
Information technology — Office equipment — Test pages and methods for measuring monochrome printer resolution

*Technologies de l'information — Équipement de bureau —
Diagrammes et méthodes pour mesurer la résolution des imprimantes
monochromes*



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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 JTC1.

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).

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For an explanation on 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 the following URL: www.iso.org/iso/forward.html.

This document was prepared by Technical Committee ISO/IEC JTC1, *Information technology*, Subcommittee SC 28, *Office equipment*.

This first edition cancels and replaces ISO/IEC TS 29112:2012.

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 the objective measurement of print quality characteristics that contribute to perceived resolution in pages printed on paper or similar opaque materials using monochrome electro-photographic printing processes.

This document prescribes the following:

- Definitions of print quality characteristics that contribute to perceived resolution.
- Definitions of conformance methods to qualify a reflection scanner for use as a measuring device.
- A testing procedure based upon:
 - a) a well-documented printer and printing environment setup,
 - b) well-controlled printing of specified test pages, and
 - c) subsequent measurement of print quality characteristics using reflection scans of test pattern elements on the printed test pages.
- Definitions of methods for measuring the contributing print quality characteristics using printed test pattern elements of the specified test pages and analysing the resulting data to derive an assessment of printer resolution.
- Requirements for the report of a printer resolution assessment that define the context of the assessment and describe the results of the assessment.

Printer resolution, a quantification of the ability of a digital printing system to depict fine spatial detail, is a perceptually complex entity with no single, simple, objective measure. Five print quality characteristics that meaningfully contribute to resolution are described in this document. These print quality characteristics are: native addressability, effective addressability, edge blurriness, edge raggedness and the printing system spatial frequency response characteristic (SFR).

- Native or physical addressability refers to the imaging framework in a digital printing process, usually a rectangular grid of printable spots, which enables depiction of fine spatial detail. Native addressability specifies only one facet of the perceived resolution of a printing system. The common unit for native addressability is DPI (dots per inch).
- Effective addressability is a measure of the minimum pitch by which the centre of a printed object (e.g. line segment) can be displaced and evaluates the effects of imaged spot position modulation, size modulation or exposure modulation.
- Edge blurriness provides an optical measure of the geometric transition width of an edge between an unprinted substrate region and a printed solid area region.
- Edge raggedness provides an optical measure of the geometric deviations of a printed edge from a requested straight line.
- The spatial frequency response characteristic (SFR) describes the ability of a linear imaging system to depict fine spatial detail. This is the spatial analogue of frequency response used to characterize sound reproduction. A common synonym of the SFR characteristic is the modulation transfer function (MTF). The ability to depict fine spatial detail is affected by edge blurriness and edge raggedness as well as the spot size and shape of the printer's marking technology and any adjacency effects that can occur in the reproduction of fine detail. Two measurement methods are described that provide estimates of the printing system's spatial frequency response including contributions from edge blurriness, edge raggedness, spot-size, spot shape and adjacency effects.

An essential part of the development of this document was verification that the specified measurement methods correlate well with perceived printer resolution (the ability of a digital printing system to depict fine spatial detail) and that the measurements are reproducible across laboratories and instruments.

The steps in and results of this process to verify the utility of the measurement methods specified in this document are presented in more detail in [Annex F](#). The applicability of the measurement methods specified in this document could be expanded by undertaking similar verification processes with other printing technologies.

Information technology — Office equipment — Test pages and methods for measuring monochrome printer resolution

1 Scope

This document defines methods for the objective measurement of the print quality characteristics that contribute to the perceived resolution of reflection mode monochrome printed pages produced by digital electro-photographic printers. The measurement methods of this document are derived from several existing techniques for the assessment of an imaging system's resolution characteristics. Each of these measurement methods is intended for the engineering evaluation of a printing system's perceived resolution and is not intended to be used for purposes of advertising claims.

The methods of this document are applicable only to monochrome prints produced in reflection mode by electro-photographic printing technology. This document is intended for monochrome printers utilizing PostScript®¹⁾ interpreters capable of accepting PostScript and encapsulated PostScript (EPS) jobs.

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 12233, *Photography — Electronic still picture imaging — Resolution and spatial frequency responses*

ISO 14524, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

ISO 16067-1, *Photography: Spatial resolution measurements of electronic scanners for photographic images — Part 1: Scanners for reflective media*

ISO/IEC 24790, *Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Monochrome text and graphic images*

3 Terms, definitions and abbreviations

3.1 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>

3.1.1

addressability

number of uniquely identifiable printable spot positions per unit distance

1) PostScript® and Encapsulated PostScript® are registered trademarks for freely usable page description formats controlled and defined by Adobe Systems Incorporated. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC.

3.1.2

bitmap

two-dimensional rectangular matrix of values representing the *pixels* (3.1.21) in a printed page

3.1.3

cross-track

oriented perpendicular to the direction of print substrate motion (cross-track direction)

3.1.4

cross-track addressability

addressability (3.1.1) of the printer in the direction perpendicular to the motion of the print substrate through the printer

3.1.6

edge blurriness

appearance of being hazy or indistinct in outline, giving a noticeable transition of density from a line element to the background substrate whose transition width is zero for an ideally sharp edge

Note 1 to entry: The measured optical width of the transition region perpendicular to the straight edge boundary between an unprinted substrate area and a solid printed area provides an assessment of edge blurriness.

