BLI

Custom Test Report

Comparative Page Yield / Reliability Evaluation

JANUARY 2013

Original HP Inkjet Print Cartridges vs. Third-Party Remanufactured and Refilled Cartridges Available in EMEA and Russia

EXECUTIVE SUMMARY

In December 2012, Buyers Laboratory LLC (BLI) completed a study for Hewlett-Packard (HP) designed to test the page yield and reliability performance of Original HP ink cartridges versus leading EMEA and Russian third-party refilled/remanufactured aftermarket cartridges. Based on test sample availability, the cartridges compared were #21 Black, #22 Color, #21XL Black, #22XL Color, #56 Black, #57 Color, #140XL Black, #141XL Color, #300XL Black, #300XL Color, #350 Black, #351 Color, #350XL Black and #351XL Color. BLI hired secret shoppers to purchase remanufactured cartridges and get empty HP cartridges refilled by leading refill service providers in four European countries: France, Germany, Russia and the UK. The empty Original HP inkjet cartridges were refilled across 11 locations.

REMANUFACTURERS
Armor
Cactus
Office Depot
PC World
Pelikan
Prink
Tesco

RE-FILLERS
Cartridge World
Refill24
Smart Cartridge
Tinten Toner Tankstation

The results of the study, in which 1,360 cartridges were tested on 18 printers, unequivocally show that the Original HP inkjet print cartridges tested significantly outperformed the remanufactured and refilled ink cartridges.

Page Yield: When comparing the total pages printed from all cartridges tested, it was concluded that Original HP inkjet print cartridges produced 54.6% more pages than all the third-party cartridges combined.

Cartridge Reliability: No Original HP inkjet print cartridges tested in the study were dead on arrival (DOA) or expired prematurely, whereas the refilled/remanufactured cartridges had a collective problem cartridge rate of 41% (14% DOA, 27% premature expires).

LAB TEST RESULTS

Page Yield

When comparing the total pages printed from the cartridges tested, it was concluded that overall the Original HP inkjet print cartridges produced 54.6% more pages than the third-party cartridges tested collectively, based on a comparison of the average page yields. Breaking down that figure by remanufacturer and re-filler, the HP cartridges printed 19.3% and 89.8% more pages, respectively. (See Appendix II for study definitions.)

Table I: Comparison of Overall Average Page Yields

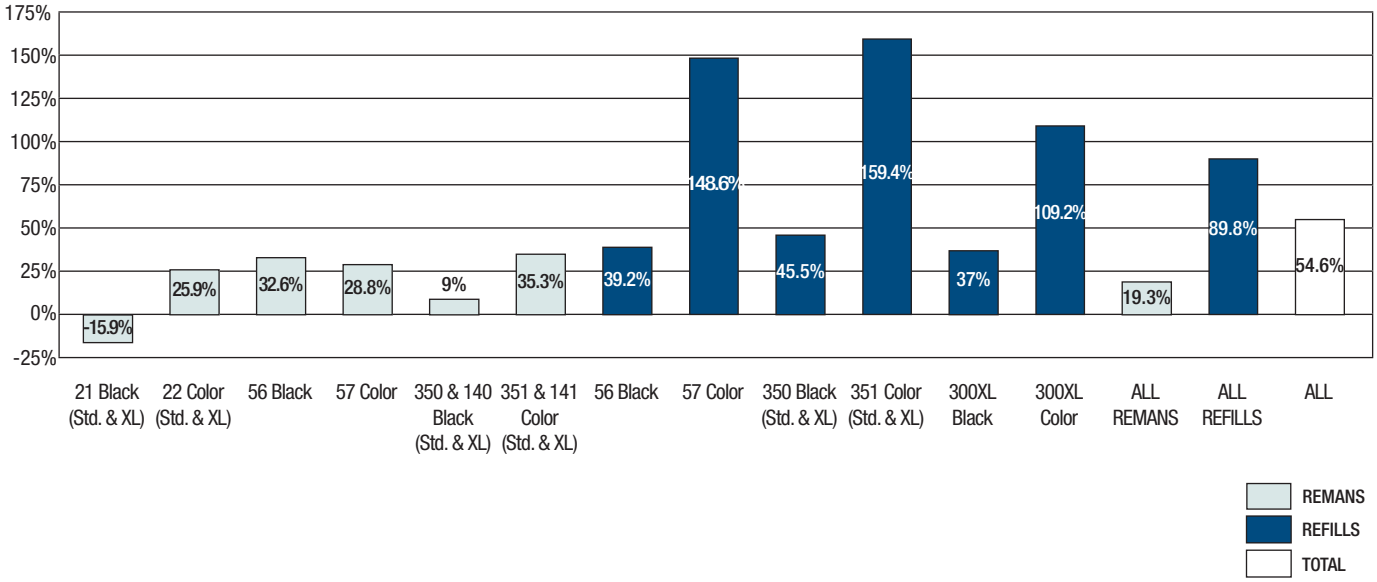
	NUMBER OF CARTRIDGES TESTED	% MORE PAGES PRODUCED BY HP (weighted by sample size where required)	AVERAGE % MORE PAGES PRODUCED BY HP	OVERALL % MORE PAGES PRODUCED BY HP
REMANUFACTURED CARTRIDGES				
21 & 21XL (black)	119	-15.9%*		
22 & 22XL (color)	119	25.9%		
56 (black)	119	32.6%	19.3%	
57 (color)	119	28.8%		
350, 350XL & 140XL (black)**	119	9%		
351, 351XL & 141XL (color)**	119	35.3%		
REFILLED CARTRIDGES				
56 (black)	68	39.2%		
57 (color)	68	148.6%		
350XL & 140XL (black)	68	45.5%		
351XL & 141XL (color)	68	159.4%	89.8%	
300XL (black)	68	37%		
300XL (color)	68	109.2%		
TOTAL THIRD-PARTY CARTRIDGES	1,122			
HP CARTRIDGES	238			

