KEYPOINT INTELLIGENCE
Buyers Lab

Custom Test Report

Comparative Page Yield / Reliability Evaluation

JULY 2017

Original HP Inkjet Print Cartridges vs. Third Party Remanufactured/Compatible/Refilled Cartridges from EMEA

EXECUTIVE SUMMARY

Keypoint Intelligence - Buyers Lab (BLI) was commissioned by HP Inc. (HP) to evaluate the page yield, reliability and number of wasted pages produced from Original HP inkjet printer cartridges versus third-party aftermarket cartridges which were refilled, new-build compatibles or remanufactured (reman).

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. But this test did not deliver page yield numbers based on the ISO/IEC 24711 standard, as ISO/IEC 24711 requires that defective cartridges are excluded from the page yield calculation. This was done to account for the negative user experience with defective or failed cartridges.

Based on test sample availability, the cartridges compared were #300XL Black, #300XL Color, #300 Black, #300 Color, #121XL Black, #121XL Color, #301XL Black, #301XL Color, #301 Black, #301 Color, #122XL Black, #122XL Color, #364XL Black, #364XL Cyan, #364XL Magenta, #364XL Yellow, #364 Black, #364 Cyan, #364 Magenta, #364 Yellow, #178XL Black, #178XL Cyan, #178XL Magenta, #178XL Yellow, #650 Black, #650 Color, #950XL Black, #950XL Cyan, #950XL Magenta, #950XL Yellow, #970XL Black, #971XL Cyan, #971XL Magenta and #971XL Yellow. Brands tested were leading/representative third-party aftermarket brands across EMEA markets. BLI hired mystery shoppers to acquire all Original HP and third-party aftermarket cartridges from the countries of UK, France, Germany, Italy, Russia and Turkey.

Table I: Brands tested were:

Activejet	Ecostore	Prink
Akgiz non-branded refill shop	France Toner	Refill 24
Amazon Basics	HP Inc.	Starink (also branded as St@r ink)
Armour	HQ Patronen	Tesco
Cactus	Instanbul non-branded refill shop	Tinten Toner Tankstation
Cartridge Master	Office Depot	Tintendienst
Cartridge World	Pelikan	
Copy Service	Prestige Cartridge	

The results of the study, in which 1,746 cartridges were tested on 48 printers, unequivocally show that the Original HP inkjet print cartridges tested significantly outperformed the third-party aftermarket cartridges.

Page Yield

When comparing the total pages printed from all cartridges tested, it was concluded that Original HP inkjet cartridges produced an average of 85% more pages than the third-party aftermarket cartridges tested.

Cartridge Reliability

No Original HP inkjet print cartridges tested in the study were dead on arrival (DOA) or expired prematurely, whereas the third-party aftermarket cartridges had a collective problem cartridge rate of 42% (11% DOA, 31% Premature expiry).

Printer Damage

Some of the third-party aftermarket inks clogged printheads during testing, rendering 40 out of the 48 printers (83%) tested unusable due to major print quality defects that could not be fixed, even after using Original HP ink cartridges to perform repeated headcleaning routines.

Wasted Pages

Third-party aftermarket cartridges produced 88 times more unusable/wasted pages then original HP cartridges.

LAB TEST RESULTS

Page Yield

When comparing the total pages printed from those cartridges tested, it was concluded that the Original HP inkjet print cartridges produced 85% more pages overall when compared to the third-party aftermarket cartridges tested, based on a comparison of the average page yields. (See Appendix II for study definitions.) Throughout testing, the Original HP inkjet printer cartridges produced combined average page yields that were superior to those of third-party aftermarket.

