



# *Institute of Paper Science and Technology*

PERMANENCE OF PAPER FOR  
PRINTED LIBRARY MATERIALS

Project 3655

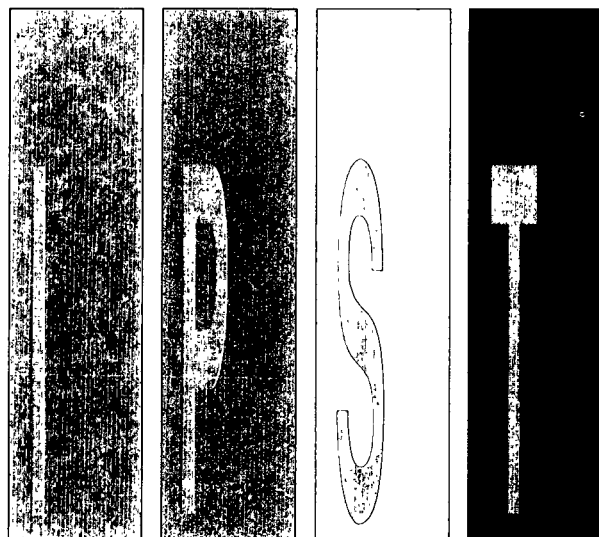
Report Three

A Progress Report

to

NATIONAL INFORMATION STANDARDS ORGANIZATION

September 21, 1990



*Atlanta, Georgia*

THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

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PRINTED LIBRARY MATERIALS

Project 3655

by

Roger H. Van Eperen

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THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

PERMANENCE OF PAPER FOR  
PRINTED LIBRARY MATERIALS

SUMMARY

Papers intended for printed library materials were subjected to accelerated ageing at 90° and 50% RH. The papers were then tested for various properties to show the effect of this aging on these properties. The properties included folding endurance, tensile strength, and tear resistance. Unaged papers were also tested for pH, alkaline reserve, and Kappa No.

Progress Report One and Two presented the results for 13 unaged samples, and for the same samples aged for 17, 120, 168, and 288 hours. This report presents data for 4 additional samples, unaged and after aging times of 288 and 576 hours.

## INTRODUCTION

Papers intended for the library market are expected to have sufficient longevity so as to last several hundred years under normal conditions of library circulation and storage without significant deterioration. The NISO-developed American National Standard for Permanence of Paper for Printed Library Materials (Z39.48) was published in 1984. The standard sets the criteria for permanence of uncoated papers. The standard is being revised to encompass coated papers. This study was undertaken to develop base-line data for the NISO Standards Committee to use in establishing criteria for coated papers.

Progress Reports One and Two presents the results of a defined set of tests on 11 coated and 2 uncoated paper samples supplied by NISO. The tests were made for unaged samples, and for samples which had been subjected to accelerated aging at 90°C, 50% RH, for periods of 17, 120, 168, and 288 hours.

The present study was undertaken to obtain similar data for 4 additional paper samples supplied by NISO. For this study, tests were made for unaged samples, and for samples which had been subjected to accelerated aging at 90°C, 50% RH, for periods of 288 and 576 hours.

## PROCEDURES

The test procedures used for the first part of the study are given below.

The 138 sheets provided for each of the 4 samples were randomly divided into 3 groups of 46 sheets each. One group was selected as the control, or unaged, sample. The remaining 2 groups were exposed to accelerated aging in a circulating oven controlled at 90°C and 50% RH. The groups were removed from the oven after aging periods of 288 and 576 hours, respectively. All 3 groups were then preconditioned at 15% RH, 23°C, and then conditioned at 50% RH, 23°C, before testing. The testing for each of the 4 samples was completed within two weeks after aging. (See Note)

It is known that volatiles given off by one sample can sometimes affect the aging rate of other samples. Hence, each of the 4 samples was exposed in the aging chamber independently.

Following aging, 14 sheets were selected from each group for fold and tensile testing. The sheets were cut so that 1 MD tensile, 1 CD tensile, 6 MD fold, and 6 CD fold tests could be made on each sheet. The tensile strength tests were made in accordance with TAPPI method T 494 om-81. The folding endurance tests were made with the MIT tester in accordance with TAPPI method T 511 om-83.

Note: The accelerated aging of Sample D-2 was carried out in another laboratory. The arrangements for this aging were made by NISO. The sample material was then forwarded to our laboratory for testing.

The remaining 32 sheets of each group were used for tear testing. The sheets were cut so that 10 MD and 10 CD tests could be made. The tests were made in accordance with TAPPI method T 414 om-82, using a 1600 g pendulum.

Seven of the unaged sample sheets were picked randomly for chemical tests, including Kappa No. (TAPPI T 236 om-85), cold extract pH (TAPPI T 509 om-83), and alkaline reserve (ASTM D3290-81). One of each type of test was made on each of the 7 sheets.

#### TEST RESULTS

The test results are given in Tables I through VIII and in the appendix. Table I is a summary table of all test data showing average results only. The averages and standard deviations for each type of test are summarized in Tables II through VIII, respectively. Standard deviations were calculated from:

$$s = [(N \sum(x)^2 - (\sum x)^2) / (N(N-1))]^{1/2}$$

The individual test results for all test types are given in the appendix. The tensile test results include stretch, tensile energy absorption, and tensile stiffness, in addition to tensile strength. These properties were not requested but are automatically reported by our data acquisition system.

TABLE I  
DATA SUMMARY

<u>Property</u>	<u>Aging Time, hrs</u>	<u>Sample A-2</u>	<u>Sample B-2</u>	<u>Sample C-2</u>	<u>Sample D-2</u>
Log <sub>10</sub> Fold-MD	0	2.00	1.80	1.87	1.54
	288	1.87	1.74	1.72	1.43
	576	1.78	1.68	1.71	1.43
CD	0	1.29	1.57	1.36	1.47
	288	1.24	1.57	1.33	1.41
	576	1.20	1.49	1.33	1.35
Tear, mN-MD	0	299	324	332	256
	288	244	281	291	239
	576	245	284	289	241
CD	0	338	321	401	271
	288	326	291	368	257
	576	303	284	377	249
Tensile, kN/m-MD	0	4.82	4.10	4.99	3.59
	288	4.82	3.93	5.24	3.59
	576	4.90	4.11	5.28	3.53
CD	0	1.88	2.47	1.95	2.25
	288	1.89	2.42	2.00	2.20
	576	1.98	2.44	1.96	2.14
pH	0	8.83	9.61	9.14	9.43
Alkaline Reserve, %	0	14.45	9.31	14.12	10.94
Kappa No.	0	5.84	2.18	7.32	1.75

Table II

## Summary of MD Tensile Data

<u>Sample Code</u>	<u>MD Tensile, kN/m</u>		
	<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2 Average	4.82	4.82	4.90
Std. Dev.	0.204	0.312	0.299
B-2 Average	4.10	3.93	4.11
Std. Dev.	0.124	0.118	0.151
C-2 Average	4.99	5.24	5.28
Std. Dev.	0.258	0.164	0.082
D-2 Average	3.59	3.59	3.53
Std. Dev.	0.119	0.146	0.157

Table III  
Summary of CD Tensile Data

<u>Sample Code</u>		CD tensile, kN/m		
		<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2	Average	1.88	1.89	1.98
	Std. Dev.	0.107	0.044	0.047
B-2	Average	2.47	2.42	2.44
	Std. Dev.	0.084	0.083	0.099
C-2	Average	1.95	2.00	1.96
	Std. Dev.	0.040	0.070	0.053
D-2	Average	2.25	2.20	2.14
	Std. Dev.	0.048	0.071	0.109

