

Competitive Ink Comparison Study – North America

Original HP InkJet vs. Non-HP Refilled and Remanufactured Cartridges

The *spencerLAB* DIGITAL COLOR LABORATORY has conducted cartridge reliability comparison testing of original HP Inc. [HP] inkjet cartridges, fourteen (14) non-HP brands of Remanufactured ink cartridges, and three (3) non-HP brands of Refill retailers in North America (NA). The study included testing of HP #63XL, #902XL, #950XL, #951XL, and #952XL cartridge SKUs. All cartridges were sourced in North America.

The non-HP brands included Remanufactured cartridges from: Cartridge World, Clover, G&G, GREENCYCLE, IKONG, LD Products, LEMERO, Limeink, NAIDE, Office Depot, OfficeWorld, Staples TRU RED, Target Up & Up, Walmart onn.; Refilled cartridges from retailers: Cartridge World, Costco, and Inkredible Ink.

Nine (9) cartridges for each brand and SKU were allocated for testing to obtain representative results. A total of 1,134 cartridges were run on 21 printers, entailing over 1,500 testing hours, in which a total of 1,036,921 pages were printed across all tested brands.

The analysis compared the Page Yield, Reliability, and Wasted Pages throughout the life of the ink cartridge models tested for each brand. Cartridge Reliability factors, such as Dead-on-Arrival (DOA) and Premature Failure (PF) [see definitions in Appendix 2], were evaluated to determine the total number of Problem Cartridges. Print Quality issues were also considered.

KEY FINDINGS

- Original HP ink cartridges tested yielded 57% more pages on average, or greater than 1.6 times more pages, than non-HP tested cartridges.¹
- Original HP ink cartridges tested showed no Problem Cartridges, whereas 32% of non-HP ink cartridges tested exhibited Dead-on-Arrival or Premature Failure on average.
- Non-HP ink cartridges produced 183% more Wasted Pages on average than Original HP ink cartridges.

¹ SpencerLab Sept 2021 study of printer inks sold in North America commissioned by HP for on-average performance of 16 brands of non-HP refill, remanufactured, and imitation cartridges vs. Original HP ink SKUs 63XL, 902XL, 950XL, 951XL, 952XL. To account for reliability-driven supplies issues, defective and failed cartridges were included in the page yield calculations. Consequently, the reported page yield numbers are not based on ISO/IEC 24711 Standard methodology, as it requires that defective supplies be excluded from page yield calculation. See <https://www.spencerlab.com/reports/HPInkReliability-NA-2021.pdf>

The *spencerLAB* DIGITAL COLOR LABORATORY, a division of Spencer & Associates Publishing, Ltd., is an independent test laboratory with a broad base of industry clients. Although this independent comparative study was commissioned by HP Inc., *spencerLAB* believes these results maintain its reputation for the integrity of its procedures and analyses. Results stated herein are based upon direct testing by *spencerLAB* of actual products believed to be representative.

Page Yield Comparison		
Cartridge Brand	Number of Cartridges Tested	Average Percentage More Pages Printed by HP Cartridges
HP	126	57%
Non-HP	1,008	

TEST RESULTS

PAGE YIELD

Testing concluded that the Original HP cartridges produced an average of 57% more pages than the non-HP cartridges tested. The tested non-HP ink printed (on average) 64% fewer pages than Original HP ink cartridges tested.

A total of 126 original HP cartridges and 1,008 non-HP cartridges, including Remanufactured and Refilled, were tested. Black and Color cartridge yields were combined to determine an overall average. The yields of individual CMY color cartridges (Cyan, Magenta, and Yellow) were averaged

