4.0 RESULTS AND DISCUSSION

In order to compare the material removed in the laboratory printing experiments with the filler size distributions measured in the surface of the paper, correlations between the following properties were investigated.

A. Fine / Filler lint area from IGT test print (Class 0 – 0.05 mm^2).

B. Fibre lint area from IGT test print (Class 0.1 – 10 mm^2)

C. Total Lint area from IGT test print (mm^2)

D. Total Filler Area from SEM, including border particles (μm^2)

E. Percentage of SEM image covered by Filler (%)

F. Filler Area from SEM > 50 μm^2

G. Filler Area from SEM > 16 μm^2

H. Filler Area from SEM > 8 μm^2

I. Total Filler Area from SEM, excluding border particles (μm^2)

J. Treeline Result

K. Heidelberg Test lint (gsm)

The full data sets for the properties are given as follows :

A-C : Appendix E

D – I : Appendix G

J- K : Appendix I

The treeline result is an indication of the presence of filler vs fines in the lint as discussed in Section 3.1.3. Figure 4.1 shows that the amount of filler deposited on the Heidelberg press blanket in the tree line area is generally proportional to the amount of filler / fines removed in the IGT test print.

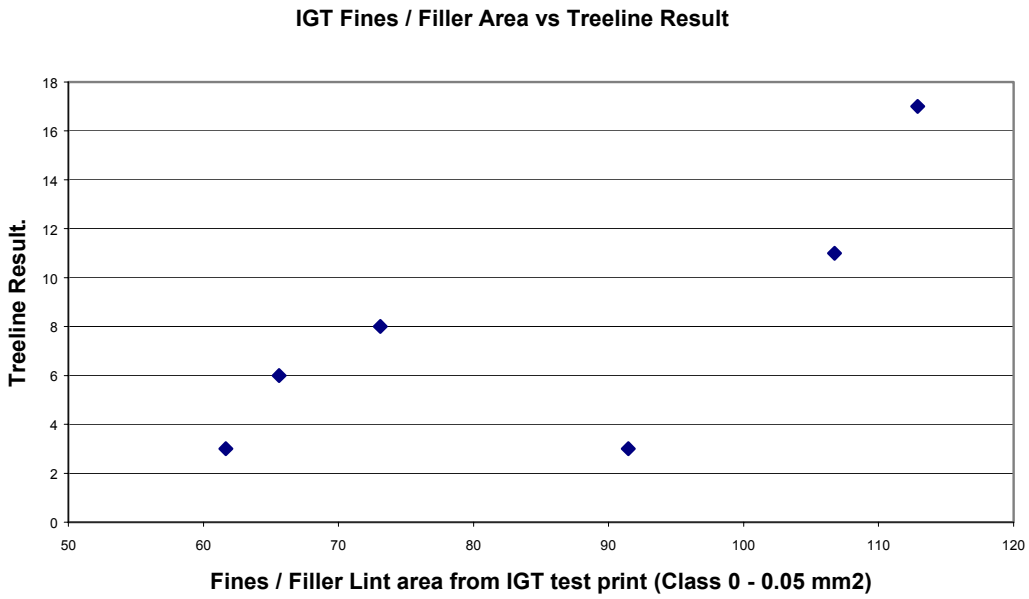

Figure 4.1 - IGT Fines / Filler Area vs Treeline Result

Figure 4.2 shows that the amount of filler deposited on the Heidelberg press blanket in the treeline area is also generally proportional to the total lint area removed in the IGT test print as the total area removed in the IGT test print is dominated by the fines / filler area.

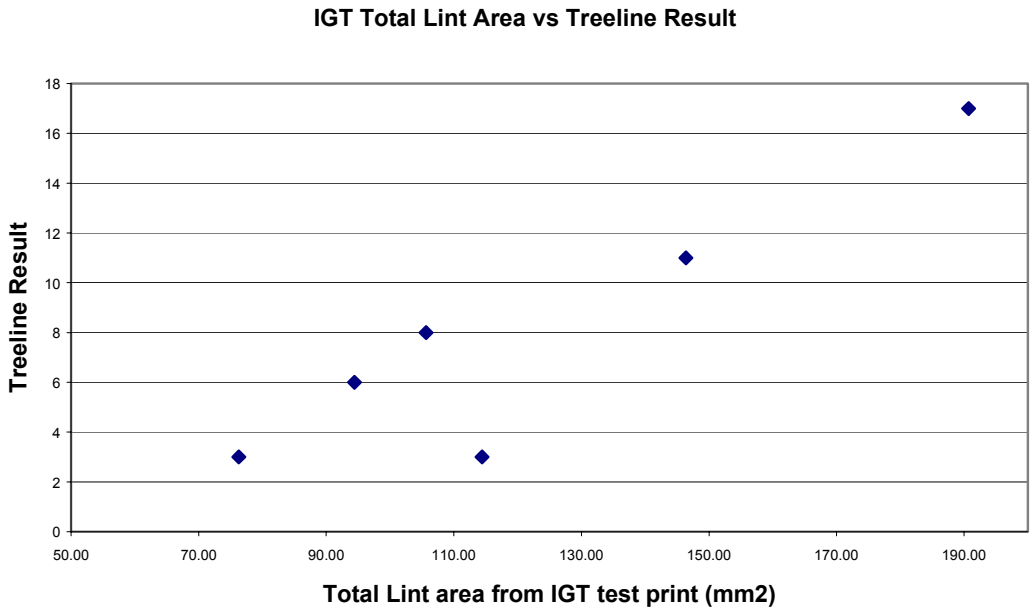

Figure 4.2 - IGT Total Lint Area vs Treeline Result

The Heidelberg tests and the IGT series of experiments has shown a good correlation between the amount of filler deposited on the Heidelberg Offset press and the amount of fines and filler removed by the IGT test print. A more robust correlation may be possible with more data. The Treeline data is limited to the bottom side of the sheet and hence the data is limited. The full data for the Treeline may be found in Appendix I.

No correlation could be found between the overall Heidelberg lint count and the amount of lint removed in the IGT test prints. This may be due to a variety of factors including differences in ink, printing pressure, printing speed and the small range of Heidelberg values from 5.5 to 7.5.

