QualityLogic®
Putting Technology to the Test

Test Report

Reliability Comparison Study

HP LaserJet Print Cartridges vs. Non-HP Toner Cartridges

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Executive Summary

In October 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 P1505 (personal printer) and P4015 (workgroup printer), HP 36A and 64A, compared to a sample of non-HP toner cartridges sold as substitutes for them. All non-hp brands tested are available in Europe, the Middle East, or Africa.

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 LaserJet print cartridges outperformed the non-HP toner cartridges in all areas of the study.

Cartridge Reliability

When combining all problem categories, HP LaserJet print cartridges exhibited no reliability failures in the study, compared to an average of 41.7% for the non-HP toner cartridges tested. Of the 216 non-HP toner cartridges tested, 3 cartridges were dead on arrival or reached an early end of life and 87 cartridges had 50% or more pages of limited or no use. (See Appendix 4 for study definitions.)

Print Quality Page Distribution

HP LaserJet print cartridges printed an average of 97.0% of sample pages categorized as acceptable for all uses, compared to an average of 61.0% for the non-HP toner cartridges tested.

Optical Density

The optical density measurements for the non-HP toner cartridges tested were an average of 15.5% lighter for the light grey patch, 12.9% lighter for the dark grey patch, and 5.1% lighter for the black patch compared to the average of the HP LaserJet print cartridges tested.

Toner Adhesion

The toner adhesion results for the non-HP toner cartridges tested were an average of 11.3% lighter (4.4X the HP result) after the toner adhesion test, compared to an average of 2.5% lighter for the HP LaserJet print cartridges tested.

Remanufactured toner cartridges tested from the following Non-HP brands:

- Armor
- HQ Emstar
- Lyreco
- Pelikan

Clone toner cartridges tested from the following Non-HP brands:

- ActiveJet
- Black Point
- Sky Print
- Solution Print

Remanufactured and/or clone toner cartridges tested from the following Non-HP brand:

- Xerox

Test Overview

Cartridge Reliability

Cartridges were classified as Dead on Arrival (DOA), Early End of Life (EEOL) or Low Quality (LQ) based on the number and quality of the pages printed. The DOA, EEOL and LQ cartridges from all non-HP toner cartridges tested were combined to create the total Problem Cartridge percentage. (See Appendix 4 for study definitions.)

Print Quality Page Distribution

Cartridge print quality page distribution was determined by inspecting a sample of pages taken at periodic intervals over the lifespan of each cartridge. To create a print 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 print 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 print quality 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 2 & 3 for additional information on the psychometric and test methodologies.)

Optical Density

Optical density was determined by taking optical density measurements from three separate patches (light grey, dark grey and black) on each sample page 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 the non-HP toner cartridges tested were combined to create the three study results for the light grey, dark grey and black test patches.

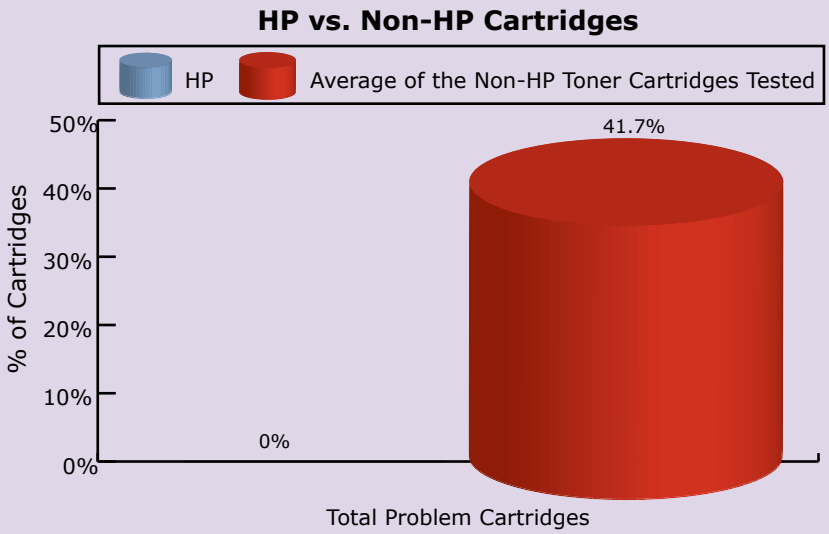
Toner Adhesion

Toner adhesion was determined by performing optical density measurements, before and after the toner adhesion test, using the black test patch for each sample page 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 result for HP and for the non-HP toner cartridges tested.