54.6%

* Some third-party brands did not differentiate between 21 standard-yield and 21XL high-yield supplies and labeled both as a standard-yield cartridge; however, based on cartridge weights, most of the “standard” 21 supplies appeared to be remanufactured XL supplies. For test purposes, the cartridges were compared to the HP model which they claimed to replace, and the final results used a weighted average based upon the sample size.

** Some third-party brands did not differentiate between standard-yield and XL high-yield supplies and labeled both as a standard-yield cartridge; however so for test purposes, the cartridges were compared to the HP model which they claimed to replace, and the final results used a weighted average based upon sample size. 350XL & 140XL (black) and 351XL & 141XL (color) supplies are different only by regional supply number but do have identical HP page yield specifications and printer compatibility.

Graph I: Percentage More Pages Printed by HP than by Remanufactured and Refilled Cartridges per SKU and per All Cartridges



Cartridge Reliability

None of the Original HP inkjet print cartridges tested failed in the study. Conversely, 26% of the remanufactured cartridges failed (12% DOA, 14% premature expires) and 67% of the refilled cartridges failed (17% DOA, 50% premature expires), for a collective failure rate of 41% (14% DOA, 27% premature expires. (See Appendix II for study definitions of DOA and premature expires.)

Table II: Cartridge Reliability

CARTRIDGE TYPE	NUMBER OF CARTRIDGES TESTED	DEAD ON ARRIVAL		PREMATURE EXPIRES		TOTAL PROBLEM CARTRIDGES	
		No.	%	No.	%	No.	%
HP	238	0	0%	0	0%	0	0%
Remanufactured	714	88	12%	96	14%	184	26%
Refilled	408	69	17%	205	50%	274	67%
TOTAL THIRD-PARTY	1,122	157	14%	301	27%	458	41%

In analyzing the breakdown of the remanufactured cartridge failures, it was observed that of the 714 remanufactured cartridges tested, 14% expired prematurely and 12% were DOA, for a total failure rate of 26%.

In analyzing the breakdown of the refilled cartridge failures, it was observed that of the 408 refilled cartridges tested, 50% expired prematurely and 17% were DOA, for a total failure rate of 67%.