No correlation could be found between the amount of lint removed in the IGT test print and the amount of filler detected in the surface of the sheet by SEM, as is shown in Figure 4.3. There is a distinct outlier in the data set. The experiments were repeated for this outlier (B3 bottom) to confirm the results, which remained unchanged from the original set of experiments. Sample B3 bottom had a very high propensity for lint, as measured by the IGT and a very high percentage of filler in the sheet surface (5.52%) compared to other samples that had percentages as low as 1.2 %.

Similarly, there was no correlation between the amount of lint removed in the IGT test print and the amount of filler detected in the surface of the sheet by SEM from either >50 μm^2 ,> 16 μm^2 or >8 μm^2 particle size ranges. The B3 bottom sample, remains an obvious outlier.

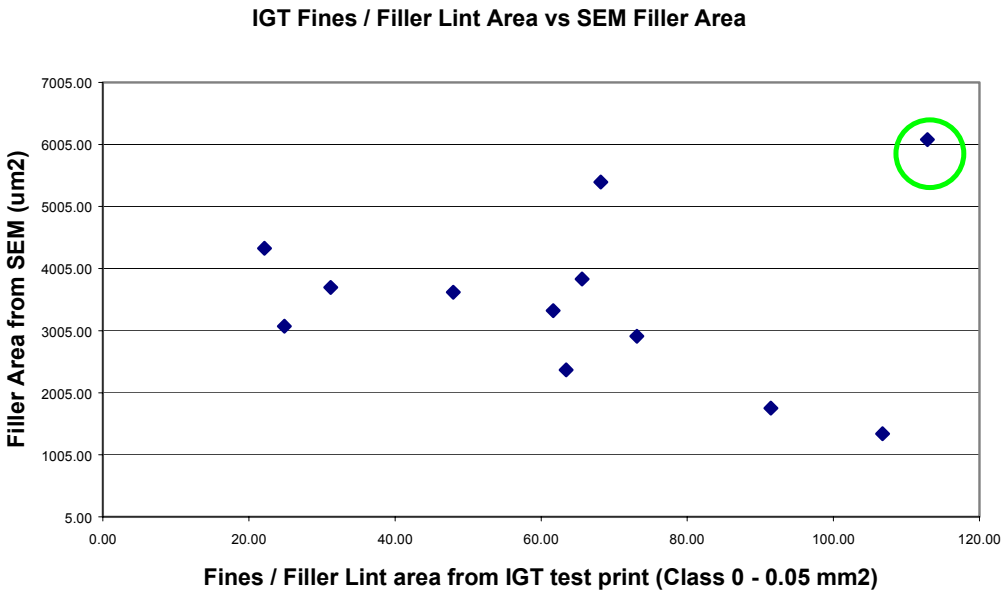

Figure 4.3 - IGT Fines / Filler Area vs Filler area from SEM

There is a fair correlation between the amount of filler detected in the surface of the sheet by SEM and the Treeline result as shown in Figure 4.4. The greater the amount of filler found in the surface of the sheet, the higher the lint count of the Treeline result which is related to the amount of filler lint particles found on the test print of the Heidelberg test. Substantially more Treeline data would prove this correlation either way.

The correlation could possibly be improved if the Heidelberg data, main and treeline, were further separated to determine the filler and fibre content of each. The treeline data, although predominantly related to filler content, would also have a fibrous content.

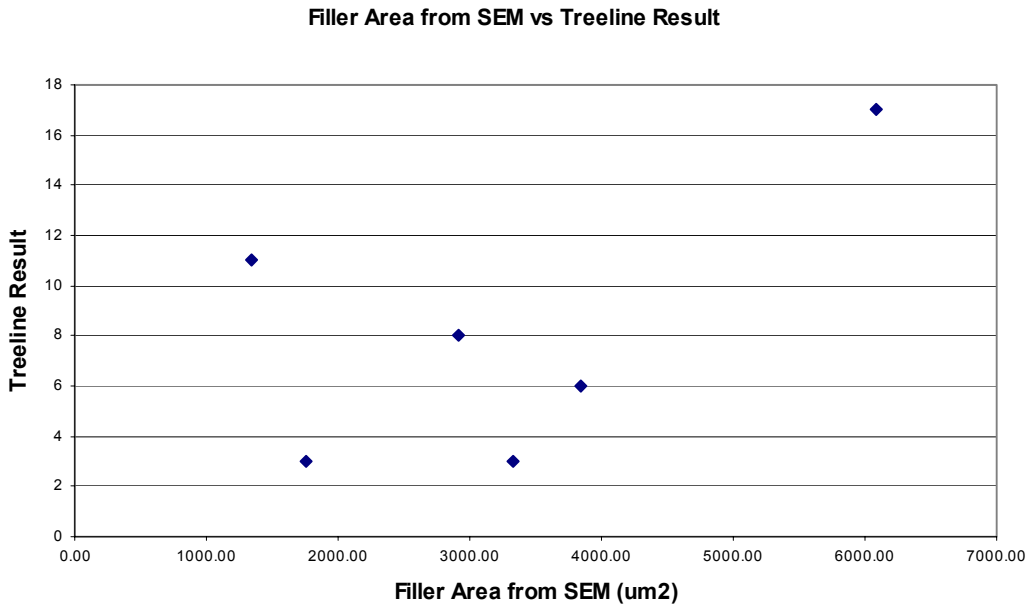

Figure 4.4 - Filler area from SEM vs Treeline result

No correlation could be found between the Heidelberg lint count and the amount of filler detected in the surface of the sheet by SEM. This may be due to a variety of factors

including ink, printing pressure, printing speed and the small range of Heidelberg values from 5.5 to 7.5.

Similarly, there was no correlation between the Heidelberg lint count and the amount of filler detected in the surface of the sheet by SEM from either >50 μm^2 ,> 16 μm^2 or >8 μm^2 particle size ranges.

The samples of paper given in Table 3.4 were all samples of the same grade of paper (Image / Norstar) manufactured at Norske Skog Boyer Mill. The paper is made with the same furnish ratios and filler content. Despite this, the amount of filler found in the surface of the sheet by SEM back scatter and image analysis varies considerably.

The full data set is given in Appendix G. As an example, sample B3 Top contained on average 4413.60 μm^2 of filler in the surface of the sheet (4 %), whereas Sample B6 Top contained 1738.88 μm^2 of filler in the surface of the sheet (1.6%). These differences show that the content of filler at the surface of the paper differs considerably despite aims to make the paper consistently.

