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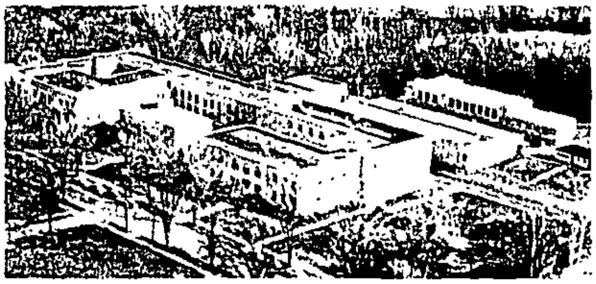

THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

COMPARATIVE PERFORMANCE STUDY

Project 2392

An Abridged Report to Directors

of

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

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May 17, 1965

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THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

SUMMARY

In the free world today there are two primary producing areas of virgin kraft containerboard -- namely, the United States and the Scandinavian countries These "producers" compete to a greater or lesser degree in practically all world containerboard markets; however, the largest joint market is Western Europe These two containerboard producing areas practice different manufacturing philosophies, each undoubtedly oriented toward the most economical manufacture and distribution of its product The two philosophies differ mainly in respect to the importance of weight and bursting strength of the components to box quality

The Scandinavian countries because of advantageous wood species, manufacturing economies specific to their area, and less restrictive regulatory specifications in certain Western European countries, notably West Germany, manufacture unbleached kraft containerboard at a lower weight and higher bursting strength than is practiced with corresponding board made in this country. In effect, the Scandinavian philosophy advocates a lighter weight container in contrast to United States practice and implies that the container weight can be reduced with impunity provided the lower weight is compensated for by an increase in bursting strength In contrast, the philosophy practiced by U.S. manufacturers suggests that a quality box requires a certain minimum weight of fiber, if more substance (fiber) is used, the bursting strength of the linerboard need not be as high as that associated with the lighter weight Scandinavian linerboard

The manufacturing philosophy practiced by the Scandinavian containerboard manufacturers places a burden on U.S. exportation of linerboard to those countries where weight is not considered a factor in containerboard quality. United States linerboard manufacturers can make linerboard to the same specifications as Scandinavian linerboard, however, this would require modifying current manufacturing practices--e.g., more refining, slower speeds, etc.--which would adversely influence costs.

In order to determine the comparative performance of combined board and boxes made with European and domestic kraft linerboards, a study was initiated at The Institute of Paper Chemistry by the Fourdrinier Kraft Board Institute, Inc. The study involved the fabrication of two Scandinavian and one domestic linerboard at each of four nominal grade weight levels with 23-lb. European and 26-lb domestic semichemical corrugating medium into A- and B-flute combined board and boxes under normal but controlled conditions of fabrication using starch as the adhesive. The four nominal grade weights of European linerboards--i.e., 25.6, 30.7, 35.8, and 41.0-lb.--were made by Enso Gutzeit (Finland) and Svenska Cellulosa (Sweden). The 23-lb. semichemical medium was made by Fiskeby. Also, a few trials were made in which a 26-lb. European semichemical corrugating medium (Finnkarton) was fabricated with domestic linerboards into combined board and boxes. The domestic linerboards--i.e., 26, 33, 38, and 42-lb.--were obtained from a member company of Fourdrinier Kraft Board Institute, Inc., and the manufacturing specifications relative to quality were those corresponding to the current industry average quality level for each grade weight.

The combined boards and boxes resulting from the fifty-two experimental material combinations used in this study, together with samples of the components used in each run, were evaluated for performance at 50 ± 2% relative humidity and 73 ± 3.5° F (standard conditions in United States), and 65% relative humidity at 68° F (standard conditions in Europe). It should be borne in mind in interpreting the results that the comparative performance is based on the results obtained on two samples of European linerboard and one sample of domestic linerboard at each of the four grade weight levels. The results, therefore, represent comparative performance only to the extent that the linerboards are representative at each grade weight level.

