Laser Printer Performance and Reliability Degrades When Using Low-Quality Cutsheet Papers

The performance and composition of cutsheet papers used in office printing applications are changing. Expanding markets in China and Asia, increasing worldwide demand, economic factors, and limitations on the availability of high-quality pulp have resulted in production of papers with more large-particle, abrasive filler content. Some of these papers manufactured in Asia and sold primarily in China and India today use fillers that have been found to significantly reduce the reliability and performance of desktop and office dry-toner electrophotographic ("laser") printers.

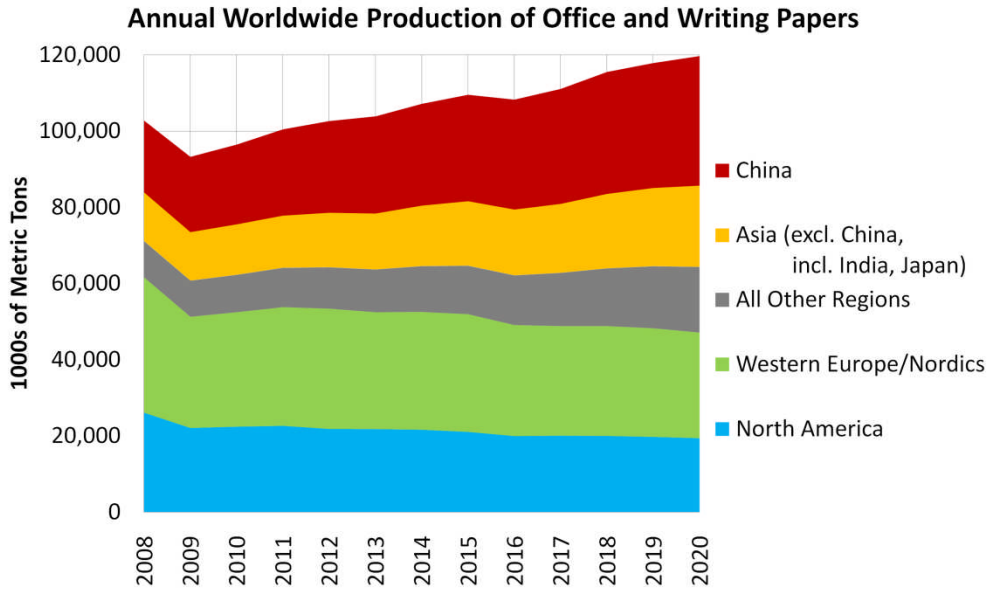
A careful study conducted by an independent, third-party testing organization commissioned by HP, Buyer's Lab Inc. ("BLI") in the United States, correlated increased misfeeding, multi-sheet feeding, misprints and reduction in print quality to increased amounts of calcium carbonate and talc filler with large particle size.

Understanding this situation and doing something about it is important to printer manufacturers, printer users, and paper manufacturers. Printer manufacturers may see substantial increases in their warranty costs directly attributable to wear-out and failures from low-quality office papers. Printer users may experience unexpected inconvenience, cost, and down-time from increased rates of printer failures and wear-out. And, paper manufacturers need a way to economically produce low-cost papers that deliver reliable results.

This document will explore the magnitude of the problem, its trends, and report the results of testing laser printers with papers having high amounts of large-particle fillers against papers that meet ColorLok® standards.

Growing Trends

The figure below shows historical and predicted trends in worldwide office and writing paper production.[1] What is immediately apparent is that the decline in production in North America and Western Europe, due to economic factors, is offset by increases elsewhere, especially in China. Overall paper production is predicted to increase by about 16% from 2008 through 2020 with the share of papers from Asia and China increasing from about 31% in 2008 to 46% in 2020.



It is the nature of paper production and distribution that many office papers produced in Asia and China could be marketed worldwide under many different brands, although they are primarily sold locally

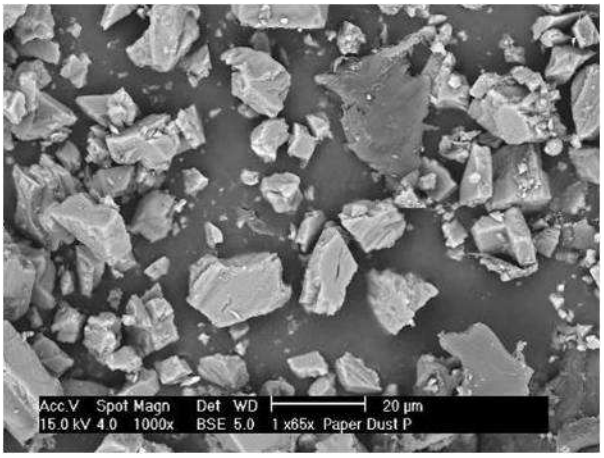
1 Source: RISI Pulp & Recovered Paper Forecast – 15 Year issued July 31, 2010

