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Information technology — Office equipment — Method for the determination of ink cartridge photo yield for colour printing with inkjet printers and multi-function devices that contain inkjet printer components

Technologies de l'information — Équipement de bureau — Méthode d'essai de la détermination du rendement des cartouches d'encre pour l'impression de photographies en couleurs avec des imprimantes à jet d'encre et des dispositifs multi-fonctions contenant des composants d'imprimantes à jet d'encre

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

This second edition cancels and replaces the first edition (ISO/IEC 29102:2011), of which it constitutes a minor revision.

Introduction

The scope of this International Standard is limited to evaluation of ink cartridge photo yield of ink-containing cartridges (i.e. integrated ink cartridges and ink cartridges without integrated printheads) for colour photo printing with colour inkjet printers. This International Standard can be applied to colour inkjet printers having an interface to a computer as well as colour inkjet printers that cannot be connected to a computer. This International Standard can also be applied to the inkjet printer component of any multifunctional device that has a digital input printing path, including multi-function devices that contain inkjet printer components. Both liquid and solid ink products can be tested using this International Standard.

The cartridge photo yields of primary cartridges are determined by an end of life judgment, or signalled with either of two phenomena: fade, caused by depletion of ink in the cartridge, or automatic printing stop, caused by an Ink Out detection function. The cartridge photo yields of supplemental cartridges are estimated. It is envisioned that one of the uses of this International Standard will be for the calculation of cost per page (CPP). While this International Standard measures a portion of this cost, it is not used as the sole component of CPP calculation. Additional factors need to be considered for accurate CPP calculations.

Information technology — Office equipment — Method for the determination of ink cartridge photo yield for colour printing with inkjet printers and multi-function devices that contain inkjet printer components

1 Scope

The purpose of this International Standard is to provide a method to determine the ink cartridge photo yield of ink-containing cartridges (i.e. integrated ink cartridges and ink cartridges without integrated printheads) for colour photo printing with colour inkjet printers and multifunction devices that contain inkjet printer components. In the case where a cartridge set can be used in multiple printer models, only one yield test needs to be performed as long as the difference between printer models does not impact yield.

NOTE A cartridge supplier may choose to use more than one market identifier for a single physical cartridge. In this case only one yield test is required as long as there are no differences in the cartridges other than market identifiers.

This International Standard prescribes the following:

— the test method that manufacturers, test laboratories, etc. use to determine ink cartridge photo yield;

— the method for determination of declared photo yield values from the test results; and

— the appropriate method of describing the photo yield of cartridges in documentation supplied to the consumer by the manufacturer.

This International Standard is only intended for the determination of ink cartridge photo yield. No other claims can be made from this testing regarding quality, reliability, etc.

This International Standard can be used to determine the yield of any cartridge that is used during the printing of the photo test file defined in ISO/IEC 29103.

This International Standard is not for use with printers whose minimum printable size is equal to or greater than A3. This International Standard is not intended to measure the yield of photo printing on paper size larger than 4×6, L or A6. In addition, this International Standard is not for use with industrial printers or point of sale printers. It only applies to desktop printing systems.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 29103, *Information technology — Office equipment — Colour photo test pages for measurement of ink cartridge yield for colour photo printing*

ISO/IEC 24711, *Method for the determination of ink cartridge yield for colour inkjet printers and multi-function devices that contain printer components*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
fade
phenomenon in which a significant colour change occurs due to ink depletion

Note 1 to entry: If a printer exhibits fade, a five minute pause is allowed to provide for recovery of the ink delivery system and printing can continue. If fade appears on the next page, then the cartridge is judged at end of life and the additional page printed after the five minute pause is not counted in the yield calculation. If fade does not appear on the next page, then printing can continue until the next fade or ink out is encountered.

Note 2 to entry: For examples of fade, please consult Annex A.

Note 3 to entry: In some printer systems, fade can occur prematurely due to the way that ink is provided to the printing system.

Note 4 to entry: It can be helpful to use the first photo test suite print samples from the first cartridge set for colour comparison.

Note 5 to entry: A blue light source (such as a blue LED) can be used to help in the detection of yellow fade.

3.2
streak
thin lines of colour that appear in test images

Note 1 to entry: Streaks differ from fade in the width.

Note 2 to entry: If streaks occur in two or more out of four consecutive test pages, then a streak removal operation is required.

Note 3 to entry: Streaks can appear due to a number of reasons; thermal issues and clogged nozzles being two of the main causes. Comparisons are made using the phenomenon sample provided in Annex B.

3.3
streak removal operation
procedure used to restore the print performance by removing streaks

Note 1 to entry: It is often called a nozzle cleaning operation.

Note 2 to entry: If streaks are observed in two or more out of four consecutive test pages, first the printer can be left idle for five minutes. Then an additional four pages are printed. If the streaks are still observed, then a streak removal operation is conducted according to the latest printer manufacturer documentation. Due to the significant amount of ink that is used for cleaning, the maximum permissible number of times that the streak removal operation can be used on a given cartridge is prescribed in 5.2.1. All test pages printed during this process will be included in the page count for determining the yield.

3.4
printhead alignment operation
function that aligns newly installed printheads

Note 1 to entry: If it is mandatory according to the latest printer manufacturer documentation, this operation is performed during testing. The pages used in the alignment procedure are not counted in the measurement of yield.

3.5
ink low
warning generated by the printing system when it has determined that the amount of ink is such that a cartridge change may be required soon

Note 1 to entry: It does not indicate that the system is out of ink.