For purpose of obtaining a general impression of the comparative performance of boxes made with domestic and European components, the results have been condensed in a series of tables.

I. Comparative Performance of Combined Board and Boxes Fabricated with U.S. and European Linerboard.

A. Box Performance

1. The trends indicated by the data on a box basis are tabulated below for each grade weight level. In all cases the results obtained on the boxes fabricated with U.S. linerboard are used as a reference.

Linerboard Grade Weight	Top-Load Compression	End-Load Compression	Corner Drop	Drum Performance
25.5-26.0-lb				
Enso Gutseit	Lower (2-5%)	Equal	Equal	Equal
Svenska Cellulosa	Lower (5-7.5%)	Equal	Equal to sl. lower	Equal to lower
30.7-33.0-lb.				
Enso Gutseit	Equal to sl. higher	Sl. lower	Equal	Sl. lower
Svenska Cellulosa	Equal	Equal	Sl. higher	Equal

Linerboard Grade Weight	Top-Load Compression	End-Load Compression	Corner Drop	Drum Performance
35.8-38.0-lb.				
Enso Gutseit	Higher (7%)	Equal to sl. higher	Sl. lower	Lower (18-20%)
Svenska Cellulosa	Equal to sl. higher	Lower (7-9%)	Higher (7-24%)	Equal
41.0-42.0-lb.				
Enso Gutseit	Higher (8-11%)	Equal	Equal	Equal to sl. lower
Svenska Cellulosa	Equal to sl. higher	Equal	Equal to sl. higher	Equal

The comparative performances tabulated above show certain trends:

(a) At the 25.6, 26.0-lb. grade weight level boxes made with European linerboards appear to give on the average 2-7.5% lower top-load compression but about equal end-load compression, and equal to slightly lower corner drop and drum performance compared to boxes made with U.S. linerboard.

(b) At the 30.7, 33.0-lb. grade weight level boxes made with European linerboard give about equal compression and rough handling performance compared to boxes made with U.S. linerboards.

(c) Boxes made with 35.8-lb. grade weight European linerboard give equal to higher top- and equal to lower end-load compression but generally slightly lower corner drop and drum results than boxes made with 38.0-lb. grade weight U.S. linerboard.

(d) Boxes made with 41.0-lb. grade weight European linerboard generally give equal to higher top-load compression, equal end-load compression, and on the average about equal drop and drum performance compared to boxes made with 42.0-lb. grade weight U.S. linerboard.

2. As previously mentioned Scandinavian linerboard is made at a lower basis weight than the corresponding grade weight of U.S. linerboard. The lower basis weight of the linerboard manifests itself in a lower combined board weight. The combined boards fabricated in this study with European linerboards ranged from 2-7% lower in basis weight than the corresponding U.S. linerboards. The comparative box performance on an equal weight basis may be seen from the results tabulated below. In all cases the results obtained on the boxes fabricated with U.S. linerboard are used as a reference:

Linerboard Grade Weight	Top-Load Compression	End-Load Compression	Corner Drop	Drum Performance
25.6, 26.0-lb.				
Enso Gutseit	Equal to sl. lower	Equal	Equal	Equal
Svenska Cellulosa	Sl. lower	Sl. higher	Equal to sl. lower	Equal to sl. lower
30.7, 33.0-lb.				
Enso Gutseit	Higher (4-8%)	Equal	Equal	Sl. lower
Svenska Cellulosa	Higher (7%)	Higher (4-7%)	Higher (24-27%)	Sl. higher
35.8, 38.0-lb.				
Enso Gutseit	Higher (11-13%)	Higher (6-10%)	Equal	Lower (15-17%)
Svenska Cellulosa	Higher (5-10%)	Lower (2-5%)	Sl. higher	Equal
41.0, 42.0-lb.				
Enso Gutseit	Higher (11-13%)	Higher (6-10%)	Equal to sl. higher	Equal to sl. lower
Svenska Cellulosa	Higher (6-10%)	Higher (6-9%)	Equal to sl. higher	Equal

The following trends may be noted from the preceding tabulation:

(a) It may be noted that at the 25.6, 26.0-lb. grade weight level, box performance is about the same on an equivalent weight basis, even though, as will be shown, the bursting strength of the combined board fabricated with 25.6-lb. grade weight European linerboard is markedly higher.