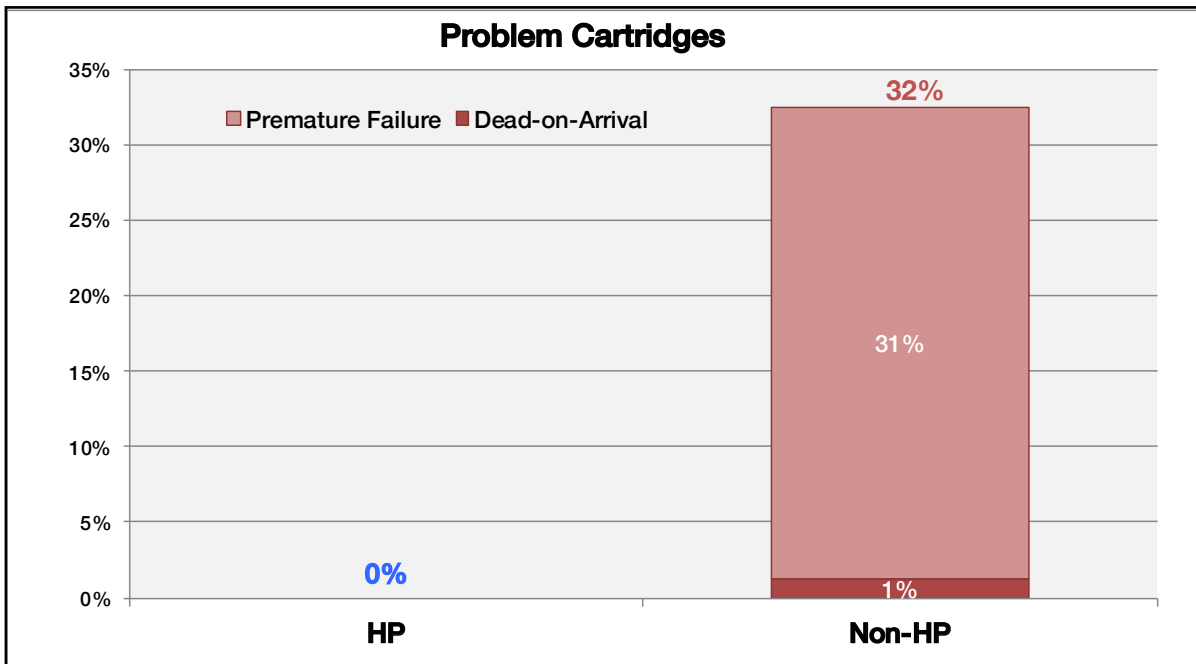
to calculate an average Color yield for 902XL, 951XL, and 952XL SKUs.