3.6
ink out
signal generated by the printing system when the usable ink in the system is depleted and the printer stops printing

3.7
end of life
condition determined by one of two mechanisms: *fade* (3.1) or *ink out* (3.6)

Note 1 to entry: For cartridges containing multiple colour inks, end of life is defined when the first colour exhibits fade or ink out. In the event that the printer can continue printing after ink out is reported, the cartridge will still be considered at end of life.

3.8
end of testing
point of time when all of primary cartridges are consumed three times per printer under testing

3.9
photo test suite
series of pages defined in ISO/IEC 29103 that are printed as separate jobs

3.10
individual cartridge photo yield
number of pages printed between cartridge installation and end of life

3.11
declared cartridge photo yield
at or below the lower 90 % confidence bound of the mean

Note 1 to entry: 90 % confidence bound of the mean is prescribed in 6.1 and 6.2.

3.12
primary cartridge
major contributing cartridge for ink consumption

Note 1 to entry: The minimum number of primary cartridges to be tested for different printing systems is prescribed in 4.2. Cartridges that reach *end of life* (3.7) first are classified as primary cartridges. They should be consumed at least three times per printer at *end of testing* (3.8).

Note 2 to entry: Colour inkjet printers commonly utilize a set of different colour inks to improve quality of photo images. The number of different colour inks ranges from three to more than 10. Ink usages of different colours are not designed to be uniform. In order to maintain testing time and cost at a reasonable level, the definition of primary cartridges is introduced in this International Standard.

3.13
supplemental cartridge
cartridge that is not classified as primary cartridge

Note 1 to entry: The determination of yield for supplemental cartridges is made according to the procedure prescribed in 6.2.

3.14
proxy cartridge
primary cartridge to be utilized for estimating yield of *supplemental cartridges* (3.13)

Note 1 to entry: The definition of proxy cartridges is prescribed in 6.2.

3.15
photo paper
coated paper for photo printing

3.16
content type selection
selection that specifies the content for printing

Note 1 to entry: Examples include photo and document. This can be selected by the user or in some cases by the printing system based on the automatic media detection.

3.17
paper media selection
selection that specifies the type of media

Note 1 to entry: This can be selected by the user and/or by the automatic media detection.

3.18
print quality level selection
user selection that specifies the various levels of printed image quality and enhancement

Note 1 to entry: Examples include normal, best or highest.

Note 2 to entry: Some printers might not have all of the selections specified in 3.16, 3.17 and 3.18 available.

4 Test parameters and conditions

4.1 Set up

Place the printer on a horizontal surface and set up the printer according to the installation guide provided in the printer user's manual. If a printer has the capability to use both PC connection and another method of data input for photo printing, the PC connection shall be used for testing. If a printer does not have PC connection capability, the method of delivering photo test page suite to printer and printing procedure shall be included in the test report. Use the most recent printer driver available from the manufacturer's website or the supplied driver with the printer. The driver version shall be specified on the test report. Cartridge installation shall be completed following the instructions in the cartridge installation guide. If there is a contradiction between the printer and cartridge manuals for the cartridge installation, the cartridge manual will take precedence except if changes are recommended for printer or driver settings.

At the start of the test, all printers shall be set up using a set of priming cartridges to ensure that the ink used in testing is primarily for printing, not for initial priming/cleaning. After the printer is set up according to the manufacturer's instructions, the priming cartridges shall be used to print until consistent images are generated. The priming cartridges shall be removed and replaced with new cartridges that will be used for testing yield. The pages printed during priming operation will be included in the test report. But, those pages are not counted towards yield. Even if required by the printer, printhead alignment does not have to be performed on the priming cartridges. The replacement of the priming cartridges with the first set of test cartridges may be done all at once or staggered individually. If done all at once, all test cartridges begin with photo test suite number 1 and continue until end of life. If the staggered start method is used, the test suite number shall be tracked separately for each cartridge. The test start method shall be included in the test report.

Print quality level selection shall be at factory pre-set configuration for the printer and default installed condition for the driver and shall be included in the test report. Any user selectable ink conservation modes, (for example, draft mode) shall be disabled during testing. If content type selection to photo is available on the printer, it shall be set to photo and included in the test report.

Paper media selection shall be set to photo paper. In case of multiple choices are available for photo paper setting, selection made for testing shall be included in the test report. If user selectable automatic media detection is available on the printer, it shall be disabled to make sure the same ink amount to be consumed for different media. If automatic media detection is used, it shall be noted on the test report. If these settings cannot be verified, then testing shall occur with automatic media detection on. If the printer and driver settings differ, then the driver defaults shall be used.

Any scaling to ensure that the photo test suite is printed correctly shall be based on printer system or driver. To facilitate automated testing, the photo test suite may be pre-generated using the printer driver. This is often accomplished using a print to file command. This method is only valid if it does not affect the measured yield. If a pre-generated file is used, it shall be noted on the test report.

4.2 Sample size

Colour inkjet printers commonly utilize different colour inks and/or overlays to improve quality of photo images. Number of different colour inks/overlays for colour photo printing is quite diverse. Some of the printers may utilize more than 10 different colour inks/overlays. Ink usages of different colours are not designed to be uniform. In order to maintain testing time and cost at reasonable level, major contributing cartridges are defined as primary cartridges in this International Standard. The rest of cartridges are regarded as supplemental cartridges. During testing, cartridges that reach end of life first are classified as primary cartridges.