3.1.7

edge raggedness

appearance of geometric distortion of an edge from its ideal position

Note 1 to entry: Measurement of the geometric deviations from straightness of a contour at a specific reflectance ratio in the edge boundary region between the unprinted substrate area and the solid printed area of a requested straight edge provides an assessment of edge raggedness.

Note 2 to entry: An ideal edge should be absolutely straight along the length of a straight line.

3.1.8

edge transition width

distance between the points of a *normal edge profile* (3.1.19) identified at 70 % of the edge transition reflectance range and 10 % of that reflectance range, the region in which *edge blurriness* (3.1.6) is measured

Note 1 to entry: The edge transition reflectance range is the reflectance difference between the maximum measured reflectance factor, $R_{\max}$, typically of the substrate, and the minimum measured reflectance factor, $R_{\min}$, typically of a region printed at a maximum printing value.

3.1.9

edge spread function

normalized spatial signal distribution in the scanned output of a printing system resulting from imaging a theoretical infinitely sharp edge

Note 1 to entry: In measurement of the edge spread function, the tone-scale of the scanning system is corrected to be linear in reflectance. See ISO 12231.

3.1.10

effective addressability

one over the minimum pitch by which the centre of a printed object can be displaced, with the constraint that the objects compared are of constant dimension in the direction parallel to the centroid position change direction

Note 1 to entry: The effective addressability of a printer can be greater than its native addressability. This higher effective addressability is generally controlled algorithmically within the digital data path processing of the printer and is generally not accessible to a user of the printer.

3.1.11**human eye modulation response**

response of the human visual system to viewed sinusoidal *modulation* (3.1.15) patterns as a function of the spatial frequency of these modulation patterns

3.1.12**in-track**

oriented along the direction of print substrate motion

3.1.13**in-track addressability**

addressability (3.1.1) of the printer in the direction parallel to the motion of the print substrate through the printer

3.1.14**limiting resolution**

spatial frequency at which the *modulation* (3.1.15) of alternating printed high-contrast lines and spaces is 10 % of the zero-frequency spatial frequency response of the printing system

3.1.15**modulation**

difference between the maximum and minimum signal levels divided by the sum of these two levels

3.1.16**modulation transfer function****MTF****spatial frequency response****SFR**

ratio, as a function of spatial frequency, of the measured *modulation* (3.1.15) response in a print produced by a printing system, to the stimulus modulation presented to that printing system

3.1.17**monochrome**

printing using a single colorant, in particular, a single black colorant

3.1.18**native addressability**

one over the minimum pitch between adjacent *spots* (3.1.35) that can be independently controlled and produced by the printer

3.1.19**normal edge profile****NEP**

reflectance trace across the transition region perpendicular to the boundary of a straight edge between an unprinted substrate area and a solid printed area

Note 1 to entry: For the edge blurriness measurement specified in this document, the transition region is measured between the 10 % and 70 % reflectance levels.

Note 2 to entry: The normal edge profile can be represented as the convolution of an edge spread function and an infinitely sharp edge transition. In turn, for a linear system, the edge spread function is the Fourier transform of the spatial frequency response (or modulation transfer function). For printing systems, which are usually not linear systems, this latter relationship is only approximate.

3.1.20**Nyquist limit****Nyquist frequency**

spatial frequency equal to one half the inverse of the sampling spacing for an adjacent pair of sampling points

Note 1 to entry: This can also be expressed as one half of the spatial sampling frequency.

3.1.21

pixel

smallest addressable element of a digital source image

3.1.22

raster image processor

RIP

component used in a printing system which produces a *bitmap* (3.1.2)

3.1.23

reflectance factor

ratio of the reflected flux as measured to the reflected flux under the same geometrical and spectral conditions for an ideal 100 % diffuse reflecting surface

3.1.24

resolution enhancement technology

control of the printed spot (3.1.36) position to a pitch that is less than the *native addressability* (3.1.18) of the printing system accomplished through local control of one or more spot characteristics

Note 1 to entry: The spot characteristics are spot reflectance (gray-level modulation), size of a spot (size modulation) or local position of a spot (position modulation).

3.1.25

reflectance threshold

R_p

level in the reflectance gradient profile of an edge that is at some specified percentage of the transition from the minimum reflectance factor, $R_{\min}$ (3.1.27), to the maximum reflectance factor, $R_{\max}$ (3.1.26), as: $R_p = R_{\min} + p\%(R_{\max} - R_{\min})$

3.1.26

$R_{\max}$

maximum measured *reflectance factor* (3.1.23), typically of the substrate

3.1.27

$R_{\min}$

minimum measured *reflectance factor* (3.1.23), typically of a region printed at a maximum printing value

3.1.28

R_{10}

contour of points of an image element where the edge gradient profiles cross a reflectance level that is 10 % of the transition from the substrate reflectance factor, $R_{\max}$ (3.1.26), to the minimum image reflectance factor, $R_{\min}$ (3.1.27): $R_{10} = R_{\min} + 10\% (R_{\max} - R_{\min})$

3.1.29

R_{25}

contour of points of an image element where the edge gradient profiles cross a reflectance level that is 25 % of the transition from the substrate reflectance factor, $R_{\max}$ (3.1.26), to the minimum image reflectance factor, $R_{\min}$ (3.1.27): $R_{25} = R_{\min} + 25\% (R_{\max} - R_{\min})$

