



The Value of Certified Consumables Yield Numbers

A QualityLogic White Paper

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Revision History

Version	Date	Description	Name
1.0	04/06/05	Initial Release	James Mater
1.1	09/15/08	Updated with new ISO and ASTM standards	Russ Mendenhall

Introduction

Manufacturers of printer products routinely publish specifications of “yield” for their printer consumables. These specifications are the basis for customer comparisons of printer cost per page and total cost of ownership. Billions of dollars of printer and consumables sales are influenced by these simple specifications.

While quality and reliability play critical roles in customer satisfaction, printer buyers typically develop an economic analysis that depends on assumed consumables yield estimates to compare the competing printing solutions available to them.

How important are yield specifications in the decision to purchase a printer? The cost of the consumables is likely to make up 60 to 80 percent of the overall hard costs of ownership (Total Cost of Ownership or TCO), compared to 10 to 15 percent for the initial hardware costs and 5 to 10 percent for paper supplies¹.

Unless the reported yields are based on standard methodologies, the press, analysts and users can and should question the use of any published claims. A September 2004 article in Lyra’s Hard Copy Supplies Journal titled “Can Manufacturer’s Ink Cost-Per-Page Claims Be Believed” highlights this issue². Although this article dealt specifically with ink yield, the measurement issues apply to toner yields, as well. The article points out that one printer vendor’s published ink yield claims differed significantly from those of two independent test labs using differing measurement processes:

“Each manufacturer measures yield using its own test file, so it is impossible to compare the yields of one manufacturer’s printer against another’s even though all manufacturers state cartridge yields in terms of 5 percent coverage. This makes the cost-per-page claims of manufacturers meaningless and makes it next to impossible for consumers to compare printers from different manufacturers.”

“The most important reason why a standard test methodology is needed is consumer fairness. Currently, the consumer has no idea what the operating cost of a printer will be when it is purchased. The consumer cannot even compare one manufacturer’s stated cost per page against another’s because of the different ways they are measured...We are actually surprised that consumer advocates have not pushed for standardized testing and labeling of

¹ QualityLogic, Inc., “Printer Total Cost of Ownership Assessment White Paper” August 31, 2004, <http://www.dell.com/downloads/global/vectors/Total%20Cost%20of%20Printing.pdf>.

² Lyra Research, Inc., The Hard Copy Supplies Journal, September 2004.

printers and cartridges just as they have for the fuel mileage of automobiles and the energy consumption of refrigerators...”

Historically printer vendors had measured yield by printing a page that had 5 percent ink or toner coverage for monochrome pages, or a series of pages with 5 percent coverage for each color cartridge (CMYK) used in color printers. While this sounds simple, several factors made it difficult to compare yield results when differing test methods were used:

- Is 5 percent coverage based on the physical size of the page, the device’s printable area, or some other criteria?
- What paper size is used for the yield calculation?
- Because of differing imaging algorithms used to optimize image quality, the same test page may use different amounts of ink or toner when printed on two different printers.
- The definition of what constitutes end of life for a cartridge is left to the subjective judgment of the printer vendor.
- How is the yield calculated?
- Color calibration, intermittent printing, temperature and humidity along with a large number of other factors can influence the test results for color ink or toner and each manufacturer used proprietary methodologies to account for these factors.

The good news for the user is that the industry has moved away from proprietary yield testing methodologies to standardized processes. There has been broad support for this shift by printer manufacturers and many third party testers. The purposes of this QualityLogic White Paper are: 1) to explain the importance of standardized ink and toner yield measurements; and 2) to provide an overview of the industry’s and QualityLogic’s approach to toner and ink yield measurements. 3) contrast the rigor of the ISO standards which are broadly supported in the printer industry to standards that are available from ASTM.

Standardized Yield Tests

The imaging industry continues to progress towards a more mature, customer-focused business. With this maturity comes more information about issues that determine the consumer’s satisfaction level with the industry’s products. Industry standards help move this information from subjective data to objective data that enables apples-to-apples comparisons between products.