The minimum number of primary cartridges to be tested is determined based on the number of cartridges utilized for printing system. Inkjet cartridges are designed in two common styles, single colour and multi-colour contained cartridges. The number of cartridges may be smaller than the number of colour inks/overlays. The minimum number of primary cartridges for various printing system is listed in Table 1.

Primary cartridges shall reach end of life at least three times on each of the printers tested. Regardless of the minimum number of primary cartridges specified in Table 1, all of the cartridges depleted three or more times on all tested printers shall be treated as primary cartridges. The minimum number of printers for testing is three. For example, if the number of primary cartridges is three, at least 27 cartridges shall be tested. (3 primary cartridges × 3 cartridges to reach end of life × 3 printers)

To represent yield variations due to cartridge and printer manufacturing tolerances, it is acceptable that additional engines and/or cartridges be used in testing.

Table 1 — Minimum number of primary cartridges

Printer system	The Minimum Number of Primary Cartridges
1 cartridge system	1
2 cartridge system	1
3 cartridge system	2
4 cartridge system	3
6 cartridge system	3
7 or more cartridge system	3

When testing additional printers and primary cartridges above the minimum, an effort shall be made to test an equal number of primary cartridges on each printer. For example, if an additional printer were to be tested for 3 primary cartridges, then the minimum number of cartridges to be tested would be 36 (3 primary cartridges × 3 cartridges to reach end of life × 4 printers).

When testing cartridges for a commercially available product, it is recommended that cartridges and printers be procured from various sources, or sampled from different production lots. The printers and cartridges shall be within their useful life as stated in their user's manual.

4.3 Print mode

Colour inkjet printers commonly need to service the printing system after a number of prints, or when the device has been powered down or not used for a given amount of time. This servicing uses ink that could have been used to print additional photos. It is realized that customers do not normally print in a continuous fashion. But, the yield test will be run in semi-continuous simplex printing to decrease

testing time and increase the repeatability of the testing process. Each photo test page shall be printed as a separate print job. This allows for some intra-job servicing and calibration to take place.

Additional pauses may take place due to paper refills and idle time due to end of work days, but pauses are not required. All print settings shall be documented in the test report to sufficient level to allow testing to be reproduced by a third party.

NOTE Depending on printing conditions, the yield experienced by a given user may vary significantly from the yield measured by this test method.

If a printer has capability to print both borderless and bordered, photo test suite shall be printed without border. If borderless printing is not allowed for a printer under testing, photo test suite can be printed with border. It shall be noted in test report. Any scaling to ensure that the photo test suite is printed correctly shall be based on printer system or driver.

4.4 Print environment

The temperature can have a profound effect on test results. For this reason, the test shall be carried out according to the following test conditions:

Temperature: Testing room average 23,0 °C ±2 °C

Readings to be made with a running average of 1 hour with readings recorded at least every 15 minutes, all running average temperatures are to be between 20,0 °C and 26,0 °C.

An example of the calculation of the temperature is shown in Table 2 for temperature readings taken on 15-min intervals for the testing of one cartridge.

Table 2 — Running temperature calculation example

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	Testing Room Average
Temperature t_i	24,0	23,4	20,5	24,2	23,6	22,0	25,5	24,7	22,1	20,8	22,0	23,5	23,0
Running Average T_i	N/A	N/A	N/A	23,0	22,9	22,6	23,8	24,0	23,6	23,3	22,4	22,1	
Running Average $T_i = (t_{i-3}+t_{i-2}+t_{i-1}+t_i)/4$ Testing Room Average = $(t_1+t_2+ \ldots +t_{12})/12$ From these formulae, the testing room average would be 23,0 °C, the maximum running average reading 24,0 °C and the minimum running average reading 22,1 °C. These values can be found highlighted in the table of temperature measurements. It shall be noted that the testing room average for temperature are averages of all measurements, not the running averages.													

Humidity shall be within the range recommended by the manufacturer for operating the device.

Environmental conditions shall be included in the test report. The maximum and minimum running averages for temperature shall be reported for each cartridge tested. Please see Annex C for test reporting form.

All materials shall be temperature acclimated to the test room environment. Prior to testing, the printer, paper and cartridges shall be acclimated to the above conditions. Before acclimation, packaging and shipping materials shall be opened with care to prevent damage to the cartridges during acclimation. Paper may be acclimated in the ream wrapper.

Any water condensation shall be avoided when printer, paper and cartridges are carried in the test environment

4.5 Paper

The paper utilized in this test represents photo paper. If photo paper is tested, it shall conform to the printer's list of approved photo papers for colour photo printing. If automatic media detection can be disabled and yield results are not affected by the type of paper, plain paper that shall conform to the printer's list of approved papers can be utilized for testing to reduce the cost for testing. If automatic media detection cannot be disabled, tester shall utilize photo paper.

Size of paper used in this test shall be 4×6, L or A6 size. It is recommended that the test will be performed with 4×6 sized paper if it can be utilized for a printer under testing. But, if a printer under testing is not capable of printing on 4×6 sized paper and/or L or A6 is of dominant paper size in the nation, L or A6 sized paper can be utilized for testing. Tester may use larger sized paper only if yield results are not affected by the size of paper.

The paper manufacturer, manufacturer's paper model and/or code, and size for the paper that is actually used in the test shall be noted on the report. When available, weight for the paper is actually used shall be noted on the report.

4.6 Maintenance

Printer maintenance shall be performed according to the printer and cartridge user's manual.

