TEST REPORT

spencerLAB DIGITAL COLOR LABORATORY

Competitive Ink Comparison Study – EMEA Region

Original HP InkJet vs. Non-HP InkJet Cartridges

The *spencerLAB* DIGITAL COLOR LABORATORY has conducted cartridge reliability comparison testing of original HP Inc. [HP] inkjet cartridges, eighteen (18) non-HP brands, including twelve (12) Remanufactured cartridge brands and six (6) Clone brands; and two (2) non-HP brands of Refill retailers in the EMEA region. The study included testing of HP #304XL, #364XL, #903XL, and #953XL cartridge SKUs. Cartridges were sourced in France, Germany, Italy, Poland, Russia, and the United Kingdom.

The non-HP brands included Remanufactured and Clone cartridges from: ActiveJet, Cactus, Cartridge World, GPC Image, Jarbo, Kingway, LCL, LEMERO, LxTek, Mony, MyCartridge, Office World, HQ-Patronen, Printing Pleasure, ToMaxIm, Toner Kingdom, Vilaxh, and ZIPRINT; Refilled cartridges from retailers: Arici and Druckertankstelle Shoppe.

Nine (9) cartridges for each brand and SKU were allocated for testing to obtain representative results. A total of 1,386 cartridges were run on 28 printers, entailing over 2,400 testing hours, in which a total of 1,189,920 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 almost 49% more pages on average, or greater than 1.5 times more pages, than non-HP tested cartridges.[1]
- Original HP ink cartridges tested showed no Problem Cartridges, whereas 28% of non-HP ink cartridges tested exhibited Dead-on-Arrival or Premature Failure on average.
- Non-HP ink cartridges produced 115% more Wasted Pages on average than Original HP ink cartridges.

[1]SpencerLab Sept 2021 study of printer inks sold in the EMEA region commissioned by HP for on-average performance of 20 brands of non-HP refill, remanufactured, and imitation cartridges vs. Original HP ink SKUs 304XL, 364XL, 903XL, 953XL. 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-EMEA-2021.pdf.

Page Yield Comparison		
Cartridge Brand	Number of Cartridges Tested	Average Percentage More Pages Printed by HP Cartridges
HP	**126**	**49%**
Non-HP	**1260**	
Reman	792	29%
Imitation/Clone	360	61%
Refill	108	546%

Test Results

Page Yield

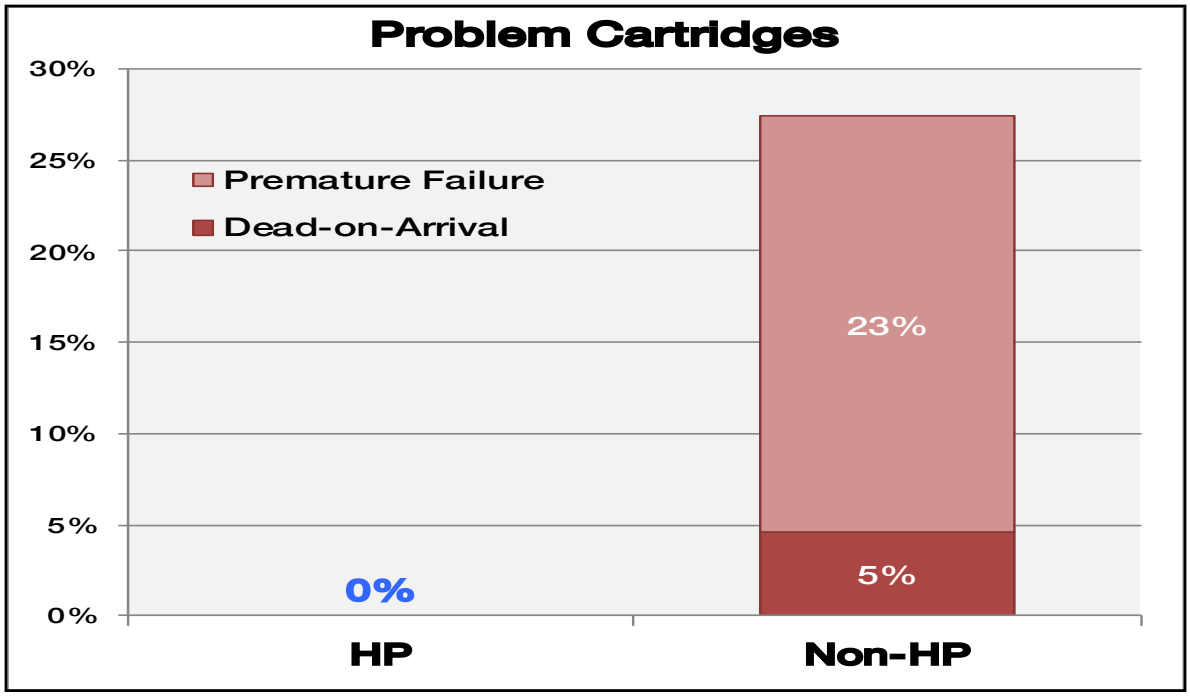
Testing concluded that the Original HP cartridges produced an average of almost 49% more pages than the non-HP cartridges tested. The tested non-HP ink printed (on average) 33% fewer pages than Original HP ink cartridges tested.

