailed instructions for the procedure.

10.3 In the modernized metric system, or System International (SI), the units of force and energy are newton (N) and joule (J), respectively. The factors for conversion from the relevant customary units to SI units are as follows:

Force:
1 lbf = 4.448 N
1 kgf = 9.807 N
Energy:
1 N·m = 1.000 J
1 ft·lbf = 1.356 J
1 m·kgf = 9.807 J
Tensile strength:
1 lbf/in. = 0.175 kN/m
1 kgf/15 mm = 0.654 kN/m
Tensile index:
The breaking length in meters is numerically equal to 102 times tensile index in newton meters per gram.
Tensile energy absorption:
1 ft·lbf/ft^2 = 14.60 J/m^2

10.4 This method was first published in 1964 as a Suggested Method and became an Official Standard in 1970.

10.5 Related methods: ASTM D828 "Tensile Breaking Strength for Paper and Paperboard," American Society for Testing and Materials, Philadelphia, PA; APPITA P 425 "Tensile Strength of Shipping Sack Paper (25.4 mm width)," Technical Association of the Australian and New Zealand Pulp and Paper Industry, Parkville, Australia; BS 4415, British Standards Institution, London, England; CPPA D-34 "Tensile Breaking Strength of Paper and Paperboard," Canadian Pulp and Paper Association, Montreal, Canada; AFNOR QO 3-001, Association Francaise de Normalisation, Paris, France; VXPCI, V12, Zellcheming, Rheinstrasse, Germany; ISO 1924, "Paper and Board, Determination of Tensile Strength," International Organization for Standardization, Geneva, Switzerland; SCAN P 16, "Tensile Strength and Stretch of Paper and Paperboard, Determined with a Pendulum Tester," Scandinavian Pulp, Paper, and Board Testing Committee, Stockholm, Sweden.

Appendix

A.1 *Adjustment and maintenance of testing machine*

A.1.1 Regularly inspect the machine for cleanliness and for faults such as wear, misalignment, loose parts, damage. Clean the machine and rectify any faults.

A.1.2 Level the machine accurately in its principal directions. Align the clamping jaws to hold specimen in the plane of the applied load throughout test.

A.1.3 Position the jaws so that the test span is specified (6.4). Verify by measuring effective test sp[illegible] e.g., by measuring the distance between the centers of line clamp impressions produced on strips of thin foil.

A.1.4 Determine appropriate clamping pressure that neither slippage nor specimen damage occurs.

NOTE 12: Papers prepared from the more highly hydrated or beaten stocks, such as tracing paper or glassine, present the most difficult gripping problem. Thus, it is recommended that the clamping pressure be adjusted by making a test with a strong tracing paper. The clamping pressure adjusted to give satisfactory results with this wide variety of papers in the intermediate weight and strength range. The use of excessively high pressure is shown by straightline breaks in, and immediately adjacent to, the clamping zone; whereas the use of too low a pressure shows an abrupt discontinuity in the load-elongation curve, or failure of the specimen beyond the clamped zone, or, following the test, a wider-than-normal impression of the clamping line.

A.2 *Calibration of testing machine*

A.2.1 After leveling the machine accurately, calibrate the load measuring mechanism with standard weights by the dead-weight method; i.e., obtain readings at about ten points evenly spaced throughout the scale, by applying known weights with increasing then decreasing increments to the clamp actuating the indicating or recording mechanism. Note the scale readings when the weights and mechanism come gently into the equilibrium position. If readings differ from the corresponding applied loads by more than 0.5%, construct a correction curve.

NOTE 13: This method is only applicable for vertical tensile instruments. For horizontal instruments, follow recommended manufacturer's procedures.

A.2.2 Calibrate the extension measuring mechanism with inside vernier calipers or other appropriate means over the entire load range of interest (*1*). Read the elongation scale at a number of points evenly spaced over the range from about 1 to 20% strain. If readings are in error by more than 0.1% strain, construct a correction curve.

A.3 *Modifications of procedure (and effects thereof)*

A.3.1 *Test specimens*

A.3.1.1 If undersized specimens must be used (e.g., because of size of sample sheets), use 25 mm (preferred) or 15 mm width and lengths long enough to be clamped in jaws either 100 ± 5 mm (4 ± 0.2 in.) or 50 ± 2 mm (2 ± 0.1 in.) apart.

A.3.1.2 The shorter test spans will give higher readings, and it is difficult to measure the elongation accurately [see the Pierce weak-link theory (*4*)]. For papers which have a poor formation, the difference between a test span of 100 mm and the standard span of 180 mm may amount to over 10% in tensile strength and TEA.

NOTE 14: The tensile breaking load, and consequently the breaking strain and TEA, is known to decrease as the test span is increased. The decrease occurs because (1) tensile specimens fail at the weakest part along their length, and (2) as the test length is increased the probability of including a still weaker part also increases.

The effect of test span on breaking load of paper has been found (*1*) to follow the Pierce (*2*) weak-link theory which states that:

$$F_{rL}/F_L = 1-4.2(1-r^{-0.2})V/100$$

where:

F_L = breaking load at span L
F_{rL} = breaking load at span rL
V = Coefficient of variation at span L

The table shows the predicted change in tensile breaking load at several test spans and levels of variability, relative to the breaking load at a test span of 200 mm.

Coefficient of variation, %	*Predicted change in breaking load, %* 50 mm span	100 mm span	200 mm span	300 mm span	400 mm span
2	2.7	1.2	—	–0.7	–1.1
4	5.4	2.5	—	–1.3	–2.2
6	8.0	3.7	—	–2.0	–3.3
8	10.7	5.0	—	–2.6	–4.3
10	13.4	6.2	—	–3.3	–5.4

References

1. *Tappi* 47 (1): 47-54 (January 1964).
2. *Journal Textile Inst.* 17: T355-368 (1926).

A.3.1.3 Varying the width of the test specimen between 12 mm and 50 mm does not, in general, make much difference in test results except for unbeaten long-fiber papers, when the difference may be appreciable.

A.3.2.1 *Procedure*

A.3.2.1 At shorter test spans, adjust the rate of jaw separation so that the strain rate matches that achieved with the test span and rate specified in 6.4 and 6.5. This strain rate (rate of jaw separation/test span) is 0.14 ± 0.04 (mm/min / mm). For example, if only one-half (90 mm) of the specified test span were used, the test speed would be set at one-half (12.5 mm/min) of the specified speed.

