QualityLogic

Reliability Comparison Study

HP LaserJet Toner Cartridges vs. Remanufactured Brands

2008

QualityLogic

Executive Summary

In 2008, QualityLogic completed a study for Hewlett-Packard (HP) designed to test the quality and reliability of HP LaserJet toner cartridges for the HP LaserJet 2300 and HP LaserJet 4350 printers, HP 10A (HP Q2610A) and HP 42A (HP Q5942A) compared to 14 brands of the remanufactured toner cartridges sold as substitutes for them.

A total of 24 cartridges were tested for each brand in the study. Printing was performed in a continuous mode in a controlled environment using test pages jointly developed by HP and QualityLogic.

The results of the study show that HP LaserJet toner cartridges clearly outperformed the remanufactured toner cartridges in both quality and reliability.

Cartridge Reliability – When combining all problem categories, HP LaserJet toner cartridges exhibited no reliability failures in the study, compared to an average of 42.6% for all remanufactured brands in the study. Of the remanufactured cartridges tested, 7.1% were dead on arrival or failed prematurely and 35.4% had 50% or more pages of limited or no use.

Print Quality Page Distribution – HP LaserJet toner cartridges printed an average of 96.1% of sample pages categorized as acceptable for all uses, compared to 61.8% for the average of remanufactured brands tested.

Remanufactured Brands Tested

- Armor
- CFI
- Dataproducts
- EQUi
- LaserNetworks
- Multilaser
- Nukote
- Office Depot
- OfficeMax
- P.I.T.
- Pelikan
- Print-Rite
- RuTONE
- Verbatim

Test Overview

Cartridge Reliability –Cartridges were classified Low Quality (LQ), Premature Failure (PF), or Dead on Arrival (DOA) based on the number and quality of the pages printed before end of life. Low Quality, Premature Failure, and Dead on Arrival cartridges were combined as total Problem Cartridges.   Total Problem Cartridges were calculated for each brand and for the whole group of remanufactured brands tested.

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 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 by brand and an average for the remanufactured brands tested. (See Appendices 2-4 for additional information on the psychometric and test methodologies.)

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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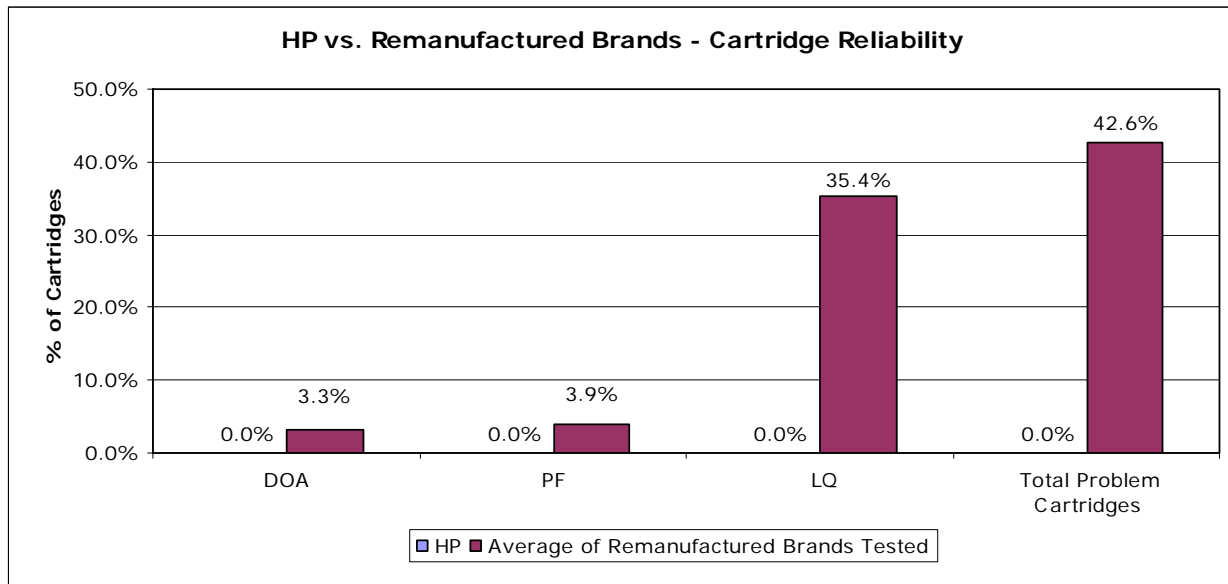
Detailed Results

Reliability – Problem Cartridges

When combining all problem categories, HP LaserJet toner cartridges exhibited no reliability failures in the study, compared to an average of 42.6% for all remanufactured brands in the study. (Additional detail is provided in Appendix 1.)