Figures 4.5 and 4.6 show an example of the back scatter images of B3 top and B6 top respectively, showing the contrast in filler area and percentage.

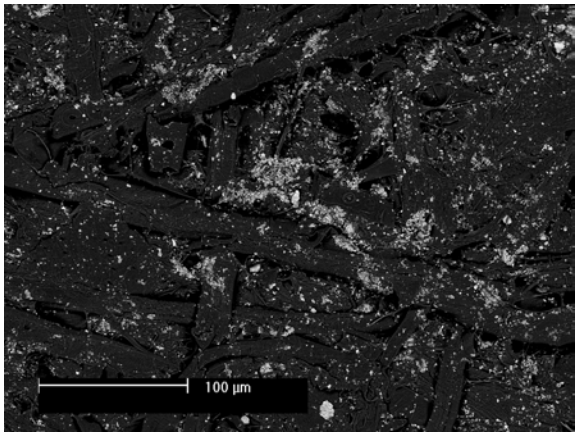

Figure 4.5 – 250 X Back Scattered Electron image of B3 top side (higher filler content)

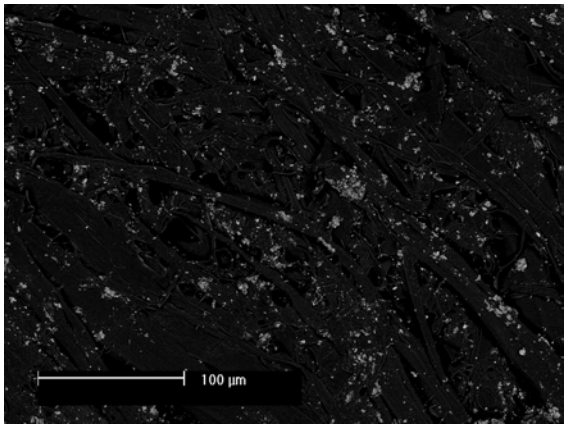

Figure 4.6 – 250 X Back Scattered Electron image of B6 top side (lower filler content)

Figure 4.7 shows the difference in filler percentage as measured by SEM back scatter in the top and bottom surfaces of the paper samples given in Table 3.4.

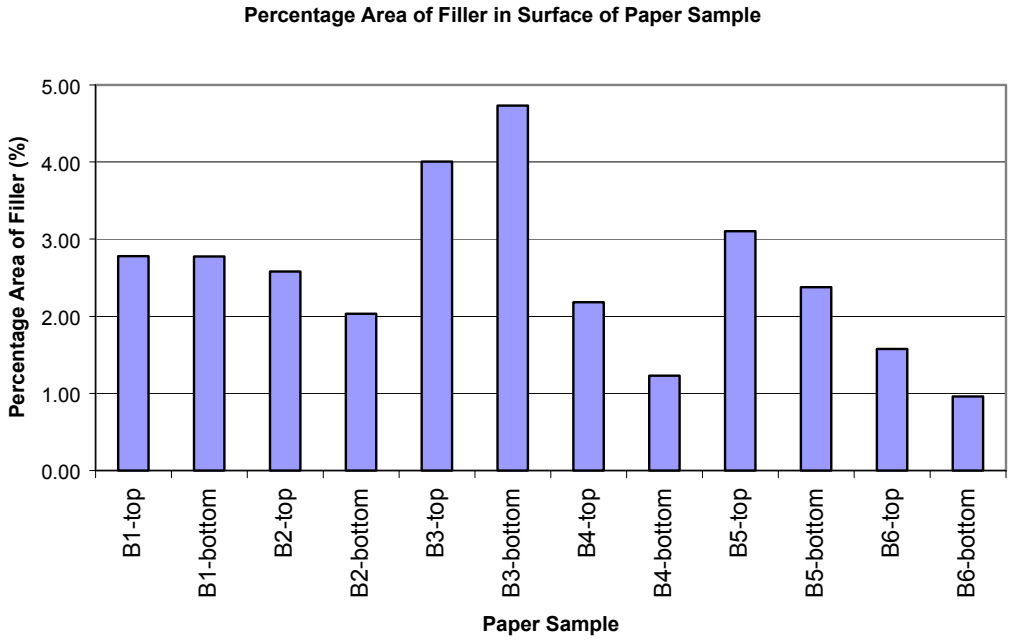

Figure 4.7 - Percentage Area of Filler in surface of Paper sample

Figure 4.8 shows the difference in % of large (> 8 μm^2) agglomerates of filler as measured by SEM back scatter in the top and bottom surfaces of the paper samples given in Table 3.4.

In can be concluded that there are substantial differences in the filler particle size distribution in the series of paper samples given in Table 3.4