Detailed Results

Cartridge Reliability

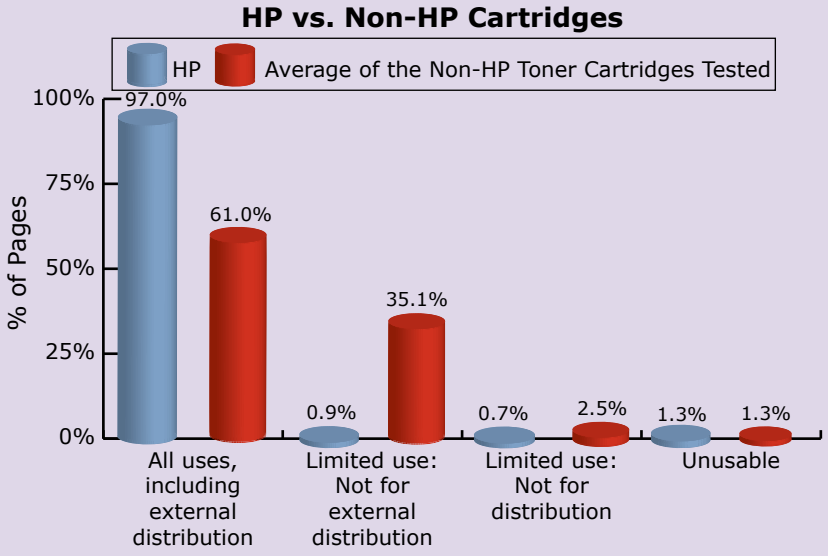
When combining all problem categories, HP LaserJet print cartridges exhibited no failures in the study, compared to an average of 41.7% for the 216 non-HP toner cartridges tested.



Brand	DOA	EEOL	LQ	Total Problem Cartridges
HP	0	0	0	0.0%
Average of the Non-HP Toner Cartridges Tested	2	1	87	41.7%

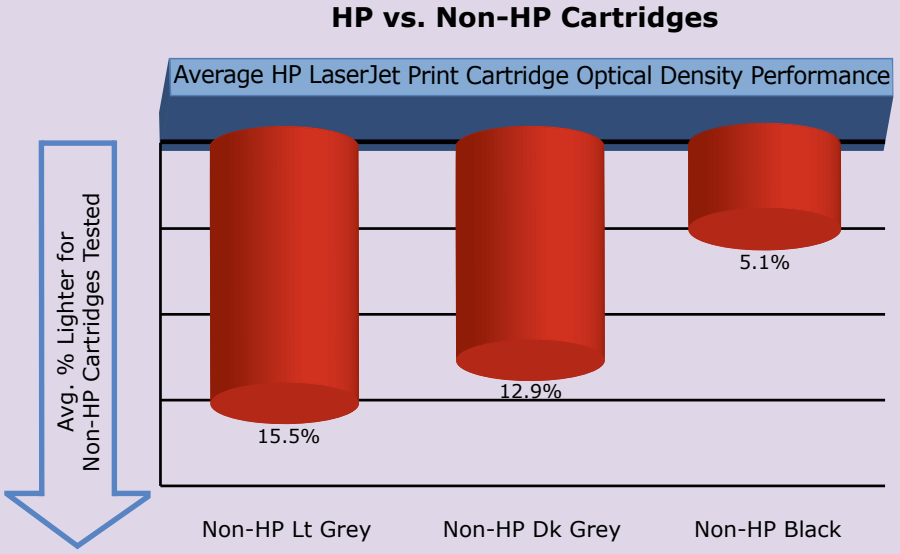
Print Quality Page Distribution

HP LaserJet print cartridges printed an average of 97.0% of sample pages categorized as acceptable for all uses, compared to an average of 61.0% for the non-HP toner cartridges tested.