A.3.2.2 Doubling the test speed (for same length specimen) will increase the apparent tensile strength and may increase TEA for some papers approximately 3%. In other cases stretch will be reduced, thus acting to keep TEA nearly constant.

Literature cited

1. Van den Akker, J.A., and Hardacker, K.W., "Instrument Studies. LXXXI. The Automatic Recording of the Load Elongation Characteristics of Paper. III. The Table Top Model Instron (Universal Testing Machine)," *Tappi* 41 (8): 224A (1958).
2. Wink, W.A., Hardacker, K. W., and Van Eperen, R.H., "The IPC Line Type Specimen Clamps," *Tappi* 47 (1): 13 (1964).
3. Lashof, T. W., "Precision of Methods for Measuring Tensile Strength, Stretch, and Tensile Energy Absorption of Paper, " *Tappi* 45 (1): 52 (1963).
4. Midgely, E., and Pierce, F. T., *Text. Inst. J.* 17: T355 (1926).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator. ■

T 414 om-88

OFFICIAL STANDARD – 1926
TENTATIVE STANDARD – 1964
OFFICIAL TEST METHOD – 1982
REVISED – 1988

This TAPPI method has been adopted and endorsed by the Tag and Label Manufacturers Institute, Inc. (TLMI).

Internal tearing resistance of paper (Elmendorf-type method)

1. Scope

1.1 This method measures the force perpendicular to the plane of the paper required to tear multiple sheets of paper through a specified distance after the tear has been started using an Elmendorf-type tearing tester. The measured results can be used to calculate the approximate tearing resistance of a single sheet. In the case of tearing a single sheet of paper, the tearing resistance is measured directly.

1.2 It is not suitable for determining the cross-directional tearing resistance of highly directional boards and papers. These materials are covered by TAPPI T 496 "Cross Directional Internal Tearing Resistance of Paperboard."

1.3 For edge-tear resistance see TAPPI T 470 "Edge Tearing Resistance of Paper (Finch Method)."

2. Summary

One or more sheets of the sample material are torn together through a fixed distance by means of the pendulum of an Elmendorf-type tearing tester. The work done in tearing is measured by the loss in potential energy of the pendulum. The instrument scale is calibrated to indicate the average force exerted when a certain number of plies are torn together (work done divided by the total distance torn).

3. Significant test variables

3.1 Several Elmendorf-type tearing testers are available and in use throughout the world, principally those of Australian, British, German, Swedish, and United States manufacture. In addition, testing practices also vary, as is reflected in the related methods for these countries or others listed in 10.3. Instruments and practices in use vary in at least three major respects:

3.1.1 One difference is in the design of the pendulum sector. The oldest model without deep cutout permitted the specimen to come in contact with the sector during the test and gave values significantly higher than those obtained using the newer models *with* a deep cutout (see Fig. 1) which eliminate this undesirable friction. The magnitude of the difference in value obtained using different styles of the instrument de-

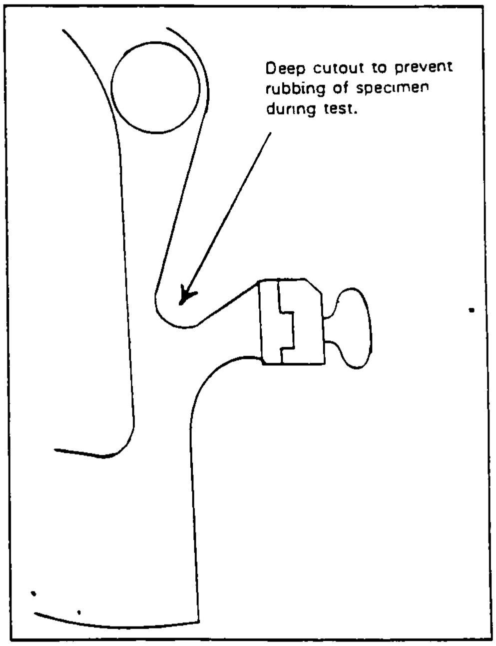

Fig. 1. Newer testing model with deep cutout.

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scribed in this test method varies as a function of instrument and with different types and grammages of paper. The instrument having the oldest-style sector does not meet the requirements of this test method. With a few materials, test values have been observed (*1*) to be as much as 10% greater with the oldest-style sector.

3.1.2 The second difference is in the design of the specimen clamps which, together with the structural characteristics of the paper which govern the nature of the tear with respect to its splitting tendencies during the test, can have an appreciable influence on the mode of tearing and may result in significant differences (2). The procedure described in Section 7.3 reduces this effect. The clamp designs used by some manufacturers may vary even for their own models. Instruments are available with pneumatically activated grips as well. When available, their use minimizes variations due to differences in clamping pressures exerted by manually tightened grips.

3.1.3 The third difference results from a combined variation in testers and testing practices. As measured tearing resistance increases or decreases for different types of paper, it may become so large or so small as to be outside the practical range of the instrument. This problem may be overcome in one of two ways; the number of sample sheets tested at one time may be changed, or the mass of the instrument pendulum may be changed either by addition of augmenting weights or by replacement of the entire pendulum with one of a different known mass. The tearing length must never be varied in an effort to alter the pendulum capacity.

3.2 The foregoing, together with other lesser differences in design details between instruments or testing practices, preclude specifying a tearing instrument and method that would give essentially the same test results when using Elmendorf instruments of different design and manufacture. Even for one specific model, some procedural variables such as the number of plies torn may alter the test values calculated on a single sheet basis substantially. Hence, by necessity, this reference method must be arbitrary and is limited to the described procedure used with instruments conforming to all of the requirements specified under Section 4.

4. Apparatus

4.1 Elmendorf tearing tester (*3–5*), with a cut-out as shown in Fig. 1, which prevents the specimen from coming in contact with the pendulum sector during the test, and having the following elements:

4.1.1 A stationary clamp; a movable clamp carried on a pendulum formed by a sector of a circle free to swing on a ball bearing; a knife mounted on a stationary post for starting the tear; means for leveling the instrument; means for holding the pendulum in a raised position and for releasing it instantaneously; and means for registering the maximum arc through which the pendulum swings when released.