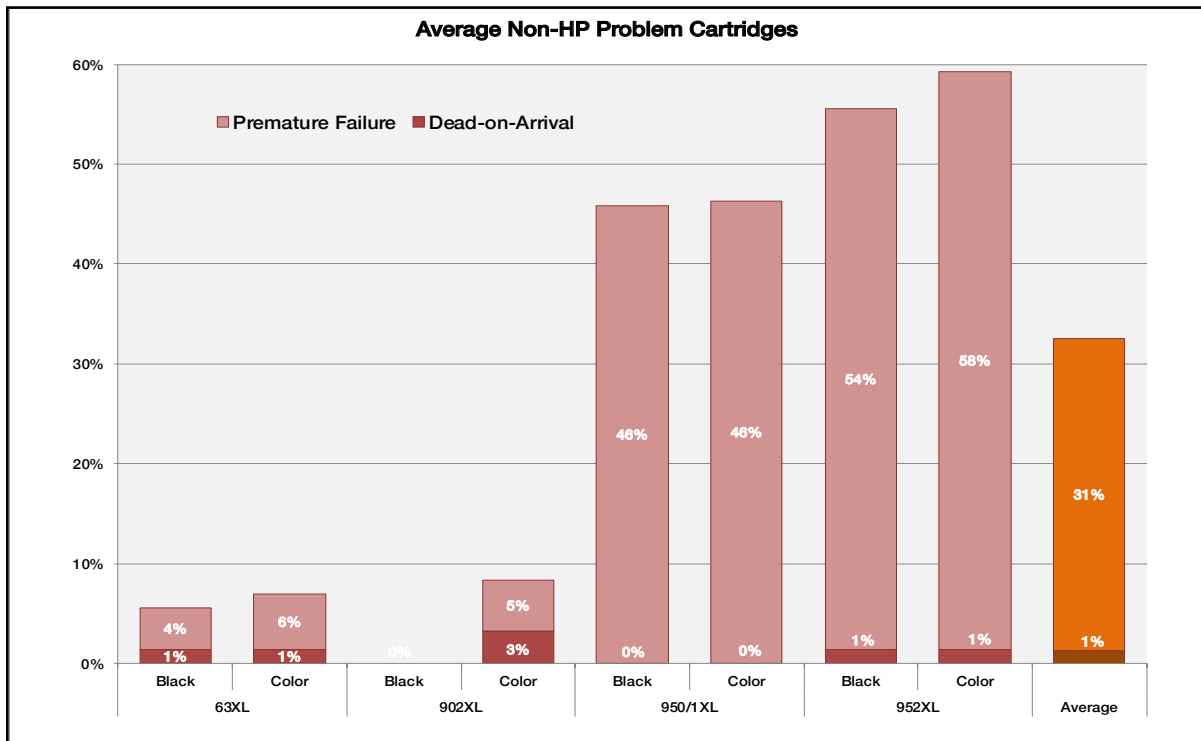
CARTRIDGE RELIABILITY

Original HP ink cartridges tested as more reliable than the non-HP tested brands; none of the original HP cartridges were deemed as Problem Cartridges (DOA or PF).

All HP cartridges completed the tests without any cartridge or printer failures.

There were no DOA or PF cartridges for original HP supplies; however, almost one-third of the non-HP Black and non-HP Color cartridges tested experienced either DOA or PF. The non-HP tested cartridges





exhibited Reliability issues before, during, and after installation.

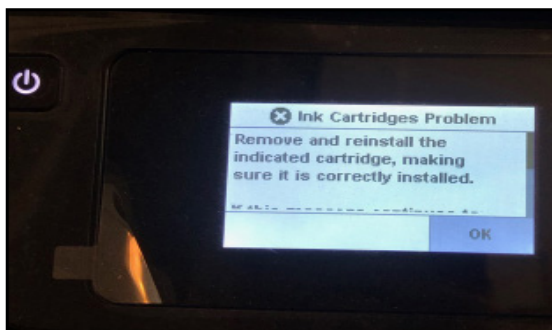
Of the 1,008 non-HP cartridges tested, 32% were deemed Problem Cartridges and were either Dead-on-Arrival (DOA), or Premature Failure (PF), both of which determined an early End-of-Life.

Thirty-one percent (31%) of the tested non-HP cartridges expired prematurely (PF), and one percent (1%) were DOA. Common causes of DOA included poor Print Quality

with defects such as streaking, color not printing, ink leakage, and incompatible cartridges not being recognized upon installation.

Premature Failure included low yield cartridges (provided less than 75% of HP stated yield for that cartridge SKU), or displayed poor print quality (such as streaking, color mix, and missing color).

The chart above shows the DOA and PF cartridge breakdown for each color and



NON-HP CARTRIDGE NOT RECOGNIZED



NON-HP CARTRIDGE INK LEAKAGE

Wasted Pages Comparison			
Cartridge Brand	Total Pages Printed	Wasted Pages	% Wasted Pages
HP	176,704	108	0.06
Non-HP	860,217	1,490	0.17
Remanufactured	434,726	1047	
Refilled	425,491	443	

SKU tested. The individual color cartridge (Cyan, Magenta, and Yellow) percentages were averaged for 902XL, 951XL, and 952XL SKUs.

WASTED PAGES

The non-HP cartridges produced 1,490 Wasted Pages (0.17% of total non-HP pages), whereas original HP ink cartridges produced only 108 Wasted Pages (0.06% of total HP pages). Out of the total non-HP wasted pages, Remanufactured ink cartridges produced 1,047 and refilled cartridges produced 443 Wasted pages.

Overall the non-HP cartridges produced over 1.8 times more Wasted Pages than HP cartridges. On average, original HP inks produced 2.8 times fewer Wasted Pages than non-HP inks tested.

