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ISO/IEC 24711

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

Méthode pour la détermination du rendement de cartouche d'encre pour les imprimantes couleur à jet d'encre et pour les dispositifs multifonctionnels qui peuvent contenir des composants d'imprimantes

Reference number
ISO/IEC 24711:2007(E)

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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.

ISO/IEC 24711 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

This second edition cancels and replaces the first edition (ISO/IEC 24711:2006), of which it constitutes a minor revision.

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Introduction

The purpose of this International Standard is to provide a process for determining the ink cartridge yield for a given colour inkjet printer model (i.e. integrated ink cartridges and ink cartridges without integrated printheads) using a standard consumer type test suite. Ink cartridge yields determined on one printer model and cartridge configuration are not applicable to another printer model or cartridge configuration even if the ink jet cartridges used in testing are the same. This test page suite is not focused on printing of photographs, but is intended to be a sampling of typical business consumer pages.

This International Standard prescribes the following:

- the test method that manufacturers, test labs, etc. use to determine ink cartridge yield;
- the method for determination of declared yield values from the test results; and
- 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 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 are considered for CPP calculations.

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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 International Standard is limited to evaluation of ink cartridge page yield for ink-containing cartridges (i.e. integrated ink cartridges and ink cartridges without integrated print heads) for colour inkjet printers. This International Standard 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 International Standard.

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

This International Standard 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.

2 Normative references

The following referenced documents are indispensable for the application 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 19752, *Information technology — Method for the determination of toner cartridge yield for monochromatic electrophotographic 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 reduction in uniformity occurs due to ink depletion

NOTE 1 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 (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 Annex A.

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NOTE 2 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 can continue. If fade appears on the next suite, then the cartridge is judged at end of life 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 is encountered and the additional diagnostic pages will be counted.

3.2
streaks
very thin lines of colour, other than intended in the bands surrounding the edge of the last page in the test page suite (Diagnostic Page)

NOTE Streaks differ from fade 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 is required. Comparisons are made using the phenomena sample provided in Annex B.

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

NOTE If streaks are observed on three consecutive diagnostic pages, first the printer can be left idle for five minutes. Then an additional three test suites 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 2). All test page suites printed during this process will be included in the page count for determining the yield.

3.4
print head alignment operation
function that aligns newly installed print heads

NOTE 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 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 as defined in 3.1, or

— ink out as defined in 3.6.

NOTE 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 will still be considered at end of life.

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3.8
test page suite
series of five pages defined by 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 (as defined in 3.7) and multiplying by five

NOTE 1 If the printer stops due to ink out in the middle of a test page suite, 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 The number of test page suites counted may contain some pages that show visible fade. 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 These colours represent the primary inks used in a traditional four-colour printing process.

3.12
supplemental cartridge
cartridge other than the full density cyan, magenta, yellow and black cartridges

NOTE 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 will 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 insure 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, 5 cycles of the standard test page suite. The priming cartridges shall be removed and replaced with new cartridges that will be used for testing yield. The pages printed during this step are not counted towards yield. Even if required by the printer, print head alignment does not have to be performed on the priming cartridges. The number of pages used in the priming operation will 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 suite number 1 and continue until end of life. If the staggered start method is used, the test suite number must be tracked separately for each cartridge. The test start method will be included in the test report.

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All image and print quality modifiers shall be at their factory pre-set 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.

To assure 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 files 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 suite standard (ISO/IEC 24712). Page placement modifiers such as page centering can be used to place the image properly on the page.

To facilitate automated testing, the 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.

NOTE The application software (for example, PDF Reader©), printer driver and printer may 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, 9 Black (K), 9 Cyan (C), 9 Magenta (M) and 9 Yellow (Y). For a typical multi-colour cartridge system where one cartridge contains C, M and Y and another cartridge contains K, the testing would use 18 total cartridges, 9 Black and 9 CMY.