4.1.1.1 The registering means may consist of a graduated scale mounted on the pendulum, a pointer mounted on the same axis as the pendulum with constant friction just sufficient to stop the pointer at the highest point reached by the swing of the sector, and an adjustable pointer stop for setting the zero of the instrument.

4.1.1.2 The pointer and scale may be replaced by a digital readout unit which gives readings of equivalent accuracy and precision (*6*).

4.1.2 With the pendulum in its initial position ready for a test, the clamps are separated by an interval of 2.8 ± 0.3 mm and are so aligned that the specimen clamped in them lies in a plane parallel to the axis of the pendulum, the plane making an angle of 27.5 ± 0.5° with the perpendicular line joining the axis and the horizontal line formed by the top edges of the clamping jaws. The distance between the axis and the top edges of the clamping jaws is 103.0 ± 0.1 mm. The clamping surface in each jaw is at least 25 mm wide and 15.9 ± 0.1 mm deep.

NOTE 1: In the past, it has been the practice for instruments commonly available in the United States to be equipped with 36 ± 1 mm wide jaws. Instruments currently available, however, may be equipped with jaws as narrow as 25 mm. Testing has shown that the effect of jaw width on test results is statistically insignificant. It is recommended, however, that the test specimen length be adjusted to match jaw width. See Note 6.

4.1.3 The instrument measures the energy (work done) used by the pendulum in tearing the test specimen. In order to convert to average tearing force, the energy must be divided by the total distance through which the force is applied. This division may be accomplished by the electronics in digital read-out instruments so that the read-out is directly in grams-force or in millinewtons (SI unit of force). For pointer and scale instruments, the scale may be in millinewtons or in grams-force for a specified number of plies; i.e., when the specified number of plies are torn together, the scale reading gives the average tearing resistance (force) of a single ply.

4.1.4 Instruments of several capacities e.g., about 2000, 4000, 8000, 16,000, 32,000 mN (200, 400, 800, 1600, 3200 gf) and perhaps others are available, with the several capacities being achieved by individual instruments, interchangeable pendulum sectors, or augmenting weights. The instrument recognized as "standard" for this method has a capacity of 1600 gf (SI equivalent 15.7 N); i.e., it has a pendulum sector of such mass and mass distribution that its 0 to 100 scale is direct reading in grams-force per ply when 16 plies are torn together. For a 16-ply test specimen, the tearing distance $K = 16 \times 4.3$ cm (tearing distance per ply) x 2 = 137.6 cm, the factor 2 being included since in tearing a given length the force is applied twice the distance. Likewise, for a 16-ply test specimen, the tearing energy per ply for a scale reading of 100 would then be 100 gf x 137.6 cm or 13760 gf·cm (SI equivalent 1349.4 mJ). For some of the instruments of different capacities where different numbers of plies are required, or when the number of plies tested using the "standard" instrument differs from 16, different values of *K* and/or the tearing energy per ply may be calculated, using the above calculation as a model.

4.1.5 In the "standard" instrument, the zero reading on the scale is at about 70° from the center line (i.e., the vertical balance line when the pendulum hangs freely), the 100 reading is at about 21° from the center line, and a vertical force of 1057.3 ± 2.0 gf (SI equivalent 10.369 ± 0.020 N) applied at 22.000 ± 0.005 cm from the pendulum axis is required to hold the pendulum sector at 90° from its freely hanging position. Other tearing instruments will require vertical forces that are factors of 2 greater or smaller than 1057.3 gf and, if calibrated in millinewtons, the zero reading would remain at 70° and the 1000 reading would be at about 19° (or the 981 reading at about 21°).

4.1.6 The cutting knife for the test specimen is centered between the clamps and adjusted in height so that the tearing distance is 43.0 ± 0.2 mm; i.e., the distance between the end of the slit made by the knife and the upper edge of the specimen is 43.0 ± 0.2 mm when the lower edge of the 63.0-mm wide specimen rests against the bottom of the clamp.

4.2 *Specimen cutter*, to insure parallel specimens 63.0 ± 0.15-mm wide with sharp and clean edges. For this purpose it is desirable to use the type having two hardened and ground base shears, twin knives tensioned against the base shears, and a hold-down mechanism.

5. Calibration and adjustment

5.1 *Verification of scale*

5.1.1 Once the scale has been verified, it is unnecessary to repeat this step, provided the tester is kept in adjustment and no parts become changed or perceptibly worn. The scale may be verified either by the potential energy method or by the method which uses the check weights obtainable from the manufacturer. The potential energy method is relatively time-consuming and complicated. The check weight method is relatively simple.

5.1.2 *Potential energy method.* The procedure (7) for verification is as follows: Anchor and level the tester as later described. Clamp a known weight (in grams) W to the radial edge of the sector beneath the jaws, the center of gravity of the weight (including means of attaching) having been previously marked by a punched dot on the face of the weight that is to be toward the front of the instrument. Close the jaw of the clamp in the sector. Raise and set the sector as for tearing a sheet and, by means of a surface gauge or cathetometer, measure in centimeters, to the nearest 0.01 cm, the height H of the center of gravity of the weight above a fixed horizontal surface. Then release the sector, allow it to swing and note the pointer reading. Without touching the pointer, raise the sector until the edge of the pointer just meets with its stop, in which position again determine the height h of the center of gravity of the weight above the fixed surface.

5.1.2.1 The work done is $W(h-H)$ gf·cm. For the standard 1600 gf tester, the pointer reading should be $W(h-H)/K$, where K = 137.6 cm. For other instruments graduated for grams-force of greater or lesser capacity, the reading will be factors of 2 greater or smaller. If graduated for millinewtons, the additional factor 9.81 must be applied.

5.1.2.2 One or more weights may be clamped on the edge of the sector for each calibration point, the work done in raising each weight being calculated and added together.

5.1.2.3 If the deviations of the indicated readings are greater than one-half division, the instrument should be returned to the manufacturer for repair and adjustment.

5.1.2.4 Calibration weights may or may not be available from the manufacturer of the instrument for use in calibration.

5.1.3 *Verification of Scale – Check Weight Method.* Use Check Weights calibrated for suitable scale values (i.e., 20%, 50% and 80% of pendulum capacity.) Different Check Weights are needed for each pendulum capacity. These weights should be so constructed that each weight can be inserted in the clamps by the procedure used for a test specimen.