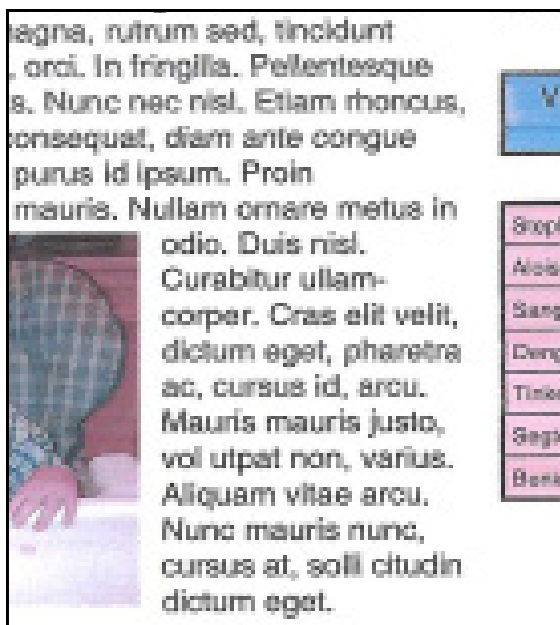
Wasted Pages include pages that display noticeably poor print quality, with defects such as streaking, color mix, ink smear, blurred characters, etc. Additional alignment pages required as a result of user interventions, and cleaning pages required as a part of a poor print quality recovery process, are also considered Waste Pages. But, not only are just pages wasted by the aforementioned issues; the user's time (and money) is also wasted.

PRINTHEAD DAMAGE

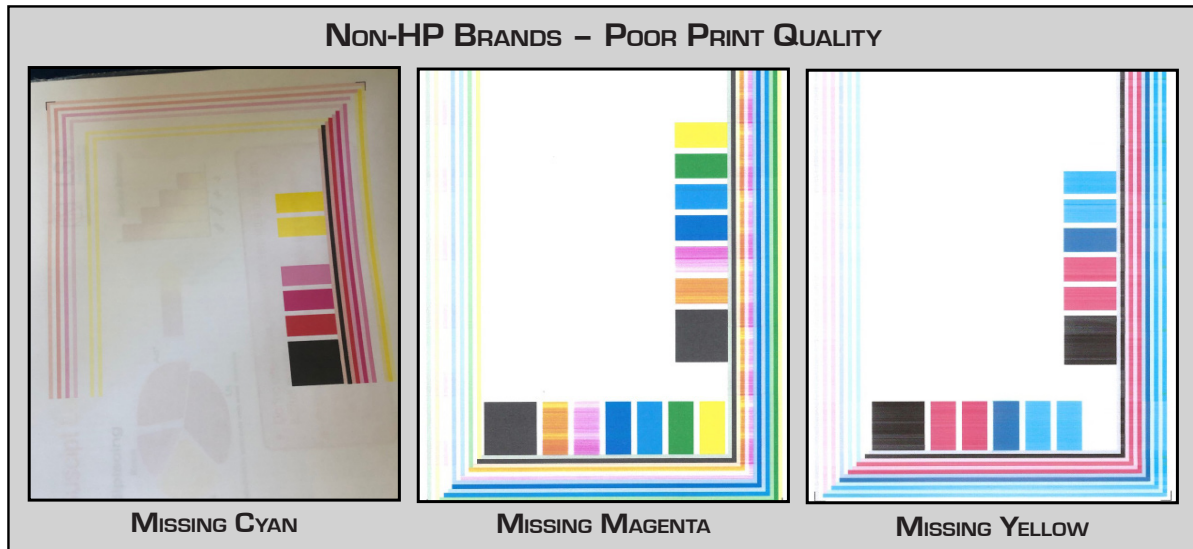
The Original HP ink cartridges did not damage any of the printheads used throughout the testing process.

CARTRIDGE DAMAGE

Some of the non-HP cartridges displayed leakage that occurred within their packaging prior to opening and some arrived with broken parts. Other non-HP cartridges were not recognized by the printer and would not function. All Original HP ink cartridges arrived in



NON-HP STREAKING AND POOR SHARPNESS



NOTE: IMAGES MAY NOT BE ACCURATELY REPRODUCED WHEN PRINTED FROM THIS REPORT.

pristine condition, with no broken parts and no leakage. All HP cartridges were recognized by the printers.

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THE *spencerLAB* DIGITAL COLOR LABORATORY

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Leading vendors and firms for whom printing is mission-critical rely upon *spencerLAB* to provide strategic support and benchmarking of Print Quality, Ink/Toner Yield and Cost-per-Print, Throughput, Availability, Reliability and Usability for ink- and toner-based as well as other printing technologies. Corporate users rely upon *spencerLAB* for guidance in print system acquisition and usage optimization.

