Purpose:

Measure basis weight, caliper, tensile, tear, STFI and z-direction tensile on the 6 sets of handsheets provided. Handsheets were prepared using the BSSM to produce 200 gsm sheets from repulped coated and uncoated test trial boxes.

Background:

Basis weight of paper is determined by weighing a known area of paper. Caliper measurements involve measuring the thickness of a single sheet of paper using contact points of a specified area applied with a specified pressure. Tensile strength is a measure of the resistance of paper to direct tension. The internal tearing resistance is measured on a pendulum type instrument (Elmendorf tear tester), which measures the amount of work done in tearing the paper through a fixed distance. The data from the short span compressive strength of linerboard and medium can be used to predict the compressive strength of corrugated boxes. The internal bond strength of paperboard provides an indication of the expected internal bond strength performance.

About IPST Paper Analysis Laboratory:

Paper Testing at IPST has over 2800 square feet of lab space dedicated to address any paper, board, and specialty product testing needs in areas of strength, optical, surface, and structural properties. In addition to conventional Tappi method testing capabilities, the Paper Testing group can provide special services in the areas of environmental simulations and accelerated aging. Environmental chambers cover high and low temperature and humidity conditions. Unique capabilities include precision paper grinding or sheet splitting to produce specific thickness sections, score cracking of linerboards, needle abrasion testing to predict relative slitter and knife blade wear

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caused by abrasive components in both base sheet and coating materials, nondestructive in-plane and out-of-plane (Z-directional) ultrasonic testing, optical 3D Moiré surface topography for the measurement of curl or cockle. Our labs also offer the latest automated capabilities for real time hygroexpansive response measurements, and horizontal plane static and kinetic coefficient of friction determinations. Humidity and temperature conditions are monitored and tracked continually to ensure proper standard Tappi conditions of 23 degrees C and 50 % RH.

The results from the IPST Paper Analysis Laboratory are guaranteed validated through IPST active participation in the Collaborative Testing Services Inc., and PAPRICAN Paper and Pulp Monitor programs. Over 400 technician hours are annually devoted to regular periodic round-robin intra-laboratory comparisons of testing results. This ensures that the equipment, methods and results are consistent with correct industry practice.

Method:

Standard TAPPI Test methods were followed as specified below:

- **Grammage of paper and paperboard (Basis Weight). TAPPI 410**. The test was performed using 5 repeats per sample set.
- **Thickness (caliper) of paper, paperboard. TAPPI 411.** The test was performed with 10 repeats for each sample set. The L&W automated micrometer is used, hard platens.
- **Tensile properties of paper and paperboard (using constant rate of elongation apparatus)**. **TAPPI 494**. The test was performed with 5 repeats per sample set using the Instron test frame and Series IX software.
- **Internal tearing resistance of paper (Elmendorf-type method). TAPPI 414.** The test was performed using 5-ply per measurement along with an 800 gram pendulum on 6 repeats per liner sample, TMI Digi-tear.

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- **Short span compressive strength of containerboard. TAPPI 826.** The test was performed with 10 repeats per sample set. The L&W STFI Awletron TH1 is used.
- **Internal bond strength of paperboard (z-direction tensile). TAPPI 541**. The test was performed using 5 repeats for each sample set. Measurements are made on a TMI Monitor/ZDT with 3M double sided tape.

Data:

A comparison of significant differences between samples can be gleaned through comparison of the results with error bars representing the 95% confidence intervals of the results from repeated measurements for each sample. Data points with overlapping error bars are not considered statistically different. The following graphs are plots of the physical properties with the inclusion of 95% confidence interval error bars.