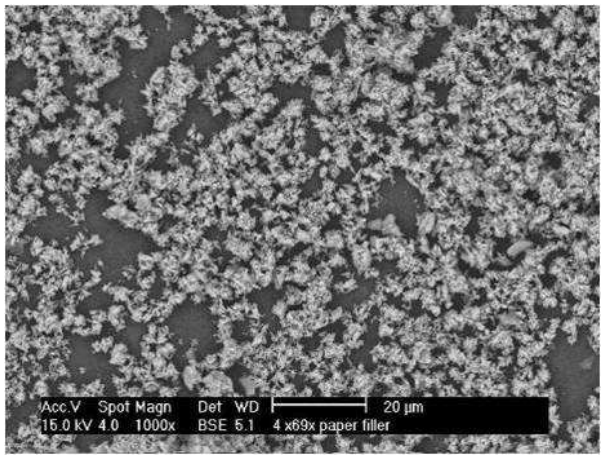
today. And, with the unavailability of economical supplies of high-quality pulp in these regions, these papers will generally have higher filler content than papers produced in North America and Western Europe.

Generally, most of the Asian and Chinese mills making lower-quality office papers must buy pulp and fillers at market prices. Pulp is not only expensive but prices are rising rapidly because many Chinese mills are increasing capacity faster than the available pulp supply. For example, compare the prices of various pulps per metric ton delivered to China in June 2009 and June 2010 at this point of the pulp pricing cycle[2]:

- Northern Bleached Softwood Kraft: US$890 (2010) vs. US$550 (2009): 62% increase
- Bleached Radiata Pine Kraft: US$880 (2010) vs. US$520 (2009): 69% increase
- Bleached Eucalyptus Kraft: US$830 (2010) vs. US$430 (2009): 93% increase

Along with talc found mostly in India, calcium carbonate is one of the most common paper filler materials. Particles of calcium carbonate are produced either by grinding or by chemical precipitation. Ground calcium carbonate is often called "GCC" and precipitated calcium carbonate is called "PCC".





Samples of filler particles are shown at the same magnification in the two photomicrographs above. Ground calcium carbonate particles are shown on the left. This low-grade GCC has large, irregular, sharp-edge particles with a very wide distribution of particle sizes. Commercial, low-grade GCC can also contain impurities, such as quartz. PCC is produced as small particles with very uniform size. PCC particles used in a ColorLok® paper are shown on the right. ColorLok® papers can also use GCC provided that the particle size and distribution falls within the ColorLok® specification.

Low-grade GCC from local Chinese or Indian producers sells for about US$110 to US$130 per metric ton. For Asian and Chinese paper mills, PCC is available for US$160 to US$190 per metric ton.

The financial incentives for replacing pulp with low-grade filler are clear. And, with paper brightness requirements increasing, calcium carbonate also offers inexpensive means to increase paper brightness while reducing the need for expensive optical brighteners.

Implications for Laser Printer Service Life, Reliability, and Quality

For more than two decades, laser printers in the home and office have established a reputation for value, reliability, quality, and long service life. While laser printers can produce good results on a wide variety of papers, office printing papers have evolved, driven by the success of laser printers, to have properties that improve laser imaging performance and help to reduce paper jams and misfeeds. It should be of major concern to printer manufacturers and users that a supply of low-quality office papers with high GCC or talc content can compromise the performance and value expected from laser printing solutions.

In addition to components that pick and transport paper through a laser printer, the fuser comes into direct contact with the paper. This means that excessively-abrasive papers increase wear on these critical imaging components causing early failure and requiring replacement. Excessive accumulation of paper dust, which is mostly filler

[2] Source: *RISI World Pulp Monthly* – July 2010 – Table 1 issued 8/4/2010

materials, can produce misfeeds, paper jams, and contamination of imaging components that affect image quality and fusing of toner to paper.

The problem facing both laser printer manufacturers and users is not simply a result of increasing filler content, but with the type of filler. In independent laboratory tests conducted by BLI and commissioned by HP, papers using high amounts of GCC and talc with large particle size were correlated to increased rates of laser printer failures including misfeeds and paper jams, reduced service life, and poorer image quality.