4.7 Test files

The test image suite used shall be as specified in ISO/IEC 29103. The test shall be conducted using the most recent official electronic test image suite as the input. The most recent official file can be located at (http://www.iso.org/jtc1/sc28). Failure to use the exact file specifications will invalidate test results. OS provided photo printing tool (for example, Windows photo printing wizard) will be used to send photo test suite to the printer. The method used for connection between the host computer and the printer shall be recorded on the test report. For automated testing, a pre-generated print file can be used if the results are equivalent to direct printing methods. This will be recorded on the test report. The version of the test file, the printer driver version and OS provided photo printing tool version and type will be included in the test report. Before starting the test, a sample file set shall be printed to check the image and ensure the proper size.

NOTE There are often several OS provided photo printing tools available; each version can have an impact on the yield results.

To reduce test variability due to other programs, it is recommended that test file generation be conducted on a printer with a "clean" install of the Operating System (OS) with only the printer driver and any test control software installed. Testing has shown that old installed drivers from the same or different printers can affect the yield results. To aid in counting and tracking pages, a header or footer can be added to the photo test page suite. Every attempt shall be made to reduce the size of this addition to minimize the effect on calculated yield. If this information is included in the photo test suite, it shall be documented in the test report.

The host computer environment such as OS, RAM size, CPU type and application software may affect the yield test results, the computer environment recommended by the printer's user manual shall be used for the test. All of this information shall be recorded on the test report. Test file shall be printed without any border if a printer has capability to print both borderless and bordered. If a printer under testing is incapable of borderless printing, test file can be printed with border. In case of bordered printing for testing, it shall be noted in test report. Any scaling to ensure that the photo test suite is printed correctly shall be based on printer system or driver.

5 Test methodology

5.1 Testing procedure

5.1.1 Preparation

a) Install at least three printers following the user's manual.

b) Install a priming cartridge into the printers.

c) Using priming cartridge, print until consistent images are generated.

d) Remove each priming cartridge.

5.1.2 Installation of test cartridges

a) Remove all packaging material from a new complete set of cartridges to be tested and weigh each cartridge individually to within 0,01 g and record the weight. Install these cartridges based on the cartridge installation guide.

If there is a contradiction between the printer and cartridge manuals for the cartridge installation, the cartridge manual will take precedence except if changes are recommended for printer or driver settings.

b) If the printer has a mandatory printhead alignment operation, it will be conducted according to the printer manual.

Pages printed for head alignment operation will not be counted in the measured yield.

5.1.3 Testing

a) Begin test and start tracking the number of test photos printed on each test cartridge.

b) When end of life is reached on any cartridge, execute the End of cartridge life procedure according to 5.1.4. End of life shall be determined as prescribed in 3.7.

c) Repeat steps 5.1.3 a) and b) until all of primary cartridges that are prescribed in 4.2 reach End of life at least three times. When the last primary cartridge reaches end of life, record individual cartridge yield for the depleted primary cartridge. Remove the depleted primary cartridge and all supplemental cartridges. When yields of supplemental cartridges are determined using proxy cartridges as specified in 6.2, weigh the removed cartridges and record in the report.

d) Repeat steps 5.1.2 to 5.1.4 for all of printers under testing. (At least three printers should be tested as prescribed in 4.2.

5.1.4 End of cartridge life procedure

a) Record individual cartridge yield for the depleted cartridge.

b) Remove the depleted cartridge, weigh and record the final weight. Replace depleted cartridge with new cartridge. Measure its weight and record as in step 5.1.2.

5.2 Procedure for handling streaks

5.2.1 General

If streaks are observed as described in 3.2, a streak removal operation (as defined in 3.3) shall be performed according to the printer user's manual. The page count and streaking colour will be recorded in test report.

5.2.2 Nozzle cleaning

a) Nozzle cleaning strength

If nozzle cleaning operation has the option of multiple cleaning strengths, the procedure indicated in the printer manual for resolving streaking will be followed. Use of a light and a strong cleaning procedure will count as one nozzle cleaning operation. Any cleaning pages printed during the nozzle cleaning operation will not be counted in the yield calculation.

b) Permissible limited number of nozzle cleaning operation

Nozzle cleaning operation will consume ink. This may affect yield test results. To reduce the influence of this operation, the maximum number of user initiated cleaning operations for a single cartridge is limited as shown in the list below. If the estimated yield for primary cartridges is equal to or less than 400 pages, the nozzle cleaning operations are allowed up to three times. If the estimated yield is greater than 400 pages, the maximum number of nozzle cleaning operation is incremented by one for every additional 150 pages.

Table 3 — Maximum number of nozzle cleaning operations allowed

Estimated cartridge yield	Number of nozzle cleaning operation
Up to 400 pages	3 times
Up to 550 pages	4 times
Up to 700 pages	5 times
Up to 850 pages	6 times
Up to 1 000 pages	7 times
Up to 1 150 pages	8 times
Up to 1 300 pages	9 times
Up to 1 450 pages	10 times

In addition to the maximum number of nozzle cleaning operation, one more additional cleaning operation can be tried. If a Fade occurs or an Ink Out is signalled on this additional cleaning operation, the yield data are still valid and the data can be used in the final yield calculation. If a Fade or Ink Out does not occur during the cleaning operation, the cartridge shall be replaced with new one regardless of streak condition. The cartridge will be considered defective for having excessive streaks and the yield data are not valid. The cartridge removed for this reason will be recorded in the test report as a failed cartridge due to excessive streaking.

c) If the nozzle cleaning operation cannot be limited to individual colour

If nozzle cleaning operation cannot be limited to the cartridge that is streaking, all other cartridges under testing will also use ink during the cleaning process. For this reason, if a nozzle clean operation affects all cartridges in a printing system, any cleaning operation performed will be counted against all cartridges. If more than the specified cleaning operations are performed on a cartridge under test, that cartridge will be removed from testing even though it was not the cause of the streaks. Cartridges removed for this reason will be recorded on the test report as removed due to excessive cleaning. These cartridges shall not be used in the calculation of yield.

