



The Value of Certified Consumables Yield Numbers

A QualityLogic White Paper

Version 1.0

April 2005

Table of Contents

Revision History	3
Introduction	4
Standardized Yield Tests	5
Mono Toner Standards	5
Reported Yield vs. ISO-Measured Yield	7
Color Technologies.....	8
QualityLogic Specific Color Toner Yield Test Decisions	9
Yield Measurement and the OEM	11
QualityLogic’s Yield Test Services	12

Revision History

Version	Date	Description	Name
1.0	04/06/05	Initial Release	James Mater

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.

But because the reported yields are not based on standard methodologies, the press and analysts are questioning the use of the 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 deals 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 printers and cartridges just as they have for the fuel mileage of automobiles and the energy consumption of refrigerators...”

¹ QualityLogic, Inc., “Printer Total Cost of Ownership Assessment White Paper” August 31, 2004, http://www1.us.dell.com/content/topics/global.aspx/solutions/en/print_solutions?c=us&cs=04&l=en&s=bsd.

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

Historically printer vendors have 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 make it difficult to compare yield results when differing test methods are 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.
- Color calibration, intermittent printing, and a large number of other factors can influence the test results for color ink or toner and each manufacturer uses a proprietary methodology to account for these factors.

The twin 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 mono and color toner yield measurements.

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.

The printer industry has an immediate need for a consistent yield assessment methodology so that products can be compared competitively in a fair manner. The industry is in the process of adopting standard methods for measuring page yields, with all of the major manufacturers supporting the standardization.

Mono Toner Standards

An international effort has been underway for many years to define a standardized methodology for measuring toner 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. The standard also addresses many of the other issues noted above that impact consistency of yield results in the industry.

There are actually two competing standards for the determination of monochrome toner yield: one from the International Standards Organization (ISO/IEC 19752) and the other from ASTM International (ASTM F 1856 04)⁴.

The critical differences between the two standards are summarized below:

1. The ASTM methodology is designed primarily for comparing two cartridges and for quality control of remanufactured cartridges, while the ISO standard is intended to provide accurate, standardized yield specifications for a printer model/cartridge model combination.
2. The ASTM standard specifies a newly designed 5 percent toner coverage for a specified print area for each printer while the ISO standard uses the same page for all printers. 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 page 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. The ASTM procedure is focused on measuring yield on a single cartridge while the ISO standard is designed to measure a statistically valid average for the cartridge model. ASTM only tests a single cartridge while the ISO standard tests a minimum of 9 cartridges on a minimum of 3 printers (3 on each) and averages the results.
4. The ASTM standard estimates yield by measuring toner use to print 1000 pages and calculating the total yield based on the weight of the remaining toner. The ISO standard prints the cartridges to a defined End-of-Life so that the real yield is measured.
5. To date, there is not an ASTM standard for measuring color toner yield, while the ISO standard is in a late draft state and is moving towards adoption.

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, first edition 2004-06-15.

⁴ "Standard Practice for Determining Toner Usage for Printer Cartridges", ASTM International, approved May 1, 2004 and published June 2004.

We know from our own research that there can be significant variance between toner cartridges of the same model in the same printer. Recent unpublished tests by QualityLogic found that a given cartridge of a cartridge model could produce 8 percent more or fewer pages than the average page yield. Thus the ASTM estimation method for measuring toner yield for a single cartridge can produce misleading yield estimates for a cartridge model. For these reasons, QualityLogic has adopted the ISO model for printer/cartridge yield testing.

Reported Yield vs. ISO-Measured Yield

In order to illustrate the impact that differences between reported and ISO-measured yields can have on a TCO calculation, we looked at a simple model to see the sensitivity of TCO to these changes. The table shows the percentage impact on the overall TCO calculation that consumables (ink/toner) represent versus the percentage difference between reported and ISO-measured yield. For instance, if the reported yield is 15 percent *less* than the ISO-measured yield, and if consumables accounted for 70 percent of the TCO, then the reported TCO would calculate costs 10.5 percent *higher* than it would actually be if all printing were done with pages that approximated the ISO standard. In this scenario, specifying the reported yield rather than the ISO-measured yield puts this printer at a TCO disadvantage.