The opportunity presented to manufacturers of low-cost office papers by the shift to papers with higher filler content is to differentiate their products through control of the quantity, particle size, and type of filler materials while offering a superior product at an affordable price. Adherence to ColorLok® standards offers that opportunity.

ColorLok® Papers

There is high demand for cutsheet papers for home and office laser printers that offer consistent, reliable printing and improved printing for inkjets. ColorLok® papers provide these benefits and are available world-wide from a growing number of paper manufacturers. ColorLok® papers are sold under various brands through retail, Internet, catalog, and contract stationers. The ColorLok® standard for office papers includes specifications on electrical properties, controlled surface characteristics (e.g., coefficient of friction and smoothness), controlled filler particle size, edge cut qualities, curl, and other paper properties that deliver high quality, dependable results.

The ColorLok® brand on paper packaging is easily recognizable and effectively communicates key benefits of papers that meet ColorLok® performance specifications. HP LaserJet recommends ColorLok® papers for best printing results.

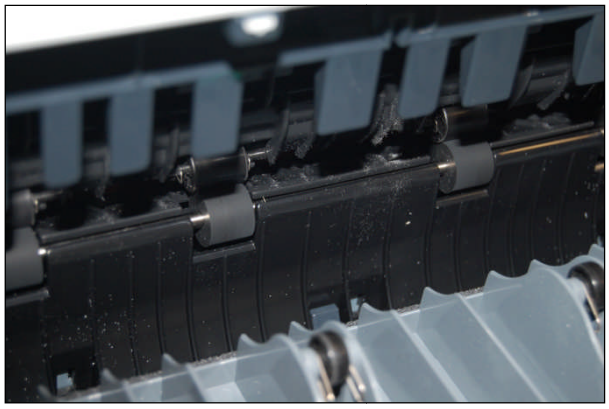
Results from Third-Party Testing

Buyers Laboratory Inc., located in Hackensack, NJ, was commissioned by HP to conduct independent tests of the reliability and image quality performance of five (5) different 70-80 gsm plain papers in five (5) leading low- to mid-range laser printer models, including four mono printers and one color printer. The performance of two leading brands of low-cost office papers with high percentages of abrasive, large-particle mineral fillers manufactured in Asia and sold mostly in China and India today (called herein the "papers that don't meet the ColorLok® quality standard") were compared to three papers that had ColorLok® validation and logo.[3,4] One low-cost papers was a 75 gsm sheet with a large talc filler particles, the other a 70 gsm sheet with large GCC filler particles.

BLI's tests demonstrated that all three ColorLok® papers provided clearly superior performance in terms of printer reliability and maintaining image quality over more pages compared to the two abrasive, large-particle filler papers that don't meet the ColorLok® quality standard. In addition to experiencing significantly fewer paper jams and other faults, ColorLok® papers left behind less dust and toner contaminants, which could potentially contribute to long-term printer reliability and image quality issues.

[3] All printers, paper and toner cartridges were purchased on the open market.

[4] Each paper type was tested in two of each of five printer models (for a total of 50 printers) and installed seam-side up. All printers were tested using their default settings, operated in simplex mode and used host PCs running the Windows XP operating system. To test reliability, BLI technicians operated the printers continuously for up to eight hours a day, with interruptions only for paper refills, cartridge changes, paper jams and other unforeseen stoppages, overnight and weekends, with paper fed from the main or highest-capacity paper tray. An XLS test file was used for reliability testing. Throughout testing, BLI monitored printer condition and documented signs of component wear, paper dust and contamination on printer components. For image quality testing, the test suite for monochrome printers included four different test files; for color printers the suite included three different test documents. The first print quality samples were output at 200 pages. For monochrome printers, additional samples of each target were printed at 20,000 pages and then at intervals of 10,000 pages thereafter. For the color printer, after the first samples were output at 200 pages, additional samples were output at 10,000 pages and thereafter samples were output at intervals of 5,000 pages. In all cases, if a cartridge was within 200 pages of end of life or if a newly installed cartridge had produced less than 200 pages, that sample would not be included in the evaluation; instead the next sample would be taken once a new cartridge had produced 200 pages. For more information, www.buyerslab.com