5.1.3.1 With the pendulum in the raised position, open the clamp of the pendulum. Slide the weight into position and fasten it securely into the clamp. The body of the weight must be beneath the clamp. Depress the pendulum stop, thus releasing the pendulum. Hold down the stop until after the pendulum swing is completed, and catch the pendulum on the return swing. Read the indicating device to the nearest division.

5.1.3.2 Repeat this procedure with each of the check weights.

5.2 *Adjustment of tearing distance*

5.2.1 To check the 43.0-mm tearing distance, apply a small amount of graphite (from an ordinary pencil), to the cutting knife so that when the cut is made, some of the graphite transfers to the paper. This serves to contrast the cut from the uncut portion of the paper and facilitates the measurement. Make this measurement with a vernier caliper with a depth gauge or a good quality steel rule, readable to 0.2 mm or better under magnification. An alternative procedure is to use a go, no-go gauge, which may be available from the manufacturer of the instrument.

5.3 *Adjustment of instrument for operation*

5.3.1 *Pendulum notching.* Sometimes, as a result of frequent use, a notch is worn in the pendulum sector at the point of contact with the sector stop, giving a jerky release of the pendulum. If this happens, either repair the sector by cutting out and replacing the worn edge, or adjust the height of the stop to the very lowest point of the sector edge. In this case, recheck the calibration of the scale.

5.3.2 *Clamp alignment and knife condition.* Rest the pendulum sector against its stop, and check the alignment of the clamps. Adjust the pendulum stop if necessary. Verify by visual check that the knife is centered between the clamps, and adjust if necessary. Check the sharpness of the knife. A dull knife will result in a square notch near the top of the cut with the paper pushed out. If necessary, sharpen the knife with a rough stone; a rough edge is better than a sharp, smooth edge. Check the tearing distance and adjust the height of the knife if necessary. *Do not* change the dimensions of the specimen to adjust the tearing distance.

5.3.3 *Instrument mounting.* Support the instrument on a table so rigid that there will be no perceptible movement of the table or instrument during the swing of the pendulum. Any movement of the instrument base during the swinging of the pendulum may be a significant source of error.

NOTE 2: Threaded bolt holes are usually provided in the base of the instrument and may be used to secure the instrument to the table. An alternative procedure is to place the instrument on a guide which ensures that the instrument always has the same position on the table. Such a guide may be available from the manufacturer of the instrument.

5.3.4 *Instrument leveling.* Level the instrument so that, with the sector free, the line on the sector indicating the vertical from the point of suspension is bisected by the edge of the pendulum stop mechanism.

5.3.5 *Pendulum friction (older instruments).* Draw a pencil line on the stop-mechanism 25 mm to the right of the edge of the sector stop. Raise the sector to its initial position and set the pointer against its stop. On releasing the sector and holding the sector stop down, the sector should make at least 20 complete oscillations before the edge of the section which engages the stop no longer passes to the left of the pencil line. Otherwise, clean, oil, and adjust the bearing.

5.3.6 *Pendulum friction (newer instruments).* In recent years, a new type of frictionless bearing made of synthetic material has been used. This bearing will not necessarily allow the pendulum sector to make 20 complete oscillations as the older one did. This does not mean that there is excess friction in the pendulum swing. These newer bearings should not be oiled. Consult the instructions supplied with the instrument for guidance.

5.3.7 *Pointer zero reading.* Operate the leveled instrument several times with nothing in the jaws, the movable jaw being closed. If zero is not registered, the pointer stop should be adjusted until the zero reading is obtained. Do not change the level to adjust the zero.

5.3.8 *Pointer friction.* Set the pointer at the zero reading on the scale before releasing the sector, and after release see that the pointer is pushed not less than 2.5 mm nor more than 4.0 mm beyond the zero. If the pointer friction does not cause it to lie between these two distances, remove the pointer, wipe the bearing clean, and apply a trace of good clock oil to the groove of the bearing, adjust the spring tension or make other adjustments to achieve the specified friction. Reassemble, readjust the zero setting, and recheck the pointer friction.

6. Sampling and test specimens

6.1 Sample the paper in accordance with T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product." From each test unit of the sample, prepare 10 representative specimens in each principal direction of the paper, unless a test in only one direction is required. For each specimen keep the wire sides of all the plies facing the same way.

NOTE 3: It has been found (*8*) that there is usually no advantage in testing more than 10 specimens of a homogeneous test unit of the sample.

6.2 Cut each ply for a test specimen at least 53 mm long by 63.0 ± 0.15 mm wide, taking all the plies to be torn together from a single sheet, or if this does not provide sufficient material, from adjacent sheets of a unit.

NOTE 4: The correct length of the test specimen to be used in making a test, measured in millimeters, is equal to the distance between the outermost edges of each of the instrument's jaws (± 2 mm). For the instrument described in 4.1.2, that distance is at least 2 x 25 mm (the minimum width for each jaw face) plus 2.8 mm (the distance between the clamps) or at least 53 mm. In the United States, the majority of instruments have jaws 36 ± 1 mm wide. In such cases, a test specimen length of 76 ± 2.0 mm, specified in previous versions of this method, continues to be the correct length.

6.3 Determine from a preliminary test or the product specification how many plies are needed to make up a specimen so that, when torn together on the instrument having a 15.7-N (1600-gf) capacity, they give an instrument scale reading nearest 40% of full scale.

NOTE 5: The work done in tearing a number of sheets of paper includes a certain amount of work to bend the paper continuously as it is torn to provide for the rubbing of the torn edges of the specimen together and to lift the paper. The number of plies torn at one time and their size can affect the test result with some papers. Empirical requirements for both the apparatus and the method are therefore necessary to keep the additional work not used for tearing to a definite quantity. For this reason, in making comparisons between two or more sets of paper of the same type and grammage, use the same number of plies for each set.

6.4 If a single-ply test specimen gives a reading higher than 75 on the standard 1600 gf instrument (75% of full scale on other instruments), use the next higher capacity instruments with one ply or, if necessary, a still higher capacity instrument.