Sample ID	Weight (grams)	Basis Weight (g/cm2)	Hard Caliper (µm)	STFI (lbf/in)	ZDT (psi)	Strength (kN/m)	Stretch (%)	TEA (J/m2)
Sample C	4.36 (+/- .11)	217.83 (+/- 5.28)	489.95 (+/- 2.28)	14.04 (+/- .86)	13.94 (+/- 1.5)	4.73 (+/- .43)	1.59 (+/- .35)	54.73 (+/- 16.78)
Sample D	4.15 (+/- .03)	207.54 (+/- 1.63)	405.57 (+/- 8.35)	14.38 (+/- .67)	16.88 (+/- 1.45)	4.36 (+/- .11)	1.42 (+/- .15)	43.62 (+/- 6.6)
Sample E	3.98 (+/- .05)	199.0 (+/- 2.57)	427.3 (+/- 2.72)	12.53 (+/- .86)	16.8 (+/- 2.04)	3.95 (+/- .25)	1.68 (+/- .17)	48.8 (+/- 8.03)
Waxed	4.15 (+/- .06)	207.33 (+/- 3.23)	446.1 (+/- 2.74)	14.88 (+/- 1.07)	20.7 (+/- 3.11)	5.01 (+/- .09)	1.65 (+/- .12)	58.44 (+/- 5.49)
Sample F	4.09 (+/- .10)	204.38 (+/- 4.83)	439.92 (+/- 1.26)	17.99 (+/- 1.05)	23.66 (+/- 1.86)	6.29 (+/- .14)	2.28 (+/- .2)	104.3 (+/- 13.08)
Base control	4.32 (+/- .10)	215.8 (+/- 4.95)	467.08 (+/- 3.59)	18.3 (+/- 1.45)	20.81 (+/- 2.16)	6.45 (+/- .24)	2.26 (+/- .15)	106 (+/- 8.0)

Table 1. Summary of Physical Testing for samples. Values in parentheses are standard deviations.

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Observations:

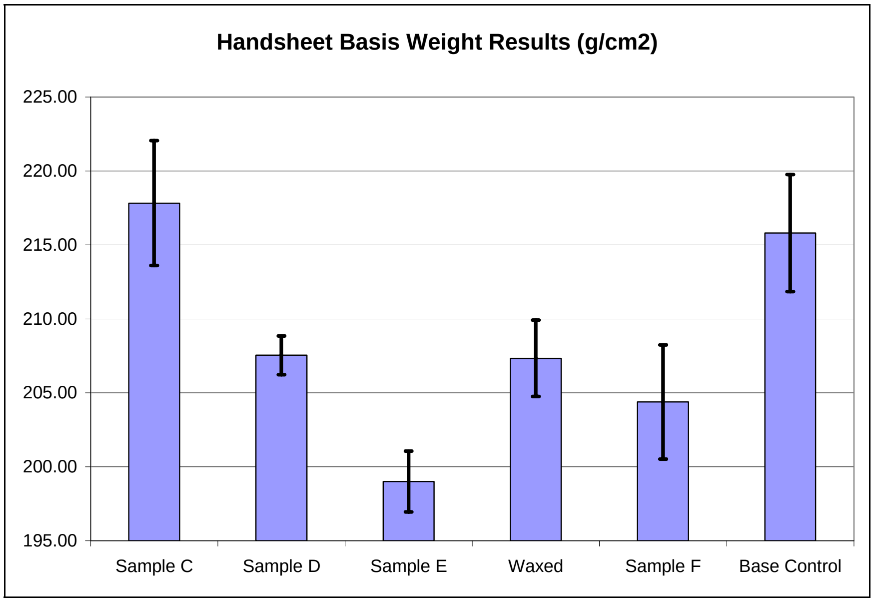

Figure 1. Basis Weight Results. The graph shows that Sample E sample has a much lower basis weight than the other 5 samples.