Comparison of Overall Average Page Yields

Third-party cartridge type	Printer type	SKU set	Percentage more pages produced by HP
Refiller	Consumer class	650 Black Colour average average	513%
		300XL/121XL-Black Tri color average	87%
		301XL/122XL-Black Tri color average	187%
		364XL/178XL-BlackTri colour average	90%
		Group average	219%
Reman/Compatible	Consumer class	300/300XL/121XL-Black Tri color average	16%
		301/301XL/122XL-Black Tri color average	5%
		364/364XL/178XL-Black Tri color average	16%
		Group average	12%
	Office class	950XL-Black Tri colour average	11%
		970XL-BlackTri color average	37%
		Group average	24%
Overall third-party aftermarket cartridges average			85%

Although some third-party inks came close to the original HP cartridges, it's important to note that 83% of printers used in testing were rendered unusable due to major image quality defects that could not be resolved through cleaning procedures.

Cartridge Reliability

None of the Original HP inkjet print cartridges tested failed for being dead on arrival (DOA) or premature expires, whereas an average of 42% of the Third-party aftermarket tested were either dead on arrival (DOA) or reached end of life early (premature expires). (See Appendix II for study definitions of DOA and premature expires). Of the Third-party aftermarket cartridge failures, it was observed that of the 1,512 refilled cartridges tested, 31% expired prematurely, while 11% were DOA.

Table II: Cartridge Reliability

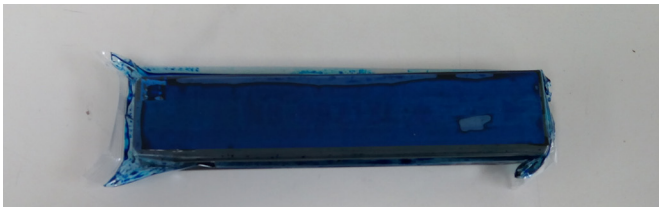
Cartridge Type	Sample size	% DOA	% Premature failure	% Problem Cartridges
HP	234	0.0%	0.0%	0.0%
Third-party aftermarket	1512	11.6%	31.0%	42.6%
Refill	576	20.8%	49.5%	70.3%
300/300XL/121XL-Black Tri color	72	20.8%	40.3%	61.1%
301/301XL/122XL-Black Tri colour	144	39.6%	27.1%	66.7%
364/364XL/178XL-Black Tri color	288	4.5%	65.6%	70.1%
650-Black Tri color	72	48.6%	38.9%	87.5%
Reman/Compatible	936	6.0%	19.7%	25.6%
300/300XL/121XL-Black Tri color	126	11.9%	14.3%	26.2%
301/301XL/122XL-Black Tri colour	126	6.3%	6.3%	12.7%
364/364XL/178XL-Black Tri color	288	5.6%	17.0%	22.6%
950/1 XL-Black Tri color	180	1.7%	23.3%	25.0%
970/1 XL-Black Tri color	216	6.5%	31.0%	37.5%

Within the reliability failures distribution, DOA in Black and Color accounted for the largest share, followed by color mix (Colour cartridge is producing incorrect colors i.e. yellow is green / brown). Premature expires among the color reman/refill cartridges was mainly due to unacceptably low page yields and poor image quality.

Percentage of Reman/Refill DOA Failures

CAUSE OF FAILURE	Overall Black and Color
DOA - Failed to print a Color	53%
Color Mix	20%
Cartridge Failure	17%
Streaking	10%
Leakage	2%

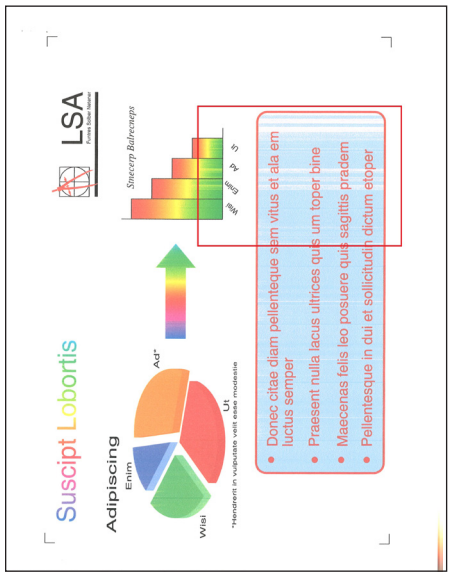
"Cartridge Failure" covers any condition that disrupts cartridge function, especially through physical or electronic incompatibilities. For example, a cartridge that cannot be loaded into the printer or that is rejected by the printer despite nominal compatibility. Some forms of image quality defects, such as "jittering," wildly erratic printout, is also included in this category.