In some printer configurations, supplemental cartridges may be installed. Please see the procedure in section 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 would be 48 (3 cartridges X 4 colours X 4 printers) for a four-cartridge system.

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 must be within their useful life as stated in their user's manual.

NOTE It is recommended that additional engines and/or cartridges be used in testing.

4.3 Print mode

For reporting cartridge yield, the test will 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 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 work days.

NOTE This does not mean that the printer must 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 Depending on use conditions, the yield experienced by a given user may vary significantly from the yield measured by this test method.

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4.4 Print environment

The temperature can have a profound effect on test results. For this reason, the test must 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.

Example: An example of the calculation of the temperature is shown below for temperature readings taken on 15-minute intervals for the testing of one cartridge.

	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	

Table 1 — Running temperature calculation example

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 this 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 must 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 weight paper and must conform to the printer's list of approved papers. The paper manufacturer, weight and size, A4 or equivalent, used in the test will be 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 of the yield performance. .

4.6 Maintenance

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

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4.7 Test files

The test files are outlined and specified in ISO/IEC 24712. The test must be conducted using the most recent official electronic test files 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. In addition to the test files a publicly available PDF Reader will be used in conjunction with the printer driver to generate the printer input and send the files 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 will be recorded on the test report. The version of the test file, the printer driver version and the PDF Reader version will be included in the test report. Before starting the test, a sample file set shall be printed to check the image and assure the proper size. The proper size for each of the pages in the test suite is specified in ISO/IEC 24712.

NOTE There are often 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 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.

NOTE 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 suite, it shall be documented in the test report.

The host computer environment such as Operating System (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 will be recorded on the test report.

5 Test methodology

5.1 Testing procedure

5.1.1 Preparation

1) Install at least three printers following the user’s manual.
2) Install a priming cartridge for each colour into the printers.
3) Using each priming cartridge, print at least 5 complete test page suites.
4) Remove each priming cartridge.

5.1.2 Installation of test cartridges

1) 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 0.01g and record the weight.

   NOTE 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.

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

2) If the printer has a mandatory print head alignment operation, it will be conducted according to the printer manual.

   NOTE These pages are not to be counted in the measured yield.

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5.1.3 Testing

1) Begin test and start tracking the number of test page suites printed on each test cartridge.

   NOTE When the 10th page (second full test suite) is printed for the first set of cartridges, save page for use as the fade reference.

2) When End of Life is reached on any cartridge, execute the End of cartridge life procedure according to the section 5.1.4.

   NOTE The end of cartridge life shall be determined as prescribed in section 3.7.

5.1.4 End of cartridge life procedure

1) Record Individual Cartridge Yield of the depleted cartridge as described in section 3.9.

2) 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 5.1.2.

3) Repeat steps 5.1.2 through step 2 of 5.1.4 for all remaining test cartridges. If the printer has a mandatory print head alignment operation, it will be conducted according to the printer manual.

4) Testing must 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 9 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

If Streaks are observed as described in 3.2, a Streak Removal Operation (Section 3.3) shall be performed according to the printer user's manual. The page count and streaking colour will be recorded on the test report.

5.2.1 Nozzle cleaning

1) Nozzle cleaning strength

If the 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.

2) Permissible limited number of nozzle cleaning operation

By conducting the nozzle cleaning operation, some amount of ink will be 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 below.

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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

Table 2 — Allowed cleaning cycles

NOTE The permissible limited number of nozzle cleaning operation is three times, when the assumed yield value for a printer tested is 1200 pages (240 suites) or less. The limited number is incremented by one every additional 400 pages above 1200 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 is 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 is not valid. The Cartridge removed for this reason will be recorded on the test report as a failed cartridge due to excessive streaking.

3) 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 will also use ink in 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

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, structural failure, etc. Printhead failures are usually indicated by excessive, non-cleanable streaking or other non-resolvable print quality defects in systems where the print heads 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.

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5.3.1 Defective cartridge

In the case of a defective cartridge, the number of the last test page 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 print head 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.