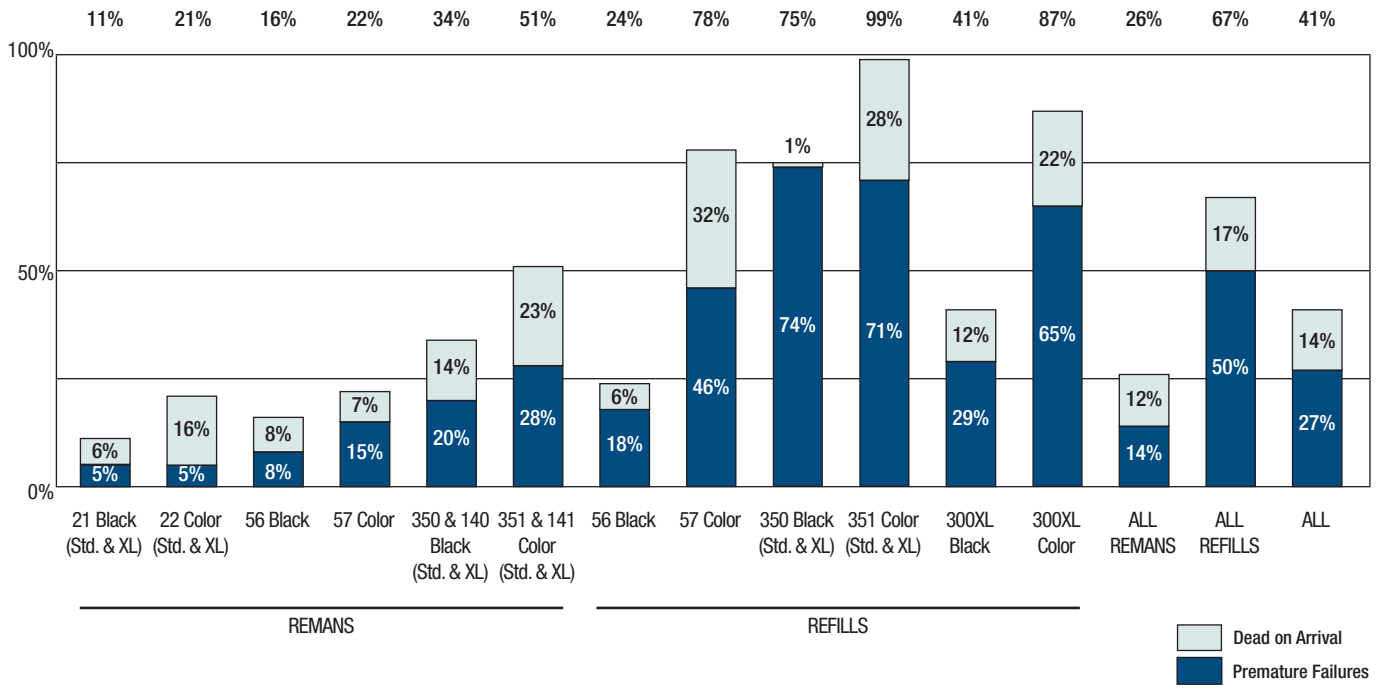
Failure Rates per Cartridge Type

REMANUFACTURED	PREMATURE EXPIRES	DOA
#21 & #21XL Black	5%	6%
#22 & #22XL Color	5%	16%
#56 Black	8%	8%
#57 Color	15%	7%
#350, #350XL & #140XL Black	20%	14%
#351, #351XL & #141XL Color	28%	23%
#300XL Black	NA	NA
#300XL Color	NA	NA

REFILLED	PREMATURE EXPIRES	DOA
#21 & #21XL Black	NA	NA
#22 & #22XL Color	NA	NA
#56 Black	18%	6%
#57 Color	46%	32%
#350XL & #140XL Black	74%	1%
#351XL & #141XL Color	71%	28%
#300XL Black	29%	12%
#300XL Color	65%	22%

This data is presented graphically below:

Graph II: Percentage of Remanufactured and Refilled Cartridge Failures by Failure Type, per SKU and per All Cartridges



Percentage of Remanufactured vs. Refilled Cartridge DOA Failures

REMANUFACTURED BLACK	
Streaking	42.4%
Immediate Fade	24.2%
Ink Leakage	15.2%
Electrical Connect Failure	15.2%
Failure to Print Black	3.0%
TOTAL	100%
REMANUFACTURED COLOR	
Streaking	38.2%
Failure to Print Color	29.1%
Ink Leakage	21.8%
Electrical Connect Failure	9.1%
Color Mix	1.8%
TOTAL	100%

REFILLED BLACK	
Streaking	15.4%
Immediate Fade	30.8%
Ink Leakage	7.7%
Electrical Connect Failure	46.2%
Failure to Print Black	NA
TOTAL	100%
REFILLED COLOR	
Streaking	8.9%
Failure to Print Color	7.1%
Ink Leakage	17.9%
Electrical Connect Failure	14.3%
Color Mix	51.8%
TOTAL	100%

HP vs. Remanufactured Cartridges

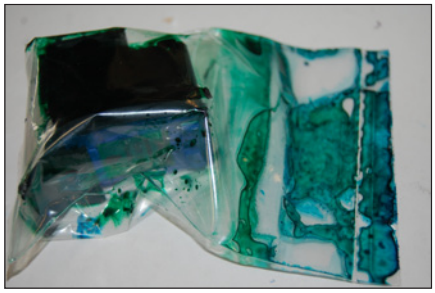
Overall, the remanufactured black cartridges failed at a rate of 20% (11% premature expires, 9% DOA) while the tri-color remanufactured cartridges failed at a rate of 31% (16% premature expires, 15% DOA).