Some cartridges, like the 971XL cartridges shown here, arrived at BLI's lab showing significant leakage.

Printer Failures/Damage Caused by Third Party Cartridges

BLI technicians experienced printer failure in 40 out of 48 printers tested. During testing of printers that used the 364, 178, 950/951 and 970/971 cartridge types, BLI technicians noted that the printheads were heavily affected by use of third-party inks. These clogged nozzles led to permanent print quality defects like the ones shown below. BLI technicians attempted to clear the defects and restore functionality through repeated headcleaning routines (using original HP cartridges to flush the system), but, in most cases, the printers had to be replaced in order to continue the testing.



On some printers, page 4 of the test suite (above left) was missing narrow bands of color in shaded areas across the top of the page. Other printers experienced wide swaths of missing color (above left) when printing pages using third party cartridges.

Summary of Printer Damage Caused by Third-Party Inks

Printer Model	Cartridge SKU	Number of Printers Tested	Number of Printers Damaged	% damaged	MSRP*
HP Photosmart 5520	#364/ #178	20	17	85%	€109.99
HP Officejet Pro 276dw	#950/#951	5	5	100%	€329.00
HP Officejet X451dw/dn	#970/#971	4	4	100%	€399.00
HP Officejet Pro X576dw	#970/#971	19	14	74%	€849.00
HP Photosmart C4780	#300/#121	6	0	0%	€139.99
HP Deskjet 1010	#301/#122	6	0	0%	€44.99
HP Deskjet 2645	#650	6	0	0%	€95.00
TOTALS		48	40	83%	

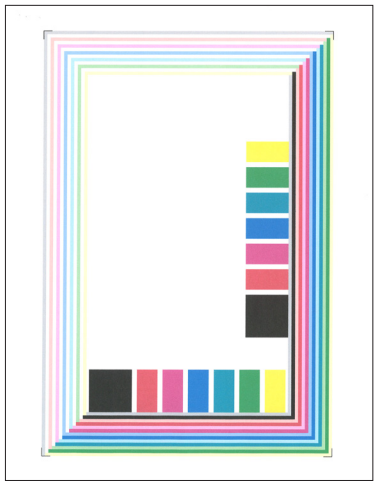
*Manufacturer's Suggested Retail Price (excluding VAT) for the German market in Euros.

Image Quality Defects/Wasted Pages

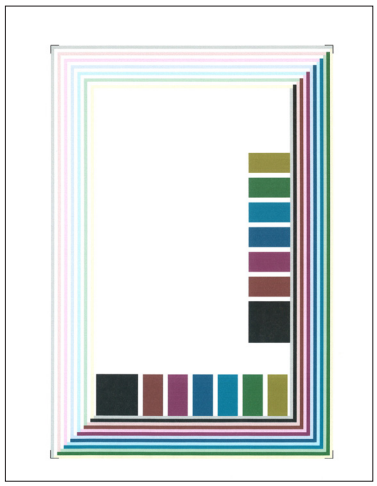
While nearly all pages printed by the Original HP cartridges were well produced and defect free, only 26 out of 428,842 pages were considered unusable. The refill/reman cartridges, on the other hand, produced 11,026 unusable pages out of 2,015,034 pages, which means the third party cartridges produced about 88 times more unusable pages than Original HP cartridges.