NOTE 6: For weaker papers, the standard 1600-gf instrument may require that 16 or more plies be torn together under the procedure specified in 6.3. For these papers, and provided lower capacity instruments are available, the number of plies may be restricted to four and the next lower capacity instrument may be used whenever the reading falls below 20% of full scale. The ISO 1974 procedure provides for testing four-ply specimens with multiple pendulum instruments. If this alternative procedure is used, so state in the report.

7. Procedure

7.1 Precondition, condition, and test the specimens in accordance with T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products."

7.2 Raise the pendulum sector to its initial position and set the pointer against its stop. Center the specimen in the clamps with the bottom edge carefully set against the stops. Securely clamp the specimen using approximately the same pressure on both clamps. Make the initial slit. Depress the pendulum stop quickly as far as it will go to release the pendulum. Hold down the stop until after the tear is completed and catch the pendulum on the return swing without disturbing the position of the pointer.

7.3 Make only one test per specimen, each specimen consisting of the same number of plies. Make tests alternately with the wire sides of all the plies of a specimen facing the pendulum and with the wire sides of all the plies away from the pendulum. Make certain that the specimen leans toward and not away from the pendulum by gently creasing the specimen at the clamp if necessary, but in doing so avoid affecting the relative humidity of the test area (9).

7.4 Record the scale readings to the nearest half division; also record the number of plies used in the specimens.

7.5 If the line of tear fails to pass through the top edge of the specimen but deviates to one side, note and report this, but do not use the reading so obtained. If more than one-third of the tests exhibit this behavior, this method should not be used for the material concerned. If the sheets split extensively when being torn, this also should be reported.

7.6 Calculate the average tearing force in millinewtons and, if desired, in grams-force required to tear a single ply as follows:

7.6.1 If the standard 1600-gf instrument with 0-100 scale is used:

Average tearing force, mN = (16 x 9.81 x average scale reading) / number of plies

Average tearing force, gf = (16 x average scale reading) / number of plies

7.6.2 If an instrument of different grams-force capacity with 0–100 scale is used:

Average tearing force, mN =
(16 x 9.81 x avg. scale reading x gf-capacity) / (number of plies x 1600 gf)

Average tearing force, gf =
(16 x average scale reading x gf-capacity) / (number of plies x 1600 gf)

7.6.3 If an instrument has an SI metric scale (e.g., 0–1000 graduations):

Average tearing force, mN =
(16 x avg. scale reading x capacity, N) / (number of plies x 15.7 N)

Average tearing force, gf =
(16 x avg. scale reading x capacity, N) / (9.81 x number of plies x 15.7 N)

7.6.4 If an instrument has a direct-reading scale (e.g., digital read-out) that directly gives the force per ply when preset for the number of plies:

Average tearing force, mN = scale reading if directly in millinewtons, *or*
= 9.81 x scale reading if in grams-force

Average tearing force, gf = scale reading / 9.81, if scale is in millinewtons, *or*
= scale reading if directly in grams-force

NOTE 7: Previously, a standard reference material (NBS Standard Sample No. 704) was available for use with this method (*10*). Instructions accompanying the material described a procedure to correct values when using this standard. Currently, this standard reference material has been exhausted and will not be replaced.

8. Report

8.1 Report results with the tear parallel with the machine direction as resistance to internal tearing in the machine direction and those with the tear perpendicular to the machine direction as resistance to internal tearing in the cross direction.

8.2 For each principal direction, report the average, maximum, and minimum of accepted test values of the force required to tear a single ply to three significant figures.

8.3 For a complete report, state the number of plies torn at one time; the number and value of any rejected readings and reasons for their rejection; if an augmenting weight was used; and the make and model number of the instrument used.

9. Precision

9.1 On the basis of studies made in accordance with T 1200 "Interlaboratory Evaluation of Test Methods Used with Paper and Board Products," the precision of test results representing the average of ten readings, has been found to be as follows:

9.1.1 Repeatability (within a laboratory) = 4.2%

9.1.2 Reproducibility (between laboratories) = 12.5%

9.1.3 Comparability (between materials) = 6.9%, in accordance with the definition of these terms in T 1206 "Precision Statement for Test Methods." Previously, reproducibility could be reduced to 8.3% by using a reference material for standardizing the instruments; however, this material is no longer available (see Note 7).

9.2 In each of the above situations, two test results, each representing an average of ten readings, may be considered alike with a probability of 95% when the two results agree within the appropriate value shown above.

10. Additional Information

10.1 Effective date of issue: November 30, 1987.

10.2 The principal changes made in this revision are: (a) discussion of the check weight method of scale verification; and (b) inclusion of the discussion on the new type of pendulum bearings.

10.3 Related methods: ASTM, D 689; Australian Appita, P 400; British BS 4468; Canadian CPPA, D.9; ISO 1974; SCAN-P 11:73.

10.4 Other references related to this method are by Jones and Galley (*11*), Van den Akker, Wink, and Van Eperen (*12*), Sun, Wilson, and Bach (*13*), Lashof (*14*), and Swartout and Setterholm (*15*).

References

1. Cohen, W. E., and Watson, A. J., *Proc. Ausralian Pulp Paper Ind. Tech. Assn.* 3: 212 (1949).
2. Wink, W. A., and Van Eperen, R. H., *Tappi* 46: 323 (1963).
3. Elmendorf, A., "Strength Test for Paper," *Paper* 26: 302 (1920).
4. Elmendorf, A. "The Principle of the Elmendorf Paper Tester," *Paper* 28:(1921).
5. Institute of Paper Chemistry, "Tearing Strength of Paper, Part 1," Instrumentation Studies XLVI, *Paper Trade J.* 118 (5):13 (1944).
6. Yarber, W. H. II, and Zdzieborski, J. H. George, *Tappi* 55: 1064 (1972).
7. Clark, J. d'A., *Tech. Assn. Papers. Series XV* 1:262 (1932); *Paper Trade J.* 94 (1): 33 (1932).
8. Lashof, T. W., *Tappi* 45: 656 (1962).
9. Balder, E. E., *Tappi* 63 (8):103 (1980).
10. "Association News and Events," *Tappi* 45 (4): 113A (1962).
11. Jones, H.W.H., and Galley, W., *Pulp Paper Mag. Can.* 53(5): 116 (1952).
12. Van DenAkker, J. A., Wink, W. A., and Van Eperen, R. H., *Tappi* 50 (9): 46 (1967).
13. Sun, B.C., Wilson, J. W., and Bach, L., *Tappi* 59(10): 106-(176).
14. Lashof, T. W., *Tappi* 47: 445 (1964).
15. Swartout, J. T., and Setterholm, V. C., U.S. Forest Service Research Note FPL, 05 (May 1968).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator. ■

Standard Method of
DROP TEST FOR FILLED BAGS[1]

1. Scope

1.1 This method covers drop tests on loaded bags for measuring the ability of the bag to withstand handling or for comparative evaluation of various bag constructions.