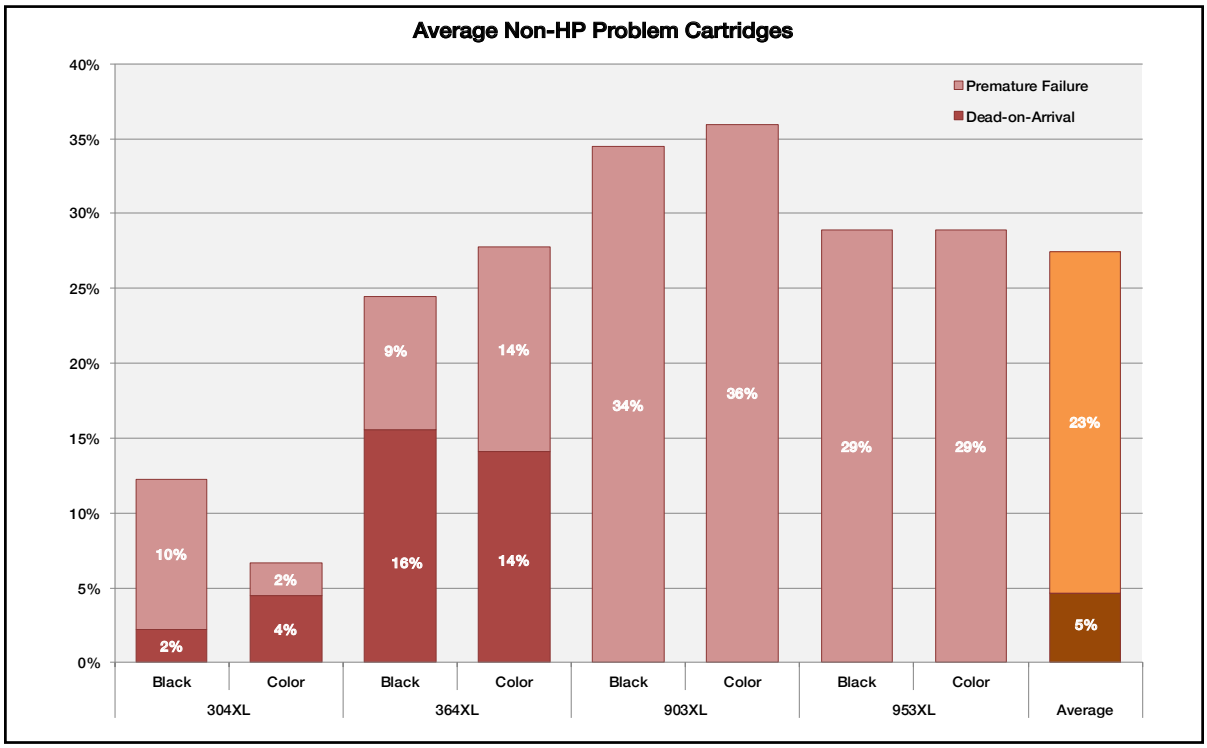
A total of 126 original HP cartridges and 1,260 non-HP cartridges, including Remanufactured, Clone, and Refilled, were tested. Black and Color cartridge yields were combined to determine an overall average. The yields of individual CMY color cartridges (Cyan, Magenta, and Yellow) were averaged to calculate an average Color yield for 364XL, 903XL, and 953XL 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 (28%) 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 1,260 non-HP cartridges tested, 28% were deemed Problem Cartridges and were either Dead-on-Arrival (DOA), or Premature Failure (PF), both of which determined an early End-of-Life.