Brand	DOA	PF	LQ	Total Problem Cartridges
HP	0.0%	0.0%	0.0%	0.0%
Average of Remanufactured Brands Tested	3.3%	3.9%	35.4%	42.6%

Table 1:
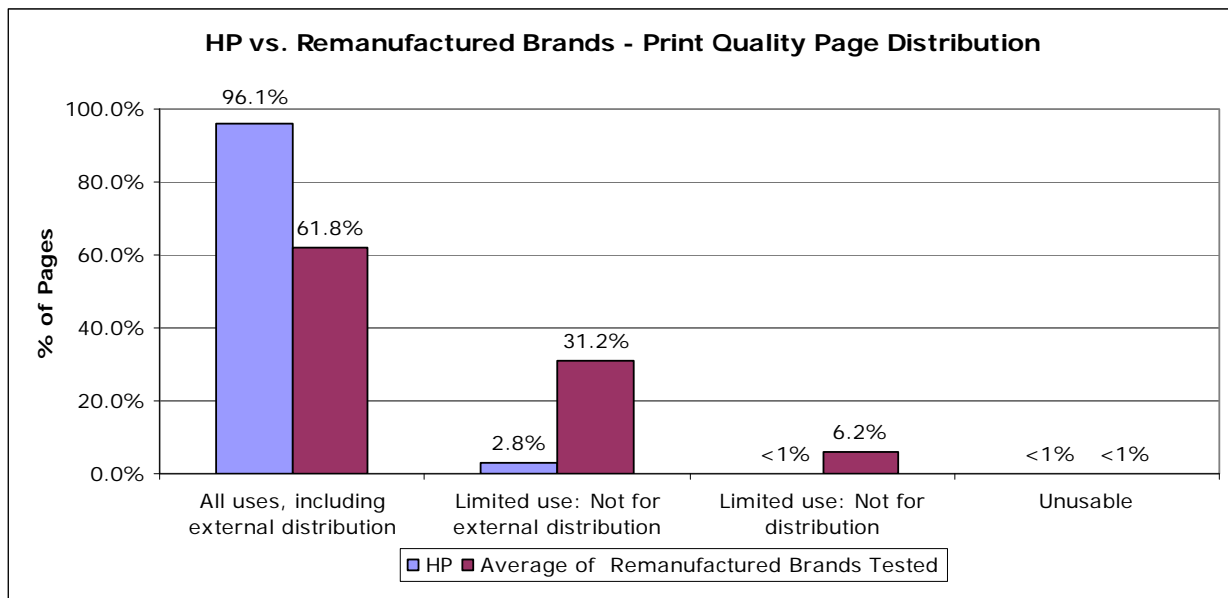**Cartridge Reliability – Problem Cartridges**

Graph 1:
Cartridge Reliability – Problem Cartridges

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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Print Quality Page Distribution

HP LaserJet toner cartridges printed an average of 96.1% of sample pages categorized as acceptable for all uses, compared to 61.8% for the average of remanufactured brands tested. (Additional detail is provided in Appendix 1.)

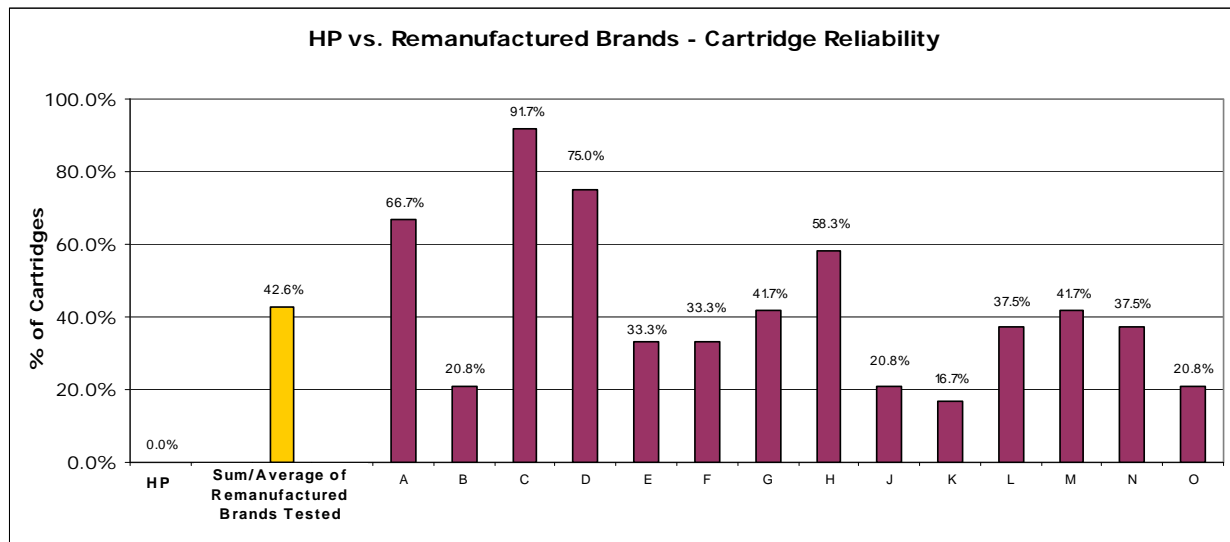| Brand	All uses, including external distribution	Limited use: Not for external distribution	Limited use: Not for distribution	Unusable
HP	96.1%	2.8%	<1%	<1%
Average of Remanufactured Brands Tested	61.8%	31.2%	6.2%	<1%