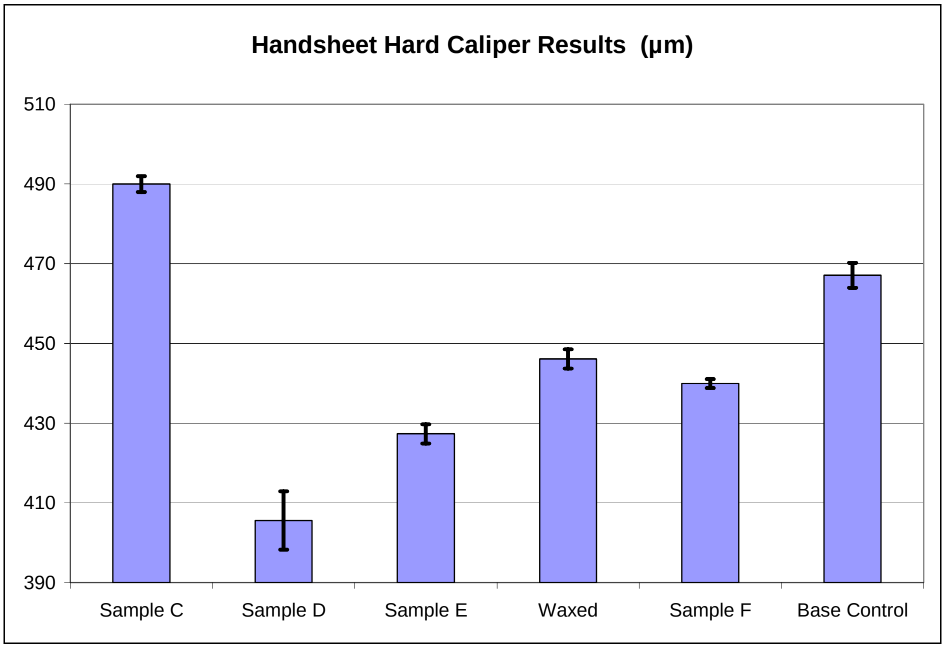

Figure 2. Hard Caliper Results. Sample C produced a much higher result than the other sample sets.

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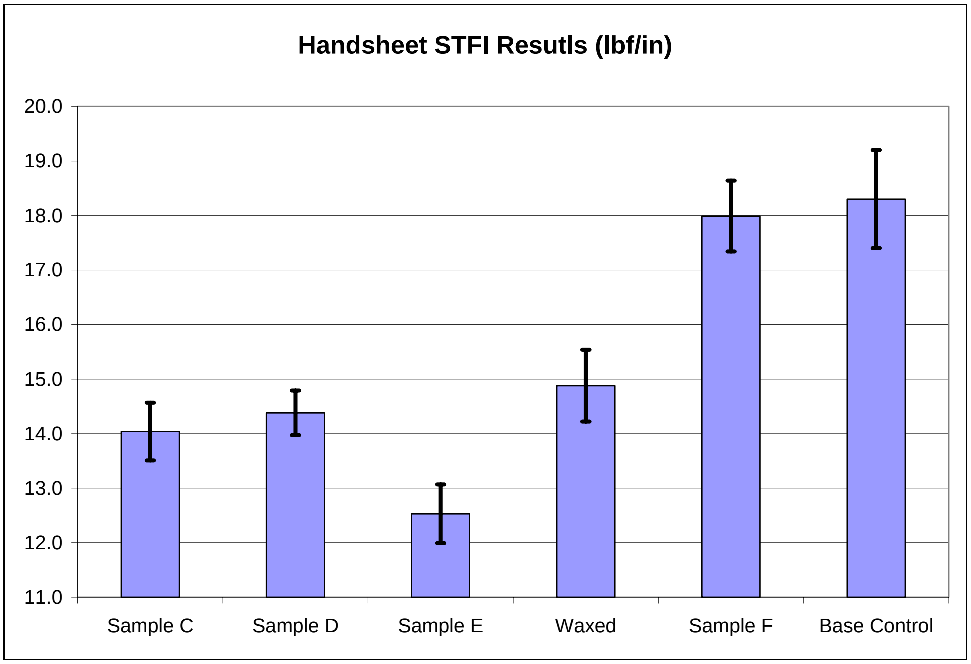

Figure 3. STFI Measurement. Sample E again produced much lower result than the other sample sets. Samples D and E are made from recycled pulp, Base Control, Waxed and Sample C are made form the same components.