Twenty-three percent (23%) of the tested non-HP cartridges expired prematurely (PF), and five percent (5%) 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),

NON-HP CARTRIDGE CAUSED CARRIAGE JAMS

NON-HP CARTRIDGE INK LEAKAGE

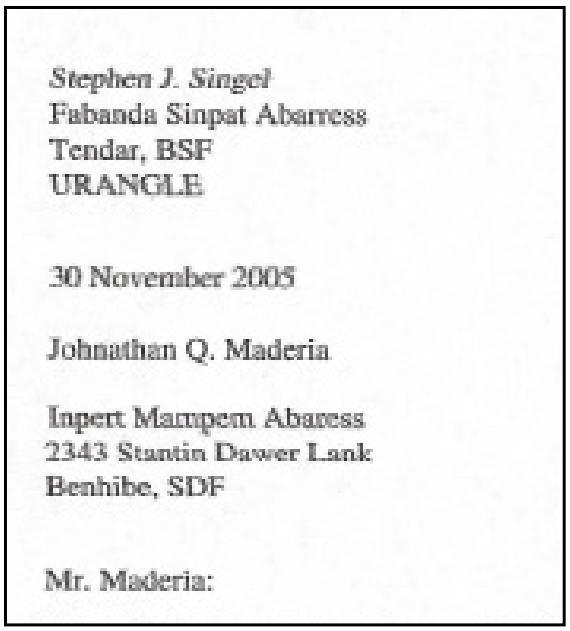
Wasted Pages Comparison			
Cartridge Brand	Total Pages Printed	Wasted Pages	% Wasted Pages
HP	**156,565**	**81**	**0.05**
Non-HP	**1,033,355**	**1,151**	**0.11**
Remanufactured	747,368	920	.12
Clone	271,117	191	.07
Refilled	14,870	40	.27

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 SKU tested. The individual color cartridge (Cyan, Magenta, and Yellow) percentages were averaged for 364XL, 903XL, and 953XL SKUs.

Wasted Pages

The non-HP cartridges produced 1,151 Wasted Pages (0.11% of total non-HP pages), whereas original HP ink cartridges produced only 81 Wasted Pages (0.05% of total HP pages). Out of the total non-HP wasted pages, Remanufactured ink cartridges produced 920, Clones produced 191, and Refilled cartridges produced 40 Wasted pages. Overall the non-HP cartridges produced 115% more Wasted Pages than HP cartridges. On average, original HP inks produced 53% fewer Wasted Pages than non-HP inks tested.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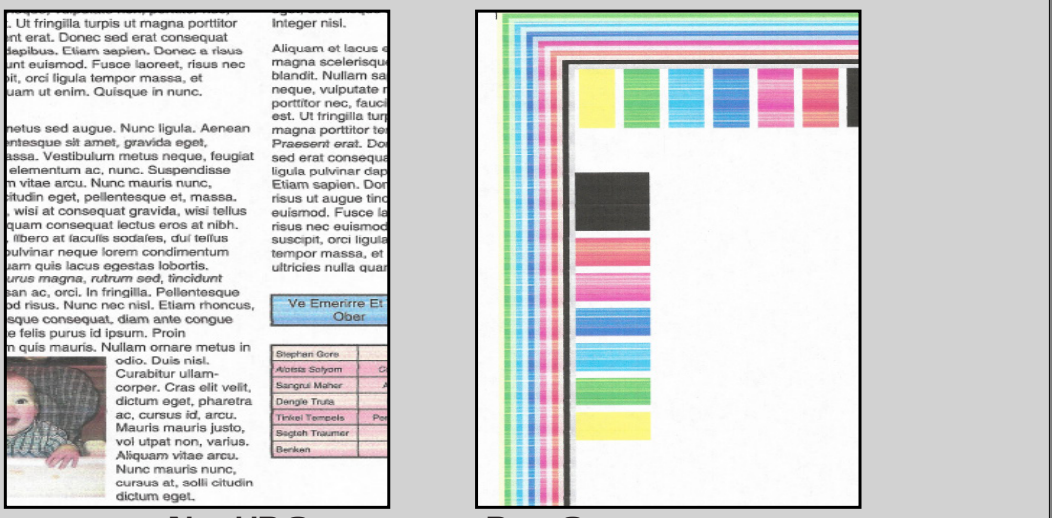
Non-HP Poor Sharpness

