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

Technologies de l'information — Équipements de bureau — Méthode pour la détermination du rendement de cartouches d'encre pour les imprimantes couleur à jet d'encre et pour les dispositifs multifonctionnels qui contiennent des composants d'imprimantes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

This fourth edition cancels and replaces the third edition (ISO/IEC 24711:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

— printer setting was corrected from duplex to simplex mode in Clause 4.1;

— the status of Annex E was changed from informative to normative to have consistency with ISO/IEC 19798;

— ISO/IEC 29142-1 has been added to the Bibliography;

— editorial changes were applied.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of this document is to provide a process for determining the ink cartridge yield for a given colour inkjet print system (i.e. integrated ink cartridges and ink cartridges without integrated printheads) using a standard consumer type test page suite. 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 can 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 document prescribes the following:

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

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

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

The cartridge yield is determined by an end-of-life judgement, 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. It is envisioned that one of the uses of this document is for the calculation of cost per page (CPP). While this document measures a portion of this cost, it is not used as the sole component of CPP calculation. Additional factors are considered for CPP calculations. It is beyond the scope of this document to provide a methodology for calculation of CPP.

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

1 Scope

The scope of this document is limited to the evaluation of ink cartridge page yield for ink-containing cartridges (i.e. integrated ink cartridges and ink cartridges without integrated printheads) for colour inkjet print systems. This document can also be applied to the 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 document.

This document is only intended for the measurement of ink cartridge page yield when printing on plain paper. No other claims can be made from this testing regarding quality, reliability, etc.

This document can be used to measure the yield of any cartridge that is used in a significant amount during the printing of the test page suite defined in ISO/IEC 24712.

This document is not for use with printers whose minimum printable size is equal to or greater than A3 or for printers designed or configured to print photos (for example, maximum printable size less than A4 or a printer configuration intended for photo-only printing). In addition, it only applies to drop-on-demand printing systems.

NOTE Integrated ink cartridges is a cartridge that includes at least: an ink containment part, an ink deposition mechanism and an ink transport part (see ISO/IEC 29142-1).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 24712, *Colour test pages for measurement of office equipment consumable yield*

ISO/IEC 29102, *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*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
fade
phenomenon in which a significant reduction in uniformity occurs due to ink depletion

Note 1 to entry: In this test, fade is defined by a significant increase in lightness, L^*, or a decrease in density on the bands surrounding the edge of the last page in the *test page suite* (3.8) (diagnostic page). This decrease in density does not have to occur completely across the page. This comparison is made using the second diagnostic test page generated during testing (the 10th page printed). For examples of fade, please consult Figure A.1.

Note 2 to entry: In some printer systems, fade can occur prematurely due to the way that ink is provided to the printing system. If a printer exhibits fade, a five-minute pause is allowed to provide for recovery of the ink delivery system and printing may continue. If fade appears on the next suite, then the cartridge is judged at *end of life* (3.7) and the additional diagnostic page printed is not counted in the yield calculation. If fade does not appear on the next diagnostic page, then printing can continue until the next fade or *ink out* (3.6) is encountered and the additional diagnostic pages shall be counted.

3.2
streak
very thin line of colour, other than intended in the bands surrounding the edge of the last page in the *test page suite* (3.8)

Note 1 to entry: The last page in the test suite is also called the diagnostic page.

Note 2 to entry: Streaks differ from *fade* (3.1) in the width and severity of increase in lightness, L^*, or reduction in density. Streaks can appear for a number of reasons, thermal issues and clogged nozzles being two of the main causes. If these streaks occur in three consecutive diagnostic pages, then a *streak removal operation* (3.3) is required. Comparisons are made using the phenomena sample provided in Figure B.1.

Note 3 to entry: This term is usually used in plural form.

3.3
streak removal operation
procedure used to restore the print performance by removing *streaks* (3.2)

Note 1 to entry: If streaks are observed on three consecutive diagnostic pages, first the printer can be left idle for five minutes. Then an additional three *test page suites* (3.8) 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 5.2.2.

Note 2 to entry: All test page suites printed during this process are 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 is 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 useable 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 with more than one colour of ink in a single cartridge, end of life is defined when the first colour within the cartridge exhibits fade or ink out. In the event that the printer can continue printing after ink out is reported, the cartridge is still considered at end of life.