Table IV  
Summary of MD Tear Data

<u>Sample Code</u>		Tear Resistance, mN		
		<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2	Average	299	244	245
	Std. Dev.	49.0	13.4	11.2
B-2	Average	324	281	284
	Std. Dev.	17.1	8.2	9.4
C-2	Average	332	291	289
	Std. Dev.	16.4	10.8	11.2
D-2	Average	256	239	241
	Std. Dev.	3.2	5.2	13.8

Table V

## Summary of CD Tear Data

<u>Sample Code</u>	<u>Tear Resistance, mN</u>		
	<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2 Average	338	326	303
Std. Dev.	14.3	15.4	6.6
B-2 Average	321	291	284
Std. Dev.	9.9	7.1	11.3
C-2 Average	401	368	377
Std. Dev.	6.7	22.0	12.8
D-2 Average	271	257	249
Std. Dev.	6.4	5.8	7.5

Table VI  
Summary of MD MIT Fold Data

		$\log_{10}$ MD Folding Endurance		
<u>Sample Code</u>		<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2	Average	2.00	1.87	1.78
	Std. Dev.	0.044	0.039	0.084
B-2	Average	1.80	1.74	1.68
	Std. Dev.	0.081	0.073	0.075
C-2	Average	1.87	1.72	1.71
	Std. Dev.	0.026	0.070	0.068
D-2	Average	1.54	1.43	1.43
	Std. Dev.	0.056	0.040	0.047

Table VII

## Summary of CD MIT Fold Data

		$\log_{10}$ CD Folding Endurance		
<u>Sample Code</u>		<u>Unaged</u>	<u>Aged 288 hrs.</u>	<u>Aged 576 hrs.</u>
A-2	Average	1.29	1.24	1.20
	Std. Dev.	0.094	0.134	0.110
B-2	Average	1.57	1.57	1.49
	Std. Dev.	0.076	0.072	0.074
C-2	Average	1.36	1.33	1.33
	Std. Dev.	0.029	0.033	0.030
D-2	Average	1.47	1.41	1.35
	Std. Dev.	0.074	0.052	0.049

Table VIII

## Summary of Chemical Test Data

<u>Sample Code</u>	<u>Kappa No.</u>	<u>pH</u>	<u>Alkaline Reserve, %</u>
A-2 Average	5.84	8.83	14.45
Std. Dev.	0.097	0.052	0.347
B-2 Average	2.18	9.61	9.31
Std. Dev.	0.039	0.037	0.313
C-2 Average	7.32	9.14	14.12
Std. Dev.	0.066	0.040	0.034
D-2 Average	1.75	9.43	10.94
Std. Dev.	0.084	0.031	0.069

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Roger H. Van Eperen  
Group Leader  
Research Services Division

APPROVED BY:



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Barry Crouse  
Director  
Research Services Division

## ELMENDORF TEAR DATA

Sample A-2  
Machine Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	353	235	240
2	407	225	235
3	294	260	240
4	323	240	245
5	269	235	265
6	289	235	250
7	255	245	240
8	274	255	250
9	255	269	255
10	269	245	225
Ave	299	244	245
Std	49.0	13.4	11.2

## Cross Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	358	348	309
2	348	348	309
3	323	314	314
4	323	314	304
5	333	309	294
6	318	309	299
7	353	343	304
8	353	323	304
9	338	323	294
10	333	328	299
Ave	338	326	303
Std	14.3	15.4	6.6

## MIT FOLD DATA

Sample A-2  
Machine Direction - Unaged

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	2.15	2.20	1.89	2.00	1.83	2.11	2.03
2	2.15	2.02	2.16	2.11	2.01	1.91	2.06
3	2.04	2.08	1.98	1.87	1.88	2.24	2.01
4	2.13	1.62	1.93	1.94	1.97	2.07	1.94
5	1.86	2.12	1.73	1.96	2.00	1.93	1.93
6	1.81	2.13	1.89	2.02	1.94	1.97	1.96
7	1.98	2.02	1.76	2.13	2.26	2.02	2.03
8	1.90	2.19	1.79	1.95	1.67	2.17	1.95
9	1.92	1.98	1.81	2.21	2.05	2.00	2.00
10	1.97	1.96	2.02	1.99	2.01	1.98	1.99
11	2.12	1.89	2.07	2.13	2.03	2.03	2.05
12	1.89	2.14	1.81	1.87	2.00	2.04	1.96
13	1.97	1.99	2.21	2.10	1.99	1.94	2.03
14	2.12	2.01	2.03	2.17	1.95	2.02	2.05
Ave							2.00
Std							0.044

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.38	1.20	1.23	1.36	1.36	1.41	1.33
2	1.34	1.30	1.38	1.43	1.32	1.36	1.36
3	1.45	1.46	1.34	1.38	1.20	1.54	1.40
4	1.18	1.36	1.28	1.28	1.28	1.34	1.29
5	1.04	1.20	1.30	1.23	1.20	1.32	1.22
6	1.18	1.65	1.38	1.48	1.49	1.46	1.44
7	1.11	1.62	1.28	1.34	1.04	1.28	1.28
8	1.11	1.65	1.11	1.15	1.26	1.20	1.25
9	1.11	1.26	1.11	1.30	1.15	1.11	1.17
10	1.28	1.23	1.30	1.36	1.56	1.20	1.32
11	1.30	1.04	1.15	1.11	1.08	1.04	1.12
12	1.20	1.26	1.15	1.46	1.32	1.26	1.27
13	1.34	1.30	1.34	1.28	1.45	1.68	1.40
14	1.26	1.28	1.04	1.23	1.08	1.15	1.17
Ave							1.29
Std							0.094

## MIT FOLD DATA

Sample A-2  
Machine Direction - Aged 288 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.87	1.89	1.78	1.74	1.99	1.94	1.87
2	1.94	1.51	2.01	2.14	1.68	1.56	1.81
3	1.89	1.84	1.94	1.78	1.80	1.90	1.86
4	1.81	1.89	1.93	1.95	1.86	1.76	1.87
5	1.90	1.84	2.09	1.81	2.05	1.81	1.92
6	1.77	1.74	1.93	1.99	1.82	1.83	1.85
7	1.86	1.67	1.86	1.72	1.83	1.83	1.80
8	1.86	1.91	2.08	1.74	1.81	2.14	1.92
9	1.82	2.07	1.81	1.93	1.87	1.76	1.88
10	2.08	1.81	1.73	1.95	1.86	1.97	1.90
11	2.00	1.69	1.54	1.65	2.06	2.03	1.83
12	2.03	1.98	1.83	1.70	1.89	2.03	1.91
13	1.82	1.66	1.77	1.82	2.17	1.93	1.86
14	1.88	1.85	1.98	1.99	1.60	2.05	1.89
Ave							1.87
Std							0.039

