



Color Fidelity Comparison Study

Remanufactured Brand Color Toner Cartridges for HP Color LaserJet printers

2009

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Executive Summary

In January 2009, QualityLogic completed a study for Hewlett-Packard (HP) designed to test the color fidelity of remanufactured color toner cartridges compared to the colors printed by original HP Color LaserJet cartridges. The study was performed with HP Color LaserJet print cartridges for the HP Color LaserJet CP3505 printer (HP Q7581A, Q7583A, Q7582A, and Q6470A cartridges) compared to 6 brands of the remanufactured color toner cartridges sold as substitutes for them.

A total of 20 cartridges were tested for each brand in the study. Remanufactured Brands tested include:

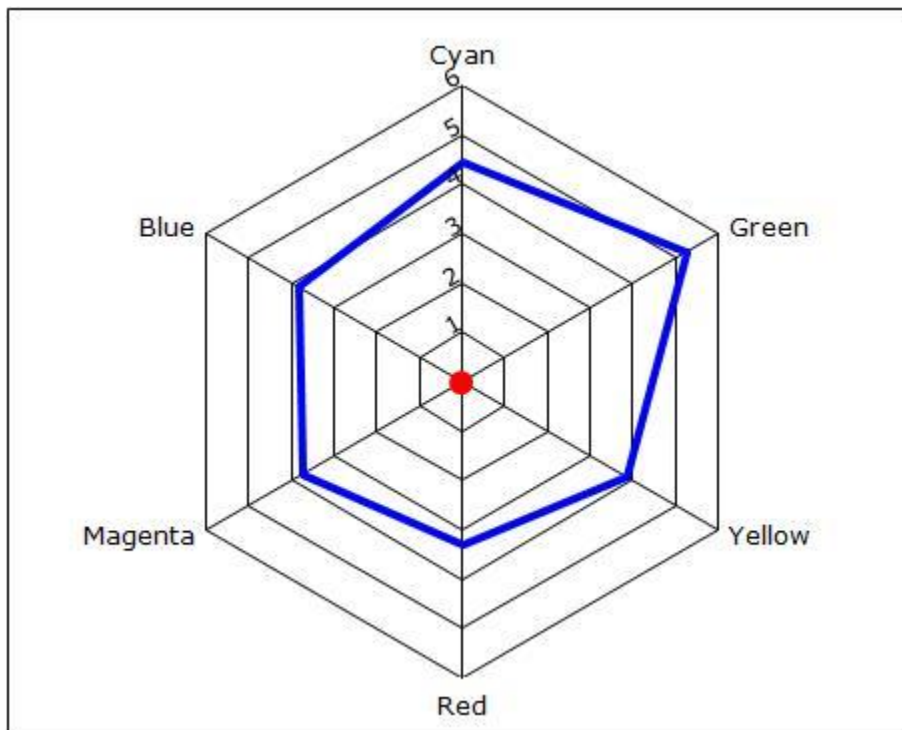
- Armor
- Berolina
- EMSTAR
- Freecolor
- Kores
- Verbatim

The study focused on measuring how consistently the remanufactured brands print colors compared to the colors printed by original HP color cartridges. Color measurements were taken from periodic sample pages spanning each cartridge brand's printed output. Measurements from each brand were compared to the average of the HP measurements for selected key colors. Deviations from the average colors printed by HP cartridges were calculated according to the CIE94 color difference model (Delta E 94 or ΔE^*_{94}).

Overall Result

Colors measured for the remanufactured brands tested differed significantly from the average colors printed by HP cartridges.