	% Change: ISO versus Reported				
% of TCO	-5%	-10%	-15%	-20%	-25%
50%	2.5%	5.0%	7.5%	10.0%	12.5%
60%	3.0%	6.0%	9.0%	12.0%	15.0%
70%	3.5%	7.0%	10.5%	14.0%	17.5%
80%	4.0%	8.0%	12.0%	16.0%	20.0%
90%	4.5%	9.0%	13.5%	18.0%	22.5%

The converse is also true. If a reported yield were 15 percent *higher* than the ISO-measured yield, then the reported TCO calculation would *underestimate* the TCO by 10.5 percent. In the second scenario, the reported yield (as opposed to the ISO yield) would give the vendor a lower estimated TCO than ISO yield would indicate.

The real impact occurs when comparing printers from different vendors, where one understated yield and the other overstated yield. The calculation using reported yield numbers could show a difference in TCO in favor of one vendor, while using the ISO-measured yield could show just the opposite. From a printer user’s standpoint, TCO comparisons based on standard yield measurements provide a more accurate comparison.

To illustrate this point, an independent test lab found significant variations between reported yields versus tested yields in a study reported in September, 2004⁵. The cartridge yields for these monochrome laser printers were measured using the recently adopted ISO standard⁶. The actual ISO-measured yield comparisons between printers varied by up to 40 percent from the manufacturers' reported yield comparisons. The measured yields produced very different comparisons on a cost-per-page (CPP) basis than the manufacturer claims produced. An unknowing buyer could choose a printer based on yield and cost-per-page claims without realizing that the methods for measuring and reporting yield were different between the two manufacturers.

For monochrome toner, the problem is solved with the ISO/IEC 19752 standard, which has been adopted by major printer manufacturers. Independent, third-party testing using the ISO standard virtually guarantees that, finally, printer buyers can trust specified yield numbers. While other factors should be considered in any buying decision, to the extent that a TCO analysis using an estimated yield influences the decision, then it is important that the comparison be based on a standard apples-to-apples metric.

Color Technologies

Additional work continues in the ISO/IEC SC28 standards group to define methodologies for color toner and color inkjet yield measurements⁷. In general, these new standards will follow the basic methods defined in the monochrome yield standard, but will also address the unique testing challenges associated with color technologies.

For color toner devices, QualityLogic has developed an interim test methodology that is consistent with the spirit of the standards work going on in this area and uses the latest proposed test pages⁸. Once ISO/IEC standards are approved for color toner, QualityLogic will implement changes to the interim QualityLogic methodology to bring it into conformance with the new standards.

The US ISO working group (the W1 Committee of the INCITS, the US organization working on printer ISO standards) has been considering the issue of intermittent versus continuous printing of color printers as part of the yield testing methodology.

⁵ "Toner/Drum Yield and Cost per Print, HP LaserJet 1300 and Dell 1700 Laser Printers", Spencer & Associates Publishing, Ltd., 30 September, 2004.

⁶ "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, first edition 2004-06-15.

⁷ "Method for the determination of ink cartridge yield for colour inkjet printers and multi-function devices that contain inkjet printer components", ISO/CD 24711, July 14, 2004.

⁸ Proposed February 3, 2005 Initial Test Pages. These may not be the final test pages in the ISO/IEC 24712 Color Test Yield adopted standard.

This issue further illustrates how, in lieu of a standard methodology, individual manufacturers can use unpublished methodologies that yield very differing results. Some proprietary work shared with the W1 committee shows that black inkjet cartridge yield results can vary by as much as 42 percent between continuous and interval printing, while color yield can vary by as much as 26 percent⁹. When intervals are introduced to the yield measurement process, additional ink or toner is used in maintenance and color calibration that can greatly degrade the actual cartridge yield experienced by users.

QualityLogic Specific Color Toner Yield Test Decisions

The color test files used in QualityLogic's methodology are the standard of comparison for the yield test results. These are derived from the draft ISO/IEC 24712 documents as referenced in version 3.0 released on 3/1/05. Should the final ISO test file suite differ, QualityLogic will adopt the final version.