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.04	1.15	1.20	1.15	1.32	1.32	1.20
2	1.48	1.34	1.18	1.40	1.15	1.18	1.29
3	1.11	1.08	1.04	1.11	1.15	1.04	1.09
4	1.15	1.20	1.15	1.26	1.11	1.46	1.22
5	1.23	1.23	1.23	1.30	1.04	1.23	1.21
6	1.36	1.20	1.08	1.46	1.52	1.52	1.36
7	1.41	1.58	1.40	1.43	1.40	1.48	1.45
8	1.43	1.52	1.43	1.49	1.63	1.46	1.49
9	1.30	1.11	1.04	1.26	1.23	1.20	1.19
10	1.08	1.34	1.32	1.30	1.56	1.30	1.32
11	0.95	1.23	1.30	0.90	1.00	0.90	1.05
12	1.04	1.04	1.15	1.11	0.95	1.00	1.05
13	1.23	1.23	1.34	1.40	1.15	1.20	1.26
14	1.26	1.08	1.26	1.15	1.20	1.23	1.20
Ave							1.24
Std							0.134

## MIT FOLD DATA

Sample A-2  
Machine Direction - Aged 576 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	2.14	1.92	1.98	1.97	1.63	1.82	1.91
2	1.90	1.72	1.83	1.80	1.72	1.70	1.78
3	1.86	1.64	1.65	1.86	1.59	1.75	1.73
4	2.09	1.82	1.82	1.77	1.81	1.85	1.86
5	1.77	1.93	1.96	1.59	1.74	1.83	1.80
6	1.57	2.05	1.85	1.46	1.58	1.86	1.73
7	1.61	1.86	2.06	1.38	1.91	1.53	1.73
8	1.51	1.80	1.71	1.51	1.58	1.38	1.58
9	1.76	1.86	1.93	1.91	1.99	1.63	1.85
10	1.98	1.92	1.94	1.92	1.75	1.82	1.89
11	1.72	1.93	1.88	1.69	1.70	1.71	1.77
12	1.83	2.07	1.89	1.64	1.70	1.64	1.80
13	1.74	1.52	1.82	1.70	1.90	1.82	1.75
14	1.54	1.57	1.93	2.08	1.65	1.73	1.75
Ave							1.78
Std							0.084

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.11	1.11	1.15	1.18	1.00	1.34	1.15
2	1.23	1.32	1.36	1.28	1.45	1.20	1.31
3	1.36	1.38	1.28	1.46	1.32	1.52	1.39
4	1.08	1.32	1.28	1.20	1.11	1.08	1.18
5	1.30	1.30	1.20	1.11	1.18	1.15	1.21
6	1.30	1.15	1.36	1.20	1.18	1.08	1.21
7	1.20	1.08	1.23	1.23	1.04	1.26	1.17
8	1.62	1.20	1.43	1.28	1.51	1.32	1.39
9	0.95	1.04	1.20	1.04	1.00	1.04	1.05
10	1.30	1.43	0.95	1.18	1.30	1.04	1.20
11	1.08	0.90	1.08	1.00	0.95	1.00	1.00
12	1.15	1.18	1.11	1.40	1.30	1.04	1.20
13	1.26	1.18	1.00	1.15	1.00	1.11	1.12
14	1.11	1.36	1.34	1.23	1.18	1.15	1.23
Ave							1.20
Std							0.110

## TENSILE DATA

Sample A-2  
Machine Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	4.62	4.98	5.04
2	4.58	5.08	4.52
3	4.69	4.96	5.37
4	4.65	5.00	5.21
5	5.02	5.15	4.94
6	4.56	4.42	4.79
7	5.06	4.56	4.89
8	5.06	4.63	5.19
9	4.89	4.71	4.58
10	4.75	5.04	4.89
11	4.73	5.17	5.29
12	4.92	4.94	4.37
13	5.19	4.83	4.75
14	4.75	4.08	4.77
Ave	4.82	4.82	4.90
Std	0.204	0.312	0.299

## Cross Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	1.85	1.83	1.96
2	1.69	1.94	1.98
3	1.75	1.87	1.92
4	1.94	1.88	2.00
5	1.94	1.87	1.92
6	1.87	1.98	2.04
7	1.87	1.94	2.00
8	1.79	1.83	1.94
9	1.87	1.90	2.04
10	1.85	1.90	1.94
11	2.04	1.87	1.90
12	2.10	1.87	1.98
13	1.94	1.88	2.06
14	1.83	1.87	1.98
Ave	1.88	1.89	1.98
Std	0.107	0.044	0.047

## STRETCH DATA

Sample A-2  
Machine Direction

Test Number	Unaged	Stretch, %	
		Aged 288 Hrs	Aged 576 Hrs
1	1.49	1.44	1.31
2	1.36	1.33	1.09
3	1.50	1.47	1.50
4	1.49	1.35	1.44
5	1.57	1.42	1.46
6	1.40	1.42	1.28
7	1.52	1.36	1.50
8	1.63	1.39	1.55
9	1.49	1.19	1.29
10	1.35	1.48	1.48
11	1.50	1.51	1.57
12	1.56	1.33	1.25
13	1.59	1.39	1.47
14	1.51	1.11	1.38
Ave	1.50	1.37	1.40
Std	0.081	0.110	0.136

## Cross Direction

Test Number	Unaged	Stretch, %	
		Aged 288 Hrs	Aged 576 Hrs
1	2.52	2.24	2.46
2	1.76	2.62	2.61
3	2.12	2.16	2.53
4	2.69	2.28	2.65
5	2.60	2.46	2.20
6	2.40	2.46	2.37
7	2.42	2.44	2.72
8	2.15	1.70	2.39
9	2.39	2.65	2.06
10	2.32	2.13	2.66
11	3.18	2.23	2.23
12	2.82	2.05	2.91
13	2.80	2.30	2.79
14	2.12	2.04	2.49
Ave	2.45	2.27	2.51
Std	0.360	0.253	0.240

## TEA DATA

Sample A-2  
Machine Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	43.6	44.9	40.8
2	39.1	41.7	29.9
3	45.0	45.8	50.7
4	44.1	41.7	46.8
5	50.2	45.9	45.5
6	40.2	39.5	37.7
7	49.0	38.8	46.4
8	52.8	40.2	51.1
9	46.1	34.4	36.4
10	40.1	46.6	45.2
11	45.2	49.3	52.4
12	49.2	40.8	33.6
13	52.6	41.6	43.7
14	45.7	27.5	40.9
Ave	45.9	41.3	42.9
Std	4.43	5.52	6.75

## Cross Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	34.0	29.1	34.9
2	20.4	37.2	37.9
3	26.6	28.6	35.4
4	38.1	30.8	39.1
5	36.7	33.4	30.4
6	32.6	35.3	35.0
7	32.7	34.5	40.2
8	27.7	21.0	33.8
9	32.5	36.9	29.9
10	31.0	28.7	37.9
11	48.5	29.5	30.2
12	43.7	26.9	43.0
13	40.4	31.2	42.5
14	27.2	26.8	35.8
Ave	33.7	30.7	36.2
Std	7.39	4.47	4.26

## ET DATA

Sample A-2  
Machine Direction

Test Number	Unaged	Et, kN/m Aged 288 Hrs	Aged 576 Hrs
1	567	612	660
2	588	652	646
3	580	598	657
4	570	622	646
5	606	631	608
6	583	549	637
7	616	577	593
8	596	583	620
9	607	637	599
10	633	614	600
11	587	616	628
12	593	622	587
13	618	592	573
14	589	565	605
Ave	595	605	618
Std	18.8	29.1	27.4