5.3.2 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 Section 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 will be recorded. A note will be made that all cartridges were replaced due to printhead failure. If the printer has a mandatory print head alignment operation, it will be conducted according to the printer manual.

NOTE If the printhead is not user replaceable, refer to 5.3.3.

5.3.3 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 Section 4.1. Then new cartridges shall be installed for subsequent testing. If the printer has a mandatory print head alignment operation, it will 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 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).

Sample Average for a given cartridge, $\overline{X} = \sum_{i=1}^{n} \frac{x_i}{n}$

Sample Standard Deviation for a given cartridge, $s = \sqrt{\sum_{i=1}^{n} \frac{\left(xi - \overline{X}\right)^2}{(n-1)}}$

Where

x_i Is the individual cartridge yield defined in section 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.

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It can be stated with 90% confidence that the true average yield of the cartridge is within the following values:

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

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

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

Supplemental cartridge yields must be reported individually except as specified in the note of Section 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] x 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.

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

The declaration must 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 proxy and less than one supplemental cartridge was used at the end of testing for a given printer under testing, supplemental cartridges must be tested until End of Life to determine yield.

At test completion, a minimum of 3 data points (one per printer) will exist for each supplemental cartridge. The data points will be real or estimated. The 90% LCB value will be calculated in the same manner as a primary cartridge. Only supplemental cartridges are allowed to have fewer than 9 data points.

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An example:

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

K delivers 20 grams of ink and 500 pages (average of 9 data points, Standard Deviation = 18).

C delivers 11 grams of ink and 250 pages (average of 18 data points, Standard Deviation = 21).

M delivers 11.3 grams of ink and 230 pages (average of 21 data points, Standard Deviation = 40).

Y delivers 11.5 grams of ink and 265 pages (average of 18 data points, Standard Deviation = 31).

Light C delivers 3 grams of ink and never reaches End of Life. (0 data points)

Light M delivers 11 grams of ink and 1400 pages (average of 3 data points, Standard Deviation = 62)

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

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 (11x18+11.3x21+11.5x18)/(18+21+18) = 11.27 grams. 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 500x3 = 1500 pages, but needs to be done on a per printer basis in order to generate the 3 estimated yield data points. Assume the three printers produced 1503, 1516 and 1481 total pages and the light cyan cartridges delivered 3, 3.1 and 2.9 grams of ink.

The light cyan estimated yields are

(11.27 grams) x (1503 pages) / (3 grams) = 5,646
(11.27 grams) x (1516 pages) / (3.1 grams) = 5,511
(11.27 grams) x (1481 pages) / (2.9 grams) = 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

Light Cyan 90% LCB = $5{,}638 - 2.92\frac{122.3}{\sqrt{3}} = 5{,}432$ pages

Light Magenta 90% LCB = $1{,}400 - 2.92\frac{62}{\sqrt{3}} = 1{,}295$ pages

6.3 Test data reporting

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

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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 section 6.1. The yield values used in the calculation are those determined when the first colour is depleted, as defined in section 3.7.

Example:

From Testing:

CMY Cartridge 90% LCB = 508 pages

Black cartridge 90% LCB = 1100 pages

Yield can be reported as :

Average CMY Cartridge Yield	Up to 508 pages
Average Black Cartridge Yield	Up to 1100 pages

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 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 suites 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. This value is to be called the “composite yield” and is defined below:

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

1) The supplemental cartridge has been replaced greater than or equal to 2 times at the time that the last primary C,M or Y cartridge has reached its third end of life on a printer.
2) Additional primary cartridges are tested until there have been 3 supplemental cartridges per printer tested until end of life.