Results

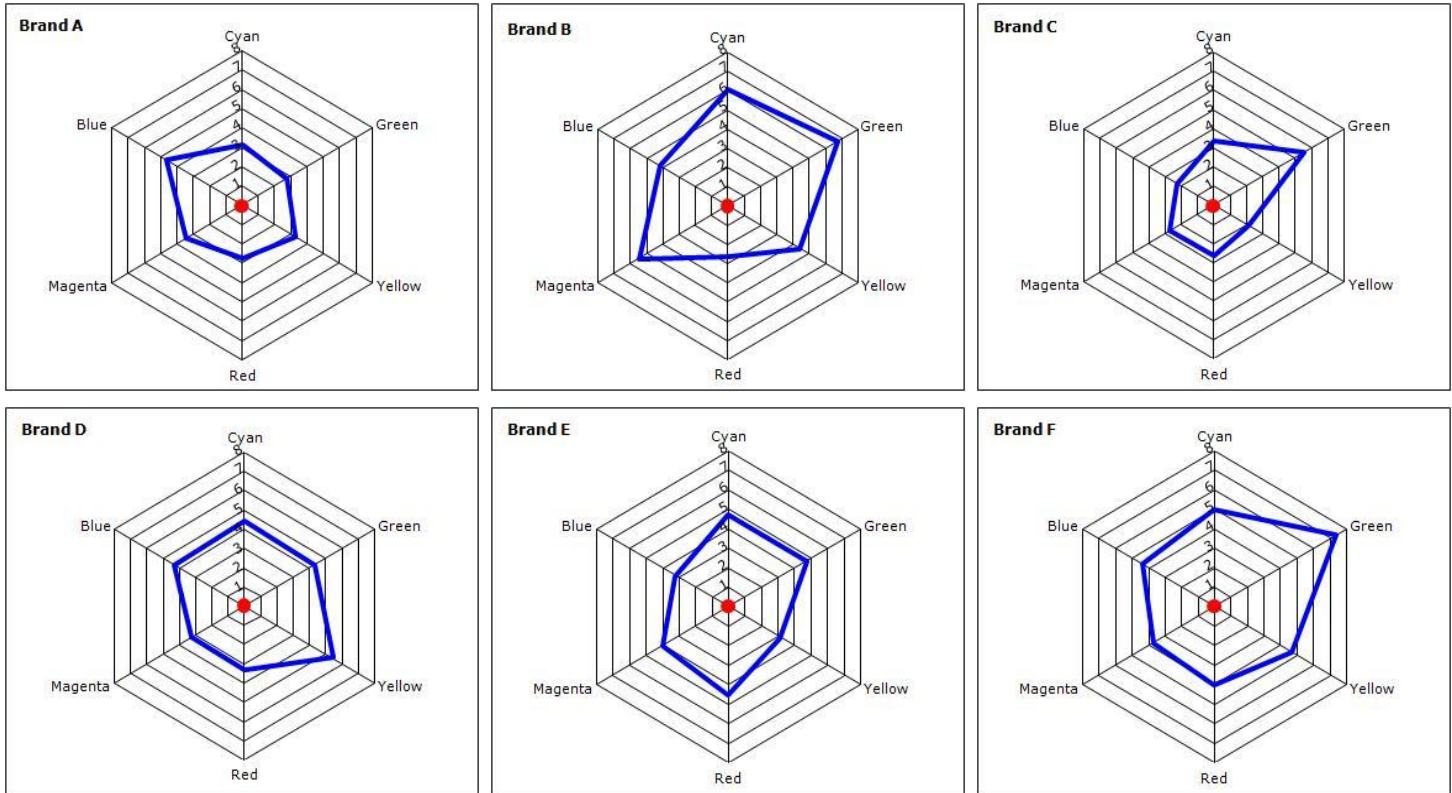


Graph 1:
Average ΔE^*_{94} by Color Compared to HP Reference
• Red center dot represents the average colors printed by HP cartridges

The center point on the graph represents the average colors printed by original HP color LaserJet cartridges.

The color measurements allowed QualityLogic to calculate the color differences generated across the output for each brand. This difference, calculated in accordance with the CIE94, is expressed in ΔE^*_{94} values. Lower ΔE^*_{94} values indicate less color deviation, higher ΔE^*_{94} values indicate larger color deviations.

A measured color difference less than 1 ΔE^*_{94} is normally not visually detectable, while a measured color difference of 1 ΔE^*_{94} is considered a just noticeable color difference. As measured color differences increase above 1 ΔE^*_{94} , the lack of color fidelity becomes progressively more obvious, and may negatively impact overall page quality.