Yield Standards

An international effort by ISO has been underway for several years to define a set of standardized methodologies for toner and ink consumables yield. In mid-2004, the first standard emerged from this effort defining a methodology for measuring monochrome toner yield (ISO/IEC 19752)³. The standard uses a well-defined business document as a test page rather than specifying a coverage percentage. This first standard was followed in December 2006 (updated in December 2007) with two standards for measuring color yield, which also includes any black cartridges. One standard (ISO/IEC 19798)⁴ is used to measure color toner (CMYK) yield while the second (ISO/IEC 24711)⁵ is used to measure color ink yield. Both of these standards use a common well-defined business document (ISO/IEC 24712)⁶ as the test page. The standards also address many of the other issues noted above that impact consistency of yield results in the industry.

There are competing standards to the above ISO methodologies for the determination of yield. The competing standards are from ASTM. The ASTM International (ASTM F 1856 04e1)⁷ can be utilized for the determination of toner yield, either monochrome or color, while the ASTM International (ASTM F 2555 06)⁸ standard can be used for color ink printers. In addition the ASTM International standard (ASTM F 2632 - 07)⁹ can be utilized for the determination of color toner yield. The ASTM F 1856 uses text only pages while ASTM F 2632 uses color bands which are more similar to the patches in the ASTM F 2555 color ink test targets. Based on our own experience and the similarity of ASTM F 2632 and ASTM F 2555 standards we have concluded that ASTM F 2632 is a better match for color toner testing. For the purposes of this discussion we will use the ASTM F 1856 standard for mono laser testing, ASTM F 2632¹⁰ for color toner and ASTM F 2555 for color ink.

³ "Information technology — Method for the determination of toner cartridge yield for monochromatic electrophotographic printers and multi-function devices that may contain printer components", ISO/IEC 19752:2004, stage 2009-09-30.

⁴ "Method for the determination of toner cartridge yield for colour printers and multi-function devices that contain printer components", ISO/IEC 19798:2007, stage 2007-12-10.

⁵ "Method for the determination of ink cartridge yield for colour printers and multi-function devices that contain printer components", ISO/IEC 24711:2007, stage 2007-12-03.

⁶ "Colour test pages for measurement of office equipment consumable yield", ISO/IEC 24712:2007, stage 2007-12-10.

⁷ "Standard Practice for Determining Toner Usage for Printer Cartridges", ASTM International, approved May 1, 2004 and published June 2004, updated in 2007 and reapproved in 2009.

⁸ "Standard Practice for Determining Yield of Ink Jet Printer Cartridges – Continuous Printing Method", ASTM International, approved June 15, 2006 and published June 2006.

⁹ "Standard Practice for Determining Toner Usage for Color Printer Cartridges", ASTM International, approved February 1, 2007 and published March 2007.

¹⁰ The ASTM F 1856 standard only supports All-in-One systems while the ASTM F 2632 standard supports the evaluation of both All-in-One and replenishment toner systems which adds further weight to its usage for comparison purposes.

The critical differences between the ISO and ATSM methodologies are summarized below for each of the technologies:

1. The ASTM toner methodologies are designed primarily for comparing two cartridges on the same printer for research and development and quality control purposes. The ASTM ink methodology is intended for the evaluation of an OEM (Original Equipment Manufacturer) cartridge compared to a refilled, remanufactured, or compatible ink jet printer cartridge when this practice is performed on the same printer. The ISO standards are intended to provide accurate, standardized yield specifications for a printer/cartridge model combination. Thus the ISO standards are designed with the ability to compare different printer model/cartridge combinations which the ASTM standards are not intended for. This is a fundamental difference in that ASTM standards are not intended to compare the yield of one manufacturer's printer and corresponding cartridges against another vendor.
2. The ASTM standards specify a newly designed page for each printer that is tested. The ASTM F 1856 toner standard specifies the development of a 5% \pm .5% toner coverage¹¹ for a specified print area while the ASTM color toner and ink standards specify that a 5% page be designed¹². Note that the \pm .5% tolerance, allowed by ASTM F 1856, on a page in reality can be \pm 10% different from another page. This would impact yield by \pm 10% on any cartridge tested with the two pages. The ISO standards use the same pages, either the mono page for mono tests or the color suite for color testing. In the real world, users don't redesign pages for each printer they want to use in order to ensure comparable toner usage. Rather they have pages they print regardless of the printer. While the ISO pages may cause variations from a 5 percent page for a specific printer, the comparative yield measurements are more realistic. In addition, manufactures or testers have no latitude to manipulate the page designs to achieve desired results and are not required to conduct elaborate page coverage measurements in the process.
3. Determining the End-of-Life of a cartridge is critical to determine its actual yield]. The End-of-Life can be due to either "ink out" or "toner out" message or due to fade. It is important to monitor for fade even if the printer has End-of-Life messages. In addition the design of the page is critical if fade is used to determine the End-of-Life. The ASTM color standards call for the development of pages which use patches that are the colors in the cartridges under test. Using