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

Where

CY= composite yield

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

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

Example:

From testing:
Cyan Cartridge 90% LCB = 450 pages
Magenta Cartridge 90% LCB = 580 pages
Yellow Cartridge 90% LCB = 500 pages

Black Cartridge 90% LCB = 1100 pages

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

For colour cartridges:

Declared yield can be based either on the individual LCBs for each colour or based on the composite yield. The 2 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 1100 pages
Values obtained by continuous printing	

Composite Yield Method:

3 Cartridge Composite Yield	Up to 505 pages
(Composite yield using C, M and Y)	
Average Black Cartridge Yield	Up to 1100 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, must be measured (as determined in reference to section 6.2) they must be reported individually and not combined into the composite yield, unless they meet the requirements set out in section 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 ISO/IEC 24711, a full test report as shown in Appendix C shall be available.

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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 24711
- Declared yield value of the cartridge
- That the value obtained was using continuous printing
- If a cartridge can be used in multiple printers one of the following shall be reported:
    - The combination of 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 four main components to the numerical part of the declaration:

1. The black cartridge yield
2. Primary cartridges other than black and any supplemental cartridges that meet the requirements of the note in section 6.4 For these cartridges there are three ways that yield can be specified
    1. CMY composite + individual supplemental yields

        For this case, the composite yield will be reported as a 3 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 will be reported as a "N" cartridge yield, with "N" being the number of cartridges in the composite yield. Also included will be a note specifying the colours of the cartridges used in the composite calculation.

    3. Individual Yield of all cartridges
3. Yield of supplemental cartridges tested, but not meeting the requirement of section 6.2
    1. Estimated by weight
    2. Estimated by actual usage (< 9 data point lower confidence bound)
4. The total number of cartridge colors used in the determination of the yield

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Recommended Examples:

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

When tested in printer YYY:
Ink Cartridge yield: 3 Cartridge Composite Yield 505 standard pages
(Composite yield using C, M and Y)

Average K Cartridge Yield 1100 standard pages

Values obtained by continuous printing using 4 cartridge colors (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: 3 Cartridge Composite Yield 505 standard pages
(Composite yield using C, M and Y)

Values obtained by continuous printing using 4 cartridge colors (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 4 cartridge colors (C,M,Y, K)

Declared yield value in accordance with ISO/IEC 24711

For a system with only C, M, Y & 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 1100 standard pages

Values obtained by continuous printing using 4 cartridge colors (C,M,Y, K)

Declared yield value in accordance with ISO/IEC 24711

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

When tested in printer YYY:

Ink Cartridge yield:	Average CMY Cartridge Yield	505 standard pages
	Average K Cartridge Yield	1100 standard pages

Values obtained by continuous printing using 2 cartridge colors (CMY, K)

Declared yield value in accordance with ISO/IEC 24711

For a system with only C, M, Y & K individual cartridges and supplemental Light C and Light M with both being estimated.

When tested in printer YYY:

Ink Cartridge yield:

3 Cartridge Composite Yield (Composite yield using C, M and Y)	505 standard pages
Average K Cartridge Yield	1100 standard pages
Estimated Supplemental Yield Light Cyan	5100 standard pages
Estimated Supplemental Yield Light Magenta	2500 standard pages

Values obtained by continuous printing using 6 cartridge colors (C,M,Y, K, c, m)

Declared yield value in accordance with ISO/IEC 24711

For a system with only C, M, Y & K individual cartridges and supplemental Light C and Light M with 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	1100 standard pages
Average Yield Light Cyan	1200 standard pages
Average Yield Light Magenta	1500 standard pages

Values obtained by continuous printing using 6 cartridge colors (C,M,Y, K, c, m)

Declared yield value in accordance with ISO/IEC 24711

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or

When tested in printer YYY:

Ink Cartridge yield:

5 Cartridge Composite Yield (Composite yield using C, M and Y, Light C, Light M)	505 standard pages
Average K Cartridge Yield	1100 standard pages

Values obtained by continuous printing using 6 cartridge colors (C,M,Y, K, c, m)

Declared yield value in accordance with ISO/IEC 24711

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Annex A
(informative)