## Cross Direction

Test Number	Unaged	Et, kN/m Aged 288 Hrs	Aged 576 Hrs
1	235	232	249
2	240	246	257
3	235	250	250
4	248	243	250
5	248	244	250
6	244	251	264
7	250	252	251
8	245	247	252
9	242	235	272
10	248	252	241
11	246	253	252
12	250	252	237
13	244	239	260
14	251	247	249
Ave	245	246	252
Std	5.2	6.6	8.9

## ELMENDORF TEAR DATA

Sample B-2  
Machine Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	314	274	289
2	304	284	294
3	318	274	284
4	314	279	299
5	323	284	284
6	314	269	284
7	338	294	269
8	314	274	289
9	348	289	274
10	356	289	274
Ave	324	281	284
Std	17.1	8.2	9.4

## Cross Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	323	294	284
2	328	279	269
3	318	299	294
4	314	284	269
5	343	299	279
6	328	289	274
7	323	284	299
8	314	299	289
9	314	289	299
10	309	289	284
Ave	321	291	284
Std	9.9	7.1	11.3

## MIT FOLD DATA

Sample B-2  
Machine Direction - Unaged

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	2.08	1.93	2.05	1.97	1.93	1.93	1.98
2	1.84	2.01	1.76	1.79	1.87	1.79	1.84
3	1.61	1.70	1.70	1.76	1.59	1.76	1.69
4	1.66	1.66	1.86	1.70	1.86	1.69	1.74
5	1.94	1.98	1.88	2.02	1.88	1.90	1.93
6	1.62	1.86	1.84	1.74	1.83	1.66	1.76
7	1.72	1.80	1.76	1.65	1.72	1.90	1.76
8	1.77	1.72	1.83	1.69	1.76	1.76	1.75
9	1.93	1.72	1.89	2.03	1.96	1.83	1.89
10	1.92	1.76	1.69	1.81	1.83	1.82	1.80
11	1.83	1.79	1.78	1.67	1.77	1.72	1.76
12	1.97	1.83	1.74	1.62	1.84	1.74	1.79
13	1.66	1.72	1.85	1.80	1.74	1.92	1.78
14	1.79	1.68	1.92	1.78	1.68	1.77	1.77
Ave							1.80
Std							0.081

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.64	1.73	1.99	1.69	1.57	1.71	1.72
2	1.53	1.63	1.56	1.48	1.57	1.56	1.55
3	1.57	1.54	1.57	1.59	1.62	1.57	1.58
4	1.57	1.60	1.66	1.60	1.51	1.46	1.57
5	1.63	1.65	1.61	1.88	1.76	1.91	1.74
6	1.53	1.53	1.52	1.46	1.51	1.48	1.50
7	1.67	1.60	1.49	1.56	1.49	1.52	1.56
8	1.43	1.54	1.51	1.45	1.51	1.61	1.51
9	1.61	1.71	1.68	1.64	1.56	1.70	1.65
10	1.48	1.60	1.57	1.49	1.46	1.66	1.54
11	1.43	1.60	1.57	1.57	1.46	1.56	1.53
12	1.56	1.51	1.49	1.49	1.46	1.54	1.51
13	1.54	1.41	1.66	1.53	1.48	1.63	1.54
14	1.46	1.51	1.66	1.62	1.49	1.40	1.52
Ave							1.57
Std							0.076

## MIT FOLD DATA

Sample B-2  
Machine Direction - Aged 288 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.77	1.73	1.71	1.58	1.76	1.92	1.75
2	1.88	1.73	1.74	1.71	1.78	1.81	1.77
3	1.74	1.78	1.36	1.70	1.89	1.61	1.68
4	1.65	1.72	1.76	1.81	1.79	1.65	1.73
5	1.82	1.79	1.62	1.82	1.71	1.69	1.74
6	1.83	1.85	1.86	1.90	1.81	1.81	1.84
7	1.68	1.63	1.56	1.88	1.89	1.83	1.74
8	1.79	1.72	1.57	1.52	1.79	1.66	1.68
9	1.82	1.84	1.68	1.34	1.58	1.75	1.67
10	2.01	1.95	1.77	1.80	1.85	1.91	1.88
11	1.61	1.92	1.80	1.76	1.67	1.71	1.75
12	1.73	1.72	1.52	1.60	1.72	1.56	1.64
13	1.56	1.62	1.79	1.57	1.75	1.57	1.64
14	1.85	1.65	1.90	1.90	1.83	1.79	1.82
Ave							1.74
Std							0.073

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.66	1.48	1.54	1.45	1.61	1.49	1.54
2	1.65	1.71	1.84	1.81	1.70	1.54	1.71
3	1.59	1.48	1.49	1.48	1.67	1.49	1.53
4	1.48	1.57	1.63	1.46	1.51	1.52	1.53
5	1.54	1.64	1.56	1.56	1.64	1.61	1.59
6	1.62	1.58	1.79	1.61	1.72	1.73	1.68
7	1.58	1.45	1.58	1.36	1.57	1.68	1.54
8	1.61	1.48	1.48	1.46	1.46	1.54	1.51
9	1.53	1.64	1.49	1.40	1.46	1.32	1.47
10	1.54	1.65	1.72	1.77	1.66	1.57	1.65
11	1.59	1.51	1.48	1.48	1.51	1.48	1.51
12	1.49	1.48	1.57	1.61	1.45	1.53	1.52
13	1.51	1.54	1.60	1.52	1.58	1.59	1.56
14	1.66	1.59	1.63	1.65	1.69	1.56	1.63
Ave							1.57
Std							0.072

## MIT FOLD DATA

Sample B-2  
Machine Direction - Aged 576 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.83	1.67	1.82	1.72	1.53	1.62	1.70
2	1.59	1.60	1.58	1.54	1.58	1.41	1.55
3	1.64	1.69	1.76	1.57	1.60	1.46	1.62
4	1.51	1.52	1.68	1.61	1.72	1.66	1.62
5	1.83	1.76	1.63	1.72	1.91	1.88	1.79
6	1.83	1.72	1.68	1.73	1.64	1.78	1.73
7	1.45	1.76	1.65	1.72	1.76	1.87	1.70
8	1.72	1.52	1.49	1.49	1.64	1.45	1.55
9	1.60	1.60	1.83	1.65	1.77	1.84	1.72
10	1.63	1.81	1.78	1.80	1.58	1.66	1.71
11	1.54	1.54	1.60	1.75	1.52	1.73	1.61
12	1.64	1.83	1.62	1.69	1.60	1.80	1.70
13	1.75	1.90	1.88	1.81	1.73	1.65	1.79
14	1.67	1.64	1.76	1.64	1.70	1.71	1.69
Ave							1.68
Std							0.075

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.46	1.73	1.53	1.57	1.64	1.66	1.60
2	1.58	1.52	1.60	1.51	1.43	1.51	1.52
3	1.40	1.40	1.48	1.45	1.52	1.43	1.45
4	1.60	1.46	1.30	1.46	1.43	1.53	1.47
5	1.75	1.84	1.57	1.54	1.58	1.62	1.65
6	1.48	1.52	1.52	1.45	1.43	1.38	1.46
7	1.49	1.54	1.38	1.38	1.43	1.54	1.46
8	1.54	1.59	1.56	1.52	1.45	1.45	1.52
9	1.38	1.49	1.38	1.40	1.43	1.52	1.43
10	1.45	1.49	1.54	1.49	1.38	1.41	1.46
11	1.34	1.43	1.52	1.36	1.40	1.45	1.42
12	1.45	1.46	1.41	1.48	1.51	1.53	1.47
13	1.60	1.58	1.66	1.62	1.54	1.57	1.60
14	1.40	1.32	1.49	1.46	1.46	1.30	1.41
Ave							1.49
Std							0.074