¹¹ The meaning 5% in all of these standards is for each cartridge color in the printer. A black only test would have 5% overall coverage, a 4 color printer will have 20% coverage and a six ink system would have 30%.

¹² The ASTM International standard F2555 refers to the ASTM International standard F 1942 - 98 which was reapproved in 2003 for the development of test targets for ink yield. The ASTM F 2632 - 07 standard includes procedures for development of the test target as part of the standard.

the colors in these cartridges for determining fade of yellow is very difficult at best. Yellow is a hard color to see fade with due to its intensity. This is not an issue with the ISO color test suite as there are patches of mixed colors which allow easy identification of fade for all colors including yellow. In addition the ISO page contains patterns typical of business documents that are specifically designed to show ink, but also toner, depletion, which causes End-of-Life. This is not required or a part of the ATSM target design requirements for any of their standards.

4. The ASTM toner standards estimate yield by measuring toner used to print 1000 pages and calculating the total yield based on the weight of the remaining toner. The ISO toner standards print the cartridges to a defined End-of-Life so that the real yield is measured for each toner cartridge tested.
5. The ASTM procedures are focused on determining yield on a single cartridge while the ISO standards are designed to measure a statistically derived yield for the cartridge model. ASTM only tests a single cartridge while the ISO standard tests a minimum of 9 cartridges of all colors¹³, spread across manufacturing lots wherever possible, of each color on a minimum of 3 printers (3 cartridges on each printer) and computes and reports what is termed the 90% lower confidence bound. The ISO yield test result is typically well below the average of the nine cartridges for each color and thus provides the user with a reasonable level of confidence that the yield they receive will be above this number on average.
 - a. For integral ink and all-in-one toner cartridges our experience is that actual yields over a set of nine cartridges in the ISO based tests vary on average by $\pm 9\%$. Thus any two cartridges could have an 18% spread in yields.
 - b. For systems with separate ink and toner reservoirs, which are becoming common in color toner printers, the variation in actual yields over a set of nine cartridges in the ISO based tests vary by an even larger amount.
 - c. This spread in individual yields seen in our testing is addressed by the ISO yield calculation methodology while the ASTM approaches do not address this issue.
6. The ASTM ink standard requires a 5% coverage page for all colors tested. For systems that have more than four inks, CMYK systems, the additional inks such as Light Cyan and Light Magenta will typically be used at a lower rate than 5% per page. The ASTM standard does not take this into account while the ISO

¹³ In a color printer the ISO methodology will frequently require the exhaustion of more than the minimum of nine cartridges for any color.

methodology does take these lighter usage cartridges into consideration in computing their yield relative to the rest of the cartridges in the printer.

7. Temperature and humidity have an impact on the yield of toner based systems while temperature impacts the yield of ink based systems. The ISO standards require control of temperature in all of their standards to an operating average of $23.0^{\circ}\text{C} \pm 2^{\circ}\text{C}$ while in the toner methodologies they require humidity control to $50\% \pm 10\%$ recorded every 15 minutes. The ASTM toner standards only require that printers be within their operating range which is much broader than the ISO limits. Manufactures or testers have little latitude to manipulate the temperature and humidity in ISO testing to achieve desired results.
8. The ASTM ink standard only covers ink jet printers while the ISO ink standard covers both solid and liquid ink systems.