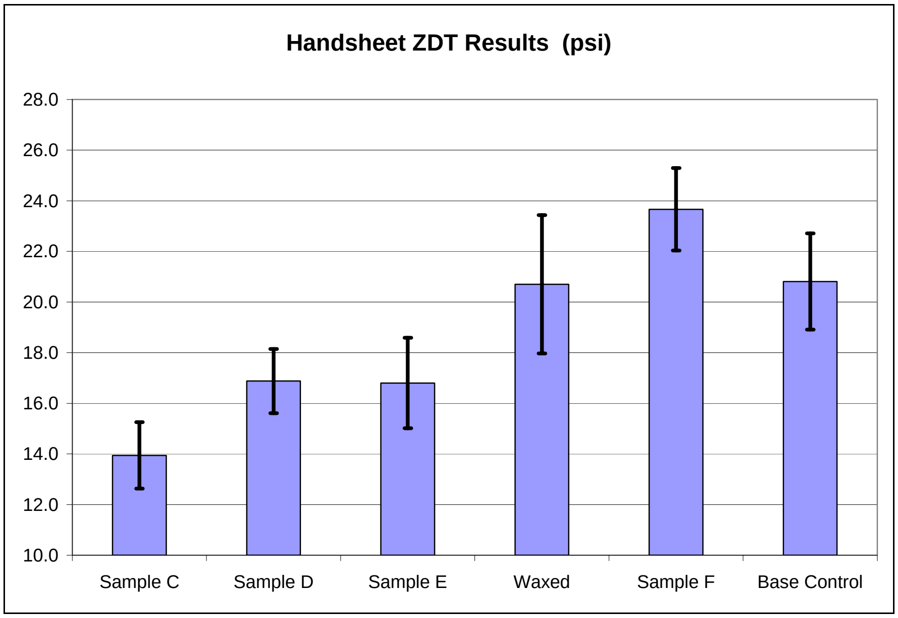

Figure 4. ZDT Results. Sample C produced a lower result than the other sample sets. As in Figure 3 above, the addition of a coating is observed to deteriorate the strength relative to an uncoated sample., "Base Control".

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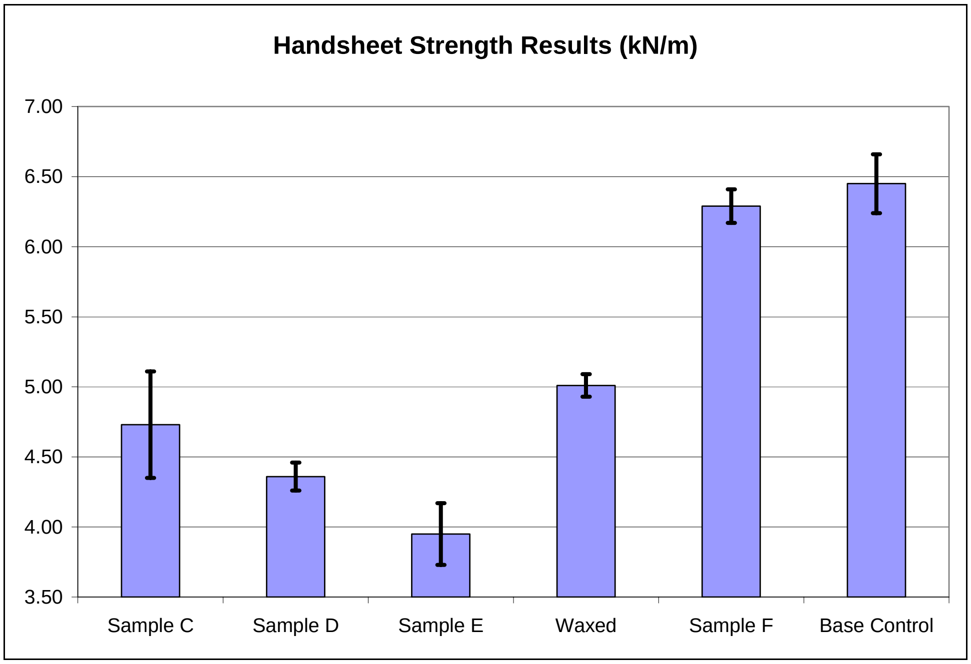

Figure 5. Tensile Strength Results. Sample E produced a lowest result among the tested samples. Tesnile strength relative to the Base Control deteriorates

