

## COMPARATIVE PERFORMANCE EVALUATION:

### BRAND A REMANUFACTURED PRINTER CARTRIDGES VS BRAND B “FACTORY RECONDITIONED” CARTRIDGES

Buyers Laboratory Inc. (BLI), Hackensack, NJ, was commissioned by Brand A to conduct a comparative performance test of Brand A brand remanufactured printer cartridges against Brand B “factory reconditioned” cartridges for the Model X printer. The objective of the test, which was conducted in accordance with the test specifications and requirements of ISO/IEC 19752, was to compare the page yield, image quality and reliability performance of the Brand A cartridges to that of the Brand B cartridges. In addition, each brand was tested for toner adhesion and abrasion resistance when printing was done on vinyl labels and these print samples were subjected to sub-freezing and refrigerated conditions. In total, 18 cartridges were tested on three printers.

## *Performance Summary*

Throughout testing, the page yield performance of the Brand B “factory reconditioned” cartridges, with an ISO Lower Confidence Bound (LCB) average yield of 20,697.8 pages, was superior to the page yield performance of the Brand A remanufactured cartridges, which had an LCB average yield of 17,570.3 pages. In fact, eight of the nine Brand B cartridges outperformed the Brand A overall page average, and six of the nine Brand B cartridges tested met or exceeded the test target page yield of 21,000 pages, while only two of the nine Brand A cartridges met or exceeded the page yield target. The three Brand B cartridges that fell short of the target yield did so by an average of 1,572 pages; the seven Brand A cartridges that fell short did so by an average of 2,879 pages. There were no premature expires with either brand.

While both cartridge brands earned passing grades in the five image quality (IQ) performance categories (text, line art, halftone pattern, halftone range and solids) evaluated, the Brand B cartridges earned higher grades for line art and halftone range. It should also be noted that virtually no background (extraneous toner) was observed on images produced with the Brand B cartridges, whereas significant background was visually observed with images produced from three Brand A cartridges. This

background gave pages an overall grayish tint, resulting in an overall IQ rating downgrade for Brand A to only Fair, in contrast to Very Good for the Brand B cartridges.

The reliability performance of both brands was comparable, with neither causing printer problems and neither experiencing mechanical or physical failures. However, one of the 10 Brand B cartridges purchased was classified as an out-of-box failure because of a heavy dark shadow approximately 2 inches wide running down the front and back of the right side of pages from the very start (see Exhibit B on page 9). BLI's test technicians also reported excessive toner build-up on the end of the transfer roller (see Exhibit A on page 9) when they were rebuilding Printer Test Unit A after testing the third Brand A cartridge on this test printer. While this did not cause printer performance problems in testing, it could very well result in image quality failures or printer reliability problems.

In evaluating image permanence on vinyl labels following exposure to sub-freezing (-40°C) and refrigerated (+6°C) conditions, BLI subjected label print samples from each brand to ASTM Tape Tests (to measure adhesion) and to the Sutherland Rub Test (to measure abrasion resistance) and found that both brands exhibited excellent adhesion and resistance to abrasion, with virtually no toner loss observed in each test and with each sample. When evaluating the affects of these extreme conditions on bar codes printed on vinyl labels from the Brand A and Brand B cartridges, all bar codes could be accurately read, indicating that the extreme test conditions had no deleterious affects on the toner from either brand.

## PERFORMANCE OVERVIEW

### PAGE YIELD

As shown in the data table below, the Brand B Model X cartridges clearly outperformed the Brand A cartridges in terms of page yield, with an overall ISO LCB average yield of 20,697.8 pages. In contrast, the overall LCB average of the Brand A cartridges is 17,570.3 pages, which puts them at an average of 3,127.5 pages below Brand B. The test data also shows that six of the nine Brand B cartridges met or exceeded the 21,000-page test target yield, while only two of the nine Brand A cartridges did.