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, whereas,



NON-HP STREAKING AND POOR SHARPNESS

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

23% (6 out of 26) of semi-permanent printheads[2] used were damaged by non-HP inks.

CARTRIDGE DAMAGE

Some of the non-HP cartridges displayed leakage that occurred within their packaging prior to opening. Other non-HP cartridges were not recognized by the printer when inserted and would not function. Other non-HP cartridges caused multiple printhead jams. All Original HP ink cartridges arrived in pristine condition, with no broken parts and no leakage. All HP cartridges were recognized by the printers and performed without any issues.

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[2] Of the 26 semi-permanent printheads in individual ink cartridge systems tested SKUs (903XL, 364XL, 953XL), 6 printhead failures were observed. Integrated printhead cartridge system not included.

The *spencerLAB* Digital Color Laboratory

Through more than three decades of industry service, Spencer & Associates Publishing, Ltd. has earned a premier reputation for its expertise in evaluating digital color imaging and printing. Its independent test division, the *spencerLAB* digital color laboratory, is internationally recognized as a leader in unbiased, third-party research and comparative analysis of digital imaging and printing system performance; the laboratory strictly adheres to the integrity of its methodology, even in commissioned studies. *SpencerLAB* provides leadership in quantitative and qualitative comparisons, benchmarking key performance metrics of digital printing systems in all technology classes, from desktop printers to digital color presses – providing research and evaluation services, compliance certifications, benchmark test software/hardware, and focus group management.

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.

Non-HP Brands Tested		
ActiveJet	Jarbo	MyCart
Arici*	Kingway**	Office World**
Cactus**	LCL	Printing Pleasure**
Cartridge World*	LEMERO	Toner Kingdom
Druckertankstelle Refill Shop*	Lxtek**	Vilaxh
GPC**	ToMax	Ziprint
HQ Patronen	Mony	
* refilled cartridges	** clone/imitation cartridges	No asterick are remanufactured cartridges

Cartridge Model/SKU	Cartridge Type	Test Printer
#304XL	Black	HP DeskJet 3720
	Tri-Color (CMY)	
#364XL	Black	HP OfficeJet Pro 5515
	Cyan	
	Magenta	
	Yellow	
#903XL		HP OfficeJet 6950
	Cyan	
	Magenta	
	Yellow	
#953XL	Black	HP Officejet Pro 8218 Printer
	Cyan	
	Magenta	
	Yellow	

Appendix 1: Methodology

Test Parameters

The test included original HP Inkjet cartridges and eighteen (18) non-HP brands of ink cartridges, including twelve (12) Remanufactured brand, six (6) Clone brands, and two (2) Refill brand cartridges sold as substitutes in the EMEA region. 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 above 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, Clone, 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, Clone, and Refilled ink cartridges in EMEA.

