

## Color Cartridge Reliability Comparison Study – 2023

### *Original HP LaserJet Toner Cartridges vs. HP EvoCycle Toner Cartridges*

The *spencerLAB* DIGITAL COLOR LABORATORY has conducted a cartridge reliability comparison testing of Original HP LaserJet and HP EvoCycle branded color toner cartridges.

The test included the HP 410X series Black, Cyan, Yellow, and Magenta set of cartridges for the HP LASERJET Pro M452dn color printer; and the HP 414X series Black, Cyan, Yellow, and Magenta set of cartridges for the HP LASERJET Pro M454dn color printer.

Analysis compared the Reliability, Print Quality (PQ), and Color Fidelity throughout the life of the toner cartridges tested for each model. Cartridge Reliability factors, such as Dead-on-Arrival (DOA), Premature Failure (PF), and Low Quality (LQ) cartridges [see definitions in Appendix 3] were evaluated to determine the total number of Problem Cartridges, if any. Print samples and color test charts were collected from each cartridge model at regular intervals over the life of each cartridge set. Print samples were sorted using a Print Quality acceptance scale generated from a psychometric research study. The four PQ levels were – External Use (all uses including distribution outside the company), Internal Use (distribution inside company), Individual Use, and Unusable. The color test charts were measured to evaluate Color Fidelity.

#### **KEY FINDINGS**

- The tested HP EvoCycle color toner cartridges performed comparatively equivalent to the tested Original HP cartridges in Reliability and Print Quality.
- Testing of both the Original HP color toner cartridges and the HP EvoCycle color cartridges yielded no Problem Cartridges.
- Original HP color cartridges produced 100% External Use Print Quality samples; the HP EvoCycle had a slightly smaller percentage at 98.1% External Use Print Quality samples.

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.

## TEST RESULTS

### CARTRIDGE RELIABILITY

Tested HP EvoCycle toner cartridges were equally reliable as the tested Original HP cartridges. None of the Original HP or HP EvoCycle cartridges were deemed Problem Cartridges; there were no Dead-on-Arrivals, no Premature Failures, and no Low Quality cartridges.

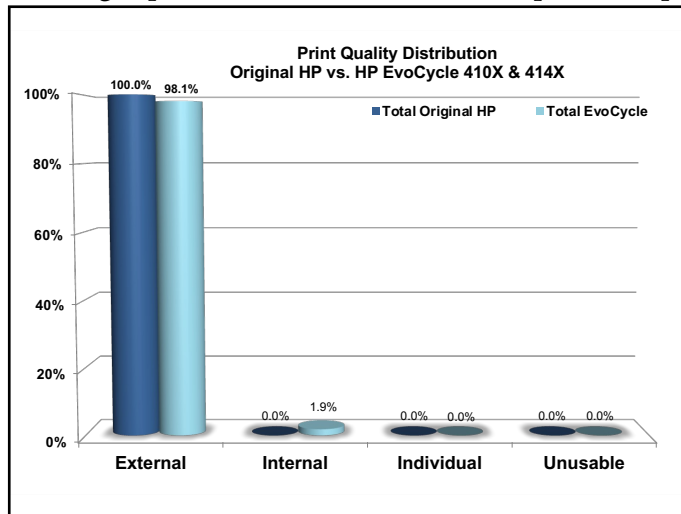
This superior cartridge reliability is critical as it can decrease downtime and increase user productivity. With providing more consistent quality results, the overall cost of printing can lessen due to the lack of having to replace supplies or reprint output.

Both HP EvoCycle and Original HP cartridges performed with superior reliability.

Problem Cartridges and Print Quality Problems				
Cartridge Brand	Problem Cartridges			PQ Problems
	Dead on Arrival	Premature Failure	Total	Interventions
Original HP	0%	0%	0%	0%
HP EvoCycle	0%	0%	0%	0%

### PRINT QUALITY DISTRIBUTION

Original HP cartridges produced just a marginally greater number of pages with higher Print Quality (PQ) than the HP EvoCycle cartridges tested. Tested Original HP cartridges produced a total of 100% of print samples categorized as for External Use. The



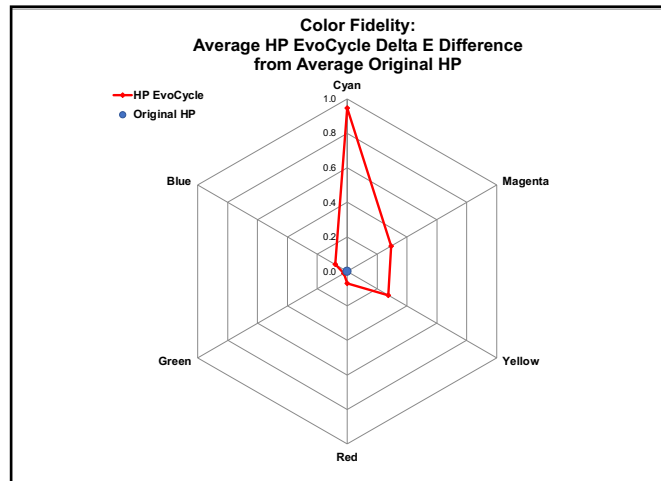
HP EvoCycle cartridges produced 98.1% of pages that were good for External Use.