(b) At the other three grade weight levels, top- and end-load compression is generally higher for the boxes made with European linerboard. Rough handling performance, on the other hand, does not appear generally to be much different.

B. Combined Board Performance

1. The comparative performance of combined board fabricated with European and U.S. linerboards may be seen from the following tabulation in which the results for the combined board fabricated with U.S. linerboards are used as a reference:

Linerboard Grade Weight	Weight	Bursting Strength	Edgewise Compression M.D.	Edgewise Compression C.D.	Flexural Stiffness, $\sqrt{D_x D_y}$	Pin Adhesion
25.6, 26.0-lb.						
Enso Gutseit	Lower (2-3%)	Higher (36-41%)	Lower (10-12%)	Lower (3-5%)	Higher (7-14%)	Lower (9-19%)
Svenska Cellulosa	Lower (3-4%)	Higher (57-65%)	Equal to sl. lower	Lower (4-5%)	Higher (4-7%)	Lower (15-20%)
30.7, 33.0-lb.						
Enso Gutseit	Lower (5-6%)	Higher (21-22%)	Lower (10-12%)	Lower (2-7%)	Higher (9-11%)	Lower (15-23%)
Svenska Cellulosa	Lower (6-7%)	Higher (4-14%)	Lower (4%)	Lower (3-7%)	Lower (2-4%)	Lower (5-15%)

Linerboard Grade Weight	Weight	Bursting Strength	Edgewise Compression M.D.	Edgewise Compression C.D.	Flexural Stiffness, $\sqrt{D_x D_y}$	Pin Adhesion
35.8, 38.0-lb.						
Enso Gutseit	Lower (3%)	Higher (18-34%)	Equal	Higher (3-5%)	Higher (34-38%)	Lower (4-12%)
Svenska Cellulosa	Lower (4-5%)	Higher (29%)	Lower (6-7%)	Higher (2%)	Higher (10-15%)	Lower (6-7%)
41.0, 42.0-lb.						
Enso Gutseit	Lower (2%)	Higher (23-26%)	Higher (11-20%)	Higher (2-4%)	Higher (33-37%)	Lower (6-16%)
Svenska Cellulosa	Lower (4-5%)	Higher (25-30%)	Higher (8-9%)	Equal	Higher (12-16%)	Lower (0-4%)

C. Linerboard Characteristics

1. A comparison of the characteristics of European and U.S. linerboards may be seen from the following abridged tabulation in which the results obtained on the U.S. linerboards are used as reference:

Test Property	25.6, 26.0-lb. EG	25.6, 26.0-lb. SC	30.7, 33.0-lb. EG	30.7, 33.0-lb. SC
Weight	Lower (3-5%)	Lower (4-5%)	Lower (9%)	Lower (11-12%)
Caliper	Lower (18-20%)	Lower (18-20%)	Lower (10-12%)	Equal
Bursting strength	Higher (37-39%)	Higher (47-53%)	Higher (18-19%)	Higher (7-12%)
Elmendorf tear, In	Lower (17-18%)	Lower (29-30%)	Lower (16-18%)	Lower (7-12%)
Cross	Lower (18-20%)	Lower (25-26%)	Lower (17-18%)	Lower (20-23%)
Modified ring compression, In	Equal	Higher (8-9%)	Lower (7-8%)	Lower (14-15%)
Cross	Equal	Equal	Lower (4-5%)	Lower (6-11%)