Unusable Pages

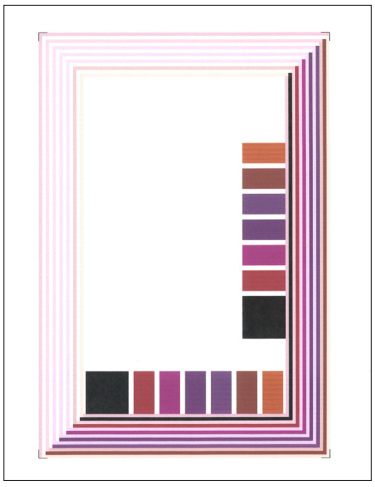
GROUP	Pages Printed	Unusable pages	% unusable
HP	428,842	26	0.006%
Third-party aftermarket	2,015,034	11,026	0.544%
X Times More Unusable Pages with Third-party aftermarket			88.77



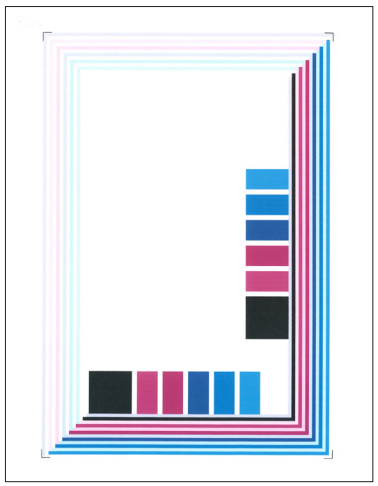
Correct Diagnostic Page



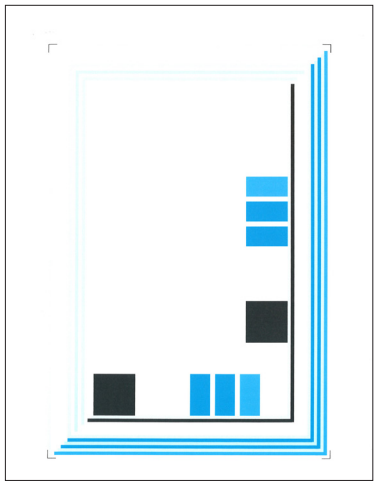
Poor Color Mix 1 (Muddy colors)



Poor Color Mix 2
(Improper mix of colors)

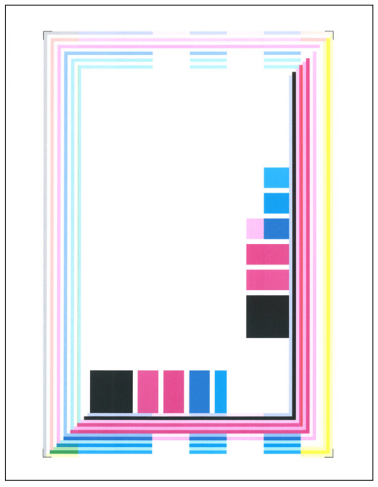


Missing Colors 1 (No yellow)



Missing Colors 2
(No magenta and yellow)

Black Roller Streaks



Color Roller Streaks

Samples shown above are representative of the defects seen in BLI testing.