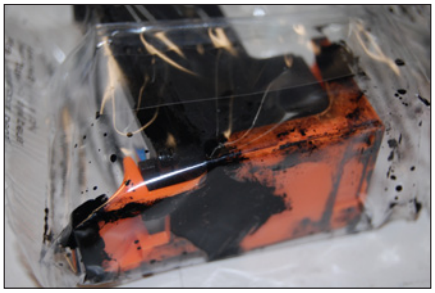
With the remanufactured black cartridges, the most prevalent cause of DOA failure was streaking, at 42.4%. Other reasons for DOA failure with the remanufactured black cartridges included immediate fade (24.2%), ink leakage (15.2%), electrical connect failure (15.2%) and failure to print black (3%).

Streaking was also the primary reason of DOA failure of the remanufactured color cartridges, at 38.2%. Other reasons for DOA failures with the remanufactured color cartridges included failure to print color (29.1%), ink leakage (21.8%), electrical connect failure (9.1%) and color mix (1.8%).

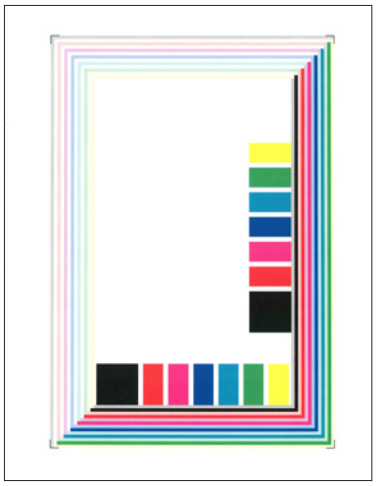
Premature expires among the remanufactured black cartridges were due to unacceptably low page yields (74.4%), electrical connect failure (17.9%) and streaking (7.7%). Unacceptably low page yields were also the primary cause of premature expires of the remanufactured color cartridges (84.2%), while streaking and electrical connect failure (7% each) and failure to print color (1.8%) were the other reasons.

The exhibits below show various forms of ink leakage with remanufactured cartridges:

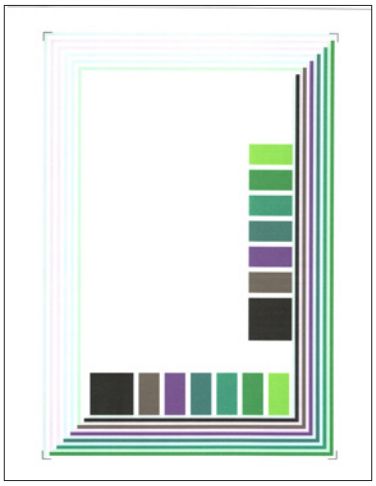




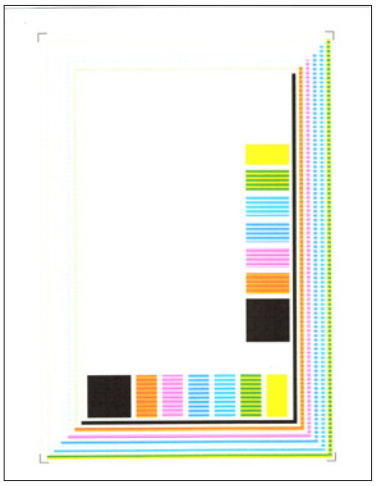
The exhibits on the following page (excluding the one labeled “Correct Diagnostic Page”) are typical of the types of irreparable image quality failures experienced with the remanufactured cartridges that resulted in DOAs. As can be seen, color fidelity was severely off, with blue, cyan and yellow printing as various shades of green, magenta as purple, and red as brown. In addition, various forms of streaking resulted in cartridges being classified as DOA, as it was excessive and could not be remedied with the three streak removal procedure.



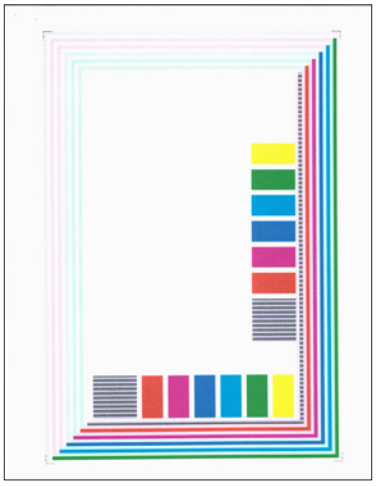
Correct Diagnostic Page



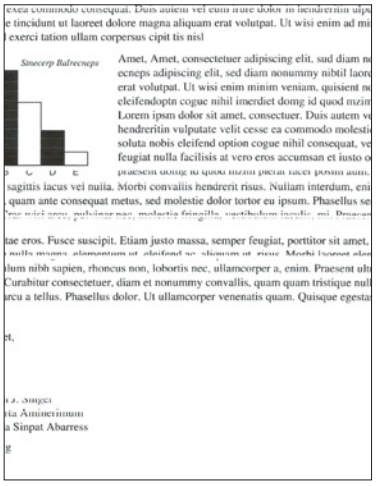
Color Mix



Color Streaking



Black Streaking



Streaking

HP vs. Refilled Cartridges

Overall, the refilled black cartridges failed at a rate of 47% (40% premature expires, 7% DOA) while the tri-color refilled cartridges failed at a rate of 88% (60% premature expires, 28% DOA).

