QualityLogic®
Putting Technology to the Test

Test Report

Reliability Comparison Study

HP LaserJet Print Cartridges vs. Asia Pacific Refilled Toner Cartridges

April 2010
(Updated October 2010)

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Executive Summary

In April 2010, QualityLogic completed a study for Hewlett-Packard (HP) designed to test the print quality, cartridge reliability, optical density and toner adhesion of HP LaserJet print cartridges for the HP LaserJet M1319f and P1008 printers, HP 12A and 88A, compared to a sample of refilled toner cartridges from refill vendors in Shanghai, China and New Delhi, India.

Printing was performed in a controlled environment using a suite of pages jointly developed by HP and QualityLogic.

The results of the study show that HP print cartridges clearly outperformed the refilled toner cartridges in all areas of the study.

Cartridge Reliability

When combining all problem categories, HP print cartridges exhibited no reliability failures in the study, compared to an average of 63.8% for the refilled toner cartridges tested. Of the refilled toner cartridges tested, 11.3% were Dead on Arrival and 52.5% were Low Quality. (See Appendix 3 for study definitions.)

Page Quality Distribution

HP print cartridges printed an average of 95.3% of sample pages categorized as acceptable for all uses, compared to 37.2% for the refilled toner cartridges tested.

Optical Density

The optical density measurements for the refilled toner cartridges tested were an average of 28.8% lighter for the light grey patch, 25.3% lighter for the dark grey patch, and 9.8% lighter for the black patch compared to the average of the HP print cartridges tested.

Toner Adhesion

The optical density measurements for the refilled toner cartridges tested were an average of 34.2% lighter (6.3X the HP test result) after the Toner Adhesion test, compared to an average of 5.4% lighter for the HP print cartridges tested.

Test Overview

Cartridge Reliability

Cartridges were classified Low Quality (LQ) or Dead on Arrival (DOA) based on the number and quality of the pages printed. The LQ and DOA cartridges from all refilled toner cartridges tested were combined to create the total Problem Cartridge percentage. (See Appendix 3 for definitions.)

Page Quality Distribution

Cartridge page quality distribution was determined by inspecting a sample of pages taken at periodic intervals over the lifespan of each cartridge. To create a page quality scale calibrated to actual business laser printing user behavior, QualityLogic conducted a psychometric study. An independent market research organization recruited a demographic cross-section of laser printing users. Study participants provided input on the page quality levels appropriate for certain uses. The study data was used to create a scale. QualityLogic page inspectors used the scale to sort sampled pages into the following categories:

- All uses, including external distribution
- Limited use: Not for external distribution
- Limited use: Not for distribution
- Unusable

The results for cartridges tested were combined to create the overall percentage of pages for each category. (See Appendices 1 & 2 for additional information on the psychometric and test methodologies.)

Optical Density

Optical density was determined by taking optical density measurements on three separate patches (light grey, dark grey and black) on each of the presentation slide sample pages in the study. Optical density measurements from each sample page were compared to the average HP measurements for the same patch to calculate the percentage of difference between the two patches. The percentage of difference for all sample pages printed by refilled toner cartridges were combined for each of the three patches to create the overall study results.

Toner Adhesion

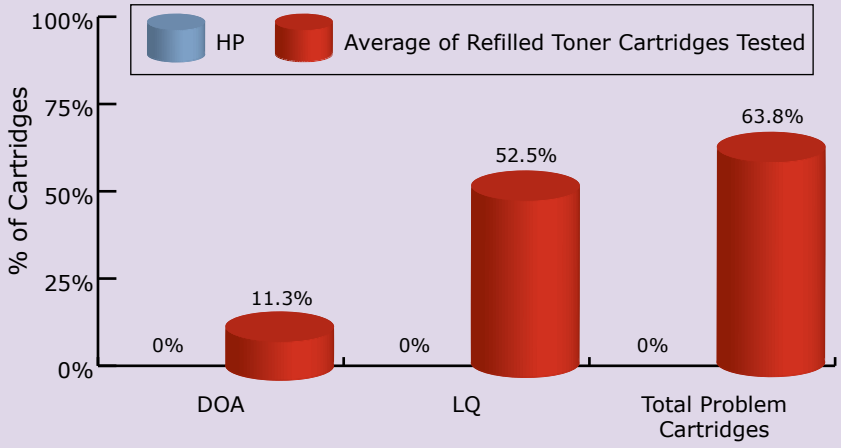
Toner adhesion was determined by performing a series of optical density measurements, before and after the toner adhesion test, using the black test patch for each of the presentation slide sample pages in the study. The change in optical density before and after the test was calculated as the percentage of difference for each sample. The percentage of difference from each sample was then combined into an average overall result for HP and for the refilled toner cartridges tested.