3.8
test page suite
series of five pages defined in ISO/IEC 24712 that are printed consecutively as a single job, ending with a diagnostic page

3.9
individual cartridge yield
value determined by counting the number of diagnostic pages (last page of the ISO/IEC 24712 test page suite) printed between cartridge installation and *end of life* (3.7) and multiplying by five

Note 1 to entry: If the printer stops due to *ink out* (3.6) in the middle of a *test page suite* (3.8), the number of the diagnostic pages printed is counted. Then, the first diagnostic page of the remaining print job is included in the subsequent cartridge yield.

Note 2 to entry: The number of test page suites counted can contain some pages that show visible *fade* (3.1). To simplify the testing, determination of end of life is only made on the diagnostic page (last page of the ISO/IEC 24712 test page suite).

3.10
declared cartridge yield
at or below the lower 90 % confidence bound of the mean as prescribed in 6.1 and 6.2

3.11
primary cartridge
cartridge containing full density black, cyan, magenta or yellow ink or a combination of full density cyan, magenta and yellow

Note 1 to entry: These colours represent the primary inks used in a traditional four-colour printing process.

3.12
proxy cartridge
primary cartridge (3.11) to be utilized for estimating yield of *supplemental cartridges* (3.13)

3.13
supplemental cartridge
cartridge other than the full density cyan, magenta, yellow and black cartridges

Note 1 to entry: The determination of yield for a supplemental cartridge is made according to 6.2.

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. 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 shall 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 manufacturers' instructions, the priming cartridges shall be used to print a minimum of 25 pages, five cycles of the standard test page suite. The priming cartridges shall be removed and replaced with new cartridges that are used for testing yield. The pages printed during this step are not counted towards yield. Even if required by the printer, printhead alignment does not have to be performed on the priming cartridges. The number of pages used in the priming operation shall be included in the test report. The replacement of the priming cartridges with the first test cartridges may be done all at once or staggered individually. If done all at once, all test cartridges begin with test page suite number 1 and continue until end of life. If the staggered start method is used, the test page suite number shall be tracked separately for each cartridge. The test start method shall be included in the test report.

All image and print quality modifiers shall be at their factory preset configuration for the printer and default-installed condition for the driver. If auto media detection is available on the printer, it shall be disabled and media-type set to plain paper. This is to avoid inaccurate sensing of the media. If the printer and driver settings differ, then the driver defaults shall be used. Any user selectable ink conservation modes, (e.g. draft) shall be disabled during testing.

For printers that default to duplex printing, the default shall be overridden and the printer shall be set to simplex for yield testing.

To ensure that the test page suite is printed correctly, any page size modifiers such as "Fit to Page" and font substitution shall be turned off. The file shall be printed using the fonts embedded in the file and shall be printed on the page in a size corresponding to the dimensions in the test page suite standard (ISO/IEC 24712). Page placement modifiers such as page centring can be used to place the image properly on the page.

To facilitate automated testing, the test page 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.

If the printer under test uses an internal PDF interpreter, it is ok to use it as long as the printer defaults are set to not substitute fonts. If the internal interpreter is used, this shall be noted on the report.

The application software (for example, Adobe Acrobat Reader[1)]), printer driver and printer can have page size modifier functions, such as Fit to Page. Make sure that all of these functions are disabled.

4.2 Sample size

Inkjet cartridges are designed in two common styles, single colour and multi-colour. The sample size shall be determined such that for each calculated yield value, a minimum of three physical cartridges are tested in each of three printers. In the case of a typical four-colour printer with four single primary colour cartridges this would result in 36 cartridges being tested, nine black (K), nine cyan (C), nine magenta (M) and nine yellow (Y). For a typical multicolour cartridge system where one cartridge contains C, M and Y, and another cartridge contains K, the testing would use 18 total cartridges, nine black and nine CMY.

In some printer configurations, supplemental cartridges can be installed. Please see the procedure in 6.2 for details on the treatment of supplemental cartridges.

