RPTA TECHNICAL REPORT

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Introduction:
An investigation of the affects of storing recycled paperboard in an unheated warehouse during the winter months and converting the board without prior conditioning was undertaken by RPTA. Z-direction tensile (ZDT), which was chosen to simulate the upward pull a sheet of board would experience during converting operations, was run on the two samples of board to determine what affect, if any, temperature had on ZDT. Two samples of coated board, a 0.26" board manufactured on a cylinder machine and a 0.18" board manufactured on an Ultraformer were used for the study. In addition to the varying temperature conditions, samples of board were flexed or stressed to determine if the interaction of temperature and stressing intensified the difference in board performance.

Summary:
Based on this investigation board stored at 0°F exhibits an approximately 14% lower ZDT than board conditioned to 72°F (58.7 vs 49.9 for the 0.18" board and 53.5 vs 46.4 for the 0.26" board). In addition board stored at 0°F and then conditioned to 72°F approaches the same performance as the control (board conditioned at 72°F) indicating that conditioning the board is important for optimum performance. The results to evaluate the affect of flexing or stressing the sample and the interaction of temperature and stressing on board performance are inconclusive.

Recommendations:
While this study does demonstrate that cold storage of board has an impact on ZDT, other questions remain unanswered. Is it the temperature alone that affects board performance or is it the moisture in the board, which is being impacted by the cold storage temperature that is responsible for the lower ZDT properties? Is there a certain temperature below which degradation does not occur? Further investigation could be undertaken to address these questions and develop a better understanding of this phenomenon.

Discussion:
To determine the impact of storage temperature on board performance, two different samples of board; 0.18" board manufactured on an Ultraformer and 0.26" board manufactured on a cylinder machine were used for the study. Sample of each board were run under five conditions and tested for ZDT. The conditions investigated were stored at 0°F, conditioned at 72°F (control), stored at 0°F and conditioned 72° F (designated as 0-72), stored at 0°F and flexed or stressed, and conditioned at 72°F and flexed.

All samples were preconditioned according to TAPPI prior to the start of the experiment. The 0°F samples were conditioned in a freezer at 0°F for 24 hours, then taped and stored at 0°F for an additional 24 hours and then immediately taken from the freezer and tested for Z-direction tensile. The control samples were conditioned at 72° F for 72 hours prior to testing. The 0-72 samples were held in the freezer for 24 hours then taped and stored for an additional 24 hours then brought into a 72°F room and allowed to condition for 72 hours.

In addition to the affects of temperature, samples of board at both 0°F and 72°F were flexed or stressed prior to stored at the specified conditions to determine if the interaction of stressing and temperature intensified the difference in board performance. Samples were flexed or stressed over a 4" diameter roll prior to cutting the ZDT samples. The results of the tests are listed in Tables I and II.

TABLE I
18 Point Board

	Board at 72° F Control	Board at 0° F	0°F to 72°	Board at 72° F and stressed	Board at 0° F and stressed
ZDT	56.8	51.4	51.0	57.0	51.1
	56.4	37.1	57.5	59.0	40.8
	58.8	55.2	59.7	58.2	50.2
	61.7	45.7	51.6	59.6	51.3
	60.1	48.2	54.5	56.5	50.2
	59.8	54.0	55.8	60.1	50.1
	59.4	50.7	55.7	60.5	49.8
	55.6	54.3	46.6	56.8	49.9
	61.1	53.1	60.0	59.0	53.6
	57.4	49.4	55.3	57.8	52.6
Average	**58.7**	**49.9**	**54.8**	**58.5**	**50.0**
Std Dev	**2.1**	**5.4**	**4.1**	**1.4**	**3.5**
Range	**6.1**	**18.1**	**13.4**	**4.0**	**12.8**