Detailed Results

Cartridge Reliability

When combining all problem categories, HP print cartridges exhibited no failures in the study, compared to an average of 63.8% for all refilled toner cartridges tested.

HP vs. Refilled Cartridges - Cartridge Reliability



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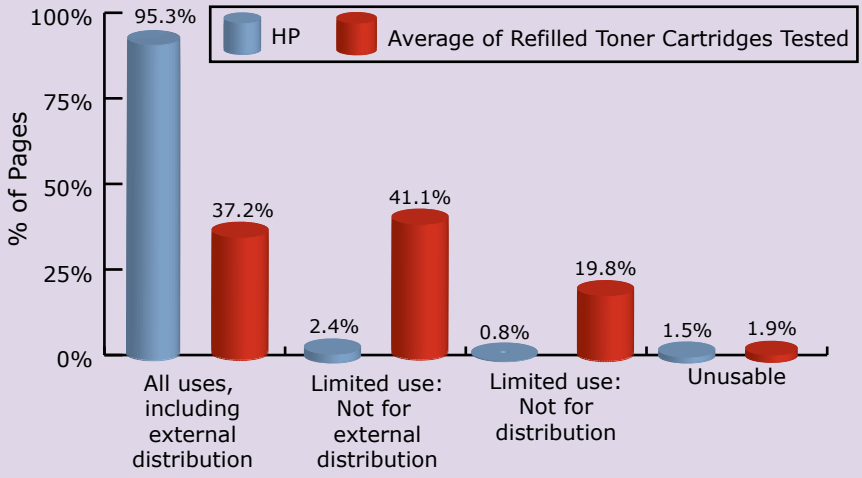
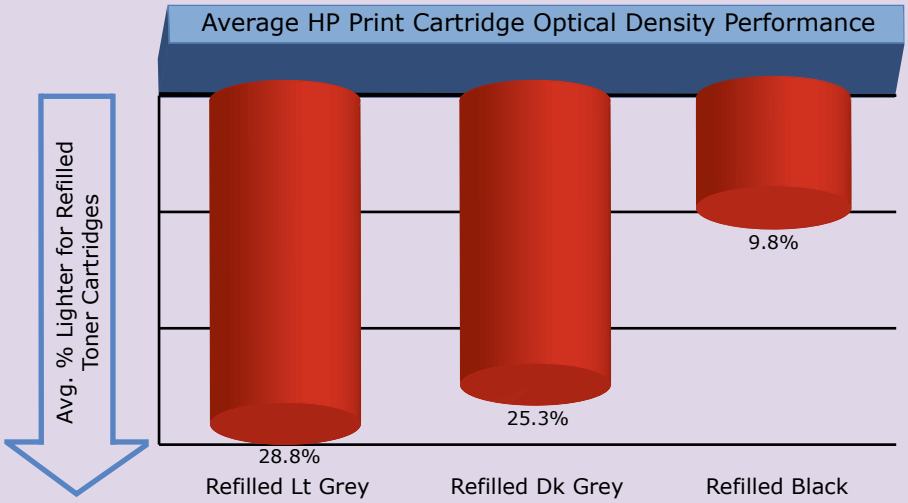
HP vs. Refilled Cartridges - Page Quality Distribution



Optical Density

The optical density measurements for the refilled toner cartridges tested were an average of 28.8% lighter for the light grey patch, 25.3% lighter for the dark grey patch, and 9.8% lighter for the black patch compared to the average of the HP print cartridges tested.