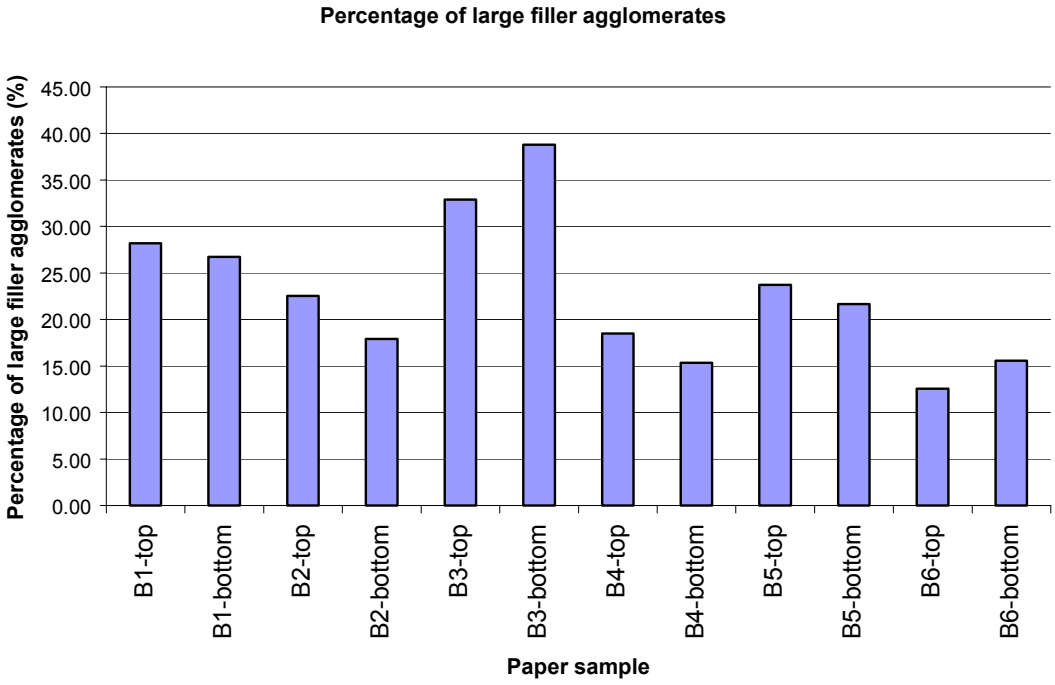

Figure 4.8 - Percentage of Large (> 8 μm^2) Agglomerates of Total Filler Area

5.0 CONCLUSIONS

The IGT Printability tester is an appropriate laboratory scale printing test unit to artificially remove filler from sheets of newsprint / paper. The IGT Printability tester provides repeatable results when evaluating the linting propensity of a series of papers, if run under the same set of experiment variables. It is difficult to quantify and qualify whether the source of lint has been from filler or small fibre fragments / fines. It is difficult to distinguish between print mottle effects, non homogenous paper surface properties and lint from filler / fines / fibre fragments.

Scanning electron microscopy coupled with backscatter detection offers an efficient method of imaging the surface of the sheet with good distinction between fibrous and filler components.

X-Ray detection in the SEM does not supply images of suitable quality to calculate the size distribution of the filler agglomerates. It does however detect the elemental constitution of a sample. Scanning electron microprobe with X-Ray detection does not supply images of suitable quality where the filler size distribution of the filler agglomerates can be calculated. It does however also detect elemental constitution of a sample.

X-Ray Tomography with Phase contrast has been evaluated as a proof of concept and shows good promise as a suitable method for the determination of filler distribution through a paper sample. Further experimental work is required to produce a proven method.

The spectra of filler and fibre as measured by FTIR are sufficiently different to enable excellent separation of signal / spectra. A scanning FTIR could potentially be used to map filler distribution on the surface of paper.

The treeline figure increases with increasing amount of lint measured on the IGT test print. The treeline figure increases with increasing amount of filler measured in the surface of the sheet as measured by SEM and image analysis. There is no robust correlation between linted areas as measured in IGT test prints, filler areas as measured by SEM and image analysis or Heidelberg Lint results. The samples measured showed wide variability in filler content and distribution, despite all being the same grade of paper and with the same nominal filler content.

6.0 RECOMMENDATIONS FOR FURTHER WORK

1. Conduct IGT Printability tester experiments including the addition of water with a second printing disc. In offset printing, both fountain solution and water emulsified ink are added to the paper surface. An improved laboratory test which may replicate the lint removed in the offset printing process should include two modes of printing, one where water / fountain solution is added and then a second, where ink of a tack equivalent to emulsified offset print is added. [6]

2. Investigate ability of X-Ray Tomography with phase contrast to quantify lifted fibres from paper surface

3. Extend experimental work with X-Ray Tomography with phase contrast to threshold intensity maps to segregate filler and fibre from 3-D reconstruction of paper volume.

4. Use the FTIR to provide elemental maps of the paper surface which may in turn be analysed by image analysis for filler particles size distribution

5. Obtain more data for the Heidelberg tests, both for the treeline and overall measurement to confirm correlations with amount of lint removed in the IGT print test and amount of filler measured in surface of paper by SEM and image analysis. The Heidelberg results should be further broken down into filler and fibre content. Hopefully a better correlation can be found when the filler distribution measured in the SEM can be plotted against the filler and fibre components of the Heidelberg overall and treeline results,

6. Continue to use SEM with back scatter detection to obtain images of paper surface, which may be subjected to image analysis for quantification of filler particle size distribution.

7. Investigate whether a dye exists which can preferentially dye paper fibres and not the filler in a sheet or vice versa. This would be an efficient and quick way to quantify filler particle size distribution of the sheet.

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APPENDIX A – Norske Skog Procedure for IGT Testing

Manual: NSTL PPSG Procedures	**Document Number: 140-A3-06-WI**	
Subject: Surface Strength of Newsprint - Picking	**Page:1 of 5**	**Version:** 8
	Prepared By: M Howard	
Authorised By: M Howard	**Date Issued: 27 February 2002**	

1.0 PURPOSE

This work instruction describes the test method used for measuring the surface strength of newsprint (picking).

2.0 SCOPE

This work instruction shall apply to people carrying out laboratory print testing who have had training.

3.0 DOCUMENTS AND FORMS

Not applicable to this work instruction.

4.0 REFERENCES

4.1 ISO Standard 3783. Paper and Board - Determination of Resistance to Picking - Accelerating Speed Method Using the IGT Tester (electric model) - Available from the PPSG Adviser (Printability).

4.2 Instruction Manual IGT Inking Unit AE - Available from the PPSG Adviser (Printability).

4.3 Instruction Manual IGT Printability Tester AIC 2-5 - Available from the PPSG Adviser (Printability).

4.4 PAPRO Report No. C162, October 1988, Updated IGT Printability Test Methods at September 1988 - Available from Technical Department Files.

* **4.5** 140-A3-11-WI Use of Image Analyser for Measuring Pick Test Strips and Ink Coverage.