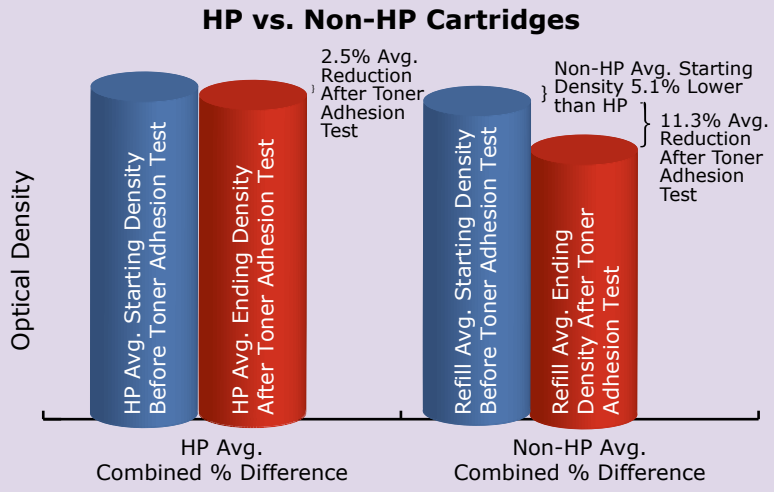
Optical Density

The optical density measurements for the non-HP toner cartridges tested were an average of 15.5% lighter for the light grey patch, 12.9% lighter for the dark grey patch, and 5.1% lighter for the black patch compared to the average of the HP LaserJet print cartridges tested.



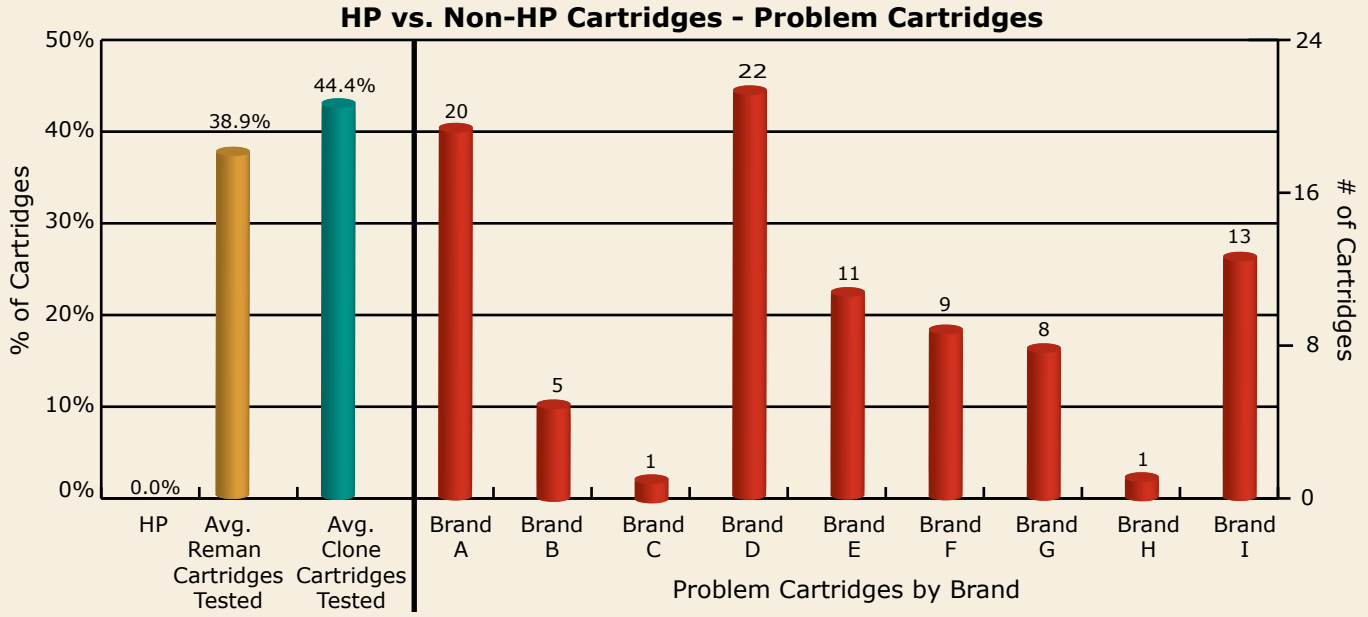
Toner Adhesion

The toner adhesion results for the non-HP toner cartridges tested were an average of 11.3% lighter (4.4X the HP result) after the toner adhesion test, compared to an average of 2.5% lighter for the HP LaserJet print cartridges tested.