Test Property		25.6, 26.0-lb. EG	25.6, 26.0-lb. SC	30.7, 33.0-lb. EG	30.7, 33.0-lb. SC
Taber stiffness,	In	Lower (20-23%)	Lower (12-15%)	Lower (0-8%)	Higher (5-11%)
	Cross	Lower (20-40%)	Lower (20-30%)	Lower (7-14%)	Equal
Tensile	In	Higher (40-43%)	Higher (57-66%)	Higher (22-24%)	Higher (11-13%)
	Cross	Higher (37-43%)	Higher (19-22%)	Higher (25-29%)	Higher (30-33%)
Modulus, E	In	Higher (53-58%)	Higher (61-62%)	Higher (32-34%)	Equal
	Cross	Higher (35-39%)	Higher (18-19%)	Higher (19-21%)	Equal
Porosity		Higher (85-120%)	Higher (208-222%)	Higher (258-303%)	Lower (31-32%)
Cobb size		Equal	Equal	Higher (19-22%)	Higher (4-8%)

Test Property		35.8, 38.0-lb. EG	35.8, 38.0-lb. SC	41.0, 42.0-lb. EG	41.0, 42.0-lb. SC
Weight		Lower (5%)	Lower (6-8%)	Lower (3%)	Lower (7-8%)
Caliper		Lower (8-11%)	Lower (10-12%)	Lower (4-5%)	Equal
Bursting strength		Higher (37-38%)	Higher (38-40%)	Higher (27-28%)	Higher (19-26%)
Elmendorf tear,	In	Lower (7-11%)	Lower (8-11%)	Equal	Lower (7-10%)
	Cross	Lower (10-11%)	Lower (15-16%)	Lower (3-4%)	Lower (12-14%)
Modified ring compression,	In	Higher (2-4%)	Lower (1-4%)	Higher (8-17%)	Higher (1-8%)
	Cross	Higher (13-14%)	Higher (6-10%)	Higher (7-11%)	Higher (2-4%)

Test Property		35.8, 38.0-lb. EG	35.8, 38.0-lb. SC	41.0, 42.0-lb. EG	41.0, 42.0-lb. SC
Taber stiffness,	In	Higher (0-4%)	Lower (7-9%)	Higher (15-21%)	Higher (24-28%)
	Cross	Higher (25-31%)	Higher (6-13%)	Higher (25-31%)	Higher (4-17%)
Tensile	In	Higher (35-36%)	Higher (28-29%)	Higher (29-32%)	Higher (30-33%)
	Cross	Higher (63-66%)	Higher (58-62%)	Higher (54-55%)	Higher (37-41%)
Modulus, E	In	Higher (42-43%)	Higher (22-23%)	Higher (37-38%)	Higher (20-22%)
	Cross	Higher (68-69%)	Higher (35-37%)	Higher (49-51%)	Higher (7-10%)
Porosity		Higher (293-369%)	Higher (96-121%)	Higher (289-300%)	Higher (136%)
Cobb size		Equal	Equal	Equal	Higher (11-16%)

D. General Conclusions

In addition to the foregoing comparisons, the following general conclusions may be drawn from the results:

1. The comparative performance of combined board and boxes fabricated with European linerboard was such that the competitive potentials of European linerboard cannot be disregarded.

2. European linerboard appears to be made from a furnish consisting mainly of Scotch pine, refined to a lower freeness and shorter average fiber length and presumably made at a slower machine speed than its U.S. counterpart.

3. European linerboard is made at a lower weight but substantially higher bursting strength than the corresponding U.S. linerboard.

4 The superiority of the European linerboard in bursting strength is not reflected in a correspondingly high box performance. This illustrates the inadequacy of bursting strength as a criterion of quality.

5. Box compression is shown to be far better related to combined board edgewise compression and flexural stiffness than to bursting strength.

6. It is believed that the characteristic of European linerboard responsible for its competitive potential is not bursting strength but the level to which the more basic mechanical properties such as edgewise compression, modulus of elasticity, tensile strength, etc., develop concomitantly with bursting strength.