3.1.30

R_{40}

contour of points of an image element where the edge gradient profiles cross a reflectance level that is 40 % of the transition from the substrate reflectance factor, $R_{\max}$ (3.1.26), to the minimum image reflectance factor, $R_{\min}$ (3.1.27): $R_{40} = R_{\min} + 40\% (R_{\max} - R_{\min})$

3.1.31

R_{70}

contour of points of an image element where the edge gradient profiles cross a reflectance level that is 70 % of the transition from the substrate reflectance factor, $R_{\max}$ (3.1.26), to the minimum image reflectance factor, $R_{\min}$ (3.1.27): $R_{70} = R_{\min} + 70\% (R_{\max} - R_{\min})$

3.1.32**sampling efficiency**

fraction of the *Nyquist frequency* (3.1.20) corresponding to the frequency where the *spatial frequency response* characteristic (3.1.16) has dropped to 10% of its zero-frequency value

3.1.33**sampling frequency**

spatial frequency of adjacent sampling points where sampling points are conventionally oriented along the direction of print substrate motion, the *in-track direction* (3.1.12), or perpendicular to the direction of print substrate motion, the *cross-track direction* (3.1.3)

3.1.34**scanner tone-scale calibration****opto-electronic conversion function****OECF**

digital signal conversion that adjusts the relationship between the reflectance values of large imaged areas and the corresponding digital code values

Note 1 to entry: Code values are the reflection scanner response to a scanned reflection stimulus, e.g. *test elements* (3.1.37). Scanner tone-scale calibration can be used to adjust the relationship between scanned pixel values and large area reflectance to an aim relationship, e.g. scanned pixel values that have a linear relationship with measured print reflectance.

3.1.35**spot**

smallest mark that can be placed under user control at a desired position on a printed page, independently from all other adjacent marks

3.1.36**tangential edge profile****TEP**

array of geometric positions of a contour at a specific *reflectance threshold* (3.1.25) along the printed rendition of a perfectly straight edge boundary between an unprinted substrate area and a solid printed area

Note 1 to entry: For the edge raggedness measure specified in this document, the contour is taken at a 40 % reflectance level.

3.1.37**test element**

elemental part of a test pattern used to assess a particular aspect of a printing system

3.1.38**test page**

arrangement in a printable page of *test elements* (3.1.37) or *test patterns* (3.1.39) designed to test one or more particular aspects of a printing system

3.1.39**test pattern**

specified arrangement of printable objects [*test elements* (3.1.37)] designed to test a particular aspect of a printing system

3.1.40**test suite**

set of printable *test pages* (3.1.38) designed to test a number of different aspects of a printing system

3.2 Abbreviations

Abbreviation	Term
cy/mm	cycles per millimetre
	NOTE 1 This is the unit for specifying spatial frequency.
dpi (DPI)	dots per inch
	NOTE 2 This is the common unit for printing system native addressability.
lp/mm	line pairs per millimetre
	NOTE 3 This is the unit for specifying resolution in terms of the number of equal width black and white line pairs per millimetre that can be resolved according to a criterion such as limiting resolution (3.1.14).
MTF	modulation transfer function (3.1.16)
NEP	normal edge profile (3.1.19)
ppi (PPI)	pixels per inch
	NOTE 4 This refers to the physical addressability of a digital scanning system.
RIP	raster image processor (3.1.22)
TEP	tangential edge profile (3.1.36)
SFR	spatial frequency response (3.1.16)
spi (SPI)	spots per inch
	NOTE 5 The printing system native addressability can be expressed in spots per inch. This is an alternative to the more common term DPI.

4 Print resolution characteristics — Methods for measurement and analysis

4.1 Conformance requirements

4.1.1 General

The print resolution characteristic measurement methods defined in this document rely on the objective evaluation of digital images scanned from printed test pages. The single exception to this is the method for native addressability which relies on the visual evaluation of a printed test page.

The test pages, the printing process employed to print test page samples for evaluation, the characteristics of the scanner employed for objective evaluation and the measurement methods utilized shall all meet conformance requirements to ensure that the reported measurements are valid.

4.1.2 Test page conformance

The test pages used with the measurement methods specified in this document are available from <http://standards.iso.org/iso-iec/29112/ed-1/en> in the ZIP file named Test pages.zip.

— The latest collection of these test pages shall always be used.

— The test page name and version used in printer resolution assessment shall be recorded in the test report.

- Test page names referred to in this document are base file names without a version number suffix. Version numbers will be incremented in later collections of test pages.

These test pages are provided for PostScript compatible printers in Encapsulated PostScript (EPS) format and in PostScript Document Format (PDF). The EPS format, that permits automatic matching of the test page content to the addressability characteristics of the printer's raster image processor (RIP), is the preferred format for use in printing test pages for evaluation using the measurement methods specified in this document. For printing systems with a native addressability known to be either 600 spi or 1 200 spi, test pages for these known addressabilities are also provided in PostScript-based PDF format.

Test pages provided for use with the measurement methods specified in this document are encoded as separation black which avoids colour re-interpretation in most workflows so that only the black printer colorant is used. Colour mixtures and half-tone reproduction of test pages shall be avoided. The provided EPS files can be edited to evaluate the resolution capability of printing systems using any separation colorant. The black separation colorant provides the highest contrast for measurement.

The name and version of a test page used in printer resolution assessment shall be recorded in the test report.

4.1.3 Printing process conformance

The printing process specified in this document avoids the re-interpretations of test page content provided by many imaging or graphics applications. The assessment of printer resolution characteristics is thus made independent of application features and is therefore representative of the inherent capability of the printer.