TABLE II
26 Point Board

	Board at 72° F Control	Board at 0° F	0°F to 72°	Board at 72° F and stressed	Board at 0° F and stressed
ZDT	54.4	45.2	57.6	49.9	42.9
	53.1	44.4	52.1	53.2	49.5
	54.3	45.9	50.8	49.9	47.9
	51.6	42.7	54.5	52.3	49.8
	56.8	48.0	56.6	42.3	46.3
	53.6	49.6	54.7	53.0	42.1
	55.3	50.4	59.3	48.9	41.3
	48.7	42.1	50.5	48.3	44.8
	54.4	49.9	53.1	52.3	48.3
	52.9	45.7	52.7	42.9	40.3
Average	**53.5**	**46.4**	**54.2**	**49.3**	**45.3**
Std Dev	**2.2**	**3.0**	**2.9**	**3.9**	**3.5**
Range	**8.1**	**8.3**	**8.8**	**10.9**	**9.5**

Affect of Temperature

For the 0.18" Ultraformer board there is a statistical difference between the ZDT of the board stored at 0° F and conditioned at 72°F (the control). There is also a statistical difference between the board at stored at 0°F and the board stored at 0 °F and then reconditioned to 72°F (the 0-72 sample). And for this sample there is a difference between the 72°F sample and the 0-72 sample. [1]

For the 0.26" cylinder board there is a statistical difference between board stored at 0°F and conditioned at 72°F. There is a statistical difference between the board stored at 0°F and the 0-72 sample. There is no statistical difference between the 72°F sample and the 0-72 sample [2]

Based on the above statistical data it is concluded that board stored at 0°F exhibits a lower ZDT than board conditioned to 72°F. In addition board stored at 0°F and then conditioned to 72°F approaches the same performance as the control (board conditioned at 72°F).

Affect of Stressing

Results of the affect of stressing on board performance are inconclusive. Statistical analysis of the affect of stressing alone, showed no difference in performance for the 0.18" board but did indicate a difference for the 0.26" board. However, the interaction of temperature and stressing, did not show a statistical difference for either board. [3]

Conclusion

There is evidence that that conditioning of board is an important part of the converting process. The following chart was obtained from literature in the public domain, and can be used to determine the amount of time a pallet or roll of board will need to condition to different temperatures.

Warming up time of paper or board pallets or reels (hours)

Weight or Shortest Dimension		Temperature Difference						
Kg (lbs)	Mm (inches)	5°C 41°F	10°C 50°F	15°C 59°F	20°C 68°F	25°C 77°F	30°C 86°F	35°C 95°F
200 (441)	650 (25.5)	10 hours	30	45	60	75	85	95
400 (882)	700 (27.6)	15	35	50	65	80	90	100
600 (1323)	750 (29.5)	20	40	55	70	95	95	105
800 (1764)	800 (31.5)	25	45	60	75	90	100	110
1000 (2204)	850 (33.5)	25	50	65	80	95	105	115
1200 (2646)	900 (35.4)	30	55	75	90	105	115	125
1400 (3086)	950 (37.4)	35	60	85	100	115	125	135
1600 (3527)	1000 (39.4)	40	70	95	110	125	135	145 hours

To determine the required warming up time in hours, refer to either the weight or the shortest dimension of pallet or reel, and then to the difference in temperature between the warehouse and converting facility. If the weight and shortest dimension indicate different warming-up times, then choose the shorter of the two times.

[1] P value for one-way Anova comparing the 0°F with the 72°F (0.18" board) sample is 0.000 indicating there is a statistical difference . (A P value <0.05 the samples are different). P value for 0°F vs 0-72 sample is 0.036, and the P value for the 72°F vs 0-72 sample is 0.015)

[2] P value for one-way Anova comparing the 0°F with the 72°F (0.26" board) sample is 0.000 indicating there is a statistical difference . P value for 0°F vs 0-72 sample is 0.000, and the P value for the 72°F vs 0-72 sample is 0.564

[3] P values for stressing (.018) are 0.924 and (.026) 0.014. P values for the interaction of Temperature and Stressing are (.018) 0.887 and (.026) 0.132 . Confidence level chosen was 95% so a P value equal to or less than 0.05 means the test results are statistically different.