7. The rough handling performance of boxes made with European linerboards was considerably better than would normally be anticipated from the tearing strength properties of the linerboard and combined board In terms of rough handling, the lower tearing strength of the European linerboard and combined board is compensated for, in part at least, by substantially higher tensile and energy absorption characteristics compared to U.S linerboard.

8. In general, the combined boards made with European linerboards exhibited lower pin adhesion strength This is believed to be due to the generally less porous structure of the European linerboards; hence it would be expected that greater difficulty would be encountered with European linerboards relative to bonding on the corrugator, especially at higher speeds.

9. In general, the U.S. linerboards are more uniform than the European linerboards in terms of such properties as bursting strength, Elmendorf tearing strength, modified ring compression, Taber stiffness, etc.

10 As would be expected, the test results at 65% R.H (European standard condition) were lower for those tests involving stiffness but higher for all tests involving energy absorption than the results at 50% R H (U S standard condition). The effect of relative humidity was about the same on European and U.S linerboards.

II. Comparative Performance of Combined Board and Boxes Fabricated with U. S. and European Medium

A. *Box Performance*

1. The trends observed relative to the comparison of 23-lb. European medium and 26-lb. U.S. medium are indicated below. In all cases the results obtained with the U.S. 26-lb. medium are used as the reference.

		Linerboard Grade Weight			
Box Performance		25.6, 26.0-lb.	30.7, 33.0-lb.	35.8, 38.0-lb	41.0, 42.0-lb
Top-load compression					
	A-flute	Higher (3-5%)	Equal	Equal	Equal to sl lower
	B-flute	Equal	Equal to sl. lower	Equal	Equal to sl. lower
End-load compression					
	A-flute	Equal	Equal	Equal	Equal
	B-flute	Equal to sl lower	Equal to sl. lower	Lower (7-9%)	Equal
Corner drop,	A-flute	Lower (25-29%)	Equal to sl. lower	Lower (14-21%)	Lower (17-18%)
	B-flute	Lower (15-21%)	Equal to sl. lower	Equal to sl lower	Equal to sl. lower
Drum,	A-flute	Lower (24-33%)	Equal to sl. lower	Lower (16-25%)	Lower (25-30%)
	B-flute	Equal to sl lower	Lower (21-35%)	Equal to sl lower	Equal to sl lower

2. The comparative performance of boxes fabricated with 23 and 26-lb. European medium relative to 26-lb. U.S. medium, all with U.S. linerboard, may be seen from the following tabulation in which the results obtained with 26-lb. U.S. medium are used as the reference:

Linerboard Grade Weight	Top-Load Compression	End-Load Compression	Corner Drop	Drum Performance
26.0-lb.				
23-lb. European	Higher (6-7%)	Lower (4-6%)	Lower (27-29%)	Lower (20-33%)
26-lb. European	Higher (1-3%)	Lower (2-7%)	Lower (27-28%)	Lower (4-15%)
33.0-lb.				
23-lb. European	Lower (1-4%)	Equal to sl. lower	Lower (14-20%)	Equal
26-lb. European	Higher (3-10%)	Equal to sl. higher	Lower (8-15%)	Equal to sl. higher
38.0-lb.				
23-lb. European	Higher (0-4%)	Equal to sl. lower	Lower (5-14%)	Lower (21-22%)
26-lb. European	Higher (1-2%)	Equal to sl. higher	Lower (8-18%)	Lower (24-39%)
42.0-lb.				
23-lb. European	Equal	Lower (2-3%)	Lower (19-22%)	Lower (17-24%)
26-lb. European	Lower (0-4%)	Equal to 7% higher	Lower (13-14%)	Lower (4-35%).