The procedure specified in [Annex A](#) shall be used to submit the test pages for this printer resolution assessment to the printer being assessed. The name of the printer, the settings of the low-level printing application used to submit the test pages and a specification of the printing application, as specified in [6.2](#) and in [Annex A](#), shall be recorded in the test report.

To ensure that the printer is properly warmed up, one or more pages shall be printed prior to an assessment.

4.1.4 Scanner characteristics conformance

Many of the measurement methods utilized in this document employ a reflection scanner as an analytic measurement device. These measurements provide an accurate assessment of printer resolution characteristics only if the scanner capabilities are high enough, so that the scanner itself does not limit the assessment, and if the scanner control application is configured to deliver accurate and repeatable imagery. [Annex B](#) specifies the conditions that shall be met by a reflection scanner and its scanner control application for qualification as a measurement device with the measurement methods specified in this document.

4.1.5 Measurement method conformance

The procedures specified in [Annex C](#) shall be used to qualify the measurement method implementations specified in this document.

Failure to use a compliant implementation of the measurement methods specified in this document shall invalidate any test results obtained using that implementation. The name of the implementation and its conformance shall be recorded in the test report as specified in [6.2](#) for each measurement method used in printer resolution assessment.

4.2 Native addressability

4.2.1 General

Native addressability, often referred to as physical addressability, or simply addressability, can differ in the in-track direction and in the cross-track direction of the printing process.

A PostScript printer RIP provides a value for the printer addressability when queried. When printed, the EPS version of the native addressability test page automatically obtains addressability values from the RIP.

NOTE In most cases, an evaluation of the printed target simply verifies the native addressability reported by the printer's RIP.

4.2.2 Method for measuring native addressability

Unlike the other measurement methods specified in this document, visual evaluation is used to determine the native addressability of a printing system. This visual evaluation procedure can be iterative. The context for printing the test page and evaluating the native addressability of a printing system is summarized in [Table 1](#).

Table 1 — Native addressability

Test page:	TP1_NativeAddr.eps (from latest Test pages.zip)
Test page editing:	(Optional) To over-ride addressability values reported by the RIP
Printing method:	According to the procedure specified in Annex A
Samples to print:	Single printed sample
Analysis method:	Visual evaluation

Print the test page TP1_NativeAddr.eps according to the method specified in [Annex A](#). The native addressability test page contains four types of elements as shown in [Figure 1](#).

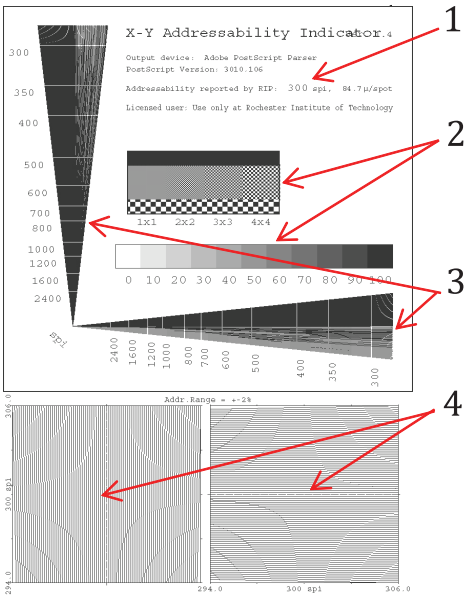


Figure 1 — Native addressability test page

Printing status and configuration check elements:

Element type 1 shows the native addressability reported by the RIP. Element type 2 indicates the two check elements to be visually evaluated to verify that the printing configuration allows correct

native addressability assessment. All four checkerboard patterns and all eleven levels of the tone scale ramp shall be evident and distinct. If not evident and distinct, a workflow or RIP configuration error is indicated (improper resolution, high-contrast tone-scale, binary rendition, etc.) which shall be remedied before utilizing this target.

Coarse native addressability assessment scales:

Element type 3 indicates cross-track and in-track scales used to estimate the approximate native addressability of a printing system. Moiré patterns in these elements disappear at the printer resolution. Visual assessment of these scales provides an indication of the approximate native addressability.

Fine native addressability assessment scales:

Element type 4 indicates cross-track and in-track scales used for precise estimation of native addressability.

Visual assessment of the position where the moiré patterns in these elements disappear provides a very precise and accurate measure of the native addressability of the printing system under assessment.

The TP1_NativeAddr.eps file queries the addressability characteristics of the printer's raster image processor (RIP) and adjusts the test page content to exactly match these reported addressability characteristics.

NOTE 1 In most cases, the evaluation of a printed page of the TP1_NativeAddr.eps file simply verifies the native addressability that is reported by the printer RIP and displayed in the upper right corner area of the target.

Visual assessment of the native addressability test page is complete when these two conditions are met:

- 1) The native addressability indicated by examination of the coarse native addressability assessment scales is within two percent of the native addressability reported by the RIP.
- 2) The native addressability indicated by examination of the fine native addressability assessment scales is within 0,2 pixels per centimetre (or 0,5 pixels per inch) of the native addressability reported by the RIP.