4.6 Fume Cupboard Instructions.

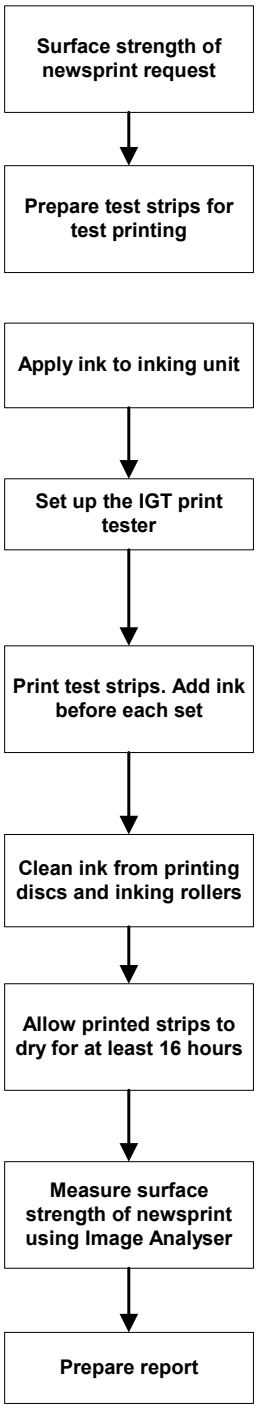
5.0 DEFINITIONS

	5.1	Surface strength, picking:	The rupture of the surface of newsprint and/or the removal of fibres from the surface of newsprint.
	5.2	CTH Room:	Constant Temperature and Humidity Room within the Technical Centre
*	**5.3**	Blanket Wash remove and	Chemical cleaning solution used to clean ink from the IGT print tester.

6.0 CONTROL

This work instruction is controlled by the PPSG Adviser (Printability).

7.0 FLOWCHART



1. Strip 29-31cm MD, 5.2cm CD
2. Label - Ensure strips are labelled top side or bottom side
3. Ensure test room atmosphere is 23 +/-1ºC and 50 +/-2% RH (ISO 187)

1. 1 mL or 1.14g of SICPA stable high tack black ink (11056096)
2. Ink up both sides. Put on accelerated inking rollers
3. Leave two minutes to give even spread of ink on the rollers

1. Rubber inking discs, 5cm; No sector packing; constant speed high range 2.5 m/s; force 625 N, top inking disk station

Read the IGT printing force setting from the correction chart kept above the IGT Printability Tester

1. Print four strips. Add 0.15 ml ink to each side using the ink pipette
2. * Wipe the inking discs clean with a minimum amount of blanket wash and print four further strips
3. Repeat 1 and 2
4. Repeat 1 and 2
5. Allow a minimum of 30 seconds inking per printing disc

* 1. Use rags and a minimum amount of blanket wash

1. In the CTH Room away from light

Follow 140-A3-11-WI to measure the pick test strips

8.0 PROCEDURE

8.1 SURFACE STRENGTH OF NEWSPRINT

To date, there has not been a satisfactory method available to measure the absolute surface strength of paper (see ISO 3783). With the IGT equipment, practical limitations restrict the number of samples in a group to four. Sometimes a so-called "standard" sample of paper is used as one of these four samples. In this way, the unknown samples can be compared against the "standard". In this fashion, a crude benchmark is established to compare between groups of four tests.

This method is based on ISO Standard 3783 and PAPRO Report No. C162. It has needed to be extensively modified to suit Tasman's needs, and now uses a constant, rather than accelerating speed.

8.2 PREPARE TEST STRIPS FOR TEST PRINTING

When labeling, make sure the sides of the newsprint are not interchanged. A good system is to cut four strips for each sample being tested and label them "1", "2", "3", "4" and TS or BS before starting to print.

As ink tacks are sensitive to temperature changes, it is necessary to ensure the CTH room atmosphere is within ISO specifications (temperature 23 ± 1 °C relative humidity 50 ± 2%).

8.3 APPLY INK TO INKING UNIT

Switch on the fume cupboard and leave on until at least 10 minutes after cleaning up. The ink currently being used is SICPA stable high tack black ink (11056096). Fill the ink pipette.

Each side of the inking unit has 1.14 g (or 1 ml from the ink pipette) of ink added to it. This needs to be left for at least two minutes for the ink to distribute evenly on the rollers with the accelerated rollers in place. The ink should be used within half an hour of applying, as ink properties can change with temperature and loss of ink vehicle.

8.4 SET UP THE IGT PRINT TESTER

Follow the general guidelines given in the IGT Manual (see 4.3). The critical settings are:

Rubber inking discs	-	5 cm (red rubber)
Sector packing	-	None
Printing speed	-	Constant; final speed 2.5 m/s (high range)
Printing force	-	625 N
Printing disc shaft	-	Use the top shaft position

NOTE 1: Use correction chart for setting the printing force. This chart is situated above the IGT Tester.

NOTE 2: The printing speed may be altered, depending on the testing requirements. Deviations from 2.0 m/s should be noted in test records.

8.5 PRINT TEST STRIPS USING CONSTANT LEVELS OF INK APPLICATION FOR EACH SET

The current scheme for test printing is to print four samples in parallel. Four replicates of each sample are printed in four sets. 0.15 ml of ink is added to each side of the inking unit with the IGT ink pipette in between each set of replicates. The ink is left for two minutes to re-distribute before the discs are inked up for the next set of replicates. Allow a minimum of 30 seconds for each disc to ink up. The discs are cleaned after printing each set.

8.6 CLEAN INK FROM PRINTING DISCS AND INKING ROLLERS

* Very soon after completing a series of prints, the ink should be removed from both the inking unit rollers and the printing discs. The best method is to use the rags provided and wipe off the majority of ink. Next, apply a minimum amount of blanket wash to remove the final amounts of ink.

NOTE: Gloves must be worn when using blanket wash, and the extraction fan in the fume cupboard must be on.

8.7 MEASURE THE SURFACE STRENGTH OF NEWSPRINT

* Leave the prints to dry for at least 15 minutes on the bench and then for at least 16 hours (preferably for two to three days) hanging in the CTH Room away from the light.

Follow the method in 140-A3-11-WI for measuring the surface strength of the newsprint samples using image analysis (the Optomax Speck Check).

Visually check the prints to ensure picking has actually taken place rather than “print misses”, which can occur on rough papers.

8.8 PREPARE REPORT

If a new or different sample of paper is used as a “standard” for comparative purposes, the new sample shall be compared with the old standard sample and the amount of picked fibre checked. The results will be filed in M Howards file and File No. 9.21.

* It is important to report the detection level used to measure the pick strips (if it is not as detailed in 140-A3-11-WI) and the standard deviation or coefficient of variation, as this test is quite variable.

9.0 SAFETY

*

- Gloves must be worn when using blanket wash and the extraction fan in the fume cupboard must be running
- The fume cupboard fan should be left running for at least 10 minutes after cleaning
- All people using blanket wash should have a knowledge of the products health hazards and other safety information

This information is located next to the IGT printer

10.0 ENVIRONMENTAL IMPACTS

* Used cleaning rags containing blanket wash should initially be disposed into a plastic bag inside the fume cupboard. This helps minimise any vapour inhalation.