When testing additional engines and cartridges above the minimum, an effort shall be made to test an equal number of cartridges on each engine. For example, if an additional engine were to be tested then the minimum number of cartridges to be tested shall be 48 (3 cartridges × 4 colours × 4 printers) for a four-cartridge system.

1) Adobe Acrobat Reader is the trade name of a product supplied by Adobe Systems Incorporated. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

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.

It is recommended that additional engines and/or cartridges be used in testing to allow for the possibility of a cartridge and/or printer failure during testing.

4.3 Print mode

For reporting cartridge yield, the test shall be run in semi-continuous simplex printing and set in the driver default print mode at or near rated print speed. Each copy of the test page suite shall be printed as a separate five-page print job. This allows for some intra-job servicing and calibration to take place. Additional pauses can take place due to paper refills and idle time due to end of workdays.

NOTE 1 This does not mean that the printer is required to stop between printed jobs.

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 pages. It is realized that customers do not normally print in a continuous fashion, but these changes are made to decrease testing time and increase the repeatability of the testing process.

NOTE 2 Depending on the use conditions, the yield experienced by a given user can vary significantly from the yield measured by this test method.

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 h with readings recorded at least every 15 min, all running average temperatures shall be between 20,0 °C and 26,0 °C.

EXAMPLE An example of the calculation of the temperature is shown in Table 1 for temperature readings taken on 15-min intervals for the testing of one cartridge.

Table 1 — Running temperature calculation example

Values in Celsius

	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	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.

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 a sample 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 used in this test shall represent a common medium grammage paper and shall conform to the printer's list of approved papers. The paper manufacturer, grammage and size, A4 or equivalent, used in the test are noted on the report. If auto media detection is available on the printer, it shall be disabled and the media type set to plain paper. The auto-detect process can have a significant effect on the yield performance.

4.6 Maintenance

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

4.7 Test file

The test file outlined and specified in ISO/IEC 24712 shall be used. The test shall be conducted using the most recent official electronic test file as the input. The most recent official file can be located at https://standards.iso.org/iso-iec/24712/. Failure to use the exact file specifications invalidates test results. In addition to the test file, a publicly available PDF reader is used in conjunction with the printer driver to generate the printer input and send the file directly 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 shall be recorded on the test report. The version of the test file, the printer driver version and the PDF reader version shall 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. The proper size for each of the pages in the test page suite shall be in accordance with ISO/IEC 24712.

There are several PDF reader versions available; each version can have an impact on the yield results. It is recommended that the latest version of the chosen PDF reader be used for testing.

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, PDF reader 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 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 test page suite, it shall be documented in the test report.

The host computer environment such as OS, RAM size, CPU type and application software can 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.

5 Test methodology

5.1 Testing procedure

5.1.1 Flow chart

Flowchart of testing procedure is shown at Annex D.

5.1.2 Preparation

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

b) Install a priming cartridge for each colour into the printers.

c) Using each priming cartridge, print at least five complete test page suites.

d) Remove each priming cartridge.

5.1.3 Installation of test cartridges

a) Remove all packaging material from a new complete set of cartridges to be tested and install these cartridges by following the cartridge installation guide. Weigh each cartridge individually to within 0,01 g and record the weight.

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

NOTE In the case that the printing system does not use supplemental cartridges, weighing of the cartridges is not mandatory.

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

These pages shall not be counted in the measured yield.

5.1.4 Testing

a) Begin test and start tracking the number of test page suites printed on each test cartridge. When the 10th page (second full test page suite) is printed for the first set of cartridges, save page for use as the fade reference.

b) When fade or streaks are observed, appropriate procedure in 3.1 or 5.2 shall be applied. Depending on the systems, there are some cases that ink low (3.5) appears before ink out (3.6). But testing shall be continued until the end of life (3.7) is reached.

c) When end of life (3.7) is reached on any cartridge, execute the end of cartridge life procedure according to 5.1.5.