If the visual inspection results differ from the value reported by the RIP by more than two percent, then the fine assessment scales are out of range and do not provide an unambiguous measure of the printing system's true native addressability. Further investigation is required and consists of three steps:

- 1) Open a renamed copy of the TP1_NativeAddr.eps file in a text editor and edit the /SetDPI line in this PostScript text file that is used to over-ride use of the RIP queried values for in-track and cross-track native addressability values to reflect the values determined by visual inspection of the original sample print of the native addressability target. The /SetDPI line of the PostScript text file is illustrated below.

```
/SetDPI 0 def          % You can set the DPI that the program will adapt to. When
                        % set to zero, this will be done automatically, by checking the
                        % number of addressability steps per inch of the output device.
                        % Zero should be the normal setting. But, if it is necessary to
                        % adjust the center spi to show in the large squares (because
                        % the automatic adjustment is off center) then it is possible to
                        % set it here.
```

- 2) Print and evaluate the edited and saved test page. When the coarse in-track and cross-track native addressability obtained by evaluation of the most recently printed test page are each within two percent of the addressability values entered through the text editor into the defining fields of the test page file, then the fine native addressability scales are in range and visual evaluation can provide a measurement of the true native addressability of the printing system that is accurate to

- within 0,2 pixels per centimetre (or 0,5 pixels per inch). This is the tolerance required for evaluation of printer native addressability.
- 3) If the visual inspection of the printed test page still indicates an addressability outside the two percent range of the fine native addressability scales, continue to refine the edited native addressability setting in the Postscript file in order to evaluate the printing system native addressability by repeating steps 1 to 3.

NOTE 2 Usually, one iteration of this process is sufficient to provide an accurate estimate of the native addressability of a printing system.

NOTE 3 If editing the EPS file, the PRange variable controls the fine addressability range displayed in a print. This variable can be changed to display a different range and assess printer addressability to a different accuracy.

The values obtained through this evaluation process for in-track native addressability and for cross-track native addressability shall be entered into the printer resolution test report as described in 6.3.

4.3 Effective addressability

4.3.1 General

The effective addressability of a printer can be greater than its native addressability. This higher effective addressability is generally controlled algorithmically within the digital data path processing of the printer and is generally not accessible to a user of the printer. The effective addressability of a printer can differ in the in-track direction and in the cross-track direction.

4.3.2 Method for measuring effective addressability

Create a renamed copy of the files TP2-H2x_EffAddrHorz.eps and TP2-V2x_EffAddrVert.eps. Open these copies in a text editor and edit the line that specifies the native addressability of the printer to be tested.

Print the edited and saved test page files according to the method specified in Annex A. The effective addressability test pages shall be edited, saved and printed separately to evaluate in-track effective addressability and to evaluate cross-track effective addressability. The context for printing the test page and evaluating the effective addressability of a printing system is summarized in Table 2.

Table 2 — Effective addressability

Test page:	TP2-H2x_EffAddrHorz.eps (from latest Test pages.zip)
	TP2-V2x_EffAddrVert.eps (from latest Test pages.zip)
Test page editing:	(Required) To specify addressability
Printing method:	According to the procedure specified in Annex A
Samples to print:	Single printed sample of each test page
Scanner conformance:	According to the procedure specified in Annex B
Scanner OECF:	Reflectance
Measurement conformance:	According to the procedure specified in Annex C
Measurement method:	ISOIEC29112_EffectiveAddressability (.exe or .m) (Use latest version)

The set of sample prints created by printing the edited and saved test page files shall be scanned at a resolution equal to or greater than the native addressability of the printing system being assessed, at a scanning resolution that is at least half of the effective addressability of the printing system being assessed or 1 200 ppi, whichever is greatest. Each of the sample prints of an effective addressability test page shall be rotated ~45° on the platen of the scanner. Measurement of effective addressability can require re-scanning at a higher scan resolution. The test page and measurement procedure are designed to allow the effective addressability to exceed the scan resolution. The scanner characteristics at this resolution shall conform to the requirements specified in Annex B to provide valid lossless image files

for analysis. An illustrative region of a printed TP2-H2x_EffAddrHorz.eps file is illustrated in [Figure 2](#). The direction of paper motion in [Figure 2](#) is from right to left. The element labelled 1 indicates printed line segments spaced from a fiducial line, element 2, at fractions of the native addressability. Printer capability quantizes these spacings.

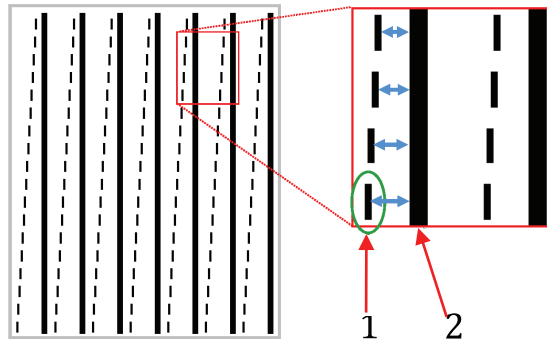


Figure 2 — Horizontal effective addressability test page

[Figure 2](#) illustrates measurement of in-track effective addressability using the TP2-H2x_EffAddrHorz test page. Horizontal and vertical refer to the direction of centre displacement being evaluated in a test page. In-track refers to the direction of paper motion (or paper track) through the printing system. Cross-track refers to the direction that is perpendicular to the direction of paper motion.