#### Model X Printer Cartridges (Target Yield: 21,000 pages)

Printer Design.	Cartridges		Weight			Media	Meter Count		Page Yield				
	MFR	Number	Start	End	Toner (g)		Start	End	Total	Endpoint	p/g	S.D.	LCB
A	Brand A	1	1921.4	1419.1	502.3	Paper	911	18910	17999	17999	35.8		
		2	1834.5	1334.1	500.4	Paper	18741	36347	17606	17606	35.2		
		3	1846.4	1324.8	521.6	Paper	36457	52929	16472	16472	31.6		
B		1	1830.3	1343.4	486.9	Paper	5	19522	19517	19517	40.1		
		2	1835.9	1329.3	506.6	Paper	19577	41991	22414	22414	44.2		
		3	1901.2	1426.4	474.8	Labels	7330	23966	16636	16636	35.0		
C		1	1818.4	1335.3	483.1	Paper	5	19268	19263	19263	39.9		
		2	1824.6	1320.4	504.2	Paper	19333	38685	19352	19352	38.4		
		3	1925.1	1399.7	525.4	Labels	46206	72515	26309	26309	50.1		
Averages			1859.8	1359.2	500.6					19507.6	38.9	3125.4	17570.3
A	Brand B	4	1844.3	1322.8	521.5	Paper	52986	75025	22039	22039	42.3		
		5	1918.1	1423.7	494.4	Paper	75110	97729	22619	22619	45.8		
		6	1836.7	1318.3	518.4	Labels	97812	120894	23082	23082	44.5		
B		4	1844.9	1349.4	495.5	Paper	24015	44290	20275	20275	40.9		
		5	1785.5	1337.6	447.9	Paper	44415	62499	18084	18084	40.4		
		6	1840.4	1386.5	453.9	Labels	62747	82672	19925	19925	43.9		
C		4	1852.8	1332.1	520.7	Paper	31030	57494	26464	26464	50.8		
		5	1789.3	1320.0	469.3	Paper	57716	87261	29545	29545	63.0		
		6	1797.4	1334.8	462.6	Paper	87356	111056	23700	23700	51.2		
Averages			1834.4	1347.2	487.1					22859.2	47.0	3487.0	20697.8

\*S.D.: Standard Deviation, based on ISO 19752 specifications.

\*LCB (Lower Confidence Bound): Page yield based on ISO calculation that indicates average yield that can be expected with 90% of the cartridges.

†Printers were replaced due to printer-related problems.

#### Premature Expires (cartridges that netted 75% or fewer pages than the target yield):

Brand A	None
Brand B	None

## IMAGE QUALITY

Both cartridge brands earned passing grades in the five image quality (IQ) performance categories below; however, whereas their scores were the same in three categories, the Brand B cartridges earned higher grades for line art and halftone range. In addition, whereas no background (extraneous toner) was visually observed on images produced with the Brand B cartridges, significant background was visually observed on images produced from three of the nine Brand A cartridges, giving images an overall grayish (or dirty) tint. Significant background was also recorded with most of the Brand A IQ samples when they were scanned with an ImageXpert IQ evaluator. In fact, the Brand A overall average background measurement was 3,035 particles per square inch, whereas it was only 558 particles per square inch with Brand B. Consequently, the overall IQ rating for the Brand A cartridges was downgraded to a Fair, while the Brand B cartridges earned an overall IQ rating of Very Good.

### Brand A

Overall IQ rating	Fair*	
Text	Very Good	Above average formation, sharpness and darkness, with minimal overspray and no break-up
Line Art	Good	Consistency of line thickness is average, with some break-up and some toner overspray
Halftone Pattern	Good	Average graininess with some banding
Halftone Range	Good	Separation between most levels
Solids	Good	Average darkness with some mottling; in some cases, left side is darker than right
*Image Quality Defects	Excessive background. Background of 3,035 particles per square inch, which is very significant, was recorded and visually observed on pages from Brand A cartridges, giving them an overall grayish tint. In contrast, negligible background of 558 particles per square inch, which could not be visually observed, was recorded with Brand B IQ samples.	
Average Density	1.41	Range for monochrome printers tested to date: 1.15 to 1.54.

### Brand B

Overall IQ rating	Very Good	
Text	Very Good	Above average formation and darkness; with no overspray or break-up
Line Art	Very Good	No toner overspray; above average production of closely spaced fine lines and average consistency of line thickness
Halftone Pattern	Good	Average graininess and minimal banding
Halftone Range	Very Good	Distinct separation between levels
Solids	Good	Average darkness with some mottling (more on left)
Image Quality Defects	Slight speckling on pages with one cartridge.	
Average Density	1.32	Range for monochrome printers tested to date: 1.15 to 1.54

## IMAGE PERMANANCE ON VINYL LABELS *(sub-freezing/refrigerated conditions)*

Per the test data below, following exposure to sub-freezing (-40°C) and refrigerated (+6°C) conditions, image permanance on vinyl labels from the Brand A and Brand B toner cartridges proved to be excellent, as demonstrated by the negligible change in density readings (before and after exposure). BLI's lab technicians also noted that virtually no image flaking or cracking occurred with both brands, and that bar code readings could be accurately taken from all print samples from both brands. Consequently, it was concluded that exposure to these extreme test conditions had virtually no deleterious affects on the toner from either the Brand A or Brand B cartridges tested. Both brands earned an ASTM rating of 5, which is the highest possible rating (on a scale of 1 to 5).