5.1.5 End of cartridge life procedure

a) Record individual cartridge yield of the depleted cartridge as described in 3.9.

b) Remove the depleted cartridge, weigh and record the final weight. Replace depleted cartridge with new cartridge that has had its weight recorded as in step 5.1.3.

c) Repeat steps 5.1.3 through step b) of 5.1.5 for all remaining test cartridges. If the printer has a mandatory printhead alignment operation, it shall be conducted according to the printer manual.

d) Testing shall continue using additional cartridges until the test is completed. The test is completed when all of the primary cartridges for the predetermined sample size have reached end of life. (A minimum of nine cartridges, three cartridges of each colour on three printers.) This might result in use of more than three of each colour cartridge being tested.

NOTE In the case that the printing system does not use supplemental cartridges, weighing of the cartridges is not mandatory.

5.2 Procedure for handling streaks

5.2.1 Over view

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

5.2.2 Nozzle cleaning

a) Nozzle cleaning strength

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

b) Permissible limited number of nozzle cleaning operation

By conducting the nozzle cleaning operation, some amount of ink is consumed affecting yield test results. To reduce the influence of this operation, the maximum number of times a user-initiated cleaning operation for a single cartridge can be performed is limited as shown in the list in Table 2.

Table 2 — Allowed cleaning cycles

Estimated cartridge yield	Number of cartridge cleanings allowed
Up to 1 200 pages	3 times
Up to 1 600 pages	4 times
Up to 2 000 pages	5 times
Up to 2 400 pages	6 times
...	...
Up to 4 000 pages	10 times

NOTE The permissible limited number of nozzle cleaning operation is three times, when the assumed yield value for a printer tested is 1 200 pages (240 suites) or less. The limited number is incremented by one every additional 400 pages above 1 200 pages.

One more additional cleaning operation than the specified number of times can be tried. If on the additional cleaning operation, a fade occurs or an ink out is signalled, 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 shall be considered defective for having excessive streaks and the yield data are not valid. The cartridge removed for this reason shall be recorded on the test report as a failed cartridge due to excessive streaking.

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

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

5.3.1 General

During testing, a failure of the cartridge, printhead or printer can occur. This shall 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, 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 shall 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 test page suite printed and reason for failure shall be recorded on the report. The cartridge shall then be replaced with a new cartridge and the testing continued. If the printer has a mandatory printhead alignment operation, it shall be conducted according to the printer manual. For the purposes of yield calculation, the defective cartridge shall 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 shall 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 shall 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 test page suite printed for each cartridge using the defective printhead shall be recorded. A note shall be made that all cartridges were replaced due to printhead failure. If the printer has a mandatory printhead alignment operation, it shall be conducted according to the printer manual.

NOTE If the printhead is not user replaceable, refer to 5.3.4.

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 shall be conducted according to the printer manual. On the report, the number of the last test page suite printed by the cartridges in the defective printer shall be recorded and it shall be noted that the cartridges were replaced due to printer failure. The failure of the printer shall 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 shall 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 are obtained from the test runs (e.g. $n = 9$).

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

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

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

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

where

x_i is the individual cartridge yield (3.9), i.e. the number of standard test page suites printed between cartridge installation and end of life multiplied by 5;

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):

$$B_{\mathrm{LC}} = \overline{X} - \left(t_{\alpha,n-1}\right) \times \frac{s}{\sqrt{n}} \tag{3}$$

$$B_{\mathrm{UC}} = \overline{X} + \left(t_{\alpha,n-1}\right) \times \frac{s}{\sqrt{n}} \tag{4}$$

where

B_{LC} is the lower confidence bound (LCB);

B_{UC} is the upper confidence bound (UCB);

$t_{\alpha,n-1}$ 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 yields a different $t_{\alpha,n-1}$.

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

6.2 Yield of supplemental cartridges

Supplemental cartridge yields shall be reported individually except as specified in the note of 6.4. Supplemental cartridges are not required to reach end of life. If a supplemental cartridge does not reach end of life for the minimum sample size of cartridges per printer by end of test, the yield can be estimated. Yield can be expressed as follows.

— In the case that less than one cartridge per printer was used:

  Yield = delivered ink [grams] × usage rate [pages/gram].

— In the case that less than the minimum sample size per printer but more than one cartridge were used:

  Use all individual cartridge yields obtained and calculate 90 % LCB [Formula (3)].

$$B_{\mathrm{LC}} = \overline{X} - \left(t_{\alpha,n-1}\right) \times \frac{s}{\sqrt{n}}$$

The declaration shall include a description stating the value is "estimated yield".