Original HP cartridges produced no pages deemed as Internal, Individual, or Unusable; HP EvoCycle produced just 1.9% pages Internal Use pages, and no Unusable nor Individual Use pages.

## COLOR FIDELITY

The HP EvoCycle cartridges rendered overall equivalent accurate colors when compared to the colors produced by the Original HP color cartridges, that were used as the benchmark.

The average color difference (delta E) between color values printed by Original HP and HP EvoCycle color cartridges for each of six color patches is shown in the adjacent spider chart.



The HP EvoCycle cartridges showed an average of 0.28 delta E (dE) on six color patches (Red, Green, Blue, Cyan, Magenta, and Yellow). The greatest difference from the Original HP average was noted on HP EvoCycle color Cyan with an average of 0.95 dE. It should be noted that a dE of less than 1.0 is imperceptible to the human eye.

## THE *spencerLAB* DIGITAL COLOR LABORATORY

Through over thirty years 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](http://www.spencerlab.com).

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## APPENDIX 1: METHODOLOGY

### TEST PARAMETERS

The test included Original HP and HP EvoCycle CF410X (Black), CF411X (Cyan), CF412X (Yellow), and CF413X (Magenta) color cartridges for use with the HP LASERJET Pro M452dn color printer; and 414X Black (W2020X), 414X Cyan (W2021X), 414X Yellow (W2022), and 414X Magenta (W2023) color cartridges for use with the HP LASERJET Pro M454dn color printer.

The Original HP cartridges and all printers were procured by *spencerLAB* within the United States; the HP EvoCycle SKUs were in pre-production, and therefore provided to *spencerLAB* by HP. A total of three complete cartridge sets were tested for each brand and SKU, for a total of 48 cartridges.

At test start, test cartridges were installed in a test printer; this set of four color cartridges (CMYK) was considered a Cartridge Set. Additional spare cartridges were purchased and used to offset any differences in individual color cartridge page yields in order to accommodate the running of complete Cartridge sets.



A six-page PDF suite, comprised of five Print Quality files and the TC9.18 RGB patch target file [see Page 4], were printed from a Windows 10 operating system using Acrobat Reader DC 2022.003.20322. Test files were printed in default mode for plain paper, using the latest printer drivers available from HP's website, on Hammermill Fore Multi-Purpose 20lb., 96 Brightness, office paper. All test printing was performed by *spencerLAB*.

All test supplies, including printers, toner cartridges, and paper, were acclimated to office ambient temperature and humidity for at least twelve hours prior to testing. Printing was performed in a semi-continuous manner, with stops for paper replenishment, overnight, etc., until toner cartridges reached the end-of-test. End-of-Test is defined as printer notification of 'Toner Very Low', indicating that a cartridge is at the estimated end of its useful life, degradation of Print Quality of any one page of the five Print Quality files to Unusable [see Appendix 2], or other conditions noted in Appendix 3.

### **CARTRIDGE RELIABILITY TESTING**

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

### **PRINT QUALITY ASSESSMENT**

Overall Print Quality was evaluated on a total of eighty print samples from each cartridge set. Samples were collected from sixteen five-page suites collected at equally dispersed intervals over the life of each cartridge set, for a total of four hundred eighty print samples from each of the two SKU models.

Using the psychometric Print Quality acceptance scale, *spencerLAB* evaluators independently assessed and graded the overall Print Quality of each of the samples by categorizing them into one of four Print Quality levels: External Use, Internal Use, Individual Use, and Unusable. The Print Quality level of each print sample was determined with any defects noted.

As a part of evaluator training, the Print Quality evaluators graded a set of twenty print samples, three times each. Consistency of grading was measured among the evaluators, as well as among each evaluators' three grades for a sample. This exercise was repeated until all evaluators had acceptable consistency in grading among each other and among their three trials per sample. During evaluation of the test print samples, the Print Quality assessment by evaluators was continuously monitored to ensure consistency. Each evaluation session lasted one hour with a thirty minute break between sessions.

The Print Quality scale samples, determined during psychometric testing, were mounted in front of evaluator workstations for reference. Print Quality evaluation was performed in a neutral environment with uniform lighting.

### **COLOR FIDELITY ANALYSIS**

The TC9.18 RGB target file was printed along with the five-page Print Quality files. The printed patch file output was measured using a Techkon SpectroDens Premium spectrophotometer at D50/2°. The CIELAB measurements ( $L^* a^* b^*$ ) of each color patch were averaged over the life of the cartridge, from beginning to end-of-test, for each model cartridge.

HP EvoCycle cartridge patch file measurements were then evaluated against Original HP cartridge values for Color Fidelity analysis. With Original HP cartridge average  $L^* a^* b^*$  values as reference, the overall color difference (delta E 1976), was calculated for six color patches – Cyan, Magenta, Yellow, Red, Green, and Blue.