5.3 Procedure for handling a defective cartridge, printhead or printer

5.3.1 General

During testing, a failure of the cartridge, printhead or printer may occur. This will be handled as described below: Cartridge failures are defined as occurrences of problems that would result in replacement of the ink cartridge before End of life. Examples of this could be excessive nozzle clogging (for integrated printheads), excessive ink leakage, and/or structural failure, etc. Printhead failures are

usually indicated by excessive, non-cleanable streaking or other non-resolvable print quality defects in systems where the printheads can be replaced. Printer failures are defined as non-user clearable errors that prevent normal printer operation from occurring. An example of this might be the failure of the paper feed mechanism or excessive streaking on a non-replaceable printhead. All defective cartridges, printheads and printers will be recorded on the testing report along with reason for failure.

5.3.2 Defective cartridge

In the case of a defective cartridge, the number of the last photo test suite printed and reason for failure will be recorded on the report. The cartridge will then be replaced with a new cartridge and the testing continued. If the printer has a mandatory printhead alignment operation, it will be conducted according to the printer manual. For the purposes of yield calculation, the defective cartridge will not be used.

When a defective cartridge is encountered, the yield data of all the cartridges installed in the printer cannot be used for yield calculation unless it can be proven that those data would not be affected by the defective cartridge or the streak removal operation conducted immediately following the cartridge replacement. This justification will be noted in the test report.

5.3.3 Defective printhead

In the case of a defective printhead, the printhead shall be replaced as specified in the printer user's manual. For the purposes of yield calculation, all cartridges that were in the printer at the time of the failure will not be used in calculation of the final yield. After replacement of the printhead, the printer shall be set up using a set of priming cartridges as specified in 4.1. A new set of cartridges shall be weighed and installed for subsequent testing. On the report, the number of the last photo test suite printed for each cartridge using the defective printhead will be recorded. A note will be made that all cartridges were replaced due to printhead failure. If the printer has a mandatory printhead alignment operation, it will be conducted according to the printer manual. If the printhead is not user replaceable, refer to 5.3.3.

5.3.4 Defective printer

In the case of a defective printer, the printer shall be repaired or replaced. After repair/replacement of the printer, the printer shall be set up using a set of priming cartridges as specified in 4.1. Then, new cartridges shall be installed for subsequent testing. If the printer has a mandatory printhead alignment operation, it will be conducted according to the printer manual. On the report, the number of the last photo test suite printed by the cartridges in the defective printer will be recorded and it shall be noted that the cartridges were replaced due to printer failure. The failure of the printer will be noted and the replacement printer serial number recorded. The yield data obtained before printer failure cannot be used for yield calculation unless it can be proved that the printer failure did not affect the previously tested cartridges. This justification will be recorded in the test report.

6 Determination of the declared yield value and declaration

6.1 Yield of primary cartridges

An average and a standard deviation will be obtained from the test runs (e.g. n = 9 when a primary cartridge is reached End of life three times and three printers are utilized for testing).

Sample average for a given cartridge is derived using Formula (1):

$$\bar{X} = \sum_{i=1}^{n} \frac{x_i}{n} \tag{1}$$

Sample standard deviation for a given cartridge is derived using Formula (2):

$$s = \sqrt{\sum_{i=1}^{n} \frac{\left(x_i - \bar{X}\right)^2}{(n-1)}} \tag{2}$$

where

x_i is the individual cartridge yield (3.10);

n is the sample size; for testing, n shall be ≥9.

It can be stated with 90 % confidence that the true average yield of the cartridge is within the values derived from Formulae (3) and (4):

$$\text{Lower Confidence Bound} = \bar{X} - \left(t_{\alpha,n-1}\right) * \frac{s}{\sqrt{n}} \tag{3}$$

$$\text{Upper Confidence Bound} = \bar{X} + \left(t_{\alpha,n-1}\right) * \frac{s}{\sqrt{n}} \tag{4}$$

where

$t_{\alpha,n-1}$ can be found on a Students' t-Distribution Table with n –1 degrees of freedom (df or 'ν') and an α of 0,1. (in this example, n–1 = 9-1 = 8) This provides a 2-tailed confidence interval with 90 % confidence. This specific t-statistic for 8 degrees of freedom, and 90 % confidence is $t_{\alpha,n-1}$ = 1,860. This can be used in the above calculation, only. A different sample size and/or different confidence interval will yield a different $t_{\alpha,n-1}$.

The declared value shall be determined so that it's at or below the calculated lower 90 % confidence value.

6.2 Yield of supplemental cartridges

6.2.1 General

Supplemental cartridges are not required to reach End of life. If a supplemental cartridge does not reach End of life three times per printer by the end of test, the yield can be estimated.