Once the plastic bag is full, it should be sealed with sellotape and placed into the general rubbish paper bag.

APPENDIX B – National Print Laboratory, Procedure for IGT Testing

NPL Work Instruction
General Method for IGT Printability Tester AIC2-5

Purpose
To simulate offset and letterpress printing under controlled conditions in a laboratory. One or two colours can be printed. There are a large number of different tests that can be carried out using this equipment. This is a general procedure for operating the AIC2-5. For individual tests the appropriate IGT test method should be consulted.

Apparatus
1. IGT Printability Tester AIC2-5 Series 414.Z.
2. IGT High Speed Inking Unit 4.
3. Damson TLC2 thermostatic bath.
4. IGT ink pipette.
5. IGT printing disc(s).
6. Ink application chart.
7. Rags and cleaning solvent.

Safety Issues
1. When using volatile and/or flammable substances make sure the fume extraction system is switched on.
2. Do not wear any loose clothing, ties or jewellery that could get caught in the rotating rollers of the High Speed Inking Unit (HSIU) or any of the moving parts of the AIC2-5 tester. Long hair should be arranged so that it is not possible for it to become entangled in any of the moving parts of the AIC2-5 tester or the HSIU.
3. Make sure that the inks and solvents used do not come into contact with the skin or eyes. Wear protective clothing such as laboratory coats, gloves and safety glasses.
4. All used cleaning rags and other waste should be disposed of by placing in the red, automatically closing bins.
5. Any chemical waste should stored in appropriate containers for later disposal. On no account should any chemical waste be poured down the sink.
6. Smoking and the use of naked flames are prohibited at any time in the laboratory.

Procedure
1. Before operating the TLC2 thermostatic bath check that the tank is filled to 1-2 cm below the lid. Add additional tap water if required.
2. Switch on the bath by turning the mains switch located on the front panel to the on position.
3. The bath is ready for use when a steady temperature of 22.5 degrees C is achieved.
4. Turn on the IGT High Speed Inking Unit (HSIU) with the switch at the bottom left-hand corner of the rear panel.
5. Place the appropriate rubber top roller (conventional or UV) into the holder on the inking unit.

6. Check that the distribution mode and disc ink-up times are set correctly. Refer to Sections 9.3-9.5 of the HSIU manual.
7. Place the printing disc(s) to be used on the shaft(s) of the HSIU. Allow the HSIU approximately 15 minutes to warm-up, with the rubber roller and printing disc(s) in contact.
8. Turn on the AIC2-5 printability tester by pressing the red coloured switch on the bottom left-hand side of the instrument.
9. Turn the operation switch to the on position – the pilot lamp immediately below the switch should light up.
10. Fit any required packing to the printing sector. If no packing is used, make sure to turn the large knurled screws clockwise as far as they will go to lock the packing clamps.
11. Cut the required number of test strips to the appropriate size. The maximum test strip size is 340 * 55 mm. Clamp the first sample to be tested onto the printing sector. The test strip may be clamped into either the front and rear clamps or the front clamp only.
12. Set the printing force for the printing disc(s) being used. Refer to Section 5.4 of the IGT AIC2-5 instruction manual.
13. Check the amount of free travel backlash in the printing disc lifters. If the amount of backlash is significantly greater than or less than 45 degrees of travel an adjustment will need to be made. The procedure for adjusting the amount of backlash is found in Section 5.5 of the instruction manual.
14. Set the printing speed as per the instructions in Section 5.6 of the AIC2-5 manual.
15. Bring the printing sector to the starting position. This is indicated by the pilot lamp on the top right-hand corner of the front panel lighting up.
16. Determine how much ink is required to obtain the desired ink film thickness by referring to IGT ink application chart.
17. Distribute the ink and ink-up the disc(s) as described in Section 10 of the instruction manual for the HSIU.
18. Place the inked printing disc(s) onto the appropriate spindles of the AIC2-5 tester. Push them on until they snap into position.
    Note: The bottom spindle of the instrument cannot be used when testing in the accelerating speed mode.
19. Press the motor starter button with your right-hand and hold it in.
20. Turn the printing disc lifter(s) anticlockwise to the ‘on’ position.
21. When the motor has reached full speed press the sector starter button with your left-hand. Keep the motor and sector starter buttons pressed until the sector has completed the printing operation. When complete release both buttons.
22. Remove the test strip from the sector and place it aside for later assessment.
23. Turn the printing disc lifter(s) clockwise to the ‘off’ position and remove the printing disc(s) from the spindle(s) and set aside for cleaning.
24. The disk(s) need to be cleaned at the completion of each print. If this is not done the amount of ink applied to subsequent prints will not be as indicated on the IGT application chart. Cleaning should be completed by hand using a minimum amount of the appropriate solvent and a lint free rag.
25. The HSIU distribution rollers need to be cleaned at the completion of each set of four prints. Cleaning is carried out as per the instructions in Sections 9-10 of the HSIU manual.

26. At the completion of testing the following items need to be attended to:
    - reset the printing force to zero on both printing stations
    - move the operation switch to the off position
    - turn off the power button on the bottom left-hand side of the AIC2-5 tester
    - turn off the HSIU and the thermostatic bath
    - thoroughly clean the printing discs, the HSIU distribution rollers and the ink pipette