## TENSILE DATA

Sample B-2  
Machine Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	4.19	3.83	4.15
2	4.10	3.77	4.08
3	4.29	3.85	4.38
4	4.12	3.88	3.94
5	4.33	4.06	4.17
6	4.21	4.17	3.92
7	3.92	4.00	4.15
8	3.98	3.90	4.04
9	4.10	4.00	4.13
10	3.98	3.96	4.40
11	3.94	3.92	3.90
12	4.13	3.85	4.06
13	4.04	4.08	4.00
14	4.06	3.79	4.15
Ave	4.10	3.93	4.11
Std	0.124	0.118	0.151

## Cross Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	2.50	2.48	2.35
2	2.44	2.50	2.50
3	2.44	2.40	2.35
4	2.40	2.44	2.38
5	2.46	2.33	2.60
6	2.31	2.46	2.31
7	2.43	2.37	2.54
8	2.56	2.29	2.44
9	2.46	2.29	2.38
10	2.44	2.56	2.40
11	2.40	2.52	2.37
12	2.44	2.44	2.35
13	2.63	2.44	2.60
14	2.60	2.40	2.54
Ave	2.47	2.42	2.44
Std	0.084	0.083	0.099

## STRETCH DATA

Sample B-2  
Machine Direction

Test Number	Unaged	Stretch, %	
		Aged 288 Hrs	Aged 576 Hrs
1	2.11	1.68	1.77
2	1.93	1.47	1.65
3	1.99	1.72	1.93
4	1.87	1.55	1.52
5	2.05	1.71	1.84
6	1.95	1.95	1.70
7	1.54	1.85	1.83
8	1.88	1.69	1.55
9	1.88	1.67	1.69
10	1.68	1.65	1.96
11	1.67	1.68	1.55
12	1.87	1.58	1.76
13	1.67	1.93	1.74
14	1.81	1.50	1.73
Ave	1.85	1.69	1.73
Std	0.161	0.144	0.135

## Cross Direction

Test Number	Unaged	Stretch, %	
		Aged 288 Hrs	Aged 576 Hrs
1	4.87	4.27	3.53
2	4.51	4.49	4.03
3	4.06	4.06	3.68
4	4.54	3.59	4.08
5	4.48	3.60	4.24
6	3.85	3.85	3.49
7	4.29	3.91	4.32
8	4.63	3.60	3.88
9	4.52	3.19	3.73
10	4.02	4.26	3.91
11	4.59	4.31	3.93
12	4.42	4.37	3.53
13	5.21	3.65	4.16
14	4.76	3.85	4.20
Ave	4.48	3.93	3.91
Std	0.354	0.379	0.280

## TEA DATA

Sample B-2  
Machine Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	60.2	42.6	48.9
2	53.4	35.8	43.7
3	57.7	44.1	57.4
4	51.8	39.0	39.1
5	60.7	45.8	51.5
6	55.2	54.7	44.2
7	39.7	49.8	50.7
8	49.7	44.0	40.5
9	51.7	44.3	46.0
10	44.0	42.9	57.5
11	43.7	43.8	39.4
12	52.3	40.0	47.4
13	44.8	53.2	46.3
14	49.1	36.8	47.1
Ave	51.0	44.1	47.1
Std	6.35	5.53	5.82

## Cross Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	91.0	80.8	62.2
2	83.1	85.3	76.9
3	75.1	74.0	65.4
4	82.3	65.4	73.5
5	83.5	62.9	82.9
6	67.2	71.4	60.9
7	78.5	70.2	81.8
8	88.2	61.9	72.2
9	84.4	54.8	67.7
10	73.2	81.9	71.6
11	84.5	82.3	70.9
12	82.2	81.3	62.7
13	103.9	67.5	81.3
14	92.8	70.0	81.3
Ave	83.6	72.1	72.2
Std	9.00	9.19	7.76

## ET DATA

Sample B-2  
Machine Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	503	509	522
2	505	517	500
3	537	507	535
4	530	521	519
5	535	518	519
6	518	502	521
7	534	498	514
8	462	521	531
9	527	532	529
10	524	515	512
11	536	521	526
12	535	510	516
13	537	501	507
14	520	515	512
Ave	522	513	519
Std	20.6	9.2	9.6

## Cross Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	277	283	284
2	285	306	296
3	298	283	278
4	280	293	290
5	290	275	301
6	284	283	292
7	290	275	292
8	294	286	295
9	285	285	291
10	289	282	295
11	290	292	291
12	299	275	297
13	307	297	295
14	282	283	327
Ave	289	285	295
Std	8.2	8.8	10.9

## ELMENDORF TEAR DATA

Sample C-2  
Machine Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	323	299	304
2	323	289	279
3	343	299	289
4	328	294	279
5	314	309	304
6	318	289	299
7	333	294	284
8	333	274	294
9	372	279	279
10	328	279	274
Ave	332	291	289
Std	16.4	10.8	11.2

## Cross Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	397	411	382
2	397	363	363
3	402	377	397
4	387	353	363
5	411	372	382
6	402	372	372
7	407	372	397
8	407	323	367
9	402	377	377
10	402	363	367
Ave	401	368	377
Std	6.7	22.0	12.8

## MIT FOLD DATA

Sample C-2  
Machine Direction - Unaged

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.92	1.81	1.85	1.76	1.84	1.94	1.85
2	1.74	1.81	1.96	1.89	1.76	1.89	1.84
3	1.83	1.86	2.00	1.92	1.97	1.76	1.89
4	1.86	1.79	1.86	1.85	1.92	1.81	1.85
5	1.88	1.79	1.83	1.89	1.81	1.84	1.84
6	1.83	1.90	1.93	1.89	1.86	1.89	1.88
7	1.83	1.79	1.81	1.88	1.89	1.86	1.84
8	1.95	1.96	1.89	1.95	1.84	1.91	1.92
9	1.81	1.83	1.80	2.02	1.80	1.78	1.84
10	1.89	1.87	1.83	1.82	1.86	1.97	1.87
11	1.84	1.84	1.82	1.89	1.94	1.98	1.88
12	1.90	1.76	1.87	1.86	1.83	1.81	1.84
13	1.93	1.87	1.88	1.86	1.85	1.86	1.87
14	2.00	1.91	2.01	1.83	1.79	1.85	1.90
Ave							1.87
Std							0.026

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.32	1.36	1.36	1.48	1.40	1.38	1.38
2	1.38	1.28	1.30	1.32	1.40	1.38	1.34
3	1.34	1.36	1.26	1.23	1.38	1.36	1.32
4	1.32	1.43	1.41	1.40	1.36	1.41	1.39
5	1.34	1.34	1.34	1.32	1.36	1.34	1.34
6	1.32	1.38	1.28	1.41	1.28	1.45	1.35
7	1.32	1.45	1.45	1.46	1.40	1.41	1.42
8	1.38	1.38	1.40	1.41	1.38	1.32	1.38
9	1.41	1.38	1.30	1.36	1.30	1.28	1.34
10	1.43	1.34	1.46	1.43	1.43	1.40	1.42
11	1.23	1.41	1.38	1.32	1.36	1.38	1.35
12	1.41	1.30	1.40	1.41	1.28	1.36	1.36
13	1.46	1.28	1.28	1.34	1.32	1.43	1.35
14	1.45	1.28	1.28	1.34	1.34	1.36	1.34
Ave							1.36
Std							0.029