For more information, please visit www.spencerlab.com.

APPENDIX 1: METHODOLOGY

TEST PARAMETERS

The test included original HP Inkjet cartridges, fourteen (14) non-HP brands of Remanufactured ink cartridges, and three (3) non-HP brands of Refill cartridges sold as substitutes in North America (NA). All original HP and non-HP cartridges, and all test printers were acquired by *spencerLAB* either through retail, online, or direct channels. All testing activities were conducted by *spencerLAB* DIGITAL COLOR LABORATORY trained technicians. The table below shows the various SKU and Printer combinations used for testing.

In order to obtain user-representative results, printers and cartridge SKUs from a wide range of HP’s current and older generation product portfolio were selected for testing. These printers and SKUs represent a large portion of products currently in use in the market. Since the tested cartridge SKUs are compatible with several HP printer models, the user experience reported in this study would be representative of all compatible printer models [see table in Appendix 3]. Nine (9) cartridges of original HP, and each non-HP Remanufactured and Refill brands for each cartridge SKU, were tested.

This study tested average performance of the market, not individual brand performance. The brands and providers selected are commonly available and make up a large portion of the overall market for Remanufactured and Refilled ink cartridges in North America.

To fairly represent the Refill cartridge user experience, original HP cartridges were depleted by printing to the first very low signal or first sign of fade, whichever was earlier. These depleted cartridges were then refilled at refill service provider locations. This process ensured that all cartridges tested as Refills were only refilled once. Pages printed while depleting the original HP cartridges for refilling were not included in the test. Additional spare cartridges were purchased, depleted, and refilled to accommodate the anticipated

Non-HP Brands Tested		
Cartridge World	IKONG**	Office Depot
Cartridge World Refill*	Inkredible Ink*	OfficeWorld
Clover	LD Products**	Staples TRU RED
Costco*	LEMERO	Target Up & Up
G&G	Limeink	Walmart onn.
GREENCYCLE	NAIDE**	
* refilled cartridges	** clone/imitation cartridges	No asterick are remanufactured cartridges

Cartridge Model/SKU	Cartridge Type	Test Printer
#63XL	Black	HP OfficeJet 3830 All-in-One
	Tri-Color [CMY]	
#902XL	Black	HP OfficeJet Pro 6978 All-in-One
	Cyan	
	Magenta	
	Yellow	
#950XL	Black	HP Officejet Pro 8610 All-in-One
#951XL	Cyan	
	Magenta	
	Yellow	
#952XL	Black	HP Officejet Pro 8210 Printer
	Cyan	
	Magenta	
	Yellow	

staggered timing of black and color cartridge End-of-Life, and for use as spares to continue testing when any other test cartridges experienced Premature Failure or reached End-of-Life.

Multiple printers were used to test each brand to obtain user-representative results. For those printer models with user-replaceable printheads, new printheads were installed for testing of each brand in order to avoid cross-contamination of brands.

Printing was performed in a continuous manner, with stops for paper replenishment, overnight, etc., until ink cartridges reached End-of-Life [see definition in Appendix 2]. All test supplies, such as printers, ink cartridges, and paper, were acclimated to normal office testing environment for at least 12 hours prior to testing. The ISO/IEC 24712 five-page color test suite was printed from a Windows 10 operating system using Acrobat Reader DC 20.009.20067. Test files were printed in printer default mode for plain paper, on Hammermill Copy Plus 20lb., 92 Brightness, office paper. All test printing was performed by *spencerLAB* technicians.

The HP OfficeJet 3830 printers (63XL) employ two print cartridges (black and tri-color), while the HP OfficeJet Pro 6978 printers (902XL), HP OfficeJet Pro 8610 printers (950XL/951XL) and the HP OfficeJet Pro 8210 printers (952XL) all use four print cartridges – Black (K), Cyan (C), Magenta (M), and Yellow (Y). In order to reconcile the individual color cartridge data for the 902XL, 951XL, and 952XL model individual cartridges with data of the 63XL tri-color cartridges, the overall yields of the CMY individual color cartridges were averaged together before aggregating into summary results. Additionally,

to replicate typical user experience with failed and/or defective cartridges, the defective cartridges were included in the page yield calculations reported.