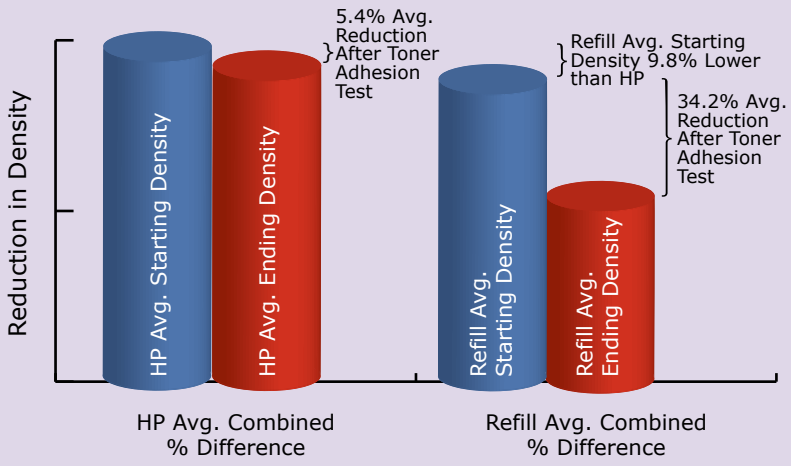
HP vs. Refilled Cartridges - Optical Density



Toner Adhesion

The optical density measurements for the refilled toner cartridges tested were an average of 34.2% lighter (6.3X the HP result) after the Toner Adhesion test, compared to an average of 5.4% lighter for the HP print cartridges tested.

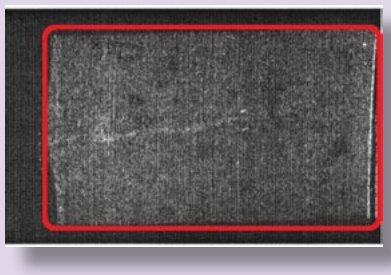
HP vs. Refilled Cartridges - Toner Adhesion



The following examples illustrate the average reduction in density for HP and the refilled toner cartridges tested.

HP 5.4% Average Reduction

Refill 34.2% Average Reduction



*Note: Scanned images may not be accurately reproduced when printed from this report.

Appendix 1: Test Methodology

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

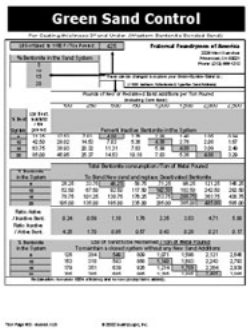
The printers and print cartridges selected for this study are shown at right.

Printer	Black Cartridge
HP LaserJet M1319f (CB536A)	HP 12A (Q2612A)
HP LaserJet P1008 (CC366A)	HP 88A (CC388A)

QualityLogic procured all printers, paper and HP print cartridges through standard retail channels in Shanghai, China and New Delhi, India. A total of 40 print cartridges were tested for HP (20 each for the LaserJet M1319f and P1008 printers). Ten refill vendors were randomly selected in the two cities, where a total of 80 refilled toner cartridges were tested (40 each for the LaserJet M1319f and P1008 printers). For the refilled toner cartridges tested, 50% were tested after being refilled once, and the other 50% were tested after having been refilled twice. A total of four refilled toner cartridges were tested from each refill vendor. In each city, five of the refill vendors selected were located in areas that are considered "commercial" and five were located in areas that are considered "non-commercial".

Printing was performed in a controlled environment, printing three-page print jobs which allowed the printer to stop between jobs. The test image suite was as shown at right.

Page 1
Business Letter



Page 2
Spreadsheet

Page 3
Presentation Slide

The process to prepare the test cartridges included printing new HP OEM print cartridges to image fade using the ISO page and fade definition in the International Standard ISO/IEC 19752. A toner cartridge tested after one refill was depleted using the ISO page, refilled, and then depleted using the test image suite. A toner cartridge tested after being refilled twice was depleted using the ISO page, refilled, depleted a second time using the ISO page, refilled a second time, and then depleted using the test image suite. Once a toner cartridge had been refilled by a particular refill vendor, that toner cartridge was returned to the same refill vendor to be refilled a second time. Cartridge depletion was completed using a set of 11 new HP LaserJet M1319f and P1008 printers in each city, one of each new printer for HP and each refill vendor. Prior to beginning the test, each printer was verified to be in a healthy operating condition by depleting the print cartridge that came with the printer to exhaustion and comparing the printed output. This was done to assure uniformity and accuracy of the test data independent of a particular printer.