The delivered ink is the total amount of ink that the supply can deliver before end of life (i.e. difference between the weight at start of cartridge life and the weight at end of life cartridge) and the usage rate is the ratio of the total number of pages printed before end of life divided by the amount of ink used to print those pages. The delivered ink amount is not known for a supplemental cartridge that did not reach end of life. It is estimated as the average amount of delivered ink from all proxy cartridges.

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. Cartridge size does not include any features that are meant to differentiate between colours, such as physical keys and tabs.

If no cartridge can be used as a proxy and less than one supplemental cartridge was run to end-of-life at the end of testing for a given printer, then one of the following methods shall be used.

— If the supplemental cartridge was a primary cartridge for the identical printing system tested according to ISO/IEC 29102, the supply end weight from the ISO/IEC 29102 test is used to estimate supplemental yield. This shall be noted in the test report.

— Supplemental cartridges are tested until end of life to determine yield.

At test completion, a minimum of three data points (one per printer) exist for each supplemental cartridge. The data points are real or estimated. The 90 % LCB value shall be calculated in the same manner as a primary cartridge. Only supplemental cartridges are allowed to have fewer than nine data points.

An example:

K, C, M, Y, Light C, Light M separate cartridges. Test uses 3 printers × 3 cartridge sets per printer.

K delivers 20 g of ink and 500 pages (average of nine data points, standard deviation = 18).

C delivers 11 g of ink and 250 pages (average of 18 data points, standard deviation = 21).

M delivers 11,3 g of ink and 230 pages (average of 21 data points, standard deviation = 40).

Y delivers 11,5 g of ink and 265 pages (average of 18 data points, standard deviation = 31).

Light C delivers 3 g of ink and never reaches end of life (0 data points).

Light M delivers 11 g of ink and 1 400 pages (average of three data points, standard deviation = 62).

All colour cartridges are the same physical size and have a starting weight of 50 g ± 5 g.

The light cyan and light magenta cartridges would be considered supplemental. The light cyan cartridge yield can be estimated. The cyan, magenta and yellow cartridges meet the criteria to be a proxy for delivered ink estimation. Therefore, the proxy delivered ink is the average of:

(11 × 18 + 11,3 × 21 + 11,5 × 18) / (18 + 21 + 18) = 11,27 g.

Since the light cyan cartridge was never changed, the number of pages printed with it is the highest yielding cartridge over the entire test. In this case, black. The black cartridge was printed to end of life three times, so the number of pages printed with the light cyan cartridge on each printer is the sum of the three black cartridge yields. On average, this is 500 × 3 = 1 500 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 1 503, 1 516 and 1 481 total pages and the light cyan cartridges delivered 3 g, 3,1 g and 2,9 g of ink.

The light cyan estimated yields are:

(11, 27 g) × (1 503 pages) / (3 g) = 5 646,

(11, 27 g) × (1 516 pages) / (3, 1 g) = 5 511,

(11, 27 g) × (1 481 pages) / (2, 9 g) = 5 755.

The light cyan estimated yield is the average of the data which is 5 638 and a standard deviation of 122,3.

The 90 % LCB is computed the same way as primary supplies.

N = 3 and t (0, 1, 2) = 2,92.

Therefore, the 90 % LCB numbers are:

$$\text{light cyan 90 \% LCB} = 5\,638 - 2{,}92\frac{122{,}3}{\sqrt{3}} = 5\,432 \text{ pages,}$$

$$\text{light magenta 90 \% LCB} = 1\,400 - 2{,}92\frac{62}{\sqrt{3}} = 1\,295 \text{ pages.}$$

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 varies 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 cartridge yield is based on a single 90 % lower confidence bound (LCB) of the mean that is calculated according to 6.1. The yield values used in the calculation are those determined when the first colour is depleted, as defined in 3.7.

EXAMPLE 1

From testing:

CMY cartridge 90 % LCB = 508 pages

Black cartridge 90 % LCB = 1 100 pages

Yield can be reported as:

Average CMY cartridge yield up to 508 pages

Average black cartridge yield up to 1 100 pages

Values obtained by continuous printing.