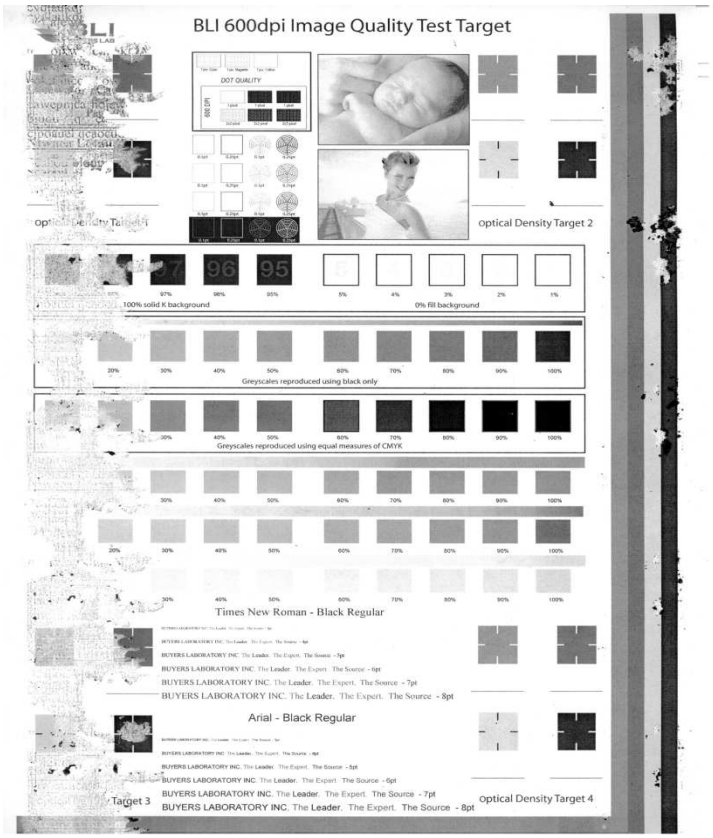
Left: Paper Dust Accumulation – Tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard

Right: Paper Dust Accumulation – ColorLok® Paper

The above photos were taken by BLI test technicians and show paper dust accumulation inside two units of the same model printer after printing 50,000 pages. Clearly, more dust is present with the tested papers that don't meet the ColorLok® quality standard with large-particle GCC filler particles.

Based on test results, BLI concluded that there was better output over more pages using ColorLok® papers, and higher productivity in terms of fewer interruptions to clear paper jams and other printing faults, including reprinting of unacceptable pages.

BLI's test results show that combined faults including misfeeds, paper jams, multi-sheet feeding, and machine errors were 53 for the thirty (30) printers using ColorLok® papers compared to 206 for the twenty (20) printers using abrasive, large particle filler papers that don't meet the ColorLok® quality standard. On a per-paper-type basis, this is a 483% higher incidence of combined printer faults (almost 5 times greater) when using the tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard.



While image quality failures were experienced with both of the abrasive, large-particle filler papers that don't meet the ColorLok® quality standard, all three ColorLok® papers completed the 50,000-page tests in all of the five printer models without any image quality failures. That's 50,000 pages in each of 30 printers for a total of 1.5 million pages printed on ColorLok® paper.

The test image shown on the left was printed on tested abrasive, large-particle filler papers that do not meet the ColorLok® quality standard at about 20,000 pages into the 50,000-page test. The print shows unacceptable image flaws: ghosting, toner flaking, and voids.

While no image quality failures occurred with any of the ColorLok® papers, severe image quality flaws that BLI considered image quality failures (i.e., meaning the output was unusable) occurred using both tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard. The most prevalent and troublesome

flaw was ghosting[5], and toner flaking, where flakes or sheets (in the worst instances) of unfused toner were found either adhered to the printed page or simply extruded from the fuser rollers.

For example, consistent ghosting was noted early with large GCC-filler paper run through the Model "B" test units, with flaking occurring soon afterwards at around 17,000 pages. These problems persisted and worsened as the test proceeded. Eventually toner voids appeared on the printed pages, and the overall image quality deteriorated so quickly that the image quality sample sets taken after 20,000 pages were rated as failures, as were all samples taken thereafter until the conclusion of the test.

From an overall reliability standpoint, BLI testing found that printers operated up to nine times longer with ColorLok® papers than with tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard.[6] In addition, this report concluded printers using tested papers with abrasive, large-particle filler that don't meet the ColorLok® quality standard experienced 400% more faults (4 times more misfeeds, double-feeds, misprints, errors)[7] and 431% more paper path obstructions (more than 4 times more) compared to printers using ColorLok® papers.[8] And, printers using ColorLok® papers delivered good-quality output for almost three times longer than with tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard.[9]

In addition to the fact that no image quality failures were experienced with the ColorLok® papers, fewer image quality defects of any type were seen on ColorLok® papers versus the tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard. Specifically, toner flaking was as issue with the tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard early in the test, but no flaking was evidenced on the output on any ColorLok® paper.