Analyse the scanned image files using the effective addressability measurement method specified in this document. If the analysis shows two peaks, the effective addressability reported by the analysis is obtained from the position of the second peak. If the analysis shows only a single peak, the effective addressability test pages shall be renamed, edited, saved, reprinted and reanalysed until the analysis shows two peaks. The process to be followed if the analysis shows only a single peak is as follows:

1. Open a re-named copy of the effective addressability test pages and edit the PostScript line specifying the target resolution. Increase the target resolution multiplier by a factor of two from its previous value (the initial value of the target resolution multiplier in any evaluation shall be 2). The effective addressability of the printing system being assessed is the target resolution times the target resolution multiplier.
2. Save and print the edited copies of the effective addressability test pages according to the method specified in [Annex A](#).
3. These newly printed samples shall be scanned at a resolution equal to or greater than the native addressability of the printing system being assessed, at a scanning resolution that is at least half of the effective addressability of the printing system being assessed, or 1 200 ppi, whichever is greatest. The scanner characteristics at this resolution shall conform to the requirements specified in [Annex B](#) to provide valid lossless image files for analysis. Each sample page shall be rotated ~45° on the platen for scanning.
4. Analyse the scanned image files using the effective addressability measurement method specified in this document. If the analysis shows two peaks, the effective addressability reported by the analysis is obtained from the position of the second peak. If the analysis shows only a single peak, the process outlined in these steps 1 to 4 shall be repeated until two peaks are identified.

The result reported by this measurement method provides a measurement of the effective addressability value of the printer for the selected test page orientation. In-track effective addressability and cross-track effective addressability are measured separately based on scans of the printed test page sets created for each of these two orientations. The values obtained for both in-track and cross-track effective addressabilities shall be entered into the printer resolution test report as specified in [6.3](#). In-

track effective addressability is a measure of the minimum pitch by which the centre of a printed object can be displaced along the direction of paper motion through the printing system.

- Depending on the orientation of the substrate being transported through the printing system, in-track effective addressability can be measured using either the horizontal or the vertical effective addressability test page.
- Similarly, cross-track effective addressability is a measure of the minimum pitch by which the centre of a printed object can be displaced perpendicular to the direction of paper motion through the printing system.

4.4 Edge blurriness and edge raggedness

4.4.1 General

Two characteristics of straight edges are of particular importance in characterizing a printing system:

- The normal edge profile (NEP) illustrates how rapidly a transition is made perpendicular to a straight edge. The width of this transition is directly related to the perceived edge blurriness of a printing system.
- The tangential edge profile (TEP) illustrates how much a straight printed edge deviates from its requested straight line behaviour. The magnitude of the deviations from straight line behaviour is directly related to the perceived edge raggedness of a printing system.

These two edge characteristics are illustrated in [Figure 3](#).

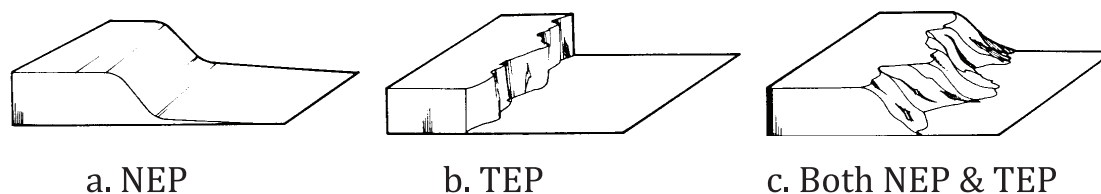


Figure 3 — Edge blurriness and edge raggedness

4.4.2 Edge blurriness

The measured width of the transition region perpendicular to a straight edge between a solid printed area and a bare substrate area correlates well with the perceived blurriness of a printing system.

- A smaller transition width correlates with smaller perceived edge blurriness (i.e. greater perceived edge sharpness).
- Edge blurriness is a characteristic of the normal edge profile (NEP) of a printed edge that is also defined in ISO/IEC 24790.

The blurriness of a printed edge is evaluated across the transition region between an unprinted substrate area, with a measured reflectance factor $R_{\max}$, and a printed solid area, with a measured reflectance factor $R_{\min}$ as shown in [Figure 4 a\)](#) and b).