Examples of fade

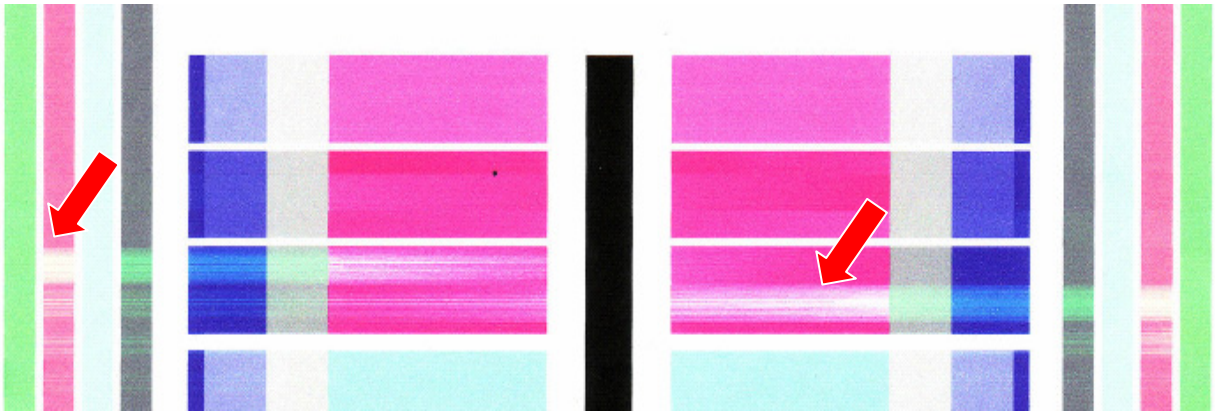

Figure A.1 — Examples of fade

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Annex B
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Examples of streaks

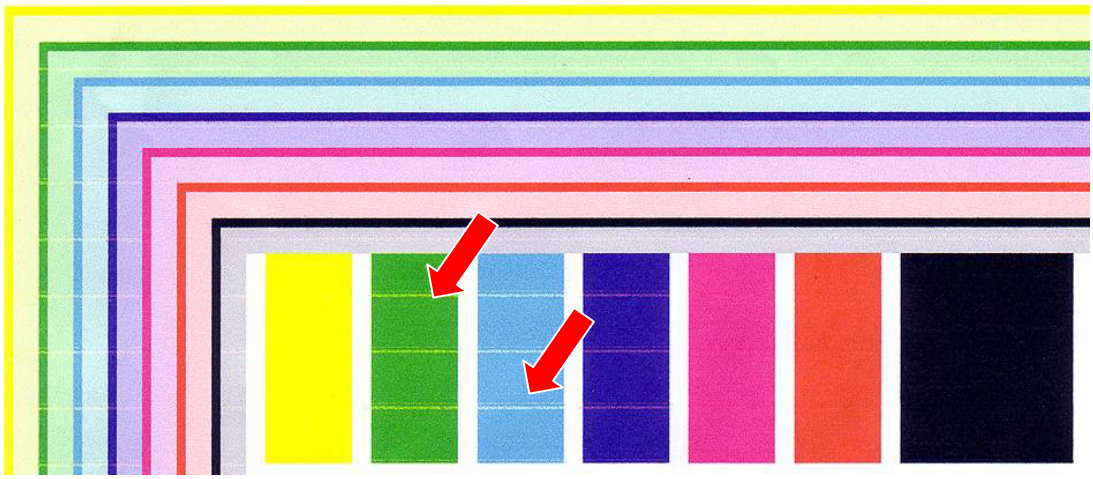

Figure B.1 — Examples of streaks

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Annex C
(normative)

Testing reporting form

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 1100 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 = 1100 pages

Date Tested: 2006/10/20 – 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

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Supplemental Cartridges	Light Cyan, Light Magenta
Print mode:	Continuous
Number of printers used in testing:	3
Media Used:	HiRight 20lb Copy paper
Paper Size:	A4
Paper feed orientation:	Short edge feed
Computer Model:	VectorPC 7155
CPU	Pentium II, 1.8GHz
Memory size	256Mbite
Interface	USB 2.0
Driver Version:	Driver Version 1.03b
Operating System:	Windows XP SP2
Application Software:	Acrobat version 6.01
Test suite Version	Version 200601
Power (off/on) everyday?	Yes
Others	Footer is used for page numbering.
	Automatic testing file AAA is used.