APPENDIX I: TEST METHODOLOGY

Printers and Print Cartridges Selected for this Study

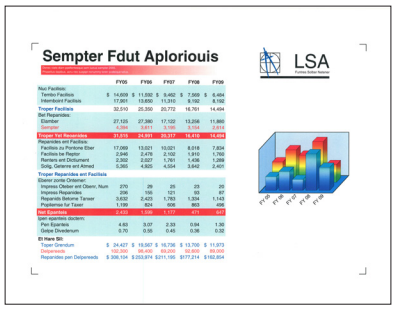
Printer	Black Cartridge	Color Cartridge
HP Office Jet Pro 276dw (CR770A)	HP 950XL CN045AN)	HP 951XL Cyan (CN046AN)
		HP 951XL Magenta (CN047AN)
		HP 951XL Yellow (CN048AN)
HP Office Jet Pro 576dw (CN598A)	HP 970XL (CN625AM)	HP 971XL Cyan (CN626AM)
		HP 971XL Magenta (CN627AM)
		HP 971XL Yellow (CN628AM)
HP Photosmart 5520 (CX042A)	HP364XL (CN322EE)	HP 364XL Cyan (CN323EE)
		HP 364XL Magenta (CN324EE)
		HP 364XL Yellow (CN325EE)
	HP178XL (CN684HE)	HP178XL Cyan (CB323HE)
		HP178XL Magenta (CB324HE)
		HP178XL Yellow (CB325HE)
	HP 364 (CB316EE)	HP364 Cyan (CB318EE)
		HP364 Magenta (CB319EE)
		HP364 Yellow (CB320EE)
HP PS C4780 (Q8380A)	HP300XL (CC641EE)	HP300XL (CC644EE)
	HP121XL (CC641HE)	HP121XL (CC644HE)
	HP300 (CC640EE)	HP300 (CC643EE)
HP Deskjet 1010 (CX015A)	HP301XL (CH563EE)	HP301XL (CH564EE)
	HP122XL (CH563HE)	HP122XL (CH562HE)
	HP301 (CH561EE)	HP301 (CH562EE)
HP Deskjet 2645 (D4H22C)	HP650 (CZ101AE)	HP650 (CZ102AE)

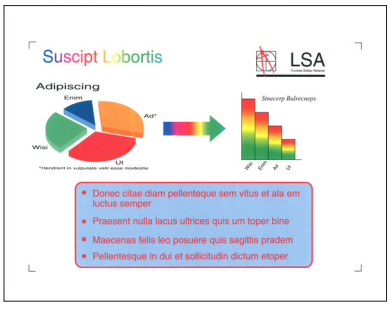
Compatible Printers

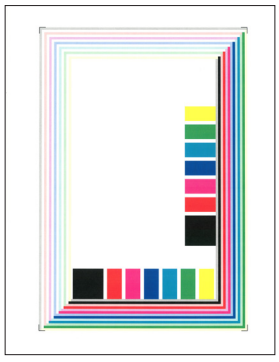
#950 / #951 (Office-class)	#970 /#971 (Office-class)	#364 / #178 (Consumer-level)	#300 /#121 (Consumer-level)	#301 /#122 (Consumer-level)	#650 (Consumer-level)
Black & Color (CMY)	Black & Color (CMY)	Black & Color (CMY)	Black & Color	Black & Color	Black & Color
OfficeJet Pro 200z	OfficeJet Pro X451dn	Photosmart 5510	Deskjet D1663	Deskjet 1000	Deskjet Ink Advantage 1015
OfficeJet Pro 251dw	OfficeJet Pro X451dw	Photosmart 5515	Deskjet D2563	Deskjet 1010	Deskjet Ink Advantage 1515
OfficeJet Pro 276dw	OfficeJet Pro X476dn	Photosmart 5520	Deskjet D2663	Deskjet 1050	Deskjet Ink Advantage 1516
OfficeJet Pro 8100	OfficeJet Pro X476dw	Photosmart 6510	Deskjet D5563	Deskjet 1050A	Deskjet Ink Advantage 2515
OfficeJet Pro 8110	OfficeJet Pro X551dw	Photosmart 6520	Deskjet F2423	Deskjet 1050se	Deskjet Ink Advantage 2516
OfficeJet Pro 8600	OfficeJet Pro X576dw	Photosmart 7510	Deskjet F2483	Deskjet 1510 AiO	Deskjet Ink Advantage 2545
OfficeJet Pro 8610		Photosmart 7520	Deskjet F2493	Deskjet 1512	Deskjet Ink Advantage 2546
OfficeJet Pro 8615		Photosmart B8850	Deskjet F4213	Deskjet 1514	Deskjet Ink Advantage 2645
OfficeJet Pro 8620		Photosmart C5324	Deskjet F4275	Deskjet 2000	Deskjet Ink Advantage 3515 e-AiO
OfficeJet Pro 8625		Photosmart C5380	Deskjet F4283	Deskjet 2050	Deskjet Ink Advantage 3545 e-AiO
OfficeJet Pro 8630		Photosmart C6234	Deskjet F4583	Deskjet 2050A	Deskjet Ink Advantage 4515 e-AiO
OfficeJet Pro 8700		Photosmart C6380	Photosmart C4683	Deskjet 2050se	
		Photosmart D5460	Photosmart C4780	Deskjet 2054A	
		Photosmart B010a	Photosmart C4783	Deskjet 2510	
		Photosmart B109a/ d/f/n	Envy 110	Deskjet 2514	
		Photosmart B110a/c/e		Deskjet 2540e-AiO	
		Photosmart Plus B209a/c		Deskjet 2542	
		Photosmart Plus B210a/c		Deskjet 2544	
		Photosmart Premium C309a/n/g		Deskjet 2549	
		Photosmart Premium C310a		Deskjet 3000	
		Photosmart Premium C410b		Deskjet 3050	
		Photosmart e-Station C510a		Deskjet 3050A e-AiO	
		Deskjet 3070A		Deskjet 3050se	
		Deskjet 3250e-AiO		Deskjet 3050ve	
		Officejet 4620		Deskjet 3052A e-AiO	
		Officejet 4622		Deskjet 3054A e-AiO	
				Deskjet 3055A e-AiO	