**Table 2:
Print Quality Page Distribution**

**Graph 2:
Print Quality Page Distribution**

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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Appendix 1: Additional Test Results

Reliability – Problem Cartridges

Brand	Sample	DOA	PF	LQ	Total Problem Cartridges #	Total Problem Cartridges %
HP	24	0	0	0	0	0.0%
Brand A	24	1	1	14	16	66.7%
Brand B	24	0	2	3	5	20.8%
Brand C	24	1	1	20	22	91.7%
Brand D	24	0	1	17	18	75.0%
Brand E	24	5	0	3	8	33.3%
Brand F	24	1	0	7	8	33.3%
Brand G	24	0	1	9	10	41.7%
Brand H	24	0	0	14	14	58.3%
Brand J	24	1	3	1	5	20.8%
Brand K	24	0	1	3	4	16.7%
Brand L	24	1	0	8	9	37.5%
Brand M	24	0	1	9	10	41.7%
Brand N	24	0	2	7	9	37.5%
Brand O	24	1	0	4	5	20.8%
Sum/Average of Remanufactured Brands Tested	336	11	13	119	143	42.6%

Table 3:
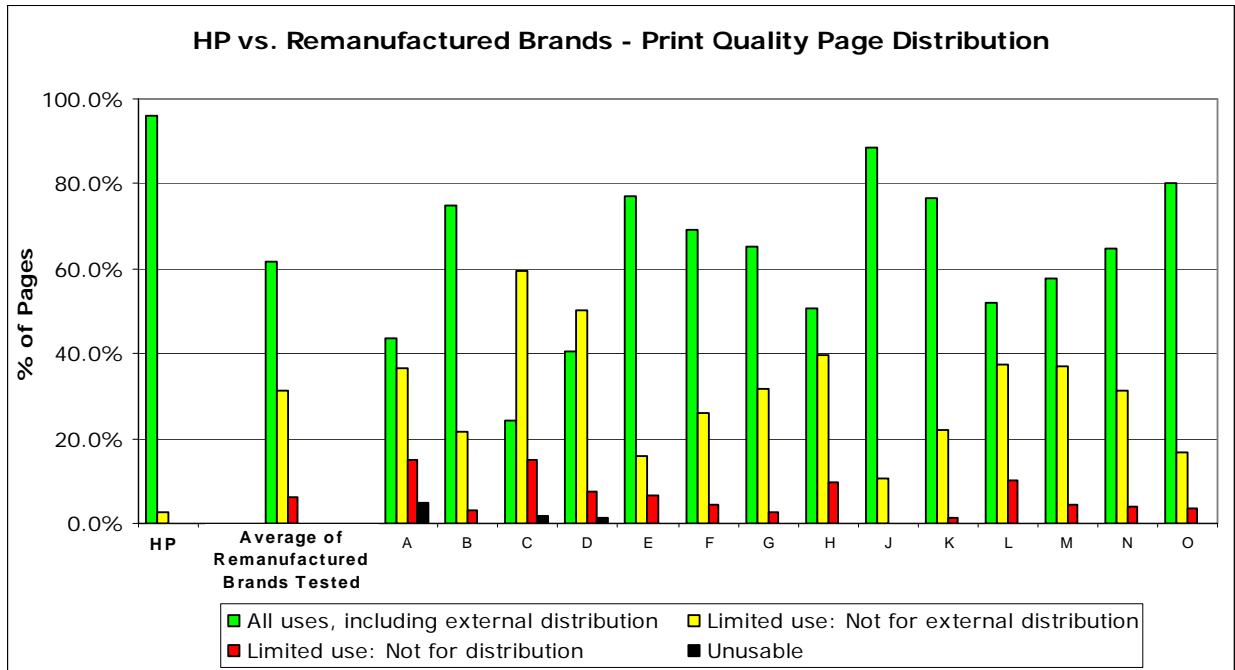**Cartridge Reliability – Problem Cartridges**

Graph 3:
Cartridge Reliability – Problem Cartridges

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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Page 6 of 14