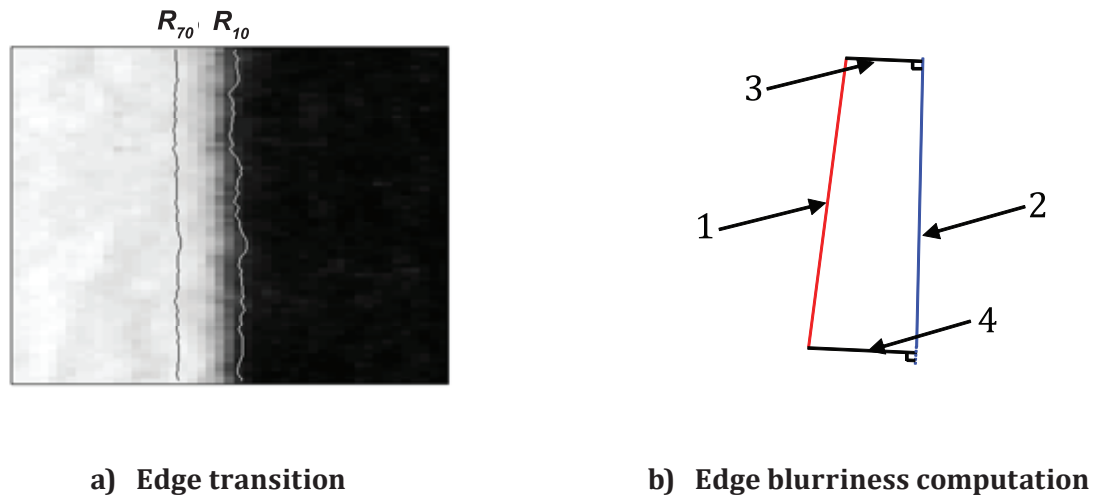


Figure 4 — Edge transition and edge blurriness computation

The region of interest (ROI) used in the evaluation of edge blurriness shall extend at least 10 mm along the printed edge and at least 4 mm perpendicular to the printed edge, extending at least 2 mm into the unprinted area and 2 mm into the printed area. The scanned image of this ROI, corrected by an OECF LUT to provide a reflectance measure, is analysed to determine the constant reflectance factor contours within the transition region at reflectance threshold values of 70 %, and 10 % (R_{70} , and R_{10} contours). The R_{70} , and R_{10} contours are then each fitted to a straight line. Since the lines fitted to the R_{70} contour (element 1 in [Figure 4 b](#)), corresponding to the contour line in the light region of [Figure 4 a](#)) and the R_{10} contour [element 2 in [Figure 4 b](#)], corresponding to the contour line in the dark region of [Figure 4 a](#)] are not always parallel, the average distance between the R_{70} and R_{10} contours, d_{70-10} , is calculated by averaging the two distances at the ends of the fitted line segments [elements 3 and 4 in [Figure 4 b](#)], respectively], according to [Formula \(1\)](#).

$$d_{70-10} = (d_3 + d_4) / 2 \quad (1)$$

The final edge blurriness value, α , is the average distance between the two fitted lines, d_{70-10} , weighted by the square root of the average density of the printed solid area region, according to [Formula \(2\)](#).

$$\alpha = d_{70-10} / \sqrt{D_{\text{avg}}} \quad (2)$$

The printed solid area density, D_{avg} , is measured in an area of at least 10 mm² within the R_{min} solid area, at least 1 mm away from any edge or light area (e.g. at the centre of one of the elements illustrated in [Figure 5](#)). Edge blurriness is measured using the edge transitions along the sides of the objects illustrated in [Figure 5](#).

4.4.3 Edge raggedness

Edge raggedness is a measure of the deviations of a printed straight edge from its expected straight line behaviour.

Edge raggedness is a characteristic of the tangential edge profile (TEP) of a printed edge.

The raggedness of a printed edge (also defined in ISO/IEC 24790) is evaluated within the transition region between an unprinted substrate area, with a measured reflectance factor R_{max} , and a printed solid area, with a measured reflectance factor R_{min} .

- The region of interest (ROI) used in the evaluation of edge raggedness shall extend at least 10 mm along the printed edge and at least 4 mm perpendicular to the printed edge, extending at least 2 mm into the unprinted area and 2 mm into the printed area.

- The scanned image of this ROI, corrected by an OECF LUT to provide a reflectance measure, is analysed to determine the constant reflectance factor contour within the transition region at a reflectance factor of 40 % (R_{40} contour).

The edge raggedness measure, β , is the standard deviation of the distances between the R_{40} contour and a straight line fitted through the R_{40} contour, according to [Formula \(3\)](#).

$$\beta = \frac{1}{n} \sum_{j=1}^n \sqrt{\frac{1}{k-1} \sum_{i=1}^k (r)^2}$$

(3)

where r represents the residuals from a line.

4.4.4 Method for measuring edge blurriness and edge raggedness

Print the test page file TP3_EdgeMeasures.eps according to [Annex A](#). A printed version of this file is illustrated in [Figure 5](#) and contains elements used to estimate the edge characteristics of a printer. The context for printing and evaluating the edge characteristics of a printing system are summarized in [Table 3](#).

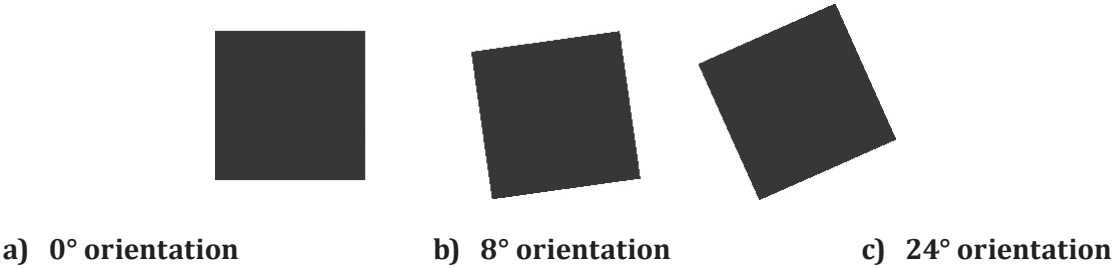


Figure 5 — Edge characteristics test page elements

The set of sample prints created by printing the test page file shall be scanned at a resolution greater than or equal to the native addressability of the printing system being assessed or 1 200 ppi, whichever is greater.

Table 3 — Edge blurriness and edge raggedness

Test page:	TP3_EdgeMeasures.eps (from latest Test pages.zip)
Printing method:	According to the procedure specified in Annex A
Samples to print:	Single printed sample (single angle, at least 5 instances)
Scanner conformance:	According to the procedure specified in Annex B
Scanner OECF:	Reflectance
Measurement conformance:	According to the procedure specified in Annex C
Measurement method:	ISOIEC29112_EdgeMeasures (.exe or .m) (Use latest version)

The scanner characteristics at this resolution shall conform to the requirements specified in [Annex B](#) to provide valid lossless image files for analysis.