We know from our own research, as noted in 6a and 6b above, that there can be significant variance between cartridges of the same model in the same printer. Thus the ASTM methods for measuring yield for a single cartridge can produce yield estimates that can be significantly misleading. For these reasons, in addition to the factors outlined above, QualityLogic has adopted the ISO methodologies for printer/cartridge yield testing and consumers should be wary of the accuracy of yield claims using other methodologies.

QualityLogic's Yield Test Services

QualityLogic has been an industry pioneer in providing standard tools and services for assessing printer performance¹⁴, consumables reliability analysis¹⁵, and functionality¹⁶.

Our research has also contributed to assessment of total cost of ownership (TCO)¹⁷. Consumer buying decisions for both initial printer purchases and subsequent supply purchases are complex and range from simple entry price considerations for minimal print users to extensive quality, reliability and TCO analyses for major corporate purchase decisions.

While in the past OEM's traditionally conducted their own yield testing, the establishment of standard tests reduces the need to conduct proprietary yield

¹⁴ QualityLogic's "PageSense", <http://www.qualitylogic.com/Contents/Printer-MFP/Products-and-Services/PageSense.aspx>.

¹⁵ "Reliability Comparison Study for HP Toner Cartridges vs. Remanufactured Cartridges, QualityLogic, Inc." (linked from <http://www.hp.com/sbso/product/supplies/landing.html>)

¹⁶ <http://www.qualitylogic.com/Contents/Printer-MFP/Products-and-Services/Outsourced-Testing.aspx>.

¹⁷ QualityLogic's "Printer Total Cost of Ownership White Paper", <http://www.dell.com/downloads/global/vectors/Total%20Cost%20of%20Printing.pdf>.

studies. As a result there has been a shift in the printer industry to the use of the ISO methodologies. Our customers have also found over time that independent certification of key product specifications such as yield can increase consumer confidence in their claims. We are the first in the industry to offer 3rd party industry standard yield test packages that includes a certification of ISO yield for mono toner, color toner, or color ink cartridges. In addition we offer a QualityLogic yield methodology for photo printers.¹⁸

Package	Test Standard	Test suite
Mono Toner Printer	ISO/IEC 19752	ISO/IEC 19752 test page
Color Toner Printer ¹⁹	ISO/IEC 19798	ISO/IEC 24712
Color Ink Printer ²⁰	ISO/IEC 24711	ISO/IEC 24712
Photo Ink	QualityLogic methodology	QualityLogic photo test suite

QualityLogic uses the ISO standard tests that are approved, and we have developed our own methodology when the ISO standard has not yet been released. The Photo methodology that we provide uses as much of the existing color ink standard as possible while using our own test suite. In addition we have filled in the missing elements with our own best practices based on end user-centered behavior. When the ISO Photo standard is completed and available we will support that standard.

We also bring our proprietary technology and processes to the yield testing service to ensure efficient testing and superior quality results. These unique additions include:

1. QualityLogic’s PageServe software and Yield Data Capture tools ensure reliable data capture, provides an audit trail for the test results;
2. QualityLogic’s environmentally conditioned test rooms that control temperature and humidity to the ISO standards;
3. Proprietary tools and methods for managing the test process for maximum efficiency while ensuring quality control of the results.

QualityLogic is engaged in additional research to add even greater efficiency and quality control to the yield measurement process.

QualityLogic’s investments in process, tools and infrastructure for yield testing allow us to provide an independent, third party standard certified yield test service for

¹⁸ ISO is currently working on the development of a photo methodology and supporting test suite.

¹⁹ Both the ISO/IEC19798 and ISO/IEC 24711 standards also allow testing and reporting of yield with the mono ISO/IEC 19752 page if done in conjunction with the ISO/IEC 24712 page.

mono toner, color toner, color ink cartridges and color photo printers. Reporting can be either a standalone, ISO-like report or a comparative report of different printer/cartridge combinations. Reports can be published and the certification includes a certification logo that can be added to web sites, packaging and marketing materials.

While standard methods for assessing the page yield of printer consumables do not address all of the issues of yield in the real world, they are an important contribution to ensuring increasingly positive user experiences with the products of the imaging industry. Quality and reliability have critical impacts on the real costs of owning a printing system. Standardized yield measures are most valuable if they eliminate confusion for consumers in their economic analysis and are considered in the context of printer and consumable quality and reliability.