1.2 The procedure is suitable for testing all types of bags.

2. Applicable Documents

2.1 *ASTM Standards:*

D 585 Method for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product[2]

D 685 Method for Conditioning Paper and Paper Products for Testing[2]

3. Significance

3.1 In the life cycle of many bags, there is a point at which the bag is handled either manually or mechanically in a manner such that there is an increased probability that the bag will fall and possibly rupture. Since bags are most often used to contain products in the form of small particles (powders, granules, etc.) which are flowable to some extent, the rupture of a bag will result in the product spilling from the rupture. This not only results in an economic loss but may additionally be the source of a health hazard and a difficult clean-up. This method is used to indicate the ability of the bag to withstand the shock produced when it is dropped. This method also is an aid in the design and improvement of bags.

4. Apparatus

4.1 *Drop Test Apparatus*—Any suitable apparatus may be used that conforms to the following requirements:

4.1.1 Permits accurate prepositioning of the bag to assure a true fall and impact at the exact places and in the direction desired,

4.1.2 Permits accurate and convenient control of the height of drop,

4.1.3 Facilitates handling and elevation of the bags, particularly when weights are in higher brackets,

4.1.4 Utilizes lifting devices that will not damage the bags,

4.1.5 Permits an absolutely free, unobstructed fall,

4.1.6 Provides for variations in height of drops within limits of anticipated requirements,

4.1.7 Provides a solid surface of concrete, stone, or steel of sufficient mass to absorb all shock without deflection, and

4.1.8 Provides a 4 by 4-in (102 by 102-mm) timber (about 4 ft (1.2 m) in length) having the edges rounded to a radius of not more than ¼ in. (6.4 mm), firmly positioned on a drop surface.

4.2 *Conditioning Apparatus*—Adequate facilities for conditioning test specimens at proper humidity and temperature prior to test in accordance with the requirements of the specifications covering the bags to be tested.

4.3 *Miscellaneous Equipment*—Drying oven, scales, knife, etc., for use in determination of the moisture content or for making other supplementary tests of the materials from which the bags are made.

5. Sampling

5.1 Any convenient or specified sampling plan may be used. When the test is for the

[1] This method is under the jurisdiction of ASTM Committee D-10 on Packaging.

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[2] *Annual Book of ASTM Standards*, Vol 15.09.

purpose of accepting a lot, Method D 585 shall be used.

5.2 In the absence of any specific plan, no fewer than five representative specimens of a given size or construction shall be selected for evaluating performance.

6. Test Specimens

6.1 Pack the bag to be tested with the actual contents for which it was designed or a dummy load simulating these contents. Close and seal the bag in the same manner as will be used in preparing it for shipment.

6.2 The procedure for the identification of the faces, edges, and butts of bags shall be as follows: Facing the front of the bag with top up, designate the front of the bag as *1*, the right side edge as *2*, the rear side as *3*, the left side edge as *4*, the bottom as *5*, and the top as *6*.

7. Conditioning

7.1 Depending on the purpose of the tests, bags filled and sealed may be conditioned prior to the drop test by either water immersion, exposure to water spray, or exposure to fixed conditions of air temperature or humidity.

8. Procedure

8.1 *Procedure A*—Drop the bags on any face, butt, or side in accordance with 8.3.

8.2 *Procedure B*—Drop the bags on faces, butts, and sides in a specified sequence of drops as follows: *(1)* front, *(2)* back, *(3)* right side, *(4)* left side, and optionally, *(5)* bottom, *(6)* top, and in accordance with 8.3. Before each drop uniformly distribute the contents throughout the bag.

8.3 Position the bag with the center of gravity of the contents over the point of impact, and the face, side, or butt on which the bag is to fall parallel to the floor. Make certain the drops are vertical, free, and unobstructed.

8.4 *Height of Drop*—Drops on faces, butts, and sides may be from the same height, or drops on butts and sides may be from lesser heights, in a definite relationship. Unless otherwise specified, the height of face drops shall be 4 ft (1.2 m).

8.5 The use of the 4 by 4-in. (102 by 102-mm) hazard is optional.

8.6 Continue the test until a specified predetermined number of drops, estimated to be equivalent to handling in actual service, have been given the bag or until failure occurs. Failure may be considered to have occurred when the contents are exposed, the contents spill from the bag, or the bag breaks open.

9. Report

9.1 The report shall include the following:

9.1.1 Dimensions of bag under test, its complete specifications, kind of material, method of closing and sealing, net and gross masses,

9.1.2 Description of the contents of the bag under test and load density in pounds per cubic foot (or kilograms per cubic metre),

9.1.3 Method, if any, of conditioning the bag and the results of any supplementary tests of the material from which the bag is made,

9.1.4 Type of apparatus and procedure used,

9.1.5 Number and height of drops to completion of test or to failure of bag,

9.1.6 Detailed record of test on each bag including damage to the bag together with any other observation that may assist in correctly interpreting the results or improving the design of the bag, and

9.1.7 Statement to the effect that all tests were made in full compliance with this method.

10. Precision and Accuracy

10.1 The drop test for filled bags produces a high degree of variation. The variation may be caused by the lack of homogeneity of both the material from which the bag is made and the contents as well. Therefore, reproducibility will not generally lie between acceptable limits.

T 441 om-90

TENTATIVE STANDARD – 1937
OFFICIAL STANDARD – 1960
REVISED – 1977
OFFICIAL TEST METHOD – 1984
REVISED – 1990

Water absorptiveness of sized (non-bibulous) paper and paperboard (Cobb test)

1. Scope

1.1 This method describes a procedure for determining the quantity of water absorbed by nonbibulous paper and paperboard in a specified time under standardized conditions. It is based on studies by Cobb and Lowe (*1*), Cobb (*2*) and other investigators (*3*, *4*).