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 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 (environmental conditions

specified in ISO/IEC 24711). 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 DeskJet 3720 printers (304XL) employ two print cartridges (black and tri-color), while the HP Pro P5515 printers (364XL), HP OfficeJet 6950 printers (903XL) and the HP OfficeJet Pro 8218 printers (953XL) 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 364XL, 903XL, and 953XL model individual cartridges with data of the 304XL 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 1,260 non-HP cartridges were tested. All sources, including remanufacturers and refillers, were located within EMEA region countries.

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: 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: 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: 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	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. 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.
Substantial Ink Leakage	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. If a significant amount of ink spilled during the refilling process, leakage was recorded, and the cartridge was determined to be DOA. 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.

Appendix 3: Compatible Printers

HP 304XL	HP 364XL	HP 903XL	HP 953XL
HP Deskjet 2630	HP Deskjet 3070A	HP OfficeJet 6950	HP OfficeJet Pro 8210
HP Deskjet 3720	HP Deskjet 3520	HP OfficeJet 6960	HP OfficeJet Pro 8218
HP Deskjet 3721	HP OfficeJet 4620	HP OfficeJet 6970	HP OfficeJet Pro 8710 AiO
HP Deskjet 3730	HP OfficeJet 4622		HP OfficeJet Pro 8715 AiO
HP Deskjet 3732	HP OfficeJet 4622		HP OfficeJet Pro 8716 AiO
HP Deskjet 3735	HP Photosmart 5510		HP OfficeJet Pro 8718 AiO
HP Deskjet 3750	HP Photosmart 5515		HP OfficeJet Pro 8719 AiO
HP Deskjet 3752	HP Photosmart 5520		HP OfficeJet Pro 8725 AiO
HP Deskjet 3760	HP Photosmart 5525		HP OfficeJet Pro 8728 AiO
HP ENVY 5020	HP Photosmart 6510		
HP ENVY 5030	HP Photosmart 6520		
HP ENVY 5032	HP Photosmart 7510		
	HP Photosmart 7520		
	HP Photosmart B8550		
	HP Photosmart C5324		
	HP Photosmart C5380		
	HP Photosmart C6324		
	HP Photosmart C6380		
	HP Photosmart D5460		

Appendix 4: Conclusion

HP Ink Outperforms Third-Party Inks			
Page Count	**Reliability**	**Wasted Pages**	**Printer Damage**
• Non-HP inks tested printed fewer than 33% the pages – on average – than tested Original HP ink cartridges, including 38% less pages on average by clone inks tested, 85% less pages on average by refill inks tested, and 22% less pages on average by remanufactured inks tested. • Original HP ink cartridges printed almost 49% more pages - on average - than non-HP inks tested, including: 61% more than clones tested, almost 546% more than refills tested, and almost 29% more than remanufacutred inks tested.	• Over 1/4 (28%) of tested non-HP inks had reliability problems; 23% expired prematurely and nearly 5% failed out of the box: • 23% of Non-HP clone inks tested had reliability problems, with 21% expired prematurely and 3% failed out of the box. • 77% of Non-HP refill inks tested had premature failure reliability problems. • 23% of Non-HP remanufactured inks tested had reliability problems, with 17% expired prematurely and 6% failed out of the box. • Original HP ink cartridges tested worked every time.	• Original HP ink cartridges tested had 53% less wasted pages on average than Non-HP inks - which can save you time and money. • Non-HP inks tested had 115% more wasted pages on average than Orignal HP inks - which can cost you time and money. • Imitation inks tested had 36% more wasted pages on average than Original HP inks tested. • Refill inks tested had almost 420% more wasted pages on average than Original HP inks tested. • Remanufactured inks tested had almost 138% more wasted pages than Original HP inks tested.	• Original HP ink cartridges tested did not cause any printhead nor printer damage. • 23% of printheads were damaged by non-HP tested inks, including 15% by non-HP clone inks and 8% non-HP remanufactured inks[2].

[2] Of the 26 semi-permanent printheads in individual ink cartridge systems tested SKUs (903XL, 364XL, 953XL), 6 printhead failures were observed. Integrated printhead cartridge system not included.