Deskjet 3057A e-AiO
Deskjet 3059A e-AiO
Officejet 2620 e-AiO
Officejet 2622
Officejet 2624 e-AiO
Officejet 4630 e-AiO
Envy 4500 e-AiO
Envy 4502 e-AiO
Envy 4504 e-AiO
Envy 5530 e-AiO
Envy 5532 e-AiO

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. To account for reliability driven cartridge issues, defective cartridges were included in the page yield calculations. Consequently, the reported page yield numbers are not based on the ISO/IEC 24711 standard, as ISO/IEC 24711 requires that defective cartridges are excluded from the page yield calculation. This was done to account for the negative user experience with defective or failed cartridges.







ISO/IEC 24712 Test Suite

Printers were either supplied by HP or purchased by BLI through standard retail channels. BLI procured all paper and Original HP inkjet print cartridges.

To test cartridges refilled by refill service providers, new HP cartridges were prepared for refilling 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 six countries in the EMEA market. Mystery buyers took the empty cartridges to multiple cartridge refiller service providers for refilling. Refill service provider cartridges were then tested in BLI's Fairfield, NJ, test facility. For the refill service providers tested, 100% of the test data is based on cartridges that had been refilled once.

Lab testing at BLI

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

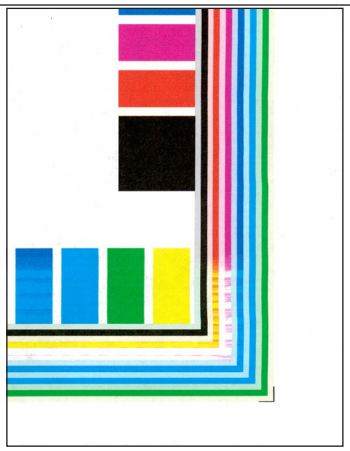
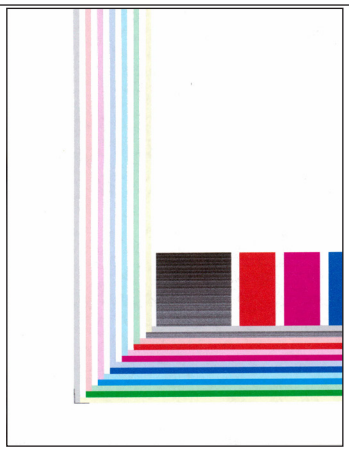
Buyers Laboratory selected Georgia Pacific Spectrum Multi Use plain paper (8½ x 11, 20 lb., 92 Brightness) for all printing in this study.