APPENDIX C – Experimental Matrix for IGT Experiments

Sample	Ink Volume (ml)	Ink Thickness (μm)	Speed Mode	Speed (m/s)	Pressure	Ink Tank
1	0.35	8	constant	1		standard
2	0.35	8	Constant	1.25	800	standard
3	0.35	8	constant	1.5	800	standard
4	0.35	8	constant	2.0	800	standard
5	0.35	8	constant	3.0	800	standard
6	0.35	8	constant	4.0	800	standard
7	0.35	8	constant	5.0	800	standard
8	0.2	5	constant	1	800	standard
9	0.2	5	constant	2	800	standard
10	0.2	5	constant	3	800	standard
11	0.2	5	constant	4	800	standard
12	0.2	5	constant	5	800	standard
13	0.1	2.25	constant	1	800	standard
14	0.1	2.25	constant	2	800	standard
15	0.1	2.25	constant	3	800	standard
16	0.1	2.25	constant	4	800	standard
17	0.1	2.25	constant	5	800	standard
18	0.1	2.25	accelerating	7	800	standard
19	0.1	2.25	accelerating	5	800	standard
20	0.1	2.25	constant	5	800	high
21	0.35	8	constant	1	800	high
22	0.35	8	constant	1.5	800	high
23	0.35	8	constant	2.0	800	high
24	0.35	2.25	constant	3.0	800	high
25	0.35	2.25	constant	4.0	800	high
26	0.2	5	constant	4.0	800	standard
27	0.2	5	constant	4.0	800	standard
28	0.2	5	constant	5.0	800	standard
29	0.2	5	constant	5.0	800	standard
30	0.2	5	constant	4.5	800	standard
31	0.2	5	constant	4.5	800	standard
32	0.2	5	constant	4.0	800	standard
33	0.2	5	constant	4.0	800	standard
34	0.2	5	constant	4.0	800	standard
35	0.2	5	constant	4.0	800	standard
36	0.2	5	constant	4.0	800	standard
37	0.2	5	constant	2.5	800	standard
38	0.2	5	constant	2.5	800	standard
39	0.2	5	constant	2.5	800	standard
40	0.2	5	constant	2.5	800	standard

Sample	Ink Volume (ml)	Ink Thickness (μm)	Speed Mode	Speed (m/s)	Pressure	Ink Tank
41	0.2	5	constant	4	750	standard
42	0.2	5	constant	4	800	standard
43	0.2	5	constant	4	800	standard
44	0.2	5	constant	4	800	standard
45	0.2	5	constant	4	800	standard
46	0.2	5	constant	4	800	standard
47	0.2	5	constant	4	800	standard
48	0.2	5	constant	4	800	standard
49	0.2	5	constant	4	800	standard
20	0.2	5	constant	4	800	standard
51	0.2	5	constant	4	800	standard

APPENDIX D – Ink Weight on Printed IGT samples

Weight of Paper (g)	Weight of Paper + Ink (g)	Weight of Ink (g)
0.8604	0.8858	0.0254
0.8301	0.8536	0.0235
0.803	0.8278	0.0248
0.8674	0.8925	0.0251
0.8352	0.8607	0.0255
0.8636	0.8888	0.0252
0.8496	0.8749	0.0253
0.8565	0.8799	0.0234
0.8605	0.8832	0.0227
0.8704	0.8945	0.0241
0.8783	0.8997	0.0214
0.8185	0.8432	0.0247
0.8513	0.8739	0.0226
0.8455	0.8692	0.0237
0.8377	0.8607	0.023
0.8823	0.9058	0.0235
0.8843	0.908	0.0237
0.8334	0.858	0.0246
0.8451	0.8702	0.0251
0.8635	0.8883	0.0248
0.878	0.9015	0.0235
0.8544	0.8786	0.0242
0.874	0.8984	0.0244
0.8525	0.8774	0.0249
0.8844	0.9083	0.0239
0.8846	0.9111	0.0265

Average weight of ink on paper = 0.0242 g
Standard deviation = 0.0011 g
95 % Confidence Interval = 0.004 g

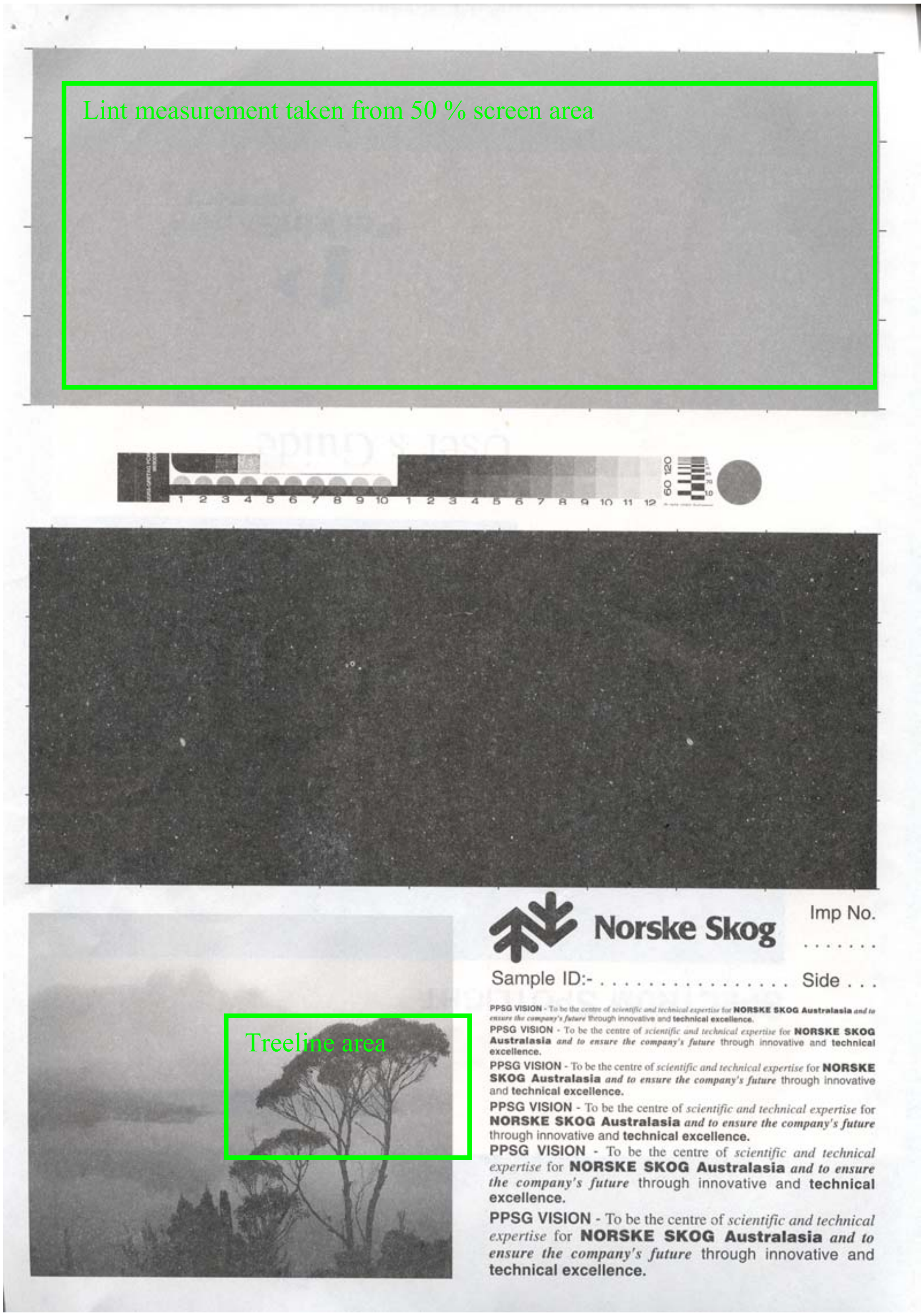
Area of Printed Image = 50mm x 208mm
= 0.0104 m^2