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

Because of differences in colourant hue and colour balance optimization among printer manufacturers, the test page suites used in this document are not 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. This value is to be called the “composite yield” and is defined below in Formula (5):

NOTE Supplemental cartridges can be included in the composite yield if the following two conditions are met.

a) The supplemental cartridge has been replaced greater than or equal to 2x at the time that the last primary C, M or Y cartridge has reached its third end of life on a printer.

b) Additional primary cartridges are tested until there have been three supplemental cartridges per printer tested until end of life.

$$Y_c = \frac{n}{\left(\frac{1}{Y_1}+\frac{1}{Y_2}+\ldots+\frac{1}{Y_n}\right)} \quad (5)$$

where

Y_c is the composite yield;

Y_i is the 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

From testing:

Cyan cartridge 90 % LCB = 450 pages

Magenta cartridge 90 % LCB = 580 pages

Yellow cartridge 90 % LCB = 500 pages

Black cartridge 90 % LCB = 1 100 pages

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

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 pages
Average magenta cartridge yield	up to 580 pages
Average yellow cartridge yield	up to 500 pages
Average black cartridge yield	up to 1 100 pages

Values obtained by continuous printing.

Composite yield method

Three-cartridge composite yield	up to 505 pages
(Composite yield using C, M and Y)	
Average black cartridge yield	up to 1 100 pages

Values obtained by continuous printing.

Note that yield for the black cartridge is always declared based on its individual LCB.

When yields for additional cartridges other than C, M, Y and K, shall be measured (as determined in reference to 6.2) they shall be reported individually and not combined into the composite yield, unless

they meet the requirements set out in 6.4. In these instances, the composite yield can still be used for the cyan, magenta and yellow cartridges.

If a yield is reported according to this document, 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 this document;

— declared yield value of the cartridge;

— declaration that the value was obtained using continuous printing;

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

— the combination of a tested printer and cartridges;

— the minimum yield of all tested printers;

— the range of yields from all tested printers (shall have reference to actual printer/cartridge yield available).

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

a) The black cartridge yield.

b) Primary cartridges other than black and any supplemental cartridges that meet the requirements of the note in 6.4. For these cartridges there are three ways that yield can be specified.

   1) CMY composite plus the individual supplemental yields.

      For this case, the composite yield shall be reported as a three-cartridge composite yield with a note specifying that this is composed of cyan, magenta and yellow.

   2) Total composite yield of all primary and supplemental cartridges meeting the requirements of 6.2.

      For this case, the composite yield shall be reported as a "N" cartridge yield, with "N" being the number of cartridges in the composite yield. Also included shall be a note specifying the colours of the cartridges used in the composite calculation.

   3) Individual yield of all cartridges.

c) Yield of supplemental cartridges tested, but not meeting the requirement of 6.2.

   1) Estimated by weight.

   2) Estimated by actual usage (<9 data point lower confidence bound).

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

The method of measuring yield of monochrome test chart with colour inkjet and colour laser printers shall be outlined in Annex E.

Recommended examples:

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 pages
(Composite yield using C, M and Y)	
Average K cartridge yield	1 100 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

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 pages
(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 24711.

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 pages

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

Declared yield value in accordance with ISO/IEC 24711.

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

When tested in printer YYY

Ink cartridge yield:	Average C cartridge yield	502 standard pages
	Average M cartridge yield	515 standard pages
	Average Y cartridge yield	489 standard pages
	Average K cartridge yield	1 100 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

For a system with only CMY combined cartridge and a K cartridge:

When tested in printer YYY

Ink cartridge yield:

Ink cartridge yield: average CMY cartridge yield	505 standard pages
Average K cartridge yield	1 100 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

For a system with only C, M, Y and K individual cartridges and supplemental light C and light M, with both being estimated:

When tested in printer YYY

Ink cartridge yield:

Three-cartridge composite yield	505 standard pages
(Composite yield using C, M and Y)	
Average K cartridge yield	1 100 standard pages
Estimated supplemental yield light cyan	5 100 standard pages
Estimated supplemental yield light magenta	2 500 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

For a system with only C, M, Y and K individual cartridges and supplemental light C and light M, with both having the minimum required sample size:

When tested in printer YYY

Ink cartridge yield:

Average C cartridge yield	502 standard pages
Average M cartridge yield	515 standard pages
Average Y cartridge yield	489 standard pages
Average K cartridge yield	1 100 standard pages
Average yield light cyan	1 200 standard pages
Average yield light magenta	1 500 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

Or

When tested in printer YYY

Ink cartridge yield:

Five cartridge composite yield	505 standard pages
(Composite yield using C, M and Y, light C, light M)	
Average K cartridge yield	1 100 standard pages

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

Declared yield value in accordance with ISO/IEC 24711.

Annex A
(informative)

Examples of fade

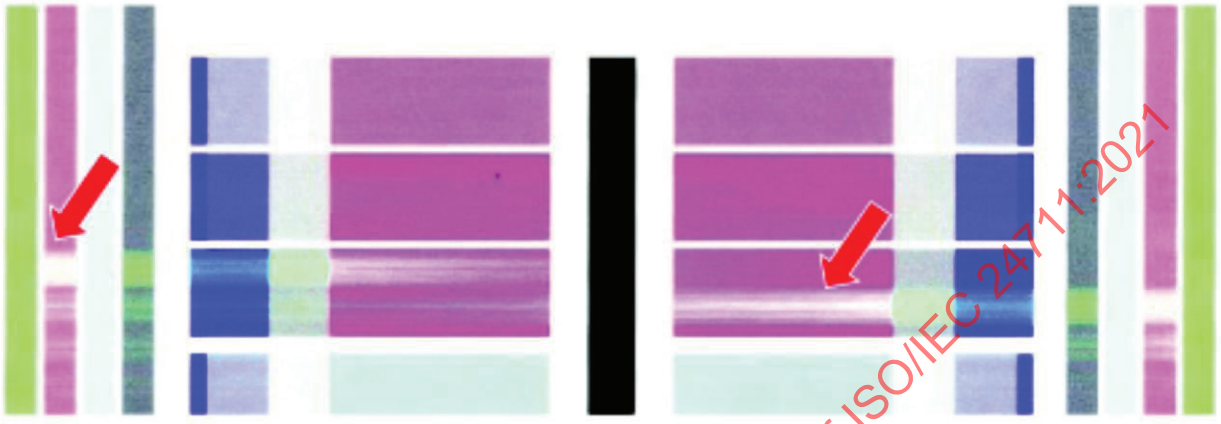

Figure A.1 — Examples of fade

Annex B
(informative)

Examples of streaks

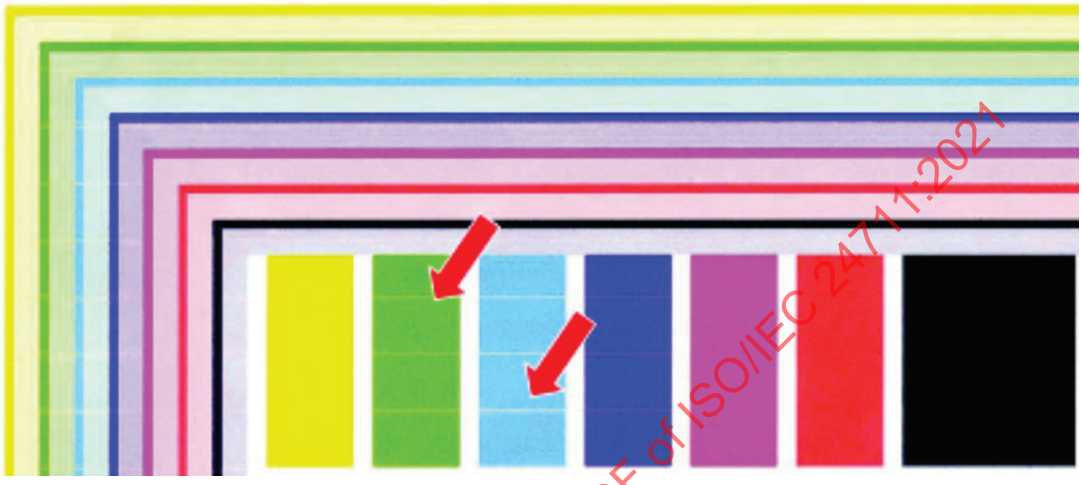

Figure B.1 — Examples of streaks

Annex C
(normative)

Test reporting form

This annex specifies the data that shall be present on all test reports; the format may vary.