## MIT FOLD DATA

Sample C-2  
Machine Direction - Aged 288 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.75	1.65	1.78	1.74	1.76	1.61	1.72
2	1.64	1.73	1.63	1.74	1.57	1.60	1.65
3	1.54	1.53	1.72	1.71	1.52	1.67	1.62
4	1.80	1.88	1.85	1.91	1.85	1.83	1.85
5	1.76	1.69	1.62	1.79	1.71	1.67	1.71
6	1.90	1.67	1.71	1.72	1.62	1.75	1.73
7	1.88	1.89	1.76	1.72	1.79	1.73	1.79
8	1.69	1.66	1.63	1.82	1.68	1.75	1.71
9	1.63	1.74	1.74	1.88	1.90	1.78	1.78
10	1.64	1.79	1.72	1.71	1.65	1.68	1.70
11	1.79	1.83	1.65	1.58	1.94	1.77	1.76
12	1.81	1.69	1.88	1.72	1.84	1.62	1.76
13	1.63	1.70	1.67	1.64	1.67	1.76	1.68
14	1.90	1.59	1.70	1.69	1.79	1.49	1.69
Ave							1.72
Std							0.060

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.34	1.34	1.26	1.32	1.28	1.23	1.30
2	1.26	1.26	1.38	1.34	1.34	1.30	1.31
3	1.23	1.30	1.32	1.34	1.26	1.32	1.30
4	1.32	1.34	1.32	1.23	1.38	1.28	1.31
5	1.32	1.38	1.28	1.36	1.32	1.41	1.35
6	1.32	1.28	1.20	1.38	1.18	1.26	1.27
7	1.30	1.38	1.41	1.41	1.32	1.43	1.38
8	1.38	1.28	1.43	1.36	1.36	1.38	1.37
9	1.38	1.41	1.30	1.43	1.38	1.34	1.38
10	1.28	1.36	1.30	1.36	1.28	1.34	1.32
11	1.34	1.38	1.34	1.36	1.28	1.28	1.33
12	1.28	1.30	1.26	1.38	1.34	1.26	1.30
13	1.32	1.34	1.28	1.26	1.34	1.30	1.31
14	1.36	1.36	1.32	1.32	1.40	1.34	1.35
Ave							1.33
Std							0.033

## MIT FOLD DATA

Sample C-2  
Machine Direction - Aged 576 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.53	1.63	1.59	1.66	1.53	1.71	1.61
2	1.94	1.92	2.03	1.72	1.81	1.78	1.87
3	1.60	1.59	1.70	1.69	1.65	1.64	1.65
4	1.71	1.77	1.65	1.73	1.70	1.75	1.72
5	1.72	1.73	1.72	1.70	1.81	1.63	1.72
6	1.59	1.67	1.62	1.87	1.61	1.74	1.68
7	1.71	1.73	1.66	1.76	1.83	1.63	1.72
8	1.72	1.66	1.63	1.72	1.60	1.77	1.68
9	1.77	1.76	1.88	1.94	1.81	1.70	1.81
10	1.75	1.51	1.72	1.85	1.70	1.82	1.72
11	1.58	1.67	1.83	1.76	1.54	1.62	1.67
12	1.57	1.72	1.61	1.61	1.67	1.62	1.64
13	1.75	1.80	1.77	1.70	1.66	1.79	1.74
14	1.60	1.73	1.77	1.75	1.85	1.78	1.75
Ave							1.71
Std							0.068

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.32	1.32	1.32	1.40	1.30	1.30	1.33
2	1.36	1.40	1.32	1.34	1.36	1.23	1.34
3	1.32	1.32	1.38	1.28	1.38	1.36	1.34
4	1.30	1.36	1.30	1.28	1.32	1.34	1.32
5	1.38	1.30	1.34	1.28	1.36	1.32	1.33
6	1.28	1.23	1.32	1.26	1.41	1.34	1.31
7	1.36	1.32	1.41	1.34	1.36	1.34	1.36
8	1.30	1.30	1.28	1.20	1.26	1.28	1.27
9	1.30	1.28	1.32	1.26	1.32	1.34	1.30
10	1.43	1.38	1.30	1.43	1.32	1.30	1.36
11	1.32	1.34	1.28	1.38	1.45	1.30	1.35
12	1.26	1.34	1.23	1.30	1.32	1.41	1.31
13	1.43	1.43	1.38	1.36	1.34	1.34	1.38
14	1.23	1.23	1.36	1.38	1.32	1.23	1.29
Ave							1.33
Std							0.030

## TENSILE DATA

Sample C-2  
Machine Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	5.12	5.35	5.25
2	4.21	5.52	5.31
3	5.06	5.27	5.27
4	5.21	5.33	5.21
5	4.96	5.40	5.31
6	5.08	5.31	5.29
7	5.04	5.06	5.21
8	5.12	5.19	5.15
9	5.15	5.27	5.17
10	4.90	5.02	5.35
11	5.17	5.38	5.21
12	5.08	5.02	5.38
13	4.69	4.98	5.44
14	5.04	5.27	5.31
Ave	4.99	5.24	5.28
Std	0.258	0.164	0.082

## Cross Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	1.98	1.88	1.96
2	2.04	2.00	2.02
3	1.90	2.08	1.92
4	1.90	2.06	1.98
5	2.00	1.96	1.92
6	1.92	2.06	1.88
7	1.96	2.08	2.02
8	1.94	2.06	2.04
9	1.96	1.88	2.00
10	1.92	2.04	1.94
11	1.94	1.96	2.04
12	1.96	2.06	1.96
13	1.92	1.94	1.90
14	2.00		1.90
Ave	1.95	2.00	1.96
Std	0.040	0.070	0.053

## STRETCH DATA

Sample C-2  
Machine Direction

Test Number	Stretch, %		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	2.00	1.76	1.72
2	1.16	1.79	1.72
3	1.75	1.72	1.73
4	2.01	1.72	1.64
5	1.68	1.78	1.67
6	1.87	1.80	1.84
7	1.87	1.59	1.64
8	1.83	1.82	1.65
9	1.82	1.92	1.67
10	1.81	1.62	1.87
11	1.90	1.94	1.82
12	1.82	1.63	1.84
13	1.62	1.56	1.80
14	1.75	2.00	1.71
Ave	1.78	1.76	1.74
Std	0.208	0.133	0.082

## Cross Direction

Test Number	Stretch, %		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	5.29	2.67	3.92
2	5.67	3.75	4.06
3	4.37	4.09	3.21
4	4.36	3.97	3.76
5	5.58	2.93	3.14
6	4.71	3.77	2.69
7	5.35	4.01	3.84
8	4.56	4.11	3.93
9	5.13	3.54	3.63
10	4.45	5.25	3.21
11	4.67	4.41	4.25
12	5.13	5.11	4.50
13	4.06	4.16	3.85
14	5.40		3.68
Ave	4.91	3.98	3.69
Std	0.515	0.721	0.483

## TEA DATA

Sample C-2  
Machine Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	69.5	62.9	59.9
2	31.7	66.3	60.9
3	59.2	60.4	60.4
4	71.2	61.3	56.7
5	55.8	64.5	58.7
6	64.1	64.5	65.7
7	64.0	53.2	56.5
8	63.2	63.8	56.3
9	63.4	68.7	57.5
10	59.6	53.6	67.2
11	66.4	70.8	63.5
12	62.0	54.3	66.7
13	50.8	51.3	65.5
14	59.0	71.8	60.7
Ave	60.0	62.0	61.1
Std	9.69	6.66	3.92