With the refilled black cartridges, the most prevalent cause of DOA failure was electrical connect failure, at 46.2%. Other reasons for DOA failure with the refilled black cartridges included immediate fade (30.8%), streaking (15.4%) and ink leakage (7.7%).

Color mix was the primary reason of DOA failure of the refilled color cartridges, at 51.8%. Other reasons for DOA failures with the refilled color cartridges included ink leakage (17.9%), electrical connect failure (14.3%), streaking (8.9%) and failure to print color (7.1%).

Premature expires among the refilled black cartridges were due to unacceptably low page yields (95.1%) and streaking (4.9%). Unacceptably low page yields were also the primary cause of premature expires of the refilled color cartridges (99.2%), while there was one occurrence of streaking (0.8%).

The exhibit below shows one form of ink leakage with refilled cartridges:

The exhibits shown on page 6 are nearly identical to the types of image quality defects BLI saw from refilled cartridges.

APPENDIX I: TEST METHODOLOGY

The following is a summary of the methodology used for this study:

Printers and Print Cartridges Selected for this Study

Printer	Black Cartridges	Color Cartridges
HP Deskjet D5560 Printer (CB774#BEV)	HP 300XL (CC641EE)	HP 300XL (CC644EE)
HP Deskjet 5650 Printer (C6490A)	HP 21 (C9351AN) HP 21XL (CH569AN) HP 56 (C9351C)	HP 22 (C9352AN) HP 22XL (CG570AN) HP 57 (C6657A)
HP Photosmart C4599 All-in-One Printer (Q8408B)	HP 350 (CB335E) HP 350XL (CB336E)	HP 351 (CB337E) HP 351XL (CB338E)

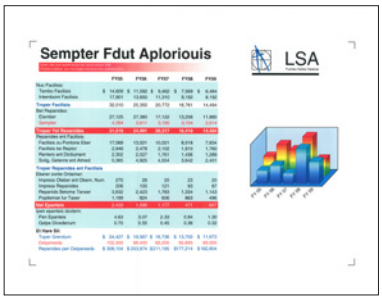
A total of 1,122 refilled ink cartridges and 238 Original HP inkjet print cartridges were tested using a total of six HP Deskjet D5560 Printers, six HP Deskjet 5650 Printers and six HP Photosmart C4599 All-in-One Printers. These devices and SKUs represent a large range of the HP portfolio, including old, previous and current generation of product. This was done to capture a wide range of products that most users may own. It should be noted that these cartridges are also compatible with a number of other HP printer models (see table below), so the user experience reported in this report would not be limited to just three HP printer models.

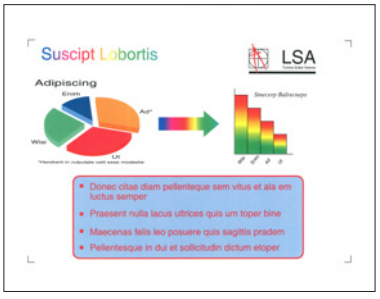
Compatible Printers

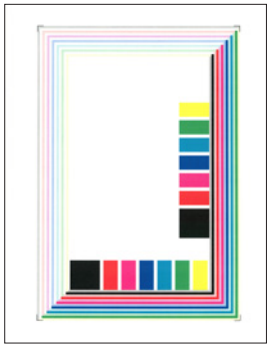
HP 21 Black, 22 Color, 21XL Black & 22XL Color	HP 56 Black & 57 Color	HP 350 Black, 351 Color, 350XL Black, 351XL Color, 140XL Black & 141XL Color	HP 300XL Black & 300XL Color
HP Deskjet 3910/3920 Printer series HP Deskjet 3930/3940 Printer series HP Deskjet D1300 Printer series HP Deskjet D1360 Printer series HP Deskjet D1400 Printer series HP Deskjet D1500 Printer series HP Deskjet D2300 Printer series HP Deskjet D2360 Printer series HP Deskjet D2400 Printer series HP Deskjet F2100 Printer series HP Deskjet F300 Printer series HP Deskjet F380 Printer series HP Deskjet F2200 AiO series HP Officejet 4300 AiO series HP PSC 1400 AiO series	HP Deskjet 5000 Color Inkjet Printer series HP Deskjet F4100 Printer series HP OfficeJet 4200 series HP Photosmart 7150 HP Photosmart 7260 HP Photosmart 7350 HP Photosmart 7450 HP Photosmart 7550 HP Photosmart 7660 HP Photosmart 7760 HP Photosmart 7960	HP Deskjet D4200 HP Deskjet D4300 HP OfficeJet 6400 series HP Officejet J5780 HP Photosmart C4200 AiO HP Photosmart C4340 AiO HP Photosmart C4380 AiO HP Photosmart C5280 HP PhotoSmart 5500 HP PhotoSmart C4400 series HP PhotoSmart C4500 series HP Photosmart D5300	HP Deskjet D1660 HP Deskjet D2500 series HP Deskjet D2530 HP Deskjet D2600 HP Deskjet D5500 HP Deskjet F2420 AiO HP Deskjet F2480 AiO HP Deskjet F4200 AiO HP Deskjet F4400 AiO series HP Deskjet F4580 HP ENVY 100 eAiO HP ENVY 110 eAiO HP ENVY 120 eAiO HP Photosmart C4600 AiO HP Photosmart C4700 AiO series Photosmart eAiO - D110a