Cartridge testing data:

Printer #1: AAAA69675

			Temperature				Humidity			
		Cartridge No.	Avg	Max	Min	Avg	Max	Min	Cartridge yield	Cartridge used in calculation
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									

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Printer #2: BBBB69675

			Temperature				Humidity			
		Cartridge No.	Avg	Max	Min	Avg	Max	Min	Cartridge yield	Cartridge used in calculation
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									

Printer #3: CCCC69675

			Temperature				Humidity			
		Cartridge No.	Avg	Max	Min	Avg	Max	Min	Cartridge yield	Cartridge used in calculation
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									

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Summary

	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. Dev.				
	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.

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Annex D
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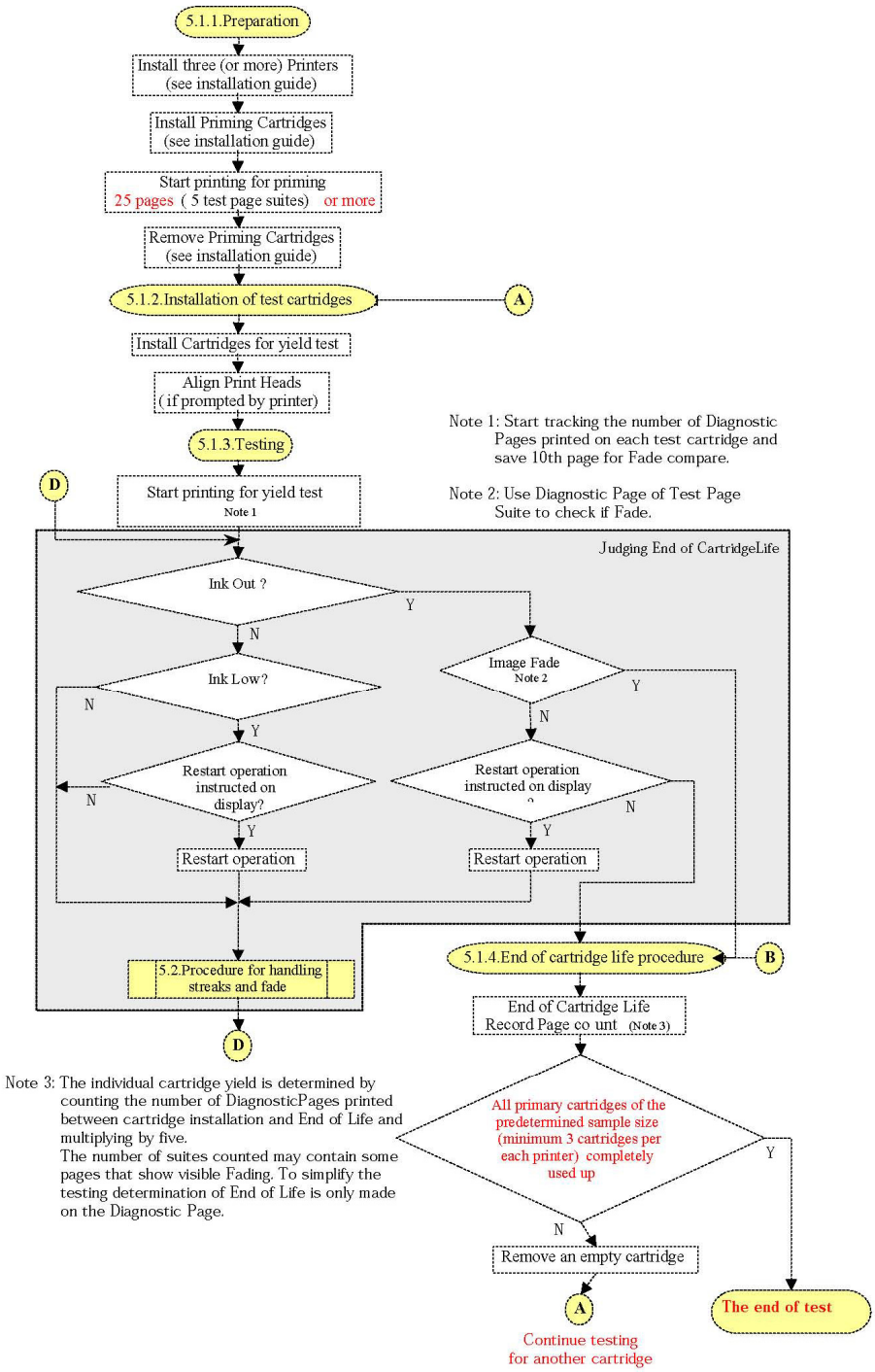
Process flowchart