Declaration of yield:

When tested in printer PDL 5900:	
Inkjet cartridge yield:	
Average continuous composite CMY cartridge yield	505 standard pages
Average continuous K cartridge yield	1 100 standard pages
Values obtained by continuous printing.	
Declared yield value in accordance with ISO/IEC 24711.	

90 % Lower confidence	Cyan cartridge	= 450 pages
	Magenta cartridge	= 580 pages
	Yellow cartridge	= 500 pages
	Black cartridge	= 1 100 pages

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
Supplemental cartridges	Light cyan, light magenta
Print mode	Continuous
Number of printers used in testing	3
Media used	HiRight 20 lb copy paper

Paper size	A4
Paper feed orientation	Short edge feed
Computer model	VectorPC 7155
CPU	Pentium II, 1,8 GHz
Memory size	256 Mbyte
Interface	USB 2.0
Driver version	Driver version 1.03b
Operating system	Windows XP SP2
Application software	Adobe Acrobat version 6.01
Test page suite version	Version 200601
Power (off/on) everyday?	Yes
Others	Footer is used for page numbering. Automatic testing file AAA is used.

Table C.1 — Example of cartridge data form for printer #1: AAAA69675

		Cartridge No.	Temperature			Cartridge yield	Cartridge used in calculation
			Avg.	Max.	Min.		
1st set	C						
	M						
	Y						
	K						
2nd set	C						
	M						
	Y						
	K						
3rd set	C						
	M						
	Y						
	K						
4th set	C						
	M						
	Y						
	K						
5th set	C						
	M						
	Y						
	K						
6th set	C						
	M						
	Y						
	K						
7th set	C						
	M						
	Y						
	K						

Table C.2 — Example of cartridge data form for printer #2: BBBB69675

		Cartridge No.	Temperature			Cartridge yield	Cartridge used in calculation
			Avg.	Max.	Min.		
1st set	C						
	M						
	Y						
	K						
2nd set	C						
	M						
	Y						
	K						
3rd set	C						
	M						
	Y						
	K						
4th set	C						
	M						
	Y						
	K						
5th set	C						
	M						
	Y						
	K						
6th set	C						
	M						
	Y						
	K						
7th set	C						
	M						
	Y						
	K						

Table C.3 — Example of cartridge data form for printer #2: BBBB69675

		Cartridge No.	Temperature			Cartridge yield	Cartridge used in calculation
			Avg.	Max.	Min.		
1st set	C						
	M						
	Y						
	K						
2nd set	C						
	M						
	Y						
	K						
3rd set	C						
	M						
	Y						
	K						
4th set	C						
	M						
	Y						
	K						
5th set	C						
	M						
	Y						
	K						
6th set	C						
	M						
	Y						
	K						
7th set	C						
	M						
	Y						
	K						

Table C.4 — Example of summary form

	Cartridge No.	C	M	Y	K		Cartridge No.	C	M	Y	K		Cartridge No.	C	M	Y	K
Printer #1	1					Printer #2	1					Printer #3	1				
	2						2						2				
	3						3						3				
	4						4						4				
	5						5						5				
	6						6						6				
	7						7						7				
	8						8						8				
	9						9						9				
	10						10						10				
	11						11						11				
	12						12						12				
	13						13						13				
	14						14						14				
	15						15						15				
	16						16						16				
	17						17						17				
	18						18						18				
	19						19						19				
	20						20						20				

Type	C	M	Y	K
Total				
Avg.				
St.Div.				
90%LCB				

Comments: (as required):

Cartridge AD499444 was stopped after 215 pages of testing due to too many cleaning operations in printer ABA6686-996. It was not used in yield calculations. The cartridge was replaced with a new cartridge and the testing continued.

Cartridge SE989395 was stopped after 234 pages of testing due to ink leakage. It was not used in calculations.

Annex D
(informative)

Process flowchart