Printing was performed in a continuous mode in a controlled environment using the ISO/IEC 24712 five-page color test suite, and the environmental conditions specified in ISO/IEC 24711. However, the page yield calculation in this study does differ from the ISO/IEC 24711 page yield calculation in that it was designed to include only reliable working cartridges. In this study, in order to account for cartridge issues, both defective cartridges and reliable cartridges were used in the page yield calculations. Consequently, the reported page yield numbers are not official ISO/IEC 24711 yields, as ISO/IEC 24711 requires that defective cartridges are excluded from the page yield calculation. This departure was done to account for the "real world" user experience of dealing with defective or failed cartridges.

The ISO/IEC 24712 Test Suite







BLI acquired all printers, Original HP inkjet print cartridges, and paper.

To test refilled cartridges, new HP cartridges were emptied by printing the ISO test suite to the first sign of fade. This is consistent with re-filler recommendations that cartridges to be refilled not be completely emptied. BLI then sent the empty cartridges to four countries in Europe in air-tight containers to prevent any undue shipping effects. Upon receipt, the mystery buyers in those countries took cartridges to multiple locations of each cartridge remanufacturer or refiller service provider. Remanufactured and refilled cartridges were then tested in BLI's Hackensack, NJ, test facility. For the third-party cartridges tested, 100% of the test data is based on remanufactured cartridges or cartridges that had been refilled once.

Pages printed while preparing cartridges for refilling were not part of the test.

Buyers Laboratory selected Georgia-Pacific Spectrum Multi-Use plain paper (8½ x 11, 20 lb., 92 Brightness) for all printing in this study.

Each cartridge was inspected for leaks or other damage upon entering the test, and a cartridge with substantial visible ink spilled in the bag or on the cartridge was declared DOA. All other cartridges were printed to End-of-Life (EOL; see study definitions in Appendix II).

Printing continued until all test cartridges reached EOL. Color and black cartridges were tested in parallel. As the color or black cartridges reached EOL, Original HP "substitute" cartridges were used to complete the testing of the unfinished third-party cartridge in the set. All results and effects of these Original HP "substituted" cartridges were ignored in the study.

This study tested average performance of the market, not individual brand performance. The brands and providers in the sample were included because, together, they make up a significant portion of the overall market for remanufactured and refilled cartridges in Europe and Russia.

Seventeen cartridges of each type were tested for HP, while various amounts of cartridges were tested for remanufacturers (see table below) and 68 of each cartridge type were tested for re-fillers. Remanufacturers and re-fillers were located in France, Germany, Russia and the UK.

Cartridges per SKU

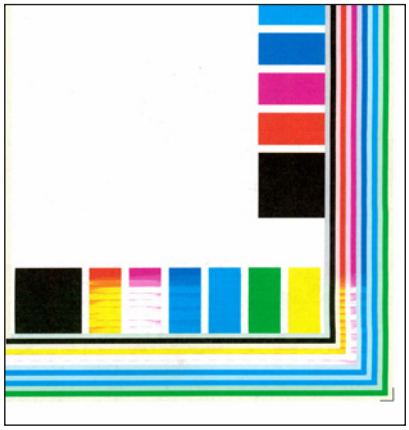
GROUP	SAMPLE SIZE
HP	238
21 Black	17
21XL Black	17
22 Color	17
22XL Color	17
56 Black	17
57 Color	17
350 Black	17
350XL Black	17
140XL Black	17
351 Color	17
351XL Color	17
141XL Color	17
300XL Black	17
300XL Color	17