The goal of the yield test is to determine average page yield of a toner cartridge when run to end of life on a specific printer model. This testing is accomplished by using a minimum of 3 printers and running a minimum of 3 of each cartridge type to end of life on each printer (a printer that supports four colors would have a minimum of 3 of each color run on a minimum of 3 printers for a minimum total of 36 cartridges).

After the completion of testing, the average yield and standard deviation for the cartridge is calculated. This information is used to determine the lower confidence bound of the average cartridge yield at a 90 percent confidence level. This lower bound confidence value is the reported yield for the cartridge for mono toner cartridges.

Although ambiguities will always exist in any test process, the ISO/IEC specifications released and in draft form, as well as QualityLogic's efforts when a standard is not yet adopted, make gigantic strides towards a consistent testing methodology for yield. Since the ISO/IEC 24712 for color toner yield testing is still in development, QualityLogic has made some judgment calls in order to develop a color toner yield methodology. Examples of these judgment calls and the rationale for them include:

Cartridge End of Life: The ISO mono toner specification indicates that a Toner Low indication can be used to trigger cartridge agitation and additional printing. The ISO color spec currently states that the occurrence of a Toner Out indication is EOL regardless of shake specifications. QualityLogic agrees with the ISO draft and a Toner Out condition causes cartridge EOL for color printers. There is no additional cartridge agitation or printing after Toner Out. (Note: manufacturers may display

⁹ These results have not been made public as of the date of this publication.

these conditions differently, such as "Order Supplies" rather than "Toner Low", and "Cartridge Out" rather than "Toner Out".)

Individual Page Yield: The ISO mono specification states that the yield is "...the number of 'standard page file' pages printed between cartridge installation and end of life." However the color specification states that "The individual page yield of a cartridge is determined by counting the number of standard suites printed between cartridge installation and End of Life and multiplying by 5. The number of suites counted may contain some pages that show visible fade. To simplify the testing, determination of End of Life based on fade is only made on the diagnostic page. If the printer stops due to Toner Out in the middle of a test suite, the suite that was being printed will be counted in the page yield."

Calibration Pauses: One of the issues with color printers is the use of toner during a color calibration process. The ISO working group is debating the best way to address this issue. In the interim, QualityLogic will run the color yield test in semi-continuous simplex printing as set in the default print mode. A series of ten 45-minute pauses are evenly distributed throughout the printing process over the expected life of each cartridge. These pauses are intended to trigger the printer to initiate maintenance activities that consume toner while in a sleep mode. This behavior is device-dependent and may differ from manufacturer to manufacturer. To the extent that the testing emulates real-world behavior and is conducted consistently from printer to printer, we believe that this methodology provides a reasonably comparative picture of color toner yield between printers.

Testing Procedure – Cartridge Instructions: The ISO mono specification requires the yield test to obey the cartridge instructions over the printer manual in conflicts, while the draft color specification states the opposite. For consistency, QualityLogic has chosen to stay with the mono specification and operate from the cartridge instructions for both mono and color toners except where they specify printer driver setting changes. In these cases, we concur with ISO's prohibition of changing driver settings between cartridge models.

Defective Cartridge: The draft ISO color specification indicates "For this test, early end-of-life is not sufficient cause for classifying a cartridge as defective." We have added this statement to the QualityLogic methodology and believe that there are other definitions that cover the determination of a defective cartridge. A cartridge that stops printing early shall be included in the yield calculations unless some clear failure mechanism can be identified which would place it in the defective cartridge category.

Declaration of the Yield: The draft ISO color specification states that the "Declared yield can be either the lower confidence bound values for each individual cartridge, or a value for the black cartridge and an average yield for the CMY cartridges using

the lowest of the 3 lower confidence bound yields for the 3 cartridges.”

QualityLogic’s methodology allows clients the choice of one method or the other, with the chosen method specified clearly in the test report.