For the estimation of yields for supplemental cartridges, a proxy cartridge is defined as any primary cartridge having the same physical size and similar starting weight as the supplemental cartridge. Cartridge size does not include any features that are meant to differentiate between colours, such as physical keys and tabs. For the supplemental cartridges whose starting weights are less than 50 g, a proxy cartridge is defined as any primary cartridge of the same physical size as the supplemental cartridge which has a starting weight within ±5 % of the supplemental cartridge starting weight. For the supplemental cartridges whose starting weights are greater than or equal to 50 g, a proxy cartridge is defined as any primary cartridge of the same physical size as the supplemental cartridge which has a starting weight within ±10 % of the supplemental cartridge starting weight.

Supplemental cartridge yields shall be reported individually except as specified in the note of 6.4. When yield for supplemental cartridges are estimated, it shall be clearly declared as "Estimated Yield".

6.2.2 Case 1: supplemental cartridges that has not reached End of life

a) If proxy cartridges are available, estimated yield of supplemental cartridge per printer is determined by Formula (5):

$$\text{Yield} = \frac{\text{Amount of Full Ink [grams]}}{\text{Amount of Delivered Ink [grams]}} \times \text{Number of Printed Pages at End of Testing [pages]} \quad (5)$$

"Amount of Full Ink" is the total amount of ink that the supplemental cartridge can deliver until end of life. (i.e. difference between the weight at Start of cartridge life and the weight at end of life). "Amount of Full Ink" is not known for a supplemental cartridge that has not reached end of life. It is estimated as the average amount of delivered ink of all proxy cartridges. "Amount of Delivered Ink" is the amount of ink that a supplemental cartridge delivered until End of testing. (i.e. difference between the weight at Start of cartridge life and the weight at End of testing). "Number of Printed Pages at the End of Testing" is the number of pages that are printed from the start of testing to End of testing.

In this case, the number of data points is equal to the number of printers utilized for testing.

Sample average for a given cartridge is derived using Formula (6):

$$\bar{X} = \sum_{i=1}^{m} \frac{x_i}{m} \quad (6)$$

Sample standard deviation for a given cartridge is derived using Formula (7):

$$s = \sqrt{\sum_{i=1}^{m} \frac{\left(x_i - \bar{X}\right)^2}{\left(m-1\right)}} \quad (7)$$

where

x_i is the estimated yield defined in Formula (5);

m is the number of data. It is equal to the number of printers utilized for testing. (m shall be ≥3).

The 90 % LCB is calculated by Formula (8):

$$\text{Lower Confidence Bound} = \bar{X} - \left(t_{\alpha,m-1}\right) * \frac{s}{\sqrt{m}} \quad (8)$$

The declared value in this case shall be determined so that it's at or below the calculated lower 90 % confidence value.

b) If no cartridge can be used as a proxy, one of the following three options may be chosen when no proxy cartridge is available.

— Option 1: Supplemental cartridges shall be tested until end of life at least once to determine yield. In this case, photo test suite prescribed in ISO/IEC 29103 is utilized for testing and the minimum of three data points (one per printer) will exist for each supplemental cartridge.

— Option 2: "Amount of Full Ink" obtained by ISO/IEC 24711 shall be utilized for this International Standard. In this case, the number of data points is equal to the number of printers utilized for testing.

— Option 3: Supplemental cartridges may be tested until end of life at least once by printing a special test image designed for fast ink consumption. In this case, the minimum of 3 data points (one per printer) will exist for each supplemental cartridge. Special test page utilized will be reported in the test report.

The declared yield value shall be determined by the method prescribed in 6.2.1. Option chosen to estimate yield for supplemental cartridge shall be noted in the test report.

6.2.3 Case 2: supplemental cartridges that have reached End of life once or twice

If a supplemental cartridge has reached End of life once or twice before End of testing for any printer utilized in testing, the declared yield value shall be determined by the method prescribed in 6.1. The size of data n will be smaller than 9. For example, if a supplemental cartridge has reached End of life once before End of testing for all of three printers utilized in testing, the number of data points will be three.

An example:

Ink cartridges: K, C, M, Y, Light C, Light M separate cartridges.

Number of printers: 3

Number of depletion for primary cartridges: 3

Number of primary cartridges: 3

Number of supplemental cartridges: 3

All colour cartridges are the same physical size and have a starting weight of 55 g ±3 g

K cartridge has different physical size.

For each printer for yield testing, M, C and Y cartridges reached End of life three times.

Y is the last primary cartridge that reached End of life three times.

K reached End of life once.

Light C and Light M never reached End of life.

Refer to Table 4 for the number of printed pages and amount of delivered ink.

Table 4 — Example of measured values

Cartridge	Average of "Amount of full ink"	Average of "Amount of delivered ink"	Number of data points	Average of printed pages	Standard deviation
K	20,0 g	-	3	500	18
C	11,0 g	-	9	250	21
M	11,3 g	-	9	230	40
Y	11,5 g	-	9	265	31
Light C	-	3 g	0	-	-
Light M	-	4 g	0	-	-

M, C and Y will be regarded as primary cartridge. K, Light C, and Light M will be regarded as supplemental cartridges.