## Cross Direction

Test Number	TEA, J/sq m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	84.3	38.7	62.4
2	93.5	59.5	66.0
3	66.8	67.8	48.7
4	66.4	65.1	59.4
5	89.8	44.4	47.3
6	72.8	61.9	39.0
7	84.9	66.8	61.8
8	70.9	67.8	64.1
9	81.7	52.8	57.5
10	68.7	87.2	49.1
11	72.7	70.1	70.1
12	81.5	86.1	71.5
13	62.4	65.3	59.1
14	87.7		56.0
Ave	77.4	64.1	58.0
Std	9.91	13.78	9.24

## ET DATA

Sample C-2  
Machine Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	639	688	689
2	662	703	674
3	659	670	666
4	646	677	673
5	653	693	677
6	643	666	655
7	645	659	687
8	659	647	666
9	659	643	670
10	629	652	666
11	652	656	655
12	651	651	677
13	628	660	690
14	656	643	685
Ave	649	665	674
Std	10.7	19.1	11.5

## Cross Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	245	256	266
2	257	266	274
3	252	266	263
4	253	272	270
5	252	268	269
6	252	267	270
7	249	268	267
8	273	264	267
9	245	249	267
10	252	254	261
11	252	259	270
12	254	261	253
13	256	257	257
14	250		251
Ave	253	262	265
Std	6.6	6.7	6.9

## ELMENDORF TEAR DATA

Sample D-2  
Machine Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	255	235	279
2	255	235	230
3	255	240	235
4	255	235	230
5	255	245	240
6	250	240	240
7	260	245	240
8	255	245	240
9	260	230	240
10	260	240	240
Ave	256	239	241
Std	3.2	5.2	13.8

## Cross Direction

Test Number	Elmendorf Tear, mN		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	274	260	255
2	260	250	240
3	284	260	250
4	274	255	245
5	269	260	235
6	269	245	260
7	269	260	250
8	269	255	255
9	274	265	250
10	265	255	245
Ave	271	257	249
Std	6.4	5.8	7.5

Sample D-2  
Machine Direction - Unaged

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.60	1.36	1.56	1.66	1.53	1.72	1.57
2	1.54	1.66	1.49	1.62	1.57	1.66	1.59
3	1.40	1.52	1.41	1.64	1.70	1.53	1.53
4	1.60	1.41	1.40	1.58	1.77	1.40	1.53
5	1.61	1.45	1.68	1.34	1.51	1.68	1.54
6	1.57	1.41	1.57	1.67	1.54	1.61	1.56
7	1.53	1.60	1.72	1.54	1.77	1.57	1.62
8	1.51	1.53	1.56	1.45	1.68	1.54	1.54
9	1.79	1.51	1.45	1.54	1.57	1.68	1.59
10	1.34	1.41	1.49	1.54	1.58	1.61	1.50
11	1.58	1.49	1.51	1.36	1.49	1.52	1.49
12	1.48	1.45	1.34	1.38	1.38	1.34	1.39
13	1.59	1.51	1.59	1.56	1.54	1.69	1.58
14	1.48	1.48	1.53	1.54	1.58	1.49	1.52
Ave							1.54
Std							0.056

Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.57	1.66	1.74	1.66	1.65	1.64	1.66
2	1.53	1.38	1.49	1.46	1.32	1.57	1.46
3	1.41	1.38	1.36	1.40	1.34	1.32	1.37
4	1.38	1.41	1.45	1.28	1.40	1.49	1.40
5	1.53	1.38	1.43	1.51	1.41	1.56	1.47
6	1.54	1.56	1.43	1.54	1.51	1.52	1.52
7	1.45	1.49	1.43	1.60	1.64	1.41	1.51
8	1.53	1.43	1.48	1.40	1.49	1.41	1.46
9	1.69	1.45	1.41	1.34	1.56	1.41	1.48
10							
11	1.45	1.32	1.30	1.40	1.34	1.45	1.38
12	1.38	1.61	1.43	1.41	1.52	1.51	1.48
13	1.46	1.56	1.62	1.56	1.41	1.52	1.52
14	1.57	1.48	1.43	1.36	1.34	1.45	1.44
Ave							1.47
Std							0.074

## MIT FOLD DATA

Sample D-2  
Machine Direction - Aged 288 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.46	1.48	1.78	1.34	1.40	1.46	1.49
2	1.57	1.38	1.40	1.36	1.40	1.30	1.40
3	1.26	1.34	1.57	1.43	1.34	1.45	1.40
4	1.46	1.36	1.34	1.51	1.34	1.41	1.40
5	1.36	1.43	1.53	1.70	1.40	1.51	1.49
6	1.48	1.54	1.45	1.30	1.30	1.43	1.42
7	1.61	1.48	1.36	1.34	1.36	1.52	1.45
8	1.51	1.38	1.30	1.45	1.58	1.49	1.45
9	1.61	1.52	1.45	1.36	1.38	1.38	1.45
10	1.38	1.57	1.41	1.52	1.38	1.32	1.43
11	1.49	1.34	1.43	1.64	1.28	1.48	1.44
12	1.28	1.40	1.41	1.41	1.30	1.28	1.35
13	1.26	1.53	1.51	1.53	1.54	1.52	1.48
14	1.48	1.56	1.40	1.26	1.28	1.48	1.41
Ave							1.43
Std							0.040

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.28	1.46	1.48	1.34	1.30	1.34	1.37
2	1.28	1.46	1.48	1.32	1.38	1.45	1.39
3	1.20	1.45	1.46	1.43	1.56	1.43	1.42
4	1.56	1.57	1.51	1.46	1.32	1.32	1.46
5	1.36	1.40	1.32	1.38	1.34	1.23	1.34
6	1.38	1.45	1.54	1.45	1.46	1.64	1.49
7	1.38	1.46	1.30	1.36	1.36	1.40	1.38
8	1.34	1.36	1.32	1.46	1.41	1.43	1.39
9	1.49	1.52	1.43	1.36	1.34	1.26	1.40
10	1.45	1.51	1.41	1.32	1.41	1.32	1.40
11	1.54	1.49	1.49	1.63	1.45	1.36	1.49
12	1.32	1.36	1.36	1.48	1.41	1.30	1.37
13	1.57	1.48	1.41	1.49	1.53	1.51	1.50
14	1.34	1.45	1.32	1.36	1.26	1.43	1.36
Ave							1.41
Std							0.052

## MIT FOLD DATA

Sample D-2  
Machine Direction - Aged 576 Hrs

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.32	1.43	1.63	1.30	1.40	1.45	1.42
2	1.34	1.53	1.40	1.30	1.40	1.28	1.37
3	1.40	1.38	1.52	1.46	1.75	1.52	1.50
4	1.41	1.45	1.48	1.59	1.57	1.46	1.49
5	1.52	1.45	1.54	1.34	1.54	1.52	1.49
6	1.53	1.36	1.40	1.41	1.51	1.57	1.46
7	1.46	1.34	1.34	1.43	1.36	1.51	1.41
8	1.34	1.36	1.45	1.51	1.40	1.45	1.42
9	1.43	1.40	1.46	1.40	1.43	1.53	1.44
10	1.38	1.28	1.38	1.36	1.51	1.57	1.41
11	1.28	1.30	1.30	1.30	1.38	1.52	1.35
12	1.40	1.51	1.46	1.46	1.36	1.32	1.42
13	1.36	1.26	1.36	1.28	1.49	1.45	1.37
14	1.32	1.45	1.52	1.46	1.41	1.36	1.42
Ave							1.43
Std							0.047