For more details on the QualityLogic methodology, see the latest version of the QualityLogic Toner Cartridge Yield Testing Methodology at www.qualitylogic.com.

Yield Measurement and the OEM

Printer manufacturers have a vested interest in seeing the measures of cartridge yield standardized. Indeed, QualityLogic is contacted periodically by large corporations doing TCO studies for printer selections because they cannot find reliable, independent data on which to develop comparisons. We are asked to conduct yield, performance and reliability studies to provide independent data.

A standard yield measurement and reporting methodology simplifies the buying process for consumers and will increase their confidence in their own comparisons of alternative solutions. A standard methodology can permit OEMs to divert the resources currently used to devise and execute their own yield tests (and to counter other OEM’s proprietary yield methodologies that are kept private) and concentrate instead on increasing the value of their products to customers in raw yield and other competitive measures.

A standard yield methodology also is useful for internal product analysis and decisions as it provides an apples-to-apples comparison with the competition as seen by consumers.

The last reason that manufacturers are motivated to support industry standard yield testing is that the largest competitors have endorsed it and are actively adopting the standards. The announcement of the ISO/IEC 19752 monochrome toner yield methodology was made with support from HP, Canon, Epson and Lexmark¹⁰. Since then Kyocera Mita has announced its support¹¹, and we expect other OEM’s to get on board also. We fully expect that soon consumers will be asking vendors for their ISO-based page yield measurements.

¹⁰ “Canon, Epson, HP, and Lexmark, Support New ISO Standard that Helps Customers Evaluate Printer and Print Cartridge Yield”, BusinessWire, June 16, 2004.

¹¹ “Kyocera Mita America Supports Standard for Measuring Monochrome Toner Cartridge Yield”, BusinessWire, November 3, 2004.

QualityLogic’s Yield Test Services

QualityLogic has been an industry pioneer in providing standard tools and services for assessing printer performance¹², consumables reliability analysis¹³, and functionality¹⁴.

Our research has also contributed to assessment of total cost of ownership (TCO)¹⁵. 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 OEM’s have traditionally conducted their own yield testing, the establishment of standard tests reduces the need to conduct proprietary yield studies. Our customers have also found over time that independent certification of key product specifications such as yield can increase consumer confidence in their claims. QualityLogic’s yield testing service is initially focused on the yield from a mono or color toner cartridge. 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 and QualityLogic yield for color.

Package	Test Standard	Coverage
Mono Toner Printer	ISO/IEC 19752	ISO page
Color Toner Printer	QualityLogic Interim (based on ISO/IEC 24712 V3.0, 3/1/05) ¹⁶	Draft ISO pages

QualityLogic uses the ISO standard tests that are approved, and we have developed our own methodology when the ISO standard is not yet approved. If a standard is in process, we attempt to use as much of the emerging standard as possible, filling in the missing elements with our own best practices based on end user-centered behavior and while also anticipating the eventual ISO standard.

¹² QualityLogic’s “PageSense”, http://www.qualitylogic.com/printer_test/performance.html.

¹³ “Reliability Comparison Study for HP Toner Cartridges vs. Remanufactured Cartridges, QualityLogic, Inc.” (linked from http://www.hp.com/sbso/product/supplies/whybuy_reliability.html?jumpid=ex_R295_go/suppliesreliability)

¹⁴ http://www.qualitylogic.com/printer_test/functionality.html.

¹⁵ QualityLogic’s “Printer Total Cost of Ownership White Paper”, http://www1.us.dell.com/content/topics/global.aspx/solutions/en/print_solutions?c=us&cs=04&l=en&s=bsd.

¹⁶ Proposed February 3, 2005 Initial Test Pages. These may not be the final test pages in the ISO/IEC 24712 Color Test Yield adopted 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 for tracking every page printed from every cartridge and every printer. This ensures an audit trail for the test results and eliminates manual or printer counting of pages which can produce measurement errors;
2. QualityLogic's environmentally conditioned test rooms that control temperature and humidity to the ISO standards;
3. Proprietary methods for managing the test process for maximum efficiency and speed 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 both mono and color toner cartridges. 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.