GROUP	SAMPLE SIZE	
REMANUFACTURED	714	
21 Black	68	119
21XL Black	51	
22 Color	51	119
22XL Color	68	
56 Black	119	
57 Color	119	
350 Black	34	119
350XL Black	68	
140XL Black	17	
351 Color	34	119
351XL Color	68	
141XL Color	17	

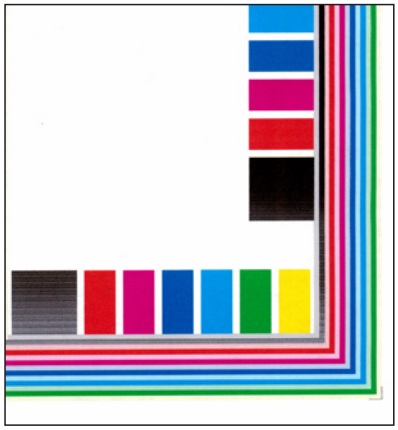
GROUP	SAMPLE SIZE
REFILLED	408
56 Black	68
57 Color	68
350XL Black	68
351XL Color	68
300XL Black	68
300XL Color	68

APPENDIX II: DEFINITIONS:

Test Project Terminology	Definition
End-of-Life (EOL)	A condition determined by one of six mechanisms: 1. Fade has occurred on the diagnostic page per ISO definition. 2. Significant reduction in density in the bands or blocks per ISO definition. 3. Streak removal procedure steps have been exhausted per ISO definition. 4. Significant leakage before or during installation or any time during printing. 5. 10 consecutive pages with color mix. 6. Cartridge fails to print or stops printing and efforts to recover are unsuccessful.
Individual Cartridge Yield	Individual cartridge yield is calculated by counting the number of diagnostic pages printed between cartridge installation and EOL, then multiplying by five. The diagnostic page is the last plot printed within the five-page test suite.
Average % More Pages	Percent More Pages is calculated for each cartridge type for each model: 100 x (HP Page Yield – Refilled Page Yield)/(Refilled Page Yield). From these calculations the Average Percent More Pages was obtained, which is defined as percent more pages printed by all HP cartridges versus all aftermarket cartridges tested. Note that these are simple averages and not weighted averages.
Dead On Arrival (DOA)	A condition determined by one of three mechanisms: 1. Cartridge found to have substantial leakage (as defined above) at start or during testing. 2. 10 or fewer pages printed by a cartridge before end of life. 3. Cartridge fails to operate upon installation.
Early End of Life (Premature Expire)	A cartridge that has a page yield of less than 75% of the HP published page yield for that cartridge model in the test.
Fade	A significant decrease in density on the bands or blocks of the last page in the test page suite, which is a diagnostic page. This decrease in density does not have to occur completely across the page to be considered fade. For a comparison to determine if fade is occurring, reference the 10th page printed by that printer.



Color Fade

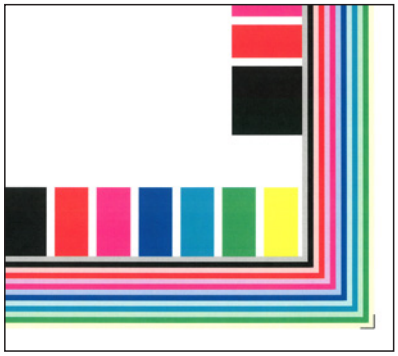


Black Fade

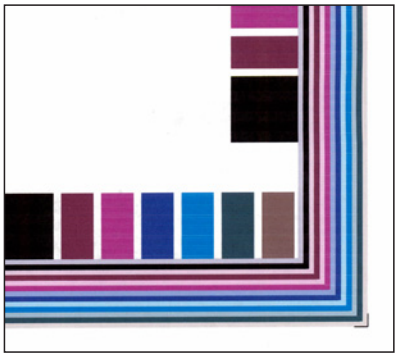
Color Mix

Defined as a color cartridge that cannot print the correct Cyan, Magenta and Yellow colors as shown on the diagnostic page 5 of the page yield test suite. Ink has mixed in an unintended manner inside the cartridge and has caused a discoloring of the ink.

An example of Color Mix is provided to the right. Compare the colored blocks in the correct example to those of the color mix page.