### Adhesion Test: Brand A Cartridges

Change in Image Density								
	Brand A-Model XB-Start	Brand A-Model XB-25%	Brand A-Model XB-75%	Brand A-Model XC-Start	Brand A-Model XC-25%	Brand A-Model XC-75%	Brand A Refrigeration	Brand A Sub-freezing
3M 600 Tape	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3M 610 Tape	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
3M 899 Tape	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Permacell 99 Tape	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Score/Tape Test	ASTM Rating = 5		The coating is completely smooth. No coating transfer to tape.					
Cross Hatch Tape Test	ASTM Rating = 5		The edges of the cuts are completely smooth. None of the square of the lattice is detached.					

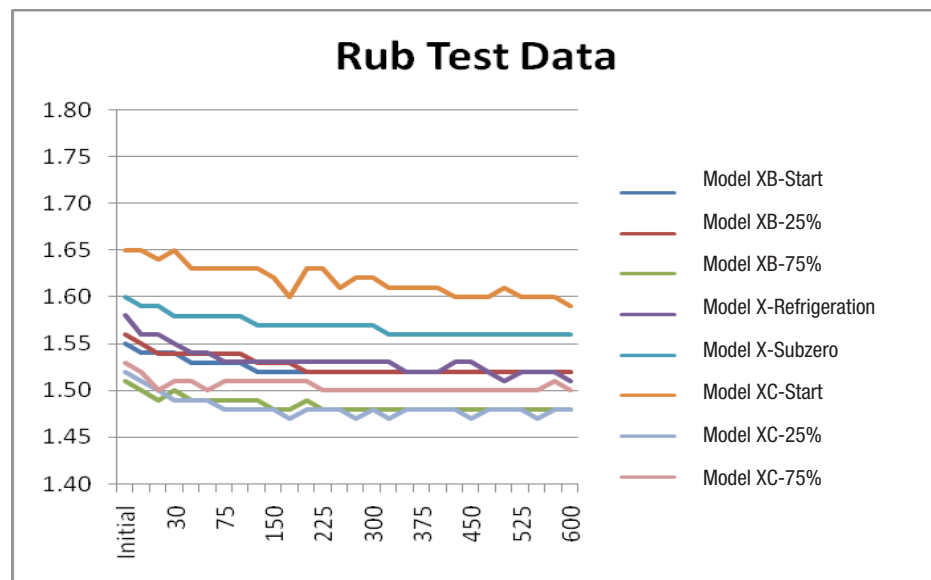
### Adhesion Test: Brand B Cartridges

Change in Image Density								
	Brand B-Model XA-Start	Brand B-Model XA-25%	Brand B-Model XA-75%	Brand B-Model XB-Start	Brand B-Model XB-50%	Brand B-Model XB-75%	Brand B Refrigeration	Brand B Sub-freezing
3M 600 Tape	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
3M 610 Tape	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
3M 899 Tape	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
Permacell 99 Tape	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Score/Tape Test:	ASTM Rating = 5		The coating is completely smooth. No coating transfer to tape.					
Cross Hatch Tape Test	ASTM Rating = 5		The edges of the cuts are completely smooth. None of the square of the lattice is detached.					