A total of 126 Original HP cartridges were tested, and a total of 1,008 non-HP cartridges were tested. All sources, including remanufacturers and refillers, were located in North America.

CARTRIDGE RELIABILITY TESTING

Prior to printing, all cartridges were carefully unpacked and inspected for any ink leakage and/or broken parts; all DOAs were noted and photographed.

PRINT QUALITY ASSESSMENT

Print quality assessments were made throughout the running of all the test cartridges.

The number of Wasted Pages was calculated from the sum of the secondary cartridge alignment pages, pages printed during the printhead cleaning processes, and unusable pages due to print quality issues.

Secondary cartridge alignments are any alignments performed following the initial alignment performed upon installation of the first set of cartridges. Contrary to Original HP cartridge performance, some non-HP brands randomly suggested performing alignments during the middle of testing, and this output was considered Wasted Pages. Pages for initial alignments are not included in the Waste Page calculation because this process is printer-initiated and common across all brands.

When print quality of printed output deteriorated, exhibiting issues such as streaking, banding, fade, etc., a printhead cleaning was performed. The number of allowable cleanings per cartridge set was per ISO/IEC 24711 guidelines, which are based upon cartridge stated yield.

If the print quality of the output improved to acceptable following the cleaning process, the test continued. If the print quality remained unsatisfactory, either additional cleanings were performed (within the cleaning limit number), or cartridge was deemed to be at End-of-Life.

End-of-Life determination could be made on a number of factors, including unusable output due to streaking, fade, banding, color mix, etc.

APPENDIX 2: TEST TERMS AND DEFINITIONS

Terms	Definitions
End-of-Life, (EOL)	A condition determined by one of six mechanisms: <ol style="list-style-type: none"> 1. Fade has occurred on the diagnostic page per ISO/IEC 24711 definition. 2. Significant reduction in density in the bands or blocks per ISO/IEC 24711 definition. 3. Streak removal procedure steps have been exhausted per ISO/IEC 24711 definition. 4. Significant ink leakage occurs before or during installation or any time during printing. 5. 10 consecutive pages contain color mix. 6. Cartridge fails to print or stops printing and efforts to recover are unsuccessful.
Page Yield	The number of Usable pages measured using the ISO/IEC 24712 five-page test suite where each brand and SKU is tested on a minimum of three printers with printers operating in factory default driver settings for “Normal” printing on plain paper.
Wasted Pages, (Unusable)	The number of Wasted Pages was calculated from the sum of the secondary cartridge alignment pages, pages printed during the printhead cleaning processes, and unusable pages due to print quality issues.
Individual Cartridge Yield	Calculated by counting the number of diagnostic pages printed between cartridge installation and end of life (EOL), then multiplying by five. The diagnostic page is the last page printed in the test suite. EOL is a condition determined by one of six mechanisms defined above.
Dead on Arrival, (DOA)	DOA has occurred when one of the four mechanisms below has occurred: <ol style="list-style-type: none"> 1. Cartridge found to have substantial leakage (as defined above) at start or during testing. 2. 10 or fewer pages printed by a cartridge when end of life occurs. 3. Cartridge fails to operate upon installation. 4. Out of box failure occurs.
Premature Failure, (PF)	PF has occurred when a cartridge has a page yield of less than 75% of the HP page yield specification for that cartridge model. Included causes may be printhead or printer damage, or out of box failure.
Print Quality	A visual print quality assessment of each page printed which, based on mutually agreed PQ rating criteria, will classify all pages as being either: <ol style="list-style-type: none"> 1. Good for all uses. 2. Unusable. 3. Printhead alignment page or print quality check page used after a printhead cleaning event.
Average % More Pages	Calculated by counting the average number of Usable pages printed.
Test Page Suite	A series of five pages that are printed consecutively in order as a single job, ending with a diagnostic page, as per ISO/IEC 24712.
Fade	A significant decrease in density on the bands or blocks of the diagnostic page. This decrease in density does not have to necessarily occur completely across the page, but was determined using a comparison to the second diagnostic page generated during testing (the 10th page printed).
Streaks	Very thin lines of color, other than intended, in the bands surrounding the edge of the last page in the test suite (the diagnostic page). Streaks can appear for a number of different reasons, including thermal issues and clogged nozzles.