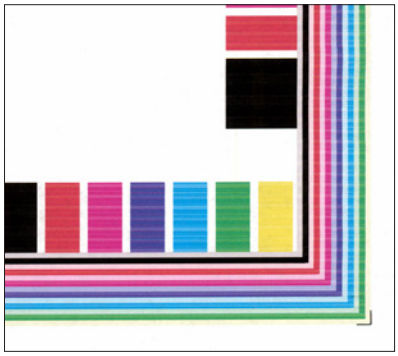
Correct Diagnostic Page



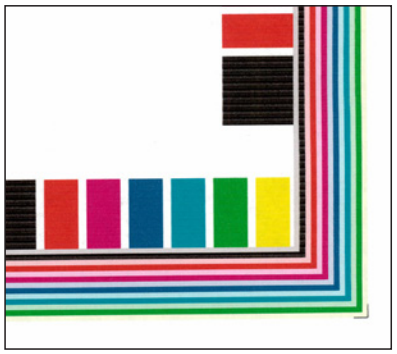
Color Mix

Streaks

Very thin lines of color or the lack of color where it should be, in the blocks surrounding the edge of the diagnostic page. Streaks differ from fade in the width and severity of the reduction in density. Streaks can appear due to a number of reasons, including thermal issues and clogged nozzles.



Color Streaking



Black Streaking

Streak Removal Procedures

This is the cartridge cleaning procedure (servicing) used to restore print performance. If streaks were observed on three consecutive diagnostic pages, a streak removal procedure was implemented. Streak removal operations were conducted according to the HP printer manual documentation. If there were additional cleaning steps advised for non-HP cartridges, these were included within the cleaning process.

1. If the cleaning operation has the option of multiple cleaning strengths, the procedure indicated in the printer manual for resolving streaking should be followed.

2. Use of a “light” and a “strong” cleaning procedure counts as one cartridge cleaning operation.

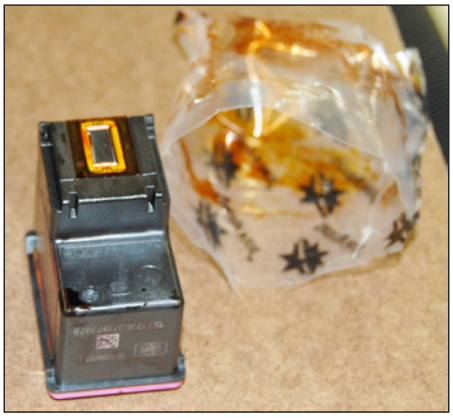
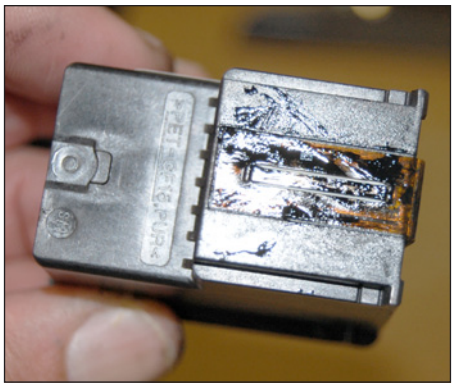
3. Cleaning is verified by the reprinting of the diagnostic plot. If streaks are still present, the cleaning procedure is repeated.

4. Any pages printed during the nozzle cleaning operation are not counted in the yield calculation.

Due to the significant amount of ink that is used for cleaning, the maximum permissible number of times that the streak removal operation can be used on a given cartridge is three (3). Cartridges which require a fourth service are considered to be at EOL.

All cleaning steps were recorded and reported by cartridge, i.e. page number streak occurred on, number and types of services required and result (e.g., whether or not the cartridge recovered).

A cartridge not demonstrating streaking or other problems but which has experienced three (3) cleanings because the other cartridge in the sku pair has experienced streaking was not considered to be at EOL.

Substantial Ink Leakage	Significant amount of ink visibly spilled in the plastic bag containing the cartridge.  Significant amount of ink visibly spilled in the interior of the cartridge packaging. Significant amount of ink visibly spilled over the printhead nozzles. 
Test Page Suite	A series of five pages that are printed consecutively in order as a single job, ending with a diagnostic page, ISO/IEC 24712.

ABOUT BUYERS LABORATORY

Since 1961, Buyers Laboratory LLC (BLI) has been the leading global independent office-equipment test lab and business consumer advocate. In addition to publishing the industry's most comprehensive and accurate test reports on office document imaging devices, each representing months of exhaustive hands-on testing in BLI's US and UK laboratories, the company has been the leading source for extensive runnability testing on imaging media and consumables, as well as extensive specifications/pricing databases on MFPs, printers, scanners and fax machines. BLI also has a long-standing reputation for being the industry's most trustworthy and complete source for quality testing services and global competitive intelligence.

In addition to testing over 200 office document imaging devices and related consumables annually for its subscribers, BLI provides consulting services to buyers and a range of private testing services that include document imaging device beta and pre-launch testing, performance certification testing, consumables testing (including toner, ink, fusers and photoconductors), solutions evaluations, and imaging media runnability testing.

For more information on BLI, call (201) 488-0404, visit www.buyerslab.com, or email info@buyerslab.com.