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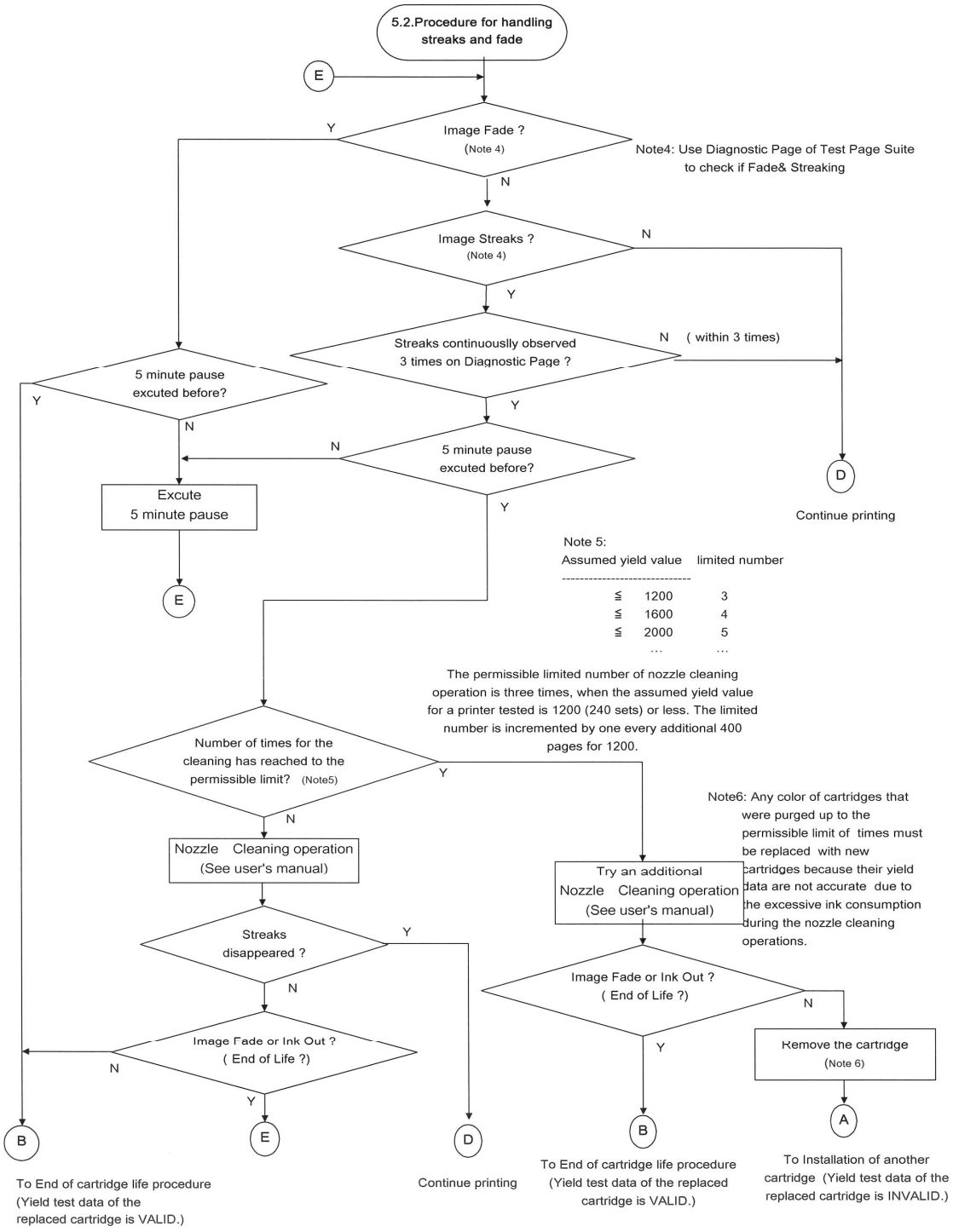