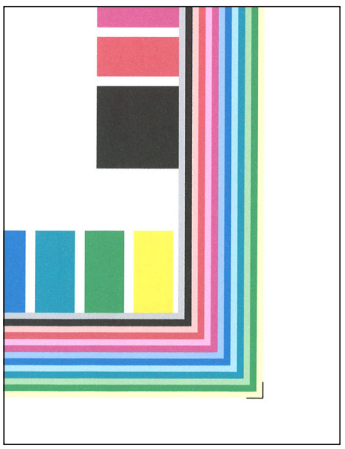
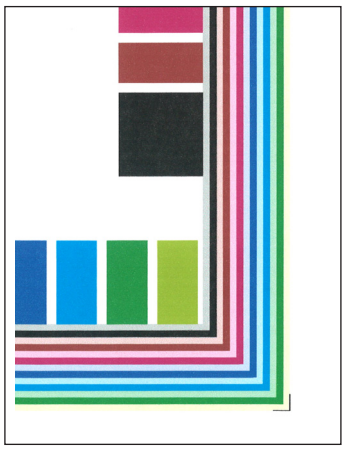
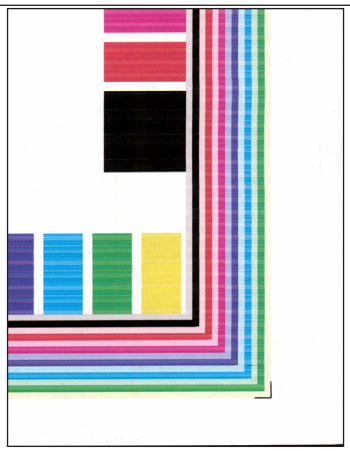
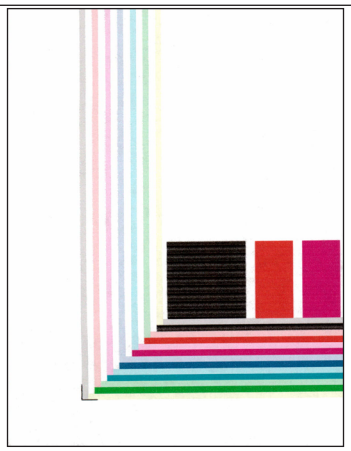
Each cartridge was inspected for leaks or other damage upon entering the test, and a cartridge with substantial visible ink spilled in the bag or on the cartridge was declared DOA. All other cartridges were printed to End of Life (EOL; see study definitions).

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 "filler" cartridges were used to complete the testing of the unfinished cartridges in the set. All results and effects of these Original HP "filler" 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 third-party aftermarket cartridges.

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.
Refilled cartridges (Refill)	HP manufactured cartridges that have been emptied and refilled with third-party inks.
New-build compatible cartridges	Cartridges manufactured by third-party suppliers with all new parts which are closely copied to mimic the original cartridge the compatible is trying to replace.
Remanufactured cartridges (Reman)	HP manufactured cartridges that have been emptied, disassembled and cleaned before being reassembled with a combination of new and recycled components and then refilled with third-party inks.
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 in the 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 mean 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.Two examples are shown here.  Color Fade  Black Fade

Color Mix	When a color cartridge cannot print the correct Cyan, Magenta and Yellow colors as shown on the diagnostic page 5 of the 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. 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 then 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 (Did the cartridge recover?) 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 print head 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 KEYPOINT INTELLIGENCE - BUYERS LAB

Since 1961, Keypoint Intelligence – Buyers Lab (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 (973) 797 2100, visit www.buyerslab.com, or email info@buyerslab.com.