**Sutherland Rub Test: Brand A Cartridges**

**Change in Image Density**

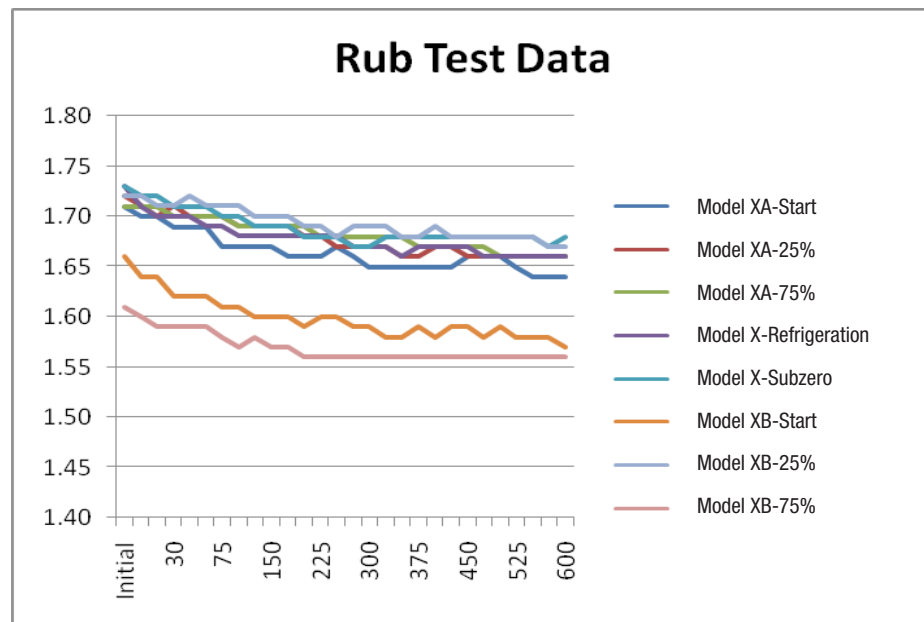
	Initial	50 Cycles	100 Cycles	300 Cycles	600 Cycles
Brand A-Model XA-Start	0.00	0.02	0.02	0.03	0.03
Brand A-Model XA-25%	0.00	0.02	0.02	0.04	0.04
Brand A-Model XA-75%	0.00	0.02	0.02	0.03	0.03
Brand A Model XB-Start	0.00	0.02	0.02	0.03	0.06
Brand A Model XB-25%	0.00	0.03	0.04	0.04	0.04
Brand A Model XB-75%	0.00	0.03	0.02	0.03	0.03
Brand A Refrigeration	0.00	0.04	0.05	0.05	0.07
Brand A Subzero	0.00	0.02	0.02	0.03	0.04
Average		0.03	0.03	0.04	0.04



**Sutherland Rub Test: Brand B Cartridges**

**Change in Image Density**

	Initial	50 Cycles	100 Cycles	300 Cycles	600 Cycles
Brand B-Model XA-Start	0.00	0.02	0.04	0.06	0.07
Brand B-Model XA-25%	0.00	0.02	0.03	0.05	0.06
Brand B-Model XA-75%	0.00	0.01	0.02	0.03	0.05
Model XB-Start	0.00	0.04	0.05	0.07	0.09
Model XB-25%	0.00	0.01	0.01	0.03	0.05
Model XB-75%	0.00	0.02	0.04	0.05	0.05
Brand B-Refrigeration	0.00	0.04	0.05	0.06	0.07
Brand B-Subzero	0.00	0.02	0.03	0.06	0.05
Average		0.02	0.03	0.05	0.06



**Bar Code Data Table:**

This table shows that the performance of both toner brands was virtually the same and that both passed testing with comparable scores, indicating that bar code readings could be accurately taken with all print samples.

ISO/ANSI Attributes	Brand B		Brand A	
	Refrigeration	Sub-freezing	Refrigeration	Sub-freezing
X Dimension	13.3mils (102%)	13.3mils (102%)	13.3mils (102%)	13.3mils (102%)
Edge Determination	Pass	Pass	Pass	Pass
Minimum Reflectance	Pass	Pass	Pass	Pass
Minimum Edge Contrast	Pass 41%	Pass 44%	Pass 40%	Pass 40%
Decode	Pass	Pass	Pass	Pass
Quiet Zone	Pass	Pass	Pass	Pass
Contrast	3.6 (A) 72%	3.6 (A) 72%	3.7 (A) 73%	3.6 (A) 72%
Modulation	2.2 (C) 57%	2.6 (B) 61%	2.0 (C) 55%	2.1 (C) 56%
Decodability	2.5 (B) 50%	2.5 (B) 50%	2.4 (C) 49%	2.3 (C) 48%
Defects	2.7 (B) 19%	2.3 (C) 21%	3.1 (B) 17%	2.9 (B) 18%
Blemish	4.0 (A) 0%	4.0 (A) 0%	4.0 (A) 0%	4.0 (A) 0%
Reflectance Min.	1%	0%	1%	1%
Reflectance Max.	73%	73%	74%	73%
Global Threshold	37%	37%	38%	37%
Bar Height	895.3mils	885.6mils	885.6mils	905.0mils
Bar Growth	6%	6%	8%	8%
ISO/ANSI Overall Grade	2.2 (C)	2.3 (C)	2.0 (C)	2.1 (C)