B. Combined Board Performance

1. The comparative performance of combined board made with 23-lb. European medium and 26-lb. U.S. medium may be seen from the following tabulation in which the results obtained on the 26-lb. U.S. medium are used as the reference:

Test Property	Linerboard Grade Weight 25.6, 26.0-lb. A-Flute	25.6, 26.0-lb. B-Flute	30.7, 33.0-lb. A-Flute	30.7, 33.0-lb. B-Flute
Basis weight	Lower (4-5%)	Lower (4-5%)	Lower (4%)	Lower (4-5%)
Bursting strength	Lower (0-4%)	Higher (7-14%)	Higher (6%)	Higher (7-10%)
Edgewise compression				
M.D.	Lower (7-15%)	Lower (2-5%)	Lower (4-5%)	Lower (7-9%)
C.D.	Higher (7-9%)	Higher (3-5%)	Higher (5-10%)	Higher (2-8%)
Flexural stiffness, $\sqrt{D_x D_y}$	Higher (1-6%)	Higher (1-3%)	Higher (1-7%)	Equal
Flat crush	Lower (12-14%)	Lower (9-12%)	Lower (9-10%)	Lower (7-16%)
Pin adhesion	Lower (8-9%)	Lower (7-16%)	Lower (3-9%)	Lower (4-9%)

Test Property	35.8, 38.0-lb. A-Flute	35.8, 38.0-lb. B-Flute	41.0, 42.0-lb. A-Flute	41.0, 42.0-lb. B-Flute
Basis weight	Lower (4%)	Lower (5%)	Lower (3-4%)	Lower (3-5%)
Bursting strength	Higher (0-3%)	Higher (8%)	Higher (5-10%)	Higher (5-11%)
Edgewise compression				
M.D.	Lower (1-9%)	Lower (2-6%)	Equal	Lower (4-7%)
C.D.	Higher (5-7%)	Higher (3-5%)	Higher (6-8%)	Higher (5-7%)
Flexural stiffness, $\sqrt{D_x D_y}$	Higher (2-5%)	Higher (1-7%)	Equal	Equal
Flat crush	Lower (5-10%)	Lower (3-11%)	Lower (3-4%)	Lower (5-12%)
Pin adhesion	Lower (0-8%)	Higher (4-9%)	Lower (2-3%)	Lower (0-3%)

a-flute

2 The comparative performance of combined board fabricated with U S linerboard and 23-lb. European, 26-lb European and 26-lb U S. medium may be seen from the following tabulation in which the results for the 26-lb. U S medium are used as the reference

Test Property	26.0-lb 23-lb. Eur.	26.0-lb 26-lb. Eur.	33 0-lb. 23-lb Eur.	33 0-lb. 26-lb Eur.
Basis weight	Lower (5%)	Lower (1%)	Lower (3-4%)	Equal
Bursting strength	Higher (1-4%)	Lower (1-5%)	Higher (3-5%)	Lower (7%)
Edgewise compression				
M.D	Lower (3-24%)	Equal to sl. higher	Lower (7-10%)	Higher (9-10%)
C.D	Higher (5-6%)	Higher (5%)	Higher (5-7%)	Higher (6-12%)
Flexural stiffness $\sqrt{\bar{D}_x \bar{D}_y}$	Higher (3-10%)	Higher (4-20%)	Equal	Equal to sl. higher
Flat crush	Lower (10-15%)	Higher (1-9%)	Lower (10-12%)	Higher (3-9%)
Pin adhesion	Lower (9-17%)	Higher (0-14%)	Equal to sl. higher	Equal

Test Property	38.0-lb. 23-lb Eur.	38.0-lb. 26-lb Eur	42.0-lb. 23-lb Eur.	42.0-lb. 26-lb Eur
Basis weight	Lower (3-4%)	Higher (1%)	Lower (3-4%)	Lower (1%)
Bursting strength	Higher (0-2%)	Higher (2-3%)	Higher (9-20%)	Higher (5-10%)
Edgewise compression				
M.D.	Equal	Higher (1-24%)	Lower (0-12%)	Higher (2-14%)
C D.	Higher (4-7%)	Higher (8-10%)	Higher (6-7%)	Higher (2-6%)