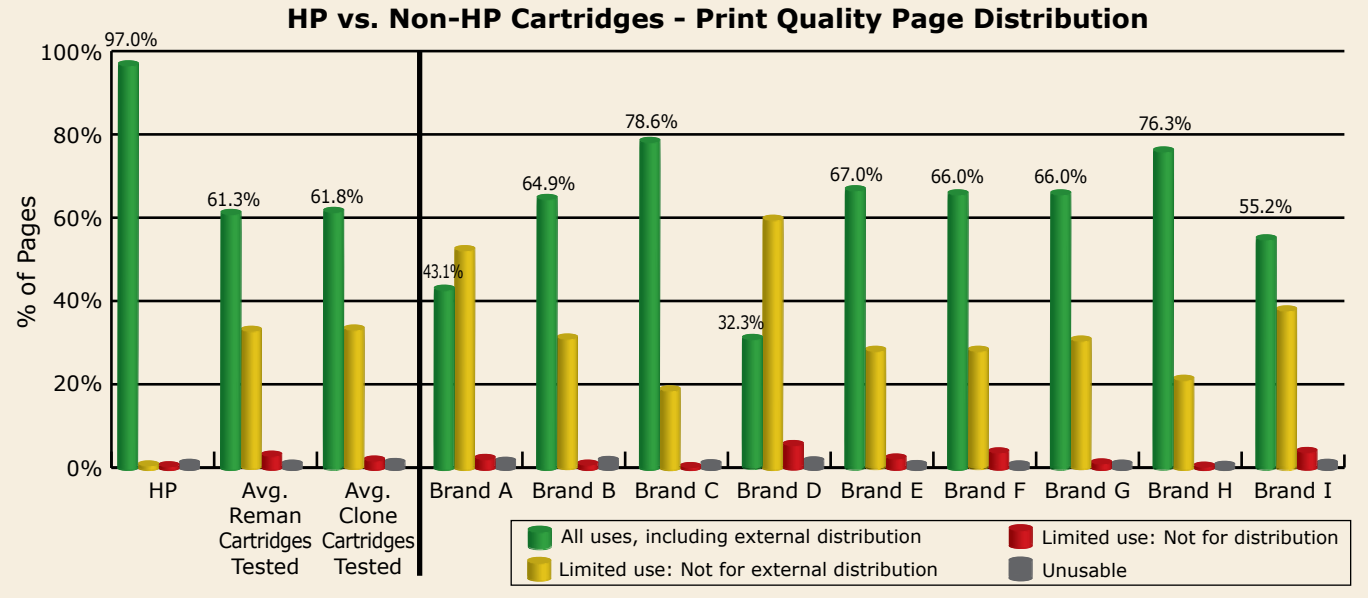


Appendix 1:
Additional Test Results

1. Cartridge Reliability



2. Print Quality Page Distribution



3. Optical Density

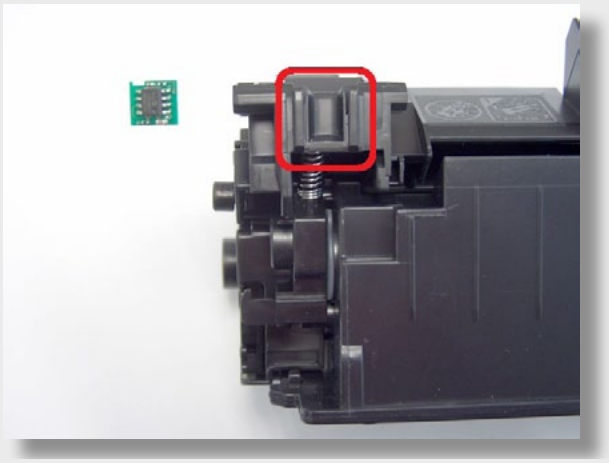
Brand	Light Grey Avg. % Lighter than HP	Dark Grey Avg. % Lighter than HP	Black Avg. % Lighter than HP
Brand A	41.4%	24.7%	5.2%
Brand B	13.3%	7.4%	2.1%
Brand C	-15.8%	-4.2%	-3.5%
Brand D	53.4%	34.4%	12.3%
Brand E	0.2%	8.3%	5.9%
Brand F	11.7%	4.0%	6.7%
Brand G	11.7%	19.5%	4.2%
Brand H	1.8%	5.4%	1.3%
Brand I	13.3%	12.2%	8.8%