Gsm of ink on printed image $= \frac{0.0242g}{0.0104m^2} = 2.33gm^{-2}$

APPENDIX E – Quantification of Printed IGT Lint

		0- 0.05	0.05 – 0.1	0.1 – 10	Total area	% 0 – 0.05	%0.05 – 0.1	% 0.1 - 10
Sample Identification		mm^2	mm^2	mm^2	mm^2			
B1	Top	47.97	10.39	16.13	74.50	64.40	13.95	21.66
B1	Bottom	65.61	12.75	16.04	94.40	69.50	13.51	16.99
B2	Top	31.21	6.88	7.11	45.20	69.05	15.22	15.73
B2	Bottom	73.09	14.20	18.35	105.65	69.18	13.45	17.37
B3	Top	68.17	9.52	9.98	87.67	77.75	10.86	11.38
B3	Bottom	112.89	30.64	47.18	190.70	59.20	16.07	24.74
B4	Top	24.85	3.82	2.98	31.65	78.52	12.06	9.42
B4	Bottom	91.46	13.85	9.14	114.45	79.92	12.10	7.99
B5	Top	22.12	2.17	2.01	26.30	84.10	8.25	7.65
B5	Bottom	61.66	9.66	4.97	76.29	80.82	12.67	6.52
B6	Top	63.41	8.73	8.74	80.88	78.40	10.79	10.81
B6	Bottom	106.73	20.81	18.86	146.40	72.90	14.21	12.88

APPENDIX F – Heidelberg Lint Test – Test Pattern



APPENDIX G– Particle Size Distribution of Filler in SEM backscatter images

Filler Area		Class 1	Class 2	Class 3	Class 4	Class 5	Total
Sample Identification		0 – 4 um^2	4 - 8 um^2	8–16 um^2	16-50um^2	> 50 um^2	um^2
B1	Top	1727.13	472.76	376.80	377.24	109.93	3063.86
B1	Bottom	1784.69	454.80	357.31	349.89	109.72	3056.42
B2	Top	1810.31	393.17	289.53	253.94	97.93	2844.87
B2	Bottom	1504.22	336.55	203.87	170.60	26.54	2241.78
B3	Top	2361.09	601.04	491.51	603.25	356.70	4413.60
B3	Bottom	2465.82	723.62	617.08	714.90	689.86	5211.28
B4	Top	1596.28	362.27	230.01	180.60	33.72	2402.88
B4	Bottom	946.36	199.10	133.43	65.22	9.02	1353.12
B5	Top	2107.55	499.62	360.16	364.28	87.37	3418.97
B5	Bottom	1675.67	375.98	284.16	220.18	62.54	2618.53
B6	Top	1269.90	250.46	131.98	77.01	9.53	1738.88
B6	Bottom	740.61	151.16	93.43	59.11	11.83	1056.13

Number of particles		Class 1	Class 2	Class 3	Class 4	Class 5
Sample Identification		0 – 4 um^2	4 - 8 um^2	8–16 um^2	16-50um^2	> 50 um^2
B1	Top	1509.75	163.85	34.20	15.05	1.35
B1	Bottom	1581.25	166.65	33.15	13.85	1.60
B2	Top	1676.10	149.65	26.70	10.40	1.30
B2	Bottom	1358.85	145.55	19.00	7.05	0.40
B3	Top	2060.35	250.25	45.20	23.15	4.00
B3	Bottom	2118.85	219.15	56.30	27.95	6.90
B4	Top	1482.75	134.30	21.25	7.45	0.40
B4	Bottom	871.25	53.40	12.20	2.85	0.10
B5	Top	1905.40	177.75	33.45	15.50	1.25
B5	Bottom	1527.35	140.25	26.10	9.15	0.75
B6	Top	1159.80	122.85	12.30	3.25	0.15
B6	Bottom	677.70	47.90	8.65	2.60	0.15

These results are the averages of 20 individual images. The area for each image tested was 110 257.4 μm^2.

% of Filler Area		Class 1	Class 2	Class 3	Class 4	Class 5
Sample Identification		0 – 4 um^2	4 - 8 um^2	8–16 um^2	16-50um^2	> 50 um^2
B1	Top	56.37	15.43	12.30	12.31	3.59
B1	Bottom	58.39	14.88	11.69	11.45	3.59
B2	Top	63.63	13.82	10.18	8.93	3.44
B2	Bottom	67.10	15.01	9.09	7.61	1.18
B3	Top	53.50	13.62	11.14	13.67	8.08
B3	Bottom	47.32	13.89	11.84	13.72	13.24
B4	Top	66.43	15.08	9.57	7.52	1.40
B4	Bottom	69.94	14.71	9.86	4.82	0.67
B5	Top	61.64	14.61	10.53	10.65	2.56
B5	Bottom	63.99	14.36	10.85	8.41	2.39
B6	Top	73.03	14.40	7.59	4.43	0.55
B6	Bottom	70.13	14.31	8.85	5.60	1.12

APPENDIX H – Specification sheet for Image / Norstar 52 gsm

APPENDIX I – Heidelberg Test results

Sample ID		Treeline Result	Heidelberg lint (gsm)
B0069368	B1-top		5.5
	B1-bottom	6	7.5
B0074346	B2-top		
	B2-bottom	8	7.2
B0067718	B3-top		
	B3-bottom	17	6.1
B0076485	B4-top		
	B4-bottom	3	6.8
B0076570	B5-top		
	B5-bottom	3	5.6
B0069624	B6-top		7.3
	B6-bottom	11	5.9