Figure D.1 — Process flowchart

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Annex E
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Method for comparison of inkjet performance to ISO/IEC 19752

It is a benefit to customers to be able to compare page yield across technologies. ISO/IEC JTC1 SC28 has developed the colour test suites in ISO/IEC 24712 to be used in both colour inkjet printers and colour laser printers. In addition, ISO/IEC 19752 defines a monochrome test page that could be use to test yield of colour inkjet and colour laser printers in situations where monochrome text is printed predominantly or comparisons need to be made between colour and monochrome printers. This is not meant to take the place of testing black yield using ISO/IEC 24712, but to be in addition to testing with ISO/IEC 24712.

Similar parameters outlined in ISO/IEC 24711 for set-up, sample size, end of life determination, and yield determination can be applied to both the mono test page and the colour test pages. The exceptions are as follows:

Section 3.1 Fade

A phenomenon whereby a noticeable reduction in density uniformity across the page occurs. The determination of the change in lightness is to be made referenced to the 100th page printed for each cartridge in testing.

Section 3.11 Supplemental Cartridge

Any installed cartridge but the full density black cartridge. This will include full density Cyan, Magenta and Yellow cartridges as well as any photo type cartridges.

Section 4.1 Set-up

All image and print quality modifiers shall be at their factory pre-set configuration for the printer and default-installed condition for the driver with the following exceptions. If a “Black Only” or “Text Only” mode is available in the driver, it shall be enabled. The selection of this modifier must be noted on the test report. 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.

After testing using the page defined in ISO/IEC 19752, all cartridges other than full density Black will be treated as supplemental cartridges and the yields reported. .

In yield reporting, it is imperative that the test pages are clearly defined, whether it is the Colour Test pages under ISO/IEC 24712 or the Monochrome Laser Test Page under ISO/IEC 19752. Comparisons can only be made if the same test page or test suite is used. In addition, this reporting cannot take the place of yield reporting for Black as defined in ISO/IEC 24711. This additional method can only be used to provide additional information and not take the place of yields determined by ISO/IEC 24711.

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

- Results derived from testing using ISO/IEC 24711
- Description that the additional yield values have been determined using the procedure defined in ISO/IEC 24711 using the test page defined in ISO/IEC 19752.
- That the value obtained was using continuous printing

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- If a cartridge can be used in multiple printers one of the following shall be reported:
    - The combination of 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

Example:

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	1100 standard pages

Values obtained by continuous printing
Declared yield value in accordance with ISO/IEC 24711

Using the test page defined in ISO/IEC 19752 provides the following results

Average K Cartridge Yield	1200 standard pages
Estimated Supplemental Cyan Yield	8100 standard pages
Estimated Supplemental Magenta Yield	5100 standard pages
Estimated Supplemental Yellow Yield	8200 standard pages

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Price based on 27 pages

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