1.2 Water absorptiveness is a function of various characteristics of paper or board such as sizing, porosity, etc. This method is generally applicable to sized paper and paperboard, but it is not recommended as a sizing test for writing paper.

1.3 For testing unsized and absorbent paper or paperboard, see T 432 "Water Absorbency of Bibulous Paper" and T 492 "Water Absorption of Paperboard (Non-Bibulous)" (water drop test); for slack sized paper and paperboard, see T 433 "Water Resistance of Sized Paper and Paperboard (Dry-Indicator Method)."

2. Apparatus

2.1 *Water absorption apparatus*[1], to permit one side of the specimen to be wetted uniformly at the moment the soaking period begins, and to allow controlled rapid removal of the water from the specimen at the end of the test period. The specimen holder (*3*) as shown in Fig. 1 comprises a metal ring with a machined lower face, 11.28 ± 0.02 cm inside diameter (corresponding to a cross-sectional area of 100 cm^2), 2.5 cm high and about 0.6 cm thick, clamped to a flat base plate about 15 x 15 cm with a metal cross bar 17 x 2.5 x 0.6 cm and two wing nuts on a pair of studs. The cross bar has a hole at one end and a slot at the other to facilitate assembly and use. On the base plate is a rubber mat, larger than the outside dimensions of the ring, on which the specimen is clamped.

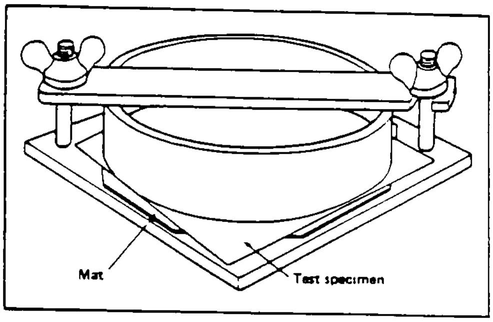

Fig. 1. Water absorption apparatus.

NOTE 1: The metal parts should preferably be of brass or other corrosion-resistant material.

NOTE 2: Several versions of the water absorption apparatus are now available. Although the basic procedure for performing the test is not changed, the clamping mechanism is. This may affect the speed at which the sample can be removed from the apparatus.

2.2 *Metal roller*, solid brass having a smooth face 20 cm wide and weighing 10.0 ± 0.5 kg.

2.3 *Timer*, stopwatch or electric timer reading in seconds.

2.4 *Graduated cylinder*, 100 mL.

2.5 *Balance*, with an accuracy of 0.01 g, or better.

[1]Names of suppliers of testing equipment and materials may be available from TAPPI Information Resources Center.

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3. Materials

3.1 *Blotting paper*[1], sheets of blotting paper, 200-250 g/m², with a capillary rise of 50-100 mm of water (mean of MD + CD) as measured by the Klemm method (see Appendix). Normally, the blotter specified in T 205 "Forming Handsheets for Physical Tests of Pulp" will meet this requirement.

3.2 *Water*, distilled or deionized.

NOTE 3: The temperature of the water is important and must be maintained at 23 ± 1°C. Renew the water for each determination.

4. Sampling and test specimens

Obtain a sample of the paper in accordance with T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product." From each test unit, cut specimens to a size slightly greater than the outside dimensions of the ring of the apparatus, i.e., squares 12.5 x 12.5 cm. The specimens should be free from folds, wrinkles, or other blemishes not commonly inherent in the paper. For hard-sized papers (absorbing less than 100 g of water/m²), use 10 specimens per test unit. For soft-sized papers (absorbing more than 100 g/m²), use 20 specimens.

5. Procedure

5.1 Condition the specimens in an atmosphere in accordance with T 402 "Standard Conditioning and Testing Atmospheres for Paper, Pulp Handsheets, and Related Products."

5.2 Weigh each specimen to the nearest 0.01 g.

5.3 Test half the specimens with the wire side up, the other half with the felt side up.

5.4 Place a dry rubber mat on the metal plate and lay a weighed specimen on it. After wiping the metal ring perfectly dry, place it upon the specimen, and fasten it firmly enough in place with the crossbar to prevent any leakage between the ring and the specimen. For reporting, the test side is the one that is in contact with the water during the test.

NOTE 4: For materials where leakage between the ring and the upper surface of the test specimen may occur during the test, a soft elastic non-absorbent gasket may be used. The gasket should have the same internal dimensions as the ring.

5.5 Pour 100 mL of water into the ring as rapidly as possible thus giving a head of 1 ± 0.1 cm. Start the stopwatch immediately. At 15 ± 5 s before the expiration of the predetermined test period, usually 120 s (see 8.3, 8.4, and 8.5), pour the water quickly from the ring, taking great care not to drop any of the water upon the outside portion of the specimen. Promptly loosen the wing nuts, swing the crossbar out of the way while holding the ring in position by pressing it down with one hand. Carefully, but quickly, remove the ring and place the specimen with its wetted side up on a sheet of blotting paper resting on a flat rigid surface.

5.6 Exactly at the end of the predetermined test period, place a second sheet of blotting paper on top of the specimen and remove the surplus water by moving the hand roller once back and once forward over the pad without exerting any additional pressure on the roller. Specimens which contain an excess of surplus water after blotting, as shown by glossy areas on the surface, should be rejected and the test repeated, decanting the water from the ring sooner. Fold the specimen with the wetted area inside. Immediately reweigh it to the nearest 0.01 g.

5.7 Subtract the conditioned weight of the specimen from its final weight, and multiply by 100 the gain in weight in grams to obtain the weight of water absorbed in grams per square meter.

NOTE 5: If any liquid has passed through the sheet to the rubber mat, the test is not acceptable. When this occurs, either shorten the time to 60 s, or staple two or more specimen sheets together outside the test area. In such a case, the calculated test area remains that of the inside ring. For hardsized papers, a longer period (e.g., 300 s) may be found advisable.

6. Report

Report the absorptiveness, calculated as the average weight of the water absorbed in grams per square meter, for the wire and the felt side of the paper separately. If desired, state also the maximum and minimum values for each side.

NOTE 6: Unless otherwise stated in the report, it is assumed that an exposure period of 120 s on a single-sheet thickness has been employed. Such conditions are suitable for most well-sized papers.