Two other image quality defects seen in the tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard types—dirty edges in the 70 gsm large GCC filler type in Printer "C" and distorted text on the 75 gsm talc-filled paper in Printer "C" were not exhibited on any of the output produced with the ColorLok® papers.

While toner speckling was seen in the output on one of the ColorLok® papers, it was considered minor and inconsistent. In contrast, speckling was seen on both tested abrasive, large-particle filler papers that don't meet the ColorLok® quality standard —from the beginning of the test with one printer model and at 20,000 pages with another.

Ghosting was observed in the output of all paper types except for one ColorLok® paper, but it occurred earlier in testing of both abrasive, large-particle filler papers that don't meet the ColorLok® quality standard. Streaking was observed with all paper types, but BLI concluded that this may be device-related because it was observed mainly with Printers "B" and "C".

Some consistent minor defects were noted with the 70gsm small-particle PCC-filled ColorLok® paper. Repeat imaging was observed with Printer "D"; this was the appearance of regular marks down the page that might be caused by a nick on the toner cartridge drum or the fuser drum and is distinguished from ghosting. Occasional banding was observed with Printer "E".

Based on the BLI test results, the three ColorLok® papers delivered superior reliability performance and maintained image quality longer compared to the two tested papers that don't meet the ColorLok® quality standard with large filler particles.

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[5] "Ghosting" describes unwanted images that appear on previous pages or from portions of the current page.

[6] Based on testing by Buyer's Lab Inc. For more information, visit www.buyerslab.com. Tested papers that did not meet the ColorLok® quality standard were manufactured in Asia, are primarily sold in China and India today, and contained high percentages of abrasive, large particle fillers (ground calcium carbonate, talc). ColorLok® papers are validated for smoothness and low percentages of abrasive, large particle fillers.

[7] Based on testing by Buyer's Lab Inc. For more information, visit www.buyerslab.com. Tested papers that did not meet the ColorLok® quality standard were manufactured in Asia, are primarily sold in China and India today, and contained high percentages of abrasive, large particle fillers (ground calcium carbonate, talc). ColorLok® papers are validated for smoothness and low percentages of abrasive, large particle fillers. Faults include misfeeds, paper jams, double feeds, and other misprints requiring user intervention and an average 1.5 minute delay for the cleaning cycle.

[8] Based on testing by Buyer's Lab Inc. For more information, visit www.buyerslab.com. Tested papers that did not meet the ColorLok® quality standard were manufactured in Asia, are primarily sold in China and India today, and contained high percentages of abrasive, large particle fillers (ground calcium carbonate, talc). ColorLok® papers are validated for smoothness and low percentages of abrasive, large particle fillers. Paper path obstructions are defined as anything requiring a user to find and remove jammed paper.

[9] Based on testing by Buyer's Lab Inc. For more information, visit www.buyerslab.com. Tested papers that did not meet the ColorLok® quality standard were manufactured in Asia, are primarily sold in China and India today, and contained high percentages of abrasive, large particle fillers (ground calcium carbonate, talc). ColorLok® papers are validated for smoothness and low percentages of abrasive, large particle fillers; assumes typical printer life is 50,000 pages.

Summary

Due to economic factors and the unavailability of high-quality pulp, mills in Asia and China are producing more low-cost office papers with high filler content which are primarily sold locally today. These papers could have worldwide distribution under many different brands. Much of the filler used in these papers is ground calcium carbonate or talc with large particle size. Independent tests conducted by third-party lab BLI, commissioned by HP found significant degradation in laser printer reliability and imaging performance using samples of these low-cost papers with abrasive large-particle mineral fillers.

The rigorous performance specifications for ColorLok® papers provide users in the home and office with a high-quality, reliable, and consistent printing experience. For paper and printer manufacturers and paper suppliers, the ColorLok® Program offers members a means to differentiate their products with a value proposition that is both recognizable and appealing to customers.

For more information

To learn more about ColorLok® benefits, visit www.hp.com/go/colorlok

To learn more about the HP ColorLok® licensing program, visit www.hp.com/hpinfo/abouthp/iplicensing/colorlok-contactus.html

To learn more about ColorLok® qualification and testing, visit www.printlab.rit.edu

Authors:

Ross R. Allen, Senior Technology Specialist, HP Printing Technology Platforms

John Stoffel, Technology Manager, HP Printing Technology Platforms

Charles P. Klass, Adjunct Professor of Paper Engineering, Chemical Engineering and Imaging at Western Michigan University

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