The impact of the cartridge on the printer's functionality was also recorded in the areas of consistent operation, leakage of toner inside the printer and failure of printer components (fusers, image drums, etc.).

Printer and driver settings were left at factory default, with the exception of ensuring that the page size was set for A4 and the paper type was set for Plain Paper. All printer/cartridge warnings were noted, and cartridges were printed to EOL.

Normal office conditions of temperature (23C ±2C) and relative humidity (50% ±10% RH) were maintained for the duration of the test. All cartridges and paper consumables were stabilized in these conditions for a minimum of 12 hours prior to use, tested in the same environment, and were subject to the same fluctuations.

All test pages were printed using Double A brand A4 (80 GSM) office paper for Shanghai, China and JK Copier Plus brand A4 (80 GSM) office paper for New Delhi, India.

Cartridge page quality distribution was determined by inspecting a sample of approximately 128 pages taken at periodic intervals over the life of each test cartridge. The scale used for grading sampled pages was created using data from a psychometric research study of business laser printing users. Further information on the psychometric study can be found in Appendix 2.

QualityLogic page inspectors categorized each of the sampled pages based on overall page quality, using the scale created from the psychometric study data. The inspectors were trained using the 30-page psychometric page set. These samples had known values on the scale based on customer research. Page inspection was performed in a test room with 18-20% reflective neutral grey walls, floor and work surfaces, and full spectrum lighting (5,000K ± 500) with luminance of 550 LUX ± 50 at the grading table. Each sampled page was graded by three inspectors. The average of the three grades determined the page quality category for the page. The consistency of grades across inspectors was monitored on a daily basis and retraining against the psychometric page set, with known scale values, was repeated as necessary.

Optical density was determined by performing an optical density test on three separate patches (light grey, dark grey and black) on each of the presentation slide sample pages in the study. Optical density measurements from each sample page were compared to the average HP measurements for the same patch to calculate the percentage of difference between the two patches. The percentage of difference for all sample pages printed by refilled toner cartridges were combined for each of the three patches to create the overall study results.

Toner adhesion was determined by performing a series of optical density measurements, before and after the toner adhesion test, using the black test patch for each of the presentation slide sample pages in the study. Adhesive tape was applied to and removed from the black patch on each sample page in a controlled manner. The change in optical density before and after the test was calculated as the percentage of difference for each sample. The percentage of difference from each sample was then combined into an average overall result for HP and for the refilled toner cartridges tested.

The test methodology for this reliability comparison study was developed by Hewlett-Packard and implemented by QualityLogic.

Appendix 2: Psychometric Study

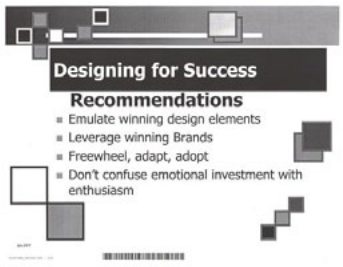
To create a page quality scale calibrated to actual business laser printing user behavior, QualityLogic conducted a psychometric study. An independent market research organization recruited a demographic cross-section of business laser printing users. The thirty-one participants were from a range of industries and business sizes, from micro/small (1-49 employees) to large/enterprise (>500 employees). All respondents used laser printers to create documents for a variety of uses, including external distribution. The study was conducted in Los Angeles, California in the summer of 2007.

QualityLogic selected a set of test pages (10 each of the test pages in this study) chosen to provide a range of page quality. In the psychometric study, participants were asked to rank order each group of 10 pages from best to worst. They were then asked to sort the pages into groups based on the following four acceptability statements (categories):

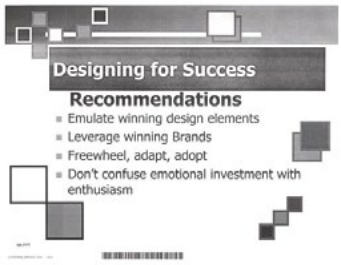
- All uses, including external distribution
- Limited use: Not for external distribution
- Limited use: Not for distribution
- Unusable

Average ranks were calculated for each of the page sets. A normalized z-score was determined from the distribution of ranks, and then a classification scheme rooted in a logistic model was used to determine category boundaries for page grades.