## RELIABILITY

### Reliability rating/problems encountered:

**Brand A:** Very Good. No physical or mechanical problems were encountered with the Brand A cartridges, and no printer related problems were encountered. However, three of the Brand A cartridges started their tests with visually noticeable background on pages for about the first 2,500 pages, after which visually obvious background faded. In addition, when rebuilding Printer Test Unit A after testing the third Brand A cartridge, BLI's lab technicians observed excessive toner build-up on the end of the transfer roller, roller rod and roller gear (see Exhibit A below). While this did not cause printer performance problems during BLI's tests, it is very likely that such toner build-up over time will result in image quality failures (such as streaking on pages) and may cause printer reliability problems (such as damage to the fuser).

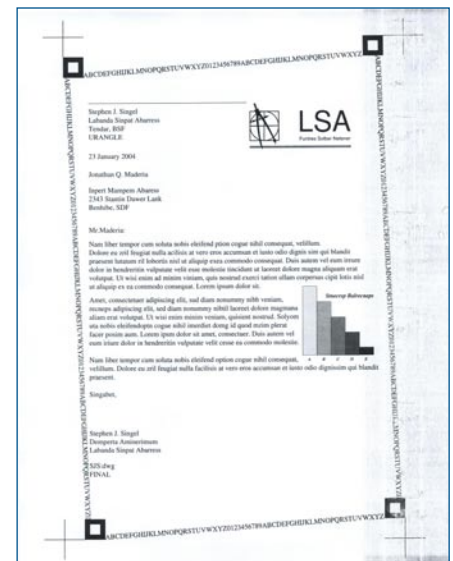
**Brand B:** Very good. No physical or mechanical problems were encountered with the Brand B cartridges, and no printer related problems were encountered. However, one of the 10 Brand B cartridges purchased was classified as an out-of-box failure, as a heavy dark shadow nearly 2 inches wide was printed down the front and back of the right side of pages from the start (see Exhibit B below). No problems of any kind were encountered with the remaining nine Brand B cartridges.

### Exhibit A:



**Transfer Roller on Right Shows Excessive Toner Contamination from Brand A Cartridge**

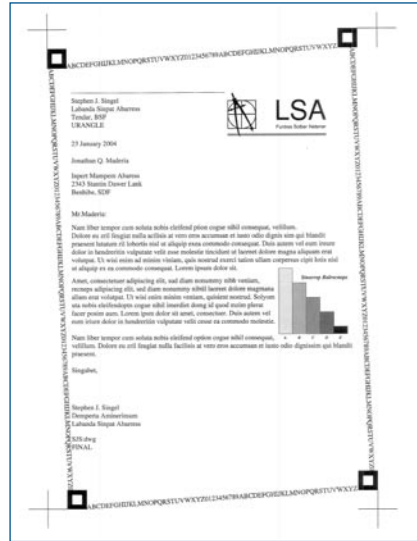
### Exhibit B:



**Image Quality Defect from Brand B Cartridge**

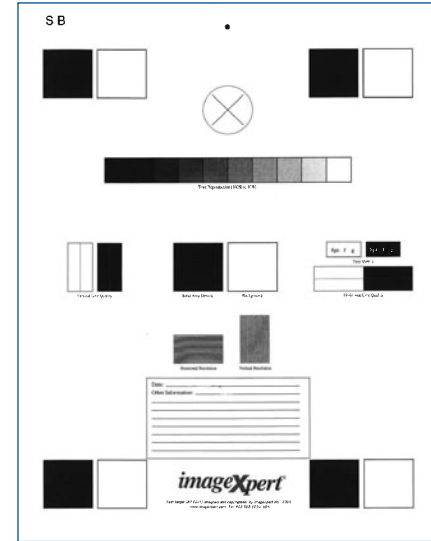
## Test Target Exhibits

Exhibit C



ISO 19752 5% Black Yield/IQ Test Target

Exhibit D



ImageXpert Image Quality Test Target

## Test Methodology Overview

Per ISO/IEC 19752 methodology, BLI ran three Model X laser printers for up to seven hours per day, five days per week, during which time three of each toner cartridge brand were tested in each of the corresponding three printers (for a total of nine cartridges per brand) to evaluate toner yield, image quality and cartridge reliability performance, per the methods below. In addition, each brand was tested for toner adhesion and abrasion resistance when printing was done on vinyl labels and labels were subjected to sub-freezing and refrigerated conditions.