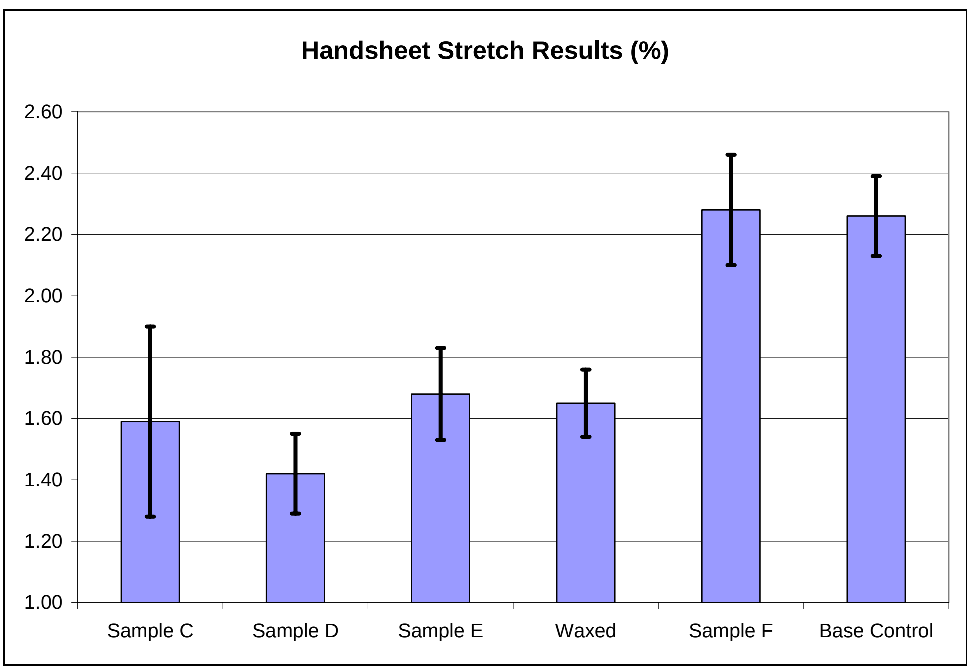

Figure 6. Tensile Stretch Results. Samples C, D, E and Waxed are statistically the same. The same hold true for Sample F and the Base Control sample sets.

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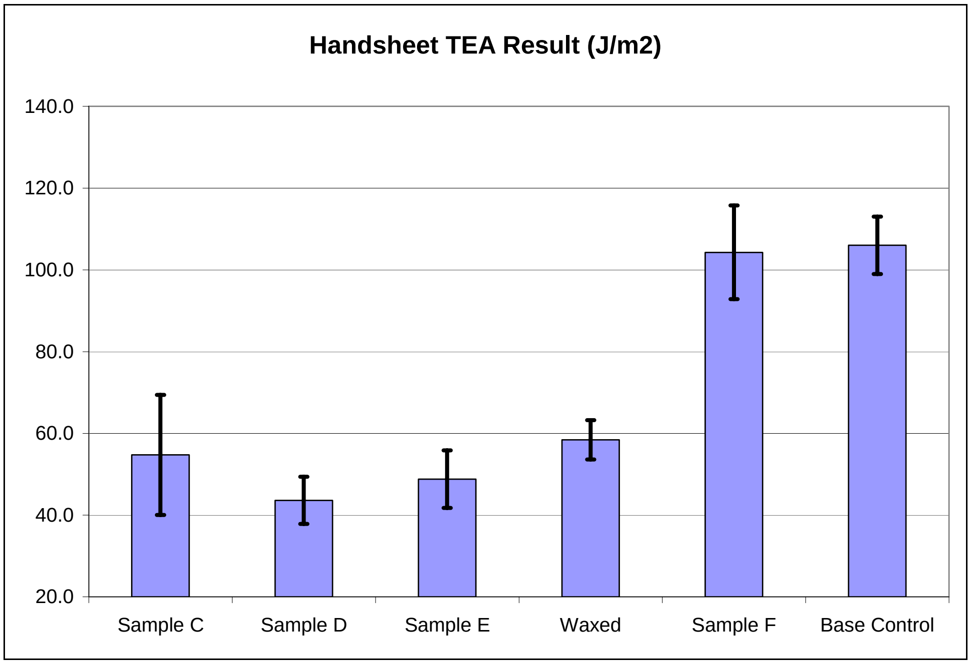

Figure 7. Tensile TEA Results. Samples C, D, E and the Waxed are statistically the same. The same hold true for Sample F and the Base Control sample sets.

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