Estimation of K yield:

Because of differences in physical size, K cartridge will not have a proxy cartridge. Since K cartridge depleted once for each of three printers, estimation method described in 6.2.2 applies to estimate yield of K cartridge. The 90 % LCB is computed by the same way as primary cartridges. See Formula (9).

$$\text{n = 3 and } t_{\alpha,n-1} = t_{0.1,2} = 2,92 \tag{9}$$

Therefore, the 90 % LCB numbers are computed using Formula (8), as follows:

$$\text{K 90 \% LCB} = 500 - 2,92\frac{18}{\sqrt{3}} = 470 \text{ pages}$$

Estimation of yields for Light C and Light M:

Since Light C and Light M never reach End of life, estimation method described in 6.2.1 1) applies. The C, M and Y cartridges meet the criteria to be a proxy. "Amount of full ink" for Light C and Light M is estimated by the average of "Amount of full ink" for C, M, and Y cartridges. It is calculated as follows:

$$\text{Amount of full ink for Light C and Light M} = \frac{(11,0 \times 9 + 11,3 \times 9 + 11,5 \times 9)}{(9 + 9 + 9)} = 11,3$$

Since Y is the last primary cartridge that reached End of life three times, "Number of printed pages at End of testing" is determined based on the number of pages printed by Y cartridge. On average, this is 265 × 3 = 795 pages, but needs to be done on a per printer basis in order to generate the three estimated yield data points. Assume the three printers produced 809, 796, and 780 total pages at end of testing and the Light C cartridges delivered 3,0 g, 3,1 g, and 2,9 g and Light M cartridges delivered 4,1 g, 4,2 g, and 3,7 g of ink.

Estimated yields for Light C are

(11,3 g) / (3,0 g) × (809 pages) = 3 047

(11,3 g) / (3,1 g) × (796 pages) = 2 901

(11,3 g) / (2,9 g) × (780 pages) = 3 039

Light C estimated yield is the average of the above data which is 2 995 and a standard deviation of 82,0.

Estimated yields for Light M are

(11,3 g) / (4,1 g) × (809 pages) = 2 229

(11,3 g) / (4,2 g) × (796 pages) = 2 141

(11,3 g) / (3,7 g) × (780 pages) = 2 382

Light M estimated yield is the average of the above data which is 2 250 and a standard deviation of 119,9.

$$\text{m = 3 and } t_{\alpha,m-1} = t_{0,1,2} = 2,92$$

Therefore, the 90 % LCB numbers are

$$\text{Light C 90 \% LCB} = 2995 - 2,92\frac{82,0}{\sqrt{3}} = 2856 \text{ pages}$$

$$\text{Light M 90 \% LCB} = 2250 - 2,92\frac{119,9}{\sqrt{3}} = 2047 \text{ pages}$$

6.3 Test data reporting

The data shall be reported as exemplified in Annex C. The report shall be made available if requested.

6.4 Declaration of the yield

The yield declaration will vary depending on whether ink is supplied in cartridges with multiple colours or in separate cartridges for each colour.

When multiple colours are combined into one cartridge, then the declared yield is based on a single 90 % lower confidence bound (LCB) of the mean that is calculated according to 6.1 and 6.2.

Example 1 Printer with CMY combined cartridge and K in a separate cartridge; CMY combined cartridge is primary and K is supplemental.

From Testing:

CMY Cartridge 90 % LCB = 508 pages

Estimated Black cartridge 90 % LCB = 1 100 pages

Yield can be reported as:

Average CMY Cartridge Yield Up to 508 photos

Estimated Supplemental Yield Black Up to 1 100 photos

Values obtained by continuous printing.

When the different colours are supplied in separate cartridges, then LCBs are computed for each colour. Declared yield can be based on the individual LCBs for each colour or based on a combined yield as specified below.

Because of differences in colourant hue and colour balance optimization among printer manufacturers, the test pages used in this International Standard will not be colour balanced for all printers. In acknowledgement of this fact, when coloured inks are in separate cartridges that are intended to have approximately equal capacities, their yields can be reported using a single value computed using yields for all of the individual colours, called "composite yield". If composite yield is to be reported, all primary cartridges shall be included. Supplemental cartridges shall not be included in the composite yield.

The composite yield is defined as Formula (10):

$$CY = \frac{n}{\left(\frac{1}{Y_1} + \frac{1}{Y_2} + \cdots + \frac{1}{Y_n}\right)} \quad (10)$$

where

CY = composite yield;

Yi = 90 % lower confidence bound (LCB) of the page yield of colour i.

This calculation provides a cost neutral result when all colourants are priced the same on a per cartridge basis.

Example 2 Primary cartridges: C, M, Y

From testing:

Cyan Cartridge 90 % LCB = 450 pages

Magenta Cartridge 90 % LCB = 580 pages

Yellow Cartridge 90 % LCB = 500 pages

Estimated Black cartridge 90 % LCB = 1 100 pages

$$CY = \frac{3}{\left(\frac{1}{450} + \frac{1}{580} + \frac{1}{500}\right)} = 505\,\text{pages}$$

For colour cartridges:

Declared yield can be based either on the individual LCBs for each colour or based on the composite yield. The two options for declaration of yield for this example are:

Individual Yield Method

Average Cyan Cartridge Yield	Up to 450 photos
Average Magenta Cartridge Yield	Up to 580 photos
Average Yellow Cartridge Yield	Up to 500 photos
Estimated supplemental Yield Black Cartridge	Up to 1 100 photos

Values obtained by continuous printing.

Composite Yield Method:

Three-Cartridge Composite Yield	Up to 505 photos
(Composite yield using C, M and Y)	
Estimated supplemental Yield Black Cartridge	Up to 1 100 photos

Values obtained by continuous printing.

When yields for additional cartridges other than C, M, Y and K are measured as determined in reference to 6.2, they shall be reported individually and not combined into the composite yield. In these instances, the composite yield may still be used for the cyan, magenta and yellow cartridges.

If a yield is reported according to this International Standard, a full test report as shown in Annex C shall be available.