**A) Toner yield:** Per the industry-standard requirements, page yield was determined by using the ISO 19752 5% black test target (see test target above) and based on the ISO 90% Lower Confidence Bound. In addition, overall averages were calculated based on standard mathematical averaging methods. Each cartridge was run until the first “fade” occurrence after the second “toner low” warning was displayed on the printer LCD, provided that image quality remained acceptable and no reliability problems were encountered. Following the first “toner low” warning, the cartridge was removed from the printer, agitated and reinstalled in the printer. Printing was

continued until the second “toner low” warning was displayed on the LCD, after which the cartridge was again removed, agitated and reinstalled in the printer, and printing was again restarted. The toner cartridge was considered depleted upon the first “fade” occurrence after the second “toner low” warning, at which time testing was halted and a page count was recorded (unless image quality degraded to an unacceptable level earlier, at which time cartridge life was considered expired).

**B) Reliability:** Throughout testing, BLI recorded cartridge malfunctions, such as mechanical failures, toner leakage, and component breakage, background on printed pages and impact on printer performance, such as damage to fusers. Cartridges that did not function out of the box, were damaged or produced 20 or fewer acceptable pages were classified as “out-of-box failures” (OOBF). Cartridges yielding 75% or fewer pages than the manufacturer specified yields were classified as “premature expires” (this is typically due to either image quality degradation, premature fade or a physical/mechanical cartridge malfunction.)

**C) Image quality:** Image quality (IQ) was monitored daily and visually evaluated at the start of testing and at 25%, 50% and 75% of specified life (page yield) for clarity and definition of text and line art, and production of halftones and solids, as well as for image quality defects, such as toner overspray, background, smearing, graininess, banding, text break-up, inconsistencies and serif fill. Visual evaluations of IQ samples were conducted under a Graphic Lite D5000 Standard Viewer and COHO Solid State 3X Camera, and image density/quality was measured with an ImageXpert and X-Rite 500 Series Densitometer. (See Exhibits C and D on page 10.)

**D) Image permanence testing under extreme conditions:** Up to six print samples from each cartridge brand were subjected to refrigerated conditions of +6°C (three samples) and sub-freezing conditions of -40°C (three samples) for 72 hours in a Tenney Jr. Tenney Engineering Temperature Chamber for 72 hours. Following exposure, each sample was reconditioned to a standard ambient environment and evaluated for degradation of image permanence (for example, image cracking and flaking). In addition, each image was scanned by an Integra 9505 bar code verifier to determine if the imprinted bar codes were readable and accurate. Following extreme temperature exposure, the vinyl label samples were also tested for image permanence by subjecting them to the following abrasion and adhesion tests:

**D-1) Sutherland Rub Test:** Per ASTM Test Method D5264 “Abrasion Resistance of Printed Materials by the Sutherland Rub Tester,” determine if routine handling will compromise image permanence by subjecting print samples to the Sutherland method for measuring abrasion resistance. The degree of degradation (impact of abrasion) with each print sample was assessed by taking before and after measurements of reflection density with a reflection densitometer.

**D-2) Adhesion Test:** Per ASTM Test Method F2452-04 (Determining Adhesion Utilizing Mechanical Stress per Score/Tape and Cross Hatch Tape Tests), determine the adhesion of toner to the imaging media by applying various Scotch brand tapes to imaged samples and measuring the degradation of images following tape removal by taking before and after density readings with a reflection densitometer.

### Test Environment/Conditions

All testing was conducted in Buyers Lab's test facility located at 20 Railroad Avenue, Hackensack, NJ, with daily conditions monitored by a Honeywell Model 61 Seven-Day Temperature/Humidity Chart Recorder.

**Temperature:** Testing room average, 23.0°C (73°F) ± 2°C. All running average temperatures were between 20.0°C and 26.0°C (68°F to 78°F) and data was logged on a per-cartridge basis.

**Relative Humidity:** Testing room average, 40% ± 5% RH. Running average was between 35% and 65% and data was logged on a per-cartridge basis.

**Conditioning:** Printers, paper and cartridges were acclimated to the above conditions for a minimum of eight hours prior to testing. Prior to acclimation, packaging and shipping materials were opened in a manner that prevented light damage from occurring to the print cartridge during acclimation. Paper was acclimated in the ream wrapper. Printers, printer components, paper and cartridges were handled in a manner that prevented exposure to water condensation.