4. Toner Adhesion

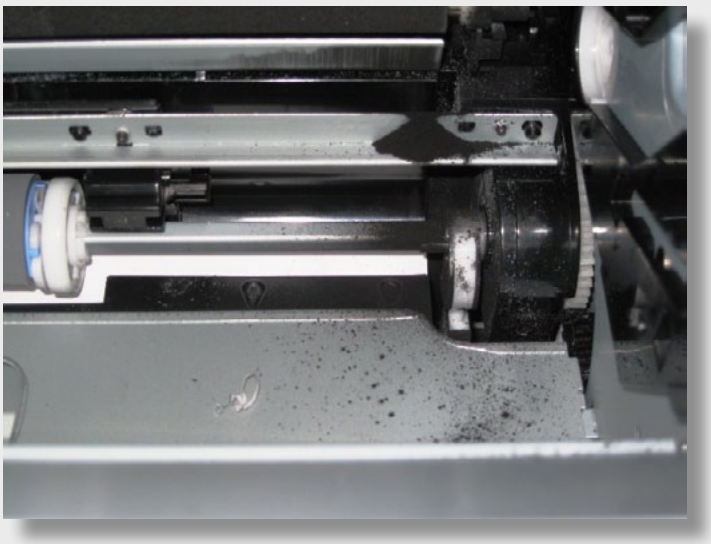
Brand	Avg. % Difference After the Toner Adhesion Test	Ratio to HP Performance
HP	2.5%	N/A
Brand A	10.4%	4.1X the HP result
Brand B	48.1%	19.0X the HP result
Brand C	7.4%	2.9X the HP result
Brand D	7.4%	2.9X the HP result
Brand E	4.6%	1.8X the HP result
Brand F	6.4%	2.5X the HP result
Brand G	3.9%	1.5X the HP result
Brand H	2.1%	0.8X the HP result
Brand I	9.7%	3.8X the HP result

Cartridge Reliability Example Photos

Brand B 36A toner cartridge - DOA due to broken parts.



Brand C 36A toner cartridge arrived for testing with the chip loose in the shipping container. Cartridge was tested without the chip with no supplies management messages provided.



Brand D 36A toner cartridge leaking toner into the printer. This leak was discovered at cartridge end of life. This cartridge was Low Quality, printing over 90% of pages categorized as limited or no use.

Appendix 2: Test Methodology

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

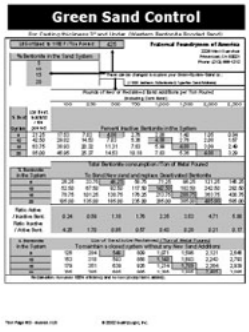
The printers and print cartridges selected for this study are shown at right.

Printer	Black Cartridge
HP LaserJet P1505 (CB412A)	HP 36A (CB436A)
HP LaserJet P4015 (CB509A)	HP 64A (CC364A)

QualityLogic procured all printers, paper, HP LaserJet print cartridges and Xerox toner cartridges through standard retail channels, from Internet websites, or directly from the manufacturer in North America. All other toner cartridges for the study were purchased through standard retail channels, from Internet websites, or directly from the manufacturers in Europe. For the cartridge brands where remanufactured cartridges were tested, both cartridge models (36A and 64A) were included in the test. For the cartridge brands where clone cartridges were tested, the 64A clone cartridges were unavailable at the time the test was completed, so all testing for these brands was performed with the 36A cartridge. The Xerox cartridge brand provided both remanufactured and clone cartridges, and was tested with both cartridge models. For all brands, a total of 24 cartridges were tested in the study.

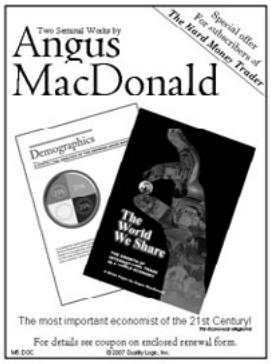
Printing was performed in a continuous mode in a controlled environment using the four-page test suite shown below.