APPENDIX 2: TEST TERMS AND DEFINITIONS (CONTINUED)

Terms	Definitions
Color Mix	A color cartridge that cannot correctly print the Cyan, Magenta, and Yellow colors as shown on the 5th page of the test suite (the diagnostic page). This occurs when ink unintentionally mixes inside the cartridge, which causes discoloring of the ink.
Printhead Cleaning	<p>The cartridge cleaning process used to restore print quality and performance. As streaks or other defects were observed, the streak removal procedures were executed according to HP printer manual instruction. When printing with non-HP cartridges, multiple levels of cleaning were required, but if performed, were counted as one individual cleaning. Any pages printed during the cleaning process were not counted in the overall page yield. Following a cleaning procedure, an additional test suite was printed, and verified by observing the diagnostic page.</p> <p>The maximum number of cleanings per SKU was calculated based on the overall HP page yield, as per ISO/IEC 24711. EOL was determined when the allowed number of cleanings had been exhausted, and an additional cleaning was required due to print quality defects.</p>
Substantial Ink Leakage	<p>If a significant amount of ink visibly spilled on either the plastic bag or box containing the cartridge, or ink spilled over the printhead nozzles, the leakage was recorded, and the cartridge was determined to be DOA.</p> <p>If a significant amount of ink spilled during the refilling process, leakage was recorded, and the cartridge was determined to be DOA.</p> <p>If a significant amount of ink leaked inside of the printer during testing, and caused a substantial visible defect on the printed pages, EOL was determined based on cartridge leakage. If the defect was not substantial enough to consider the printed pages Unusable, testing continued, and the defect was monitored and recorded.</p>

APPENDIX 3: COMPATIBLE PRINTERS

HP 63XL	HP 902XL	HP 950XL/951XL	HP 952XL
HP Deskjet 1110	HP OfficeJet 6951	HP OfficeJet Pro 251dw	HP OfficeJet Pro 7720
HP Deskjet 1112	HP OfficeJet 6954	HP OfficeJet Pro 251dw mfp	HP OfficeJet Pro 7730
HP Deskjet 2130	HP OfficeJet 6962	HP OfficeJet Pro 8100	HP OfficeJet Pro 7740
HP Deskjet 2132	HP OfficeJet Pro 6961	HP OfficeJet Pro 8600	HP OfficeJet Pro 7745
HP Deskjet 3630	HP OfficeJet Pro 6963	HP OfficeJet Pro 8600 plus	HP OfficeJet Pro 8210
HP Deskjet 3632	HP OfficeJet Pro 6966	HP OfficeJet Pro 8600 premium	HP OfficeJet Pro 8216
HP Deskjet 3633	HP OfficeJet Pro 6968	HP OfficeJet Pro 8610	HP OfficeJet Pro 8710
HP Deskjet 3637	HP OfficeJet Pro 6970	HP OfficeJet Pro 8620	HP OfficeJet Pro 8720
HP ENVY 4512	HP OfficeJet Pro 6971	HP OfficeJet Pro 8630	
HP ENVY 4520			
HP ENVY 4522			
HP ENVY 4523			
HP ENVY 4524			
HP Officejet 3830			
HP Officejet 3831			

APPENDIX 4: CONCLUSION

HP Ink Outperforms Third-Party Inks			
Page Count	Reliability	Wasted Pages	Printer Damage
<ul style="list-style-type: none"> • Non-HP inks tested printed fewer than 64% the pages – on average – than tested Original HP ink cartridges. • Original HP ink cartridges printed more than 1.6x the pages – on average – than non-HP inks tested. • Original HP ink cartridges printed 57% more pages - on average - than non-HP inks tested. 	<ul style="list-style-type: none"> • Nearly 1/3 (32%) of tested non-HP inks failed on average either during use or right out of the box. • Original HP ink cartridges tested worked every time. 	<ul style="list-style-type: none"> • Non-HP inks tested produced over 1.8x more wasted pages – on average – than Original HP ink cartridges. • Original HP inks produced 2.8 times fewer wasted pages – on average – than non-HP inks tested. 	<ul style="list-style-type: none"> • 100% of tested printheads using Original HP inks were undamaged - saving time and money vs. non-HP inks.