When an inkjet cartridge yield is declared in the user's manual, marketing materials or packaging, the following minimum information shall be included:

— description that the declared yield value has been determined in accordance with ISO/IEC 29102;

— declared yield value of the cartridge;

— that the value obtained was using continuous printing;

— if a cartridge can be used in multiple distinct print systems one of the following shall be reported:

  — the combination of a tested printer and cartridges;

  — the minimum yield of all tested printers;

  — the range of yields from all tested printers — must have reference to actual printer/cartridge performance available

There are three main components to the numerical part of the declaration.

a) The total number of cartridge colours used in the determination of the yield

b) Primary cartridge yield.

c) Supplemental cartridge yield.

The composite yield shall be reported as an "N" cartridge yield, with "N" being the number of cartridges in the composite yield. The colours of the cartridges used in the composite calculation shall be reported.

Example 3

For a system with only C, M, Y and K individual cartridges using a composite average:

When tested in printer YYY

Ink Cartridge yield:

Three-Cartridge Composite Yield	505 standard photos
(Composite yield using C, M and Y)	
Estimated Supplemental K Cartridge Yield	1 100 standard photos

Values obtained by continuous printing using four cartridge colours (C, M, Y, K).

Declared yield value in accordance with ISO/IEC 29102.

Or for just a cyan cartridge tested from the above example:

When tested in printer YYY

Ink Cartridge yield:

Three-Cartridge Composite Yield	505 standard photos
(Composite yield using C, M and Y)	

Values obtained by continuous printing using four cartridge colours (C, M, Y, K).

Declared yield value in accordance with ISO/IEC 29102.

Or for just a cyan cartridge tested from the above example without a composite yield:

When tested in printer YYY

Ink Cartridge yield:

Average C Cartridge Yield	502 standard photos

Values obtained by continuous printing using four cartridge colours (C, M, Y, K).

Declared yield value in accordance with ISO/IEC 29102.

For a system with only C, M, Y and K individual cartridges (C, M, and Y are primary cartridges and K is supplemental cartridge):

When tested in printer YYY

Ink Cartridge yield:

Average C Cartridge Yield	502 standard photos
Average M Cartridge Yield	515 standard photos
Average Y Cartridge Yield	489 standard photos
Estimated Supplemental Yield Black	1 100 standard photos

Values obtained by continuous printing using four cartridge colours (C, M, Y, K).

Declared yield value in accordance with ISO/IEC 29102.

For a system with only CMY combined cartridge and a K cartridge (CMY combined cartridge is primary and K is supplemental):

When tested in printer YYY

Ink Cartridge yield:

Average CMY Cartridge Yield 505 standard photos

Estimated Supplemental Yield Black 1 100 standard photos

Values obtained by continuous printing using two cartridge colours (C, M, Y, K).

Declared yield value in accordance with ISO/IEC 29102.

For a system with only C, M, Y, K, Light C, and Light M individual cartridges (C, M, and Y are primary cartridges and K, Light C, and Light M are supplemental cartridges):

When tested in printer YYY

Ink Cartridge yield:

Average C Cartridge Yield 502 standard photos

Average M Cartridge Yield 515 standard photos

Average Y Cartridge Yield 489 standard photos

Estimated Supplemental Yield Black 1 100 standard photos

Estimated Supplemental Yield Light Cyan 1 200 standard photos

Estimated Supplemental Yield Light Magenta 1 500 standard photos

Values obtained by continuous printing using six cartridge colours (C, M, Y, K, Light C, Light M).

Declared yield value in accordance with ISO/IEC 29102.

Or when tested in printer YYY

Ink Cartridge yield:

Three-Cartridge Composite Yield 505 standard photos

(Composite yield using C, M and Y)

Estimated Supplemental K Cartridge Yield 1 100 standard photos

Estimated Supplemental Yield Light Cyan 1 200 standard photos

Estimated Supplemental Yield Light Magenta 1 500 standard photos

Values obtained by continuous printing using six cartridge colours (C, M, Y, K, Light C, Light M).

Declared yield value in accordance with ISO/IEC 29102.

Annex A
(informative)

Examples of fade

Figure A.1 — Examples of fade

Annex B
(informative)

Examples of streaks

Figure B.1 — Examples of streaks

Annex C
(normative)

Test reporting form

Declaration of yield:

When tested in printer PDL 5900:	
Inkjet cartridge yield:	
Average Continuous C Cartridge Yield	450 standard photos
Average Continuous M Cartridge Yield	580 standard photos
Average Continuous Y Cartridge Yield	500 standard photos
Estimated Average Continuous K Cartridge Yield	1 100 standard photos
Values obtained by continuous printing	
Declared yield value in accordance with ISO/IEC 29102	

90 % Lower Confidence	Cyan Cartridge	= 450 photos
	Magenta Cartridge	= 580 photos
	Yellow Cartridge	= 500 photos
	Black Cartridge	= 1 100 photos

Date Tested: 2006/10/20 to 2006/10/30

For questions concerning testing contact:

Cartridge Testing Associates
123 Printer Lane
Ink, IL 87484

Printer Model Used	PDL 5900
Cyan Cartridge Model	C45
Magenta Cartridge Model	M45
Yellow Cartridge Model	Y45
Black Cartridge Model	K45
Number of Cartridges used in testing	C = 19, M = 19, Y = 18, K = 9
Number of Cartridges used in calculations	C = 18, M = 18, Y = 18, K = 9
Type of Cartridge	Separate
Primary Cartridges	C, M, Y
Supplemental Cartridges	K