Page 1
Business Letter



Page 2
Spreadsheet

Page 3
Presentation Slide



Page 4
Flyer

Two new HP LaserJet P1505 and P4015 printers were used for the testing of each brand to assure uniformity and accuracy of the test data independent of a particular printer. Cartridges were obtained in small lots from multiple vendors when possible, and cartridge markings were examined to ensure lot variation.

The impact of the toner 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 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 printers, 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 standard 8 ½ x 11 office paper (20 lb, 96 brightness) from Hammermill (Fore MP-White).

Each test page was serialized and identified by printer to provide exact page counts.

Cartridge print quality page distribution was determined by inspecting a sample of 170 pages taken at periodic intervals over the lifespan of each 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 3.

QualityLogic page inspectors categorized each of the sampled pages based on overall print quality, using the scale created from the psychometric study data. The inspectors were trained using the 40 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 gray 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 print 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 taking an optical density measurement on three separate patches (light grey, dark grey and black) on each sample page 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 the non-HP toner cartridges tested were combined for each of the three patches to create the three study results.

Toner adhesion was determined by taking optical density measurements, before and after the toner adhesion test, using the black test patch for each sample page 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 non-HP toner cartridges tested.

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

Appendix 3: Psychometric Study

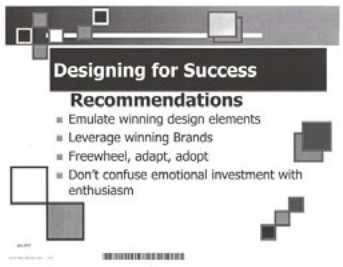
To create a print quality scale calibrated to actual business laser printing user behavior, QualityLogic conducted a psychometric study in Los Angeles, California in the summer of 2007. An independent market research organization recruited a demographic cross-section of business laser printing users. 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.

QualityLogic selected a set of test pages (10 each of the test pages in this study) chosen to provide a range of print quality. In the psychometric study, participants were asked to rank in order each test page 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

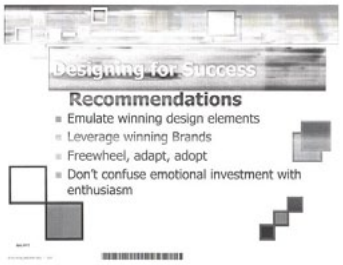
Average ranks were calculated for each of the page sets. A normalized z-score was determined from the distribution of ranks, and then a classification scheme rooted in a logistic model was used to determine category boundaries for page grades.

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

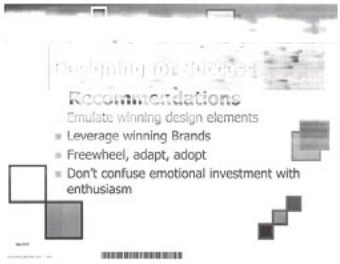


All uses, including external distribution

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 4: Definitions

Test Project 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 and efforts to recover are unsuccessful. 3. Degradation of print quality to Unusable for all pages in the test suite because of fade, streak, extra line, banding or other defect. (A cartridge could be cleaned to attempt to recover the print quality no more than 2 times during the life of a cartridge. Once print quality degraded a 3rd time, the cartridge was considered EOL.) 4. A cartridge leaks substantial toner (1 cm^3 or more) anytime during printing.
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.
Early End of Life (EEOL)	For the original HP LaserJet print cartridges, a cartridge that has a page count of less than 75% of the average page count for all HP LaserJet print cartridges of that model that were not DOA. For non-HP toner cartridges, a cartridge that has a page count of less than 75% of the average page count for all non-HP toner cartridges of that model that were not DOA, and is less than the HP average page count for that same cartridge model.
Low Quality (LQ)	A cartridge with 50% or more sampled pages categorized as Limited Use or Unusable, but was not DOA or EEOL.
Problem Cartridge	A cartridge that was either DOA, EEOL or LQ.
Print Quality Categories	The following 4 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. The optical density metric for this study was calculated as the average percent difference for each sample page printed by a non-HP toner cartridge compared to the average HP performance for each of the three test patches (Lt Grey, Dk Grey, Black) for all sampled 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 non-HP toner cartridges tested.
Remanufactured Toner Cartridge	A reused HP cartridge shell that has been disassembled, one or more components replaced, and is filled with non-HP toner.
Clone Toner Cartridge	A new non-HP cartridge shell that has new components and is filled with non-HP toner. These cartridges can, however, contain components that have had prior use.