Graphs 2-7:
Average ΔE^*_{94} by Color/Brand Compared to HP Reference
 • Red center dot represents the average colors printed by HP cartridges

Looking across all the remanufactured brands tested, all of six key colors printed by remanufactured brands deviate from the average colors printed by HP cartridges. Different colors may be distorted depending on the individual brand. Green, cyan, yellow and magenta are significantly distorted for some of the remanufactured brands.

Color	Average of the Six Remanufactured Brands Tested	Brand A	Brand B	Brand C	Brand D	Brand E	Brand F
Cyan	4.46	3.12	6.05	3.38	4.45	4.76	4.98
Green	5.24	2.77	6.78	5.51	4.27	4.75	7.34
Yellow	3.83	3.28	4.38	2.11	5.42	3.11	4.67
Red	3.31	2.75	2.59	2.66	3.34	4.49	4.00
Magenta	3.77	3.44	5.49	2.72	3.30	3.99	3.69
Blue	3.85	4.67	4.21	2.29	4.33	3.23	4.35

Table 1:
Average ΔE^*_{94} by Color/Brand Compared to HP Reference

Appendix 1: Test Methodology

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

The printer and print cartridges selected for this study were as follows:

Printer	Cartridges
HP Color LaserJet CP3505 (CB442A)	HP Q7581A (Cyan)
	HP Q7583A (Magenta)
	HP Q7582A (Yellow)
	HP Q6470A (Black)

A total of 20 cartridges, split between the four color cartridges, were tested for each brand in the study. As each individual cartridge reached end of life, that single cartridge was replaced with a new cartridge of the same color. Printing continued until a total of 20 cartridges arrived at end of life for each brand.

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



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 Europe for the Armor, Berolina, EMSTAR, Freecolor, and Kores brands and in North America for the Verbatim brand. A set of two new HP Color LaserJet CP3505 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.). The cartridge bays were inspected and wiped clean of any residual toner particles and/or paper dust before any new cartridge was installed.

For this study, color fidelity was determined by taking color measurements from sample pages selected randomly within periodic intervals throughout the printed output for each brand in the study. A standard IT8.7-3 CMYK test target was selected for this study. The IT8.7-3 test target has a total of 930 color patches with a wide variety of colors. For this study, six key colors were selected for comparison for ease of communication - cyan (C),

magenta (M), yellow (Y), red (R), green (G) and blue (B). There are two color patches per target test page for each of the key colors measured. To ensure that the color measurements were not affected by pages exhibiting print quality defects, all sample pages with visible print quality defects were removed from consideration. Some remanufactured cartridges in the study did not print. Sample pages were measured from the available output for each brand. The color measurement data was statistically analyzed to ensure it was representative of the performance of each brand in the study. The color patches on each sample page were measured with an Xrite i1iSis automated chart reader, which provided CIE L*A*B* color space values for each color patch measured in the study.

To compare the remanufactured brand color performance to that of the HP brand, the average HP performance was used as the reference standard for the study. From each of the HP sample pages in the study the L*A*B* color space values for each color patch under test were combined by color to create an average L*A*B* color space value for each key color. Remanufactured brands sampled pages were compared, page by page, against this reference standard. For each page in the study, CIE L*A*B* color space values were compared to the reference standard using the CIE 1994 (ΔL^* ΔC^*_{ab} ΔH^*_{ab}) colour-difference model to calculate the distance between the color patches expressed in ΔE^*_{94} values. The ΔE^*_{94} values from each page measured were averaged to create an average ΔE^*_{94} for each key color for each brand in the study.

Cartridge end of life (EOL) was determined by one of five events:

1. Cartridge failed to print when installed.
2. Cartridge leaked substantial toner (1 cm³ or more) before or during installation or anytime during printing.
3. Printing stops, control panel indicates the need for cartridge replacement.
4. Cartridge stops printing, without control panel indication of need to replace, but efforts to recover and continue printing are unsuccessful.
5. Degradation of page quality to unusable for test pages one through three. (A cartridge could be cleaned to attempt to recover the page quality no more than 2 times during the life of a cartridge. Once page quality degraded a 3rd time, the cartridge was considered EOL.)

Printer and driver settings were left at factory default. 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.

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