## APPENDIX 2: PSYCHOMETRIC STUDY – PRINT QUALITY SCALE

A psychometric study of color office printing users was conducted by *spencerLAB* in the greater New York City area (Hicksville, New York), to establish a Print Quality acceptance scale. Participants who printed color documents for personal, internal, and external use, were recruited from a range of professions and business sizes, from micro business (1-49 employees) to enterprise business (> 500 employees). A total of thirty-three business printing users participated in the exercise.

### TEST SUITE

*SpencerLAB* collaborated with HP to design a representative business-user test suite. *SpencerLAB* then utilized the test suite pages to simulate common Print Quality defects such as banding, streaks, dark and light density, color shifts, ghosting, etc. A total of fifteen test sets were created and each test set had a range of twelve variations (based on severity of defect) for a single defect type.

Test sets were printed on an HP LASERJET Enterprise 500 color Printer M551n using Windows 7 operating system. Test samples were printed in printer default mode for plain paper on Hammermill Fore MP 20lb., 96 Brightness, plain office paper. All printing was performed by *spencerLAB* and test sets were reviewed by *spencerLAB* to ensure that the test samples were rendered as intended.

### BUSINESS USER FOCUS GROUPS

The focus group participants judged fifteen sets of print samples and sorted the samples into four Print Quality levels based on their acceptance level of Print Quality. The test samples were rated in a neutral environment with uniform lighting and no external lights.

Participants sorted all the test samples into four Print Quality acceptance levels:

- External Use – acceptable for all uses, including distribution outside a company to customers, vendors, etc.
- Internal Use – acceptable for distribution inside a company, but not acceptable for distribution outside a company
- Individual Use – usable as a copy to read, file, or mark-up in the office, but not acceptable for distribution, either within or outside a company
- Unusable – not acceptable for any business purpose

*SpencerLAB* used proprietary sorting and analysis algorithms to calculate the average Print Quality rating of each sample for each test set. The resulting score was used to determine the rank order of samples in each test set.

## APPENDIX 3: TEST TERMS AND DEFINITIONS

Terms		Definitions
<b>End-of-Test</b>		<p>Determined by one of four mechanisms:</p> <ol style="list-style-type: none"> <li>1. Cartridge is Dead on Arrival.</li> <li>2. Cartridge stops printing and efforts to recover are unsuccessful.</li> <li>3. Degradation of Print Quality to unacceptable (Unusable) for any one of the Test Suite pages.</li> <li>4. Upon 'Toner Very Low' printer notification indicating that a cartridge is at the estimated end of its useful life.</li> </ol>
<b>Dead-on-Arrival, (DOA)</b>		<p>A condition determined by one of four mechanisms:</p> <ol style="list-style-type: none"> <li>1. A cartridge that has at least 50% of the handling surface covered in leaked toner, before or during the installation process and/or toner visibly spilled in the plastic bag containing the cartridge and/or on the exterior of the cartridge.</li> <li>2. A cartridge that within the first Test Suite has at least one PQ page categorized as Individual Use or Unusable, and does not improve during the recovery process. <ul style="list-style-type: none"> <li>• Recovery process requires following the printer manual instructions for correction of the noted defect, or if the defect is not addressed in the manual, the first attempt to recover shall be to remove the cartridge and perform a shake procedure. Following this recovery process, another Test Suite shall be printed and evaluated. If at least one PQ page is categorized as Individual Use or Unusable, a second recovery attempt of printing a cleaning page, if available, shall be performed. Following the second recovery procedure, another Test Suite shall be printed and pages evaluated for categorization. If at least one PQ page is categorized as Individual Use or Unusable following this recovery process, the cartridge is DOA.</li> </ul> </li> <li>3. Cartridge is broken or missing parts.</li> <li>4. Cartridge fails to operate upon installation and does not recover upon removing the cartridge and re-installation.</li> </ol>
<b>Premature Failure, (PF)</b>		A cartridge with a page count of less than 80% of the average page count for all Original HP toner cartridges of that model that were not DOA, unless other cartridge SKU stated yield differs from Original HP stated yield.
<b>Low Quality, (LQ)</b>		A cartridge with 50% or more pages categorized as Limited Use, but was not DOA or PF.
<b>Problem Cartridges</b>		Cartridges categorized as either DOA, PF, or LQ.
<b>Limited Use</b>		Sample pages with PQ categorized as either Internal Use, Individual Use, or Unusable.
<b>Print Quality Levels</b>	<b>External Use</b>	Acceptable for all uses, including distribution outside a company to customers, vendors, suppliers, etc. Examples: marketing materials to promote the company or products, official company correspondence, invoices.
	<b>Internal Use</b>	Acceptable for distribution inside a company, but not acceptable distribution outside a company. Examples: documents to distribute to colleagues, immediate superiors or subordinates as business communication.
	<b>Individual Use</b>	Usable as a copy to read, file, or mark-up in the office, but not acceptable for distribution, either within or outside a company.
	<b>Unusable</b>	Not acceptable for any business purpose.
<b>Usable Pages</b>		Pages that were acceptable for any use, and not deemed Unusable.



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