Test Property	58.0-lb 23-lb. Eur.	58.0-lb 26-lb. Eur.	42.0-lb. 23-lb Eur	42.0-lb. 26-lb Eur.
Flexural stiffness $\sqrt{D_x D_y}$	Equal	Equal to sl. higher	Equal	Equal
Flat crush	Lower (9-10%)	Equal	Equal	Higher (5-9%)
Pin adhesion	Equal to sl. lower	Equal	Equal	Equal

C. Comparison of Medium Characteristics

1. A comparison of the characteristics of 23-lb. European, 26-lb. European and 26-lb. U.S. corrugating medium may be seen from the following tabulation in which the results for the U.S. 26-lb. medium are used as the reference:

Test Property		23-lb European	26-lb. European
Basis weight		Lower (12%)	Equal
Caliper		Lower (14%)	Lower (7-14%)
Concora flat crush		Lower (16-18%)	Equal to sl. higher
Water drop		Higher (400-500%)	Higher (6-15%)
Elmendorf tear,	M.D.	Lower (33-34%)	Lower (28-32%)
	C.D.	Lower (37%)	Lower (20-22%)
Modified ring compression,			
	M.D.	Equal	Higher (10-11%)
	C.D.	Higher (9-10%)	Higher (9-11%)
Taber stiffness,	M.D.	Lower (29-33%)	Higher (20-29%)
	C.D.	Lower (0-14%)	Higher (14-25%)

Test Property		23-lb. European	26-lb European
Modulus, E	M D	Higher (27-30%)	Higher (52-61%)
	C.D.	Higher (75%-80%)	Higher (60-68%)
Porosity		Higher (33-36%)	Lower (25-28%)

D General Conclusions

In addition to the foregoing comparisons, the following general conclusions may be drawn:

1. In general, boxes made with 23-lb. European corrugating medium exhibited equal or lower top- and end-load compression and lower corner drop and drum results when compared with corresponding boxes made with 26-lb U S. corrugating medium.

2 Reducing the medium weight from 26 to 23-lb. is equivalent to approximately a 11 5% reduction in medium weight. When box performance was computed on an equivalent weight basis, the boxes made with 23-lb. European medium generally gave higher top- and end-load compression performance but lower corner drop and drum performance than boxes made with 26-lb. U.S. medium

3 In general, the boxes made with U.S. linerboard and 23-lb. and 26-lb European mediums exhibited slightly higher top-load compression than boxes made with U S. linerboard and 26-lb. U.S. medium. Boxes in this phase made with 23-lb. European medium gave lower end-load compression and those made with 26-lb European medium higher end-load compression than boxes made with 26-lb U S. medium, these differences, however, are not believed to be significant. Rough handling performance of boxes made with 23-lb. and 26-lb. European mediums was

lower than that for boxes made with 26-lb U S medium. There appears to be no significant difference between the rough handling performance of boxes made with 23-lb. and 26-lb. European mediums

4. 26-lb U.S. and 26-lb European mediums gave about equal Concora flat crush but considerably higher (16-18%) Concora flat crush than the 23-lb. European medium

5. The water drop test was markedly lower for 26-lb U S than for 23-lb and 26-lb European mediums. This may account for the lower pin adhesion results obtained on combined boards made with European mediums.

6. 26-lb. U.S. medium is more porous than 23-lb. European medium but less porous than 26-lb. European medium

7. The 26-lb U.S. medium was higher in tearing strength, puncture, torsion tear, and stretch than either the 23-lb. or 26-lb. European medium However, European mediums generally were higher in ring compression, tensile, and modulus of elasticity than the 26-lb. U.S. medium

8. The results obtained on the European mediums--especially the 26-lb. European medium--indicate that their competitive potentials cannot be disregarded. The 23-lb. European medium would violate the requirements of our present Rule 41

9. The 23-lb. European medium appeared to be made from a furnish consisting of 85% hardwood (birch) and 15% softwood (mainly Scotch pine). The average fiber length of the 23-lb. European medium is considerably lower than that of the 26-lb U S. medium and presumably was refined to a lower freeness.

III. The comparative performance results obtained in Phase I of this study would not appear to warrant carrying out Phase II