7. Precision

Based on limited data for hard sized papers and for means of five specimens on the same side, the repeatability is within 8% and the reproducibility between laboratories is within 10%, as defined by TAPPI T 1206 "Precision Statement for Test Methods."

8. Additional information

8.1 Effective date of issue: April 20, 1990.

8.2 The standard test area is 100 cm². If the available specimens are too small, a proportionately smaller test area may be used providing that the volume of water is reduced to provide a pressure head of 1 ± 0.1 cm. The change in area should be noted in the report.

8.3 This test is designed for nonbibulous papers and paperboards, but satisfactory results have been obtained with up to about 20 sheets of highly absorbent paper stapled together and tested for 60 instead of 120 s.

8.4 For very hard-sized or specially treated papers, the test may be extended to periods up to 18 h, to increase the sensitivity.

8.5 For layers of absorbent papers, the quantity of water absorbed is almost proportional to the time of exposure. For well-sized papers, the quantity is approximately proportional to the square root of this time.

8.6 An effect of natural aging has been noticed in many papers. For example, results on cupstock papers, aged a few weeks, are usually about 2 g/m² less than on papers tested immediately after being made.

8.7 The Cobb test may also be suitable with other (water base) solutions, such as dilute lactic acid and hot coffee for food board and cup stock and possibly ink for writing and printing papers.

8.8 Weighing the wetted specimens can be facilitated by using tared water-vapor-proof containers which will eliminate evaporation losses. Metal cans or polyethylene bags about 11 cm x 23 cm x 0.0076 cm with wire closure have been reported to be satisfactory for this purpose.

8.9 For specimens that have long penetration times or have surfaces that are difficult to wet, substitute the distilled or deionized water with water having a known concentration of wetting agent. With the results also indicate the exposure time, total head, wetting agent and concentration.

8.10 This method was revised in 1942, 1945, 1958, 1960, 1963, 1969, 1977, and 1990. The 1969 revision incorporated standardization of the test area at 100 cm² and the pressure head depth at 1.0 ± 0.1 cm, standardization of the blotting method with specification of the blotters and rollers used, and specification of the water as distilled or demineralized. The 1977 revisions were editorial. This 1990 revision makes mention of the use of alternate clamping mechanisms.

8.11 Related methods: ASTM D 3285, Canadian CPPA F.2; British Standard 2644; British PPMA PT-15; Australian APPITA P 411, Scandinavian SCAN P-12; ISO Standard 535-1976.

References

1. Cobb, R. M., and Lowe, D.V., "A Sizing Test and Sizing Theory," *Tech. Assoc. Papers* 17:213 (1934); *Paper Trade J.* 98(12):43 (1934).
2. Cobb, R.M., "What I Do Not Know About Sizing and Capillary Flow," *Tech. Assoc. Papers* 18:209 (1935); *Paper Trade J.* 100(16):42 (1935).
3. Egy, W.L., "The Cobb Sizing Test," *Pulp Paper Mag. Can.* 38(7):499 (1937).
4. Codwise, P.W., "Water Resistance of Paper," *Tech. Assoc. Papers* 19:231 (1936); *Paper Trade J.* 102(3):39 (1936).

Appendix
Measurement of blotter absorptiveness (Klemm method)

Make the test on samples conditioned according to T 402. Cut parallel specimen strips about 15 mm wide and at least 200 mm long in both machine and cross directions. Immerse the specimen strips suspended vertically to a depth of 10 mm in distilled or deionized water maintained at a temperature of 23 ±1°C. After an immersion time of 10 min, read the height in millimeters to which the water rises above the water level in the container.

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Technical Divisions Administrator. ■

BIBLIOGRAPHY

American Forest & Paper Association, "Kraft Papers", http://www.afandpa.org/Paper/About/Kraft.html,18 October 1998, 1.

Arendsen, Steven B., "Velumina® Bemis/Georgia-Pacific", presented 4/30/97 at Bemis, Peoria,IL, transcript of presentation held by author.

Bancroft Bag,Inc., "Multiwall Bag Seminar Handbook", presented and printed in 1992, 11 pp.

Cox, Edward, Eli Lilly and Co. - retired Elanco Packaging Engineer, unpublished Multiwall Manual notes, 1990, 39 pp. Manual held by author.

Cutrer, Jim, Georgia Pacific Superintendent Shipping/Customer Service, Interviewed by author, 1/23/98, Clinton, IN. Notes.

Eldred, Nelson,R., Packaging Printing, 1stEd.,(Plainveiw,NY:Jelmar Publishing Co.), 1993, 189,190pp.

Hodges, Jim, J.M. Fry Printing Inks vice president, Interviewed by author, 5/7/98, Omaha, NE. Notes.

Kline, James E., Paper and Paperboard Manufacturing and Converting Fundamentals, 2nd Ed., (New York, NY: Miller Freeman Publications, Inc.), 1991,16,33,39,40 pp.

Larson, Douglas,J.,Bemis Co. senior accounts manager, Interviewed by author, 6/3/98, Rochester, NY. Notes.

Lilly, Eli, Course MF16033, Corporate Introduction to Current Good Manufacturing Practices's, class handouts, 1995, Copy of handouts held by author.

Scott, William E., and James C. Abbott, Properties of Paper: An Introduction, 2nd Ed., (Atlanta, GE: TAPPI Press), 1995, 29,72 pp.

Smook,G.A., Handbook for Pulp and Paper Technologists,2nd Ed., (Vancouver,B.C.: Angus Wilde Publications Inc.), 1992, 309,339,340pp.

Soroka, Walter, Fundamentals of Packaging Technology, (Herndon, VA: Institute of Packaging Professionals), 1995, 504,515 pp.

T 494 om-88, Tensile breaking properties of paper and paperboard (using constant rate of elongation apparatus),(Atlanta, GE: TAPPI Press), 1988, Sec.3.3.

Wagner, Kelly, Bemis Peoria paper procurement, Interview by author, 1/22/98, Peoria,IL. Notes.

Walker, Brad, Bemis Omaha Packaging Engineer, Interviewed by author, 5/7 and 5/8/98, Omaha, NE. Notes.

Wells, Rick, Bemis Crossett Printing and Graphics Manager, Interviewed by author, 2/26/98, Crossett, AK. Notes.