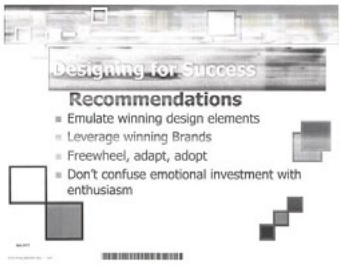
The page scans at right illustrate pages typical of each of the Print Quality Categories for this study.



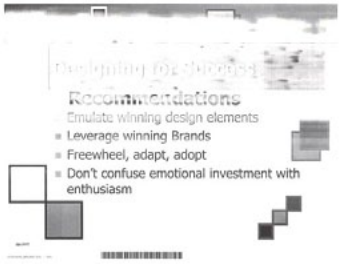
All uses, including external distribution



Limited use: Not for external distribution (Fade in black bar with 'Designing for Success' title)



Limited use: Not for distribution



Unusable

*Note: Page scans may not be accurately reproduced when printed from this report.

**Scanned pages are for demonstration purposes only, and not specific to any single printer platform or brand in the study.

Appendix 3: Definitions

Test Terminology	Definition
End of Life (EOL)	A condition determined by one of the following mechanisms: 1. Cartridge is dead on arrival (DOA). 2. Cartridge stops printing with the control panel indicating a need for cartridge replacement. 3. Cartridge stops printing without indicating the need for a cartridge replacement and efforts to recover are unsuccessful. 4. A cartridge leaks substantial toner (1 cm^3 or more) anytime during printing. 5. During the draining phases of the study, EOL is determined according to the ISO/IEC 19752 image fade definition whereby a noticeable reduction in density uniformity across the page occurs. Fade is defined as a noticeably lighter, 3 mm or greater gap located in the text or boxes around the periphery of the test page. 6. During the study test phase, EOL was determined by degradation of print quality to Unusable for all pages in the test suite because of streak, extra line, banding or other defect. (A cartridge could be cleaned to attempt to recover the print quality no more than two times during the life of a cartridge. Once print quality degraded a third time, the cartridge was considered EOL.)
Dead on Arrival (DOA)	A condition determined by one of the following mechanisms: 1. Cartridge is found to have substantial toner leakage (1 cm^3 or more) before or during the installation process. 2. A cartridge that prints 10 or fewer pages before print quality degradation to Unusable. 3. A cartridge that starts out printing pages that are "Limited Use: Not for distribution" and does not recover. 4. Cartridge is broken or missing parts. 5. Cartridge fails to print when first installed.
Low Quality (LQ)	A cartridge with 50% or more sampled pages categorized as Limited Use or Unusable but was not DOA.
Problem Cartridge	A cartridge that was either DOA or LQ.
Print Quality Categories	The following four categories exist for this study: 1. **All uses, including external distribution -** 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. 2. **Limited use: Not for external distribution** - Acceptable for distribution inside a company, but not acceptable for distribution outside a company, to customers or others. Examples: documents to distribute to colleagues, superiors or subordinates as business communication. Reprint required if intended for external distribution. 3. **Limited use: Not for distribution** - Individual use only; usable as a copy to read, file or mark-up but not acceptable for distribution, either within or outside a company. Reprint required if intended for external or internal distribution. 4. **Unusable** - Not acceptable for any business purpose. Reprint required for any use.
Optical Density	Optical density measurements were taken with an Xrite 939 Spectrodensitometer. Optical density was calculated as the average percent difference for each sample page printed by a refilled toner cartridge compared to the average HP performance for each of the three test patches (Lt Grey, Dk Grey, Black) for all sampled presentation slide pages.
Toner Adhesion	A measurement which highlights how much lighter the black patch becomes after performing the toner adhesion test (tape test). The toner adhesion test consisted of taking optical density measurements on the black test patch for all sampled pages before and after the tape test. The tape test consisted of applying and removing 3M 600 adhesive tape to the black patch in a controlled manner. Toner adhesion is calculated as the average reduction in density (percentage of difference) for all sample pages combined into an average for HP and all refilled toner cartridges tested.