## Cross Direction

Sheet Number	MIT Fold, log(10)N						Average
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	
1	1.43	1.36	1.38	1.43	1.38	1.45	1.41
2	1.36	1.34	1.40	1.34	1.28	1.38	1.35
3	1.41	1.36	1.34	1.32	1.32	1.49	1.38
4	1.41	1.49	1.49	1.41	1.48	1.56	1.47
5	1.30	1.23	1.28	1.30	1.28	1.52	1.32
6	1.20	1.34	1.36	1.30	1.23	1.23	1.28
7	1.28	1.23	1.53	1.32	1.32	1.34	1.34
8	1.26	1.23	1.38	1.36	1.28	1.34	1.31
9	1.26	1.46	1.45	1.36	1.40	1.26	1.36
10	1.28	1.46	1.41	1.52	1.32	1.28	1.38
11	1.26	1.34	1.28	1.32	1.46	1.34	1.33
12	1.40	1.23	1.41	1.36	1.23	1.26	1.32
13	1.32	1.32	1.40	1.30	1.34	1.20	1.31
14	1.34	1.41	1.28	1.26	1.34	1.43	1.34
Ave							1.35
Std							0.049

## TENSILE DATA

Sample D-2  
Machine Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	3.58	3.71	3.66
2	3.37	3.42	3.60
3	3.69	3.52	3.52
4	3.71	3.52	3.44
5	3.60	3.44	3.48
6	3.75	3.60	3.63
7	3.63	3.50	3.33
8	3.52	3.42	3.56
9	3.62	3.67	3.50
10	3.56	3.83	3.50
11	3.73	3.60	3.15
12	3.42	3.90	3.73
13	3.46	3.52	3.66
14	3.69	3.60	3.71
Ave	3.59	3.59	3.53
Std	0.119	0.146	0.157

## Cross Direction

Test Number	Tensile Strength, kn/m		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	2.25	2.12	2.17
2	2.25	2.27	2.23
3	2.23	2.21	2.21
4	2.21	2.12	2.13
5	2.21	2.27	2.15
6	2.21	2.21	2.23
7	2.35	2.37	2.00
8	2.27	2.25	2.33
9	2.33	2.15	2.23
10	2.19	2.17	2.08
11	2.21	2.23	2.04
12	2.25	2.19	2.15
13	2.31	2.13	1.92
14	2.29	2.13	2.06
Ave	2.25	2.20	2.14
Std	0.048	0.071	0.109

## STRETCH DATA

Sample D-2  
Machine Direction

Test Number	Stretch, %		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	1.75	1.69	1.52
2	1.55	1.45	1.58
3	1.76	1.53	1.52
4	1.73	1.48	1.35
5	1.84	1.54	1.47
6	1.84	1.61	1.53
7	1.77	1.47	1.33
8	1.69	1.61	1.51
9	1.75	1.60	1.44
10	1.53	1.76	1.46
11	1.87	1.51	1.40
12	1.65	1.70	1.59
13	1.60	1.63	1.52
14	1.89	1.50	1.60
Ave	1.73	1.58	1.49
Std	0.114	0.095	0.084

## Cross Direction

Test Number	Stretch, %		
	Unaged	Aged 288 Hrs	Aged 576 Hrs
1	3.75	2.72	3.14
2	3.77	3.44	3.36
3	3.32	3.15	2.75
4	3.51	2.71	2.87
5	3.54	3.45	3.06
6	3.40	2.84	3.24
7	3.58	3.64	2.46
8	3.86	3.43	3.34
9	3.82	3.22	3.11
10	3.58	3.18	3.23
11	3.72	3.27	3.38
12	3.65	3.22	3.28
13	3.62	2.76	2.77
14	3.85	2.92	3.48
Ave	3.64	3.14	3.11
Std	0.165	0.303	0.293

## TEA DATA

Sample D-2  
Machine Direction

Test Number	Unaged	TEA, J/sq m	
		Aged 288 Hrs	Aged 576 Hrs
1	41.3	41.5	36.0
2	34.3	32.2	37.0
3	43.1	35.1	35.0
4	42.5	34.0	29.9
5	44.3	34.7	33.1
6	45.9	37.8	35.9
7	42.8	33.2	28.4
8	39.3	36.4	34.9
9	41.9	38.5	32.7
10	35.7	45.1	33.1
11	46.6	35.5	28.5
12	37.2	43.8	38.9
13	36.1	38.0	35.9
14	47.1	35.1	38.8
Ave	41.3	37.2	34.2
Std	4.19	3.90	3.40

## Cross Direction

Test Number	Unaged	TEA, J/sq m	
		Aged 288 Hrs	Aged 576 Hrs
1	61.6	41.6	50.2
2	62.1	57.6	55.7
3	54.1	51.2	44.2
4	56.9	41.9	45.0
5	57.1	57.9	48.7
6	55.0	46.1	53.8
7	61.4	63.7	35.7
8	64.7	56.9	57.6
9	65.3	51.6	51.1
10	57.5	50.7	49.4
11	60.5	53.6	51.1
12	60.2	51.9	51.8
13	61.0	43.0	39.0
14	64.6	45.7	53.2
Ave	60.1	51.0	49.0
Std	3.58	6.69	6.16

## ET DATA

Sample D-2  
Machine Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	481	491	498
2	483	495	485
3	491	492	473
4	499	488	481
5	471	478	467
6	494	487	570
7	487	491	482
8	472	466	472
9	473	493	470
10	501	499	476
11	495	488	460
12	473	514	495
13	487	481	483
14	480	500	491
Ave	485	490	486
Std	10.2	11.1	26.6

## Cross Direction

Test Number	Unaged	Et, kN/m	
		Aged 288 Hrs	Aged 576 Hrs
1	267	276	281
2	266	284	279
3	268	280	288
4	270	281	275
5	266	281	276
6	273	288	281
7	276	282	273
8	263	276	290
9	268	276	276
10	266	272	260
11	265	274	252
12	269	278	269
13	273	286	249
14	275	281	252
Ave	269	280	271
Std	4.0	4.6	13.4

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Kappa No.							
Sample A-2	5.77	5.71	5.85	5.76	5.98	5.92	5.89
B-2	2.18	2.25	2.20	2.12	2.17	2.18	2.18
C-2	7.28	7.37	7.29	7.25	7.39	7.39	7.24
D-2	1.88	1.64	1.74	1.78	1.65	1.78	1.79
Cold Extract pH							
A-2	8.79	8.84	8.77	8.78	8.89	8.82	8.90
B-2	9.56	9.62	9.60	9.62	9.63	9.68	9.59
C-2	9.10	9.19	9.16	9.13	9.11	9.18	9.09
D-2	9.49	9.43	9.43	9.44	9.40	9.40	9.41
Alkaline Reserve, %							
A-2	14.02	14.92	14.11	14.20	14.57	14.80	14.50
B-2	9.86	9.11	9.08	9.02	9.13	9.37	9.53
C-2	14.06	14.11	14.15	14.14	14.10	14.11	14.16
D-2	10.97	10.97	11.06	10.92	10.84	10.90	10.93