Print Quality Page Distribution

Brand	All uses, including external distribution	Limited use: Not for external distribution	Limited use: Not for distribution	Unusable
HP	96.1%	2.8%	<1%	<1%
Brand A	43.6%	36.6%	14.8%	5.0%
Brand B	75.0%	21.7%	3.0%	<1%
Brand C	24.0%	59.5%	14.9%	1.6%
Brand D	40.7%	50.4%	7.6%	1.3%
Brand E	77.1%	16.1%	6.4%	<1%
Brand F	69.1%	26.0%	4.2%	<1%
Brand G	65.3%	31.9%	2.5%	<1%
Brand H	50.7%	39.5%	9.6%	<1%
Brand J	88.6%	10.7%	<1%	<1%
Brand K	76.7%	22.1%	1.2%	<1%
Brand L	52.1%	37.5%	10.3%	<1%
Brand M	57.8%	36.8%	4.5%	<1%
Brand N	64.7%	31.3%	3.9%	<1%
Brand O	80.0%	16.6%	3.4%	<1%
Average of Remanufactured Brands Tested	61.8%	31.2%	6.2%	<1%

Table 4:
Print Quality Page Distribution

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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HP vs. Remanufactured Brands - Print Quality Page Distribution

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

**Graph 4:
Print Quality Page Distribution**

Cartridge Reliability Example Photos

Brand C – DOA – Loose pieces, cartridge not assembled correctly.

Brand J – DOA – Toner leak in shipping bag.

Brand N – Premature Failure leaking toner into the printer.

Brand M – Premature Failure leaking toner into the printer.

Brand G – Premature Failure leaking toner into the printer.

Brand G – Premature Failure cartridge leaking toner.

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Page 9 of 14

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 were as follows:

Printer	Black Cartridge
HP LaserJet 2300 (Q2473A)	HP 10A (Q2610A)
HP LaserJet 4350 (Q5407A)	HP 42A (Q5942A)

A total of 24 cartridges were tested for each brand in the study (12 each for the LaserJet 2300 and 4350 platforms).

Printing was performed in a continuous mode in a controlled environment using the four-page test suite shown below. Test pages were as follows:

Page 1 – Business Letter	Page 2 - Spreadsheet	Page 3 – Presentation Slide	Page 4 - Flyer

QualityLogic procured all printers, paper and HP toner cartridges through standard retail channels in North America. Remanufactured toner cartridges were obtained through retail channels or directly from the manufacturer in Latin America for the EQUi, P.I.T., CFI and Multilaser brands, in North America for the Dataproducts, Office Depot, Nukote, OfficeMax, LaserNetworks and Verbatim brands, in Europe for the Armor, Pelikan and RuTONE brands, and in the Asia Pacific region for the Print-Rite brand. A set of two new HP LaserJet 4350 printers and two professionally refurbished HP LaserJet 2300 printers were used for the testing of each brand to assure uniformity and accuracy of the test data independent of a particular printer. All refurbished printers were inspected thoroughly and had all worn parts replaced. Additionally, all refurbished printers had new HP maintenance kits and fusers installed. 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.). The cartridge bays were inspected and wiped clean of any residual toner particles and/or paper dust before any new cartridge was installed.

Printer and driver settings were left at factory default, with the exception of the Job Retention setting, which was disabled for this study to prevent the printer from storing print jobs, and ensure that each print job was printed as an individual, separate job. 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 toner 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 (24 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 approximately 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.

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. 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 40 test pages (10 each of the 4 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 40 pages. 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.

Appendix 4: Definitions

Test Project Terminology	Definition
End of Life (EOL)	A condition determined by one of three 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 four test pages. (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.)
Dead on Arrival (DOA)	A condition determined by one of three 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. Cartridge fails to print when first installed.
Premature Failure (PF)	A condition determined by one of two mechanisms: 1. A cartridge that has a page yield of less than 75% of the Average Page Yield for that cartridge brand/model. 2. A cartridge which leaks substantial toner (1 cm^3 or more) anytime during printing.
Low Quality (LQ)	A cartridge with 50% or more sampled pages categorized as Limited Use or Unusable but was neither DOA or PF is considered Low Quality (LQ).
Problem Cartridge	A cartridge exhibiting one of the cartridge problems listed above: DOA, PF, or LQ.
PQ 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** 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.
Average Page Yield	Average page yield for all cartridges of the same model/brand, excluding DOAs.

Test results provided by QualityLogic. Tests were performed under laboratory conditions and end-user's results may vary.

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Appendix 5: Page Samples

The following page scans illustrate pages typical of each of the Print Quality (PQ) 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. See an electronic version of the report for the most accurate representation of the scanned pages.

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

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