Select each of the appropriate angled elements in the scanned image files for separate, independent analysis using the conforming blurriness and raggedness measurement methods initially defined in ISO/IEC 24790 and specified in [4.4.2](#) and [4.4.3](#). The results reported by these measurement methods provide measurements of the blurriness and raggedness of the printer for the selected test page orientation.

The values reported for edge blurriness and for edge raggedness shall be entered into the printer resolution test report as specified in [6.3](#).

4.5 Spatial frequency response

4.5.1 General

The spatial frequency response of a printing system provides an effective method of describing the capability of a printing system to depict detail as a function of spatial frequency. In this document, two methods for estimating complementary aspects of detail rendition capability are specified.

4.5.2 Printer SFR estimation from edge characteristics

Slanted-edge SFR (spatial frequency response) analysis of printed edge transition characteristics contributes to a measure of the printer's spatial frequency response from the Fourier transform of the edge spread function. This estimate of the printer SFR characteristic reflects the contribution of edge sharpness to the perceived resolution of a printing system.

The TP3_EdgeMeasures.eps test page, illustrated in [Figure 5](#), contains objects that can provide an estimate of the printer SFR characteristic based on the slanted-edge SFR method; see [4.5.3](#).

SFR estimates can be made using in-track, cross-track or slanted edges. These estimates of the printer SFR characteristic reflect the contribution of edge sharpness to the perceived resolution of a printing system. A choice is available to select between three sets of edges provided in the TP3_EdgeMeasures.eps test page: 0° and 90° in-track and cross-track edges, 8° and 98° slanted edges and 24° and 114° slanted edges.

4.5.3 Method for measuring printer SFR from edge characteristics

Print the test page file TP3_EdgeMeasures.eps according to [Annex A](#). The elements used to provide an estimate of the printer's SFR characteristic are illustrated in [Figure 5](#). The context for printing and evaluating the SFR characteristic from the EdgeMeasures test page is summarized in [Table 4](#).

Table 4 — SFR from edge characteristics

Test page:	TP3_EdgeMeasures.eps (from latest Test pages.zip)
Printing method:	According to the procedure specified in Annex A
Samples to print:	Single printed sample (single angle, at least 5 instances)
Scanner conformance:	According to the procedure specified in Annex B
Scanner OECF:	Reflectance
Measurement conformance:	According to the procedure specified in Annex C
Measurement method:	ISOIEC29112_SlantedEdge_PrinterSFR (.exe or .m) (Use latest version)

The set of sample prints created by printing the test page file shall be scanned at a resolution greater than or equal to the native addressability of the printing system being assessed or 1 200 ppi, whichever is greater. The scanner characteristics at this resolution shall conform to the requirements specified in [Annex B](#) to provide valid lossless image files for analysis.

The slanted-edge SFR measurement method was developed in ISO 12233 and is specified for use with reflection scanners in ISO 16067-1. The ISOIEC29112_SlantedEdge_PrinterSFR reference implementation of this measurement method, provided for use with this document, is an extension of the ISO 16067-1 Matlab^{®2)} routine sfrmat3 that employs ROI size and position variation, defined in [4.6](#), and scanner SFR normalization, defined in [B.4.4](#). Results reported by this measurement method provide measurements of the SFR characteristic of the printer based on edge characteristics for the selected test element orientation.

2) Matlab[®] is a registered trademark of The Mathworks Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO/IEC.

Printer SFR characteristic estimates provided by the slanted-edge SFR method are as follows:

- The spatial frequency at 50 % modulation provides an estimate of the perceived sharpness of edge detail, and the spatial frequency at 10 % modulation provides an estimate of the limiting resolution of edge detail. Sampling efficiency provides a Nyquist frequency normalization of the 10 % modulation frequency.
- The cascaded modulation transfer acutance, CMTA^[2], a weighting of the printing system SFR by the human eye modulation response function, provides an overall figure of merit for printing system sharpness.
- These measurements shall be recorded in the printer resolution test report as described in 6.3.

4.5.4 Printer SFR estimation from 1-D repeating patterns

Patterns that repeat at a variety of spatial frequencies provide a basis for estimating the printer SFR characteristic that is much more sensitive to spot size, spot shape and adjacency effects than a measurement based purely on edge characteristics. Fourier analysis of a repeating one-dimensional square-wave pattern provides a printer SFR characteristic estimate that reflects the contributions of spot size, spot shape and adjacency effects to the perceived resolution of a printing system.

The SquareWaveSFR test page, illustrated in Figure 6, is utilized in the estimation of the printer SFR characteristic from 1-D square-wave patterns repeated along both horizontal and vertical axes.

- If printed in the manner illustrated in Figure 6, the horizontal orientation test element with bars repeating at several different spatial frequencies along the direction of paper motion is used to measure in-track SFR.
- The vertical orientation test element with bars repeating at several different spatial frequencies across the direction of paper motion is used to measure cross-track SFR.
- Analysis of the printed one-dimensional square-wave patterns provides odd harmonic amplitudes which, in comparison with the expected amplitudes of an ideal square wave's harmonics, probe the spatial frequency response of the printer at many different spatial frequencies.
- These estimates of the printer SFR characteristic reflect the contributions of edge sharpness as well as spot size, spot shape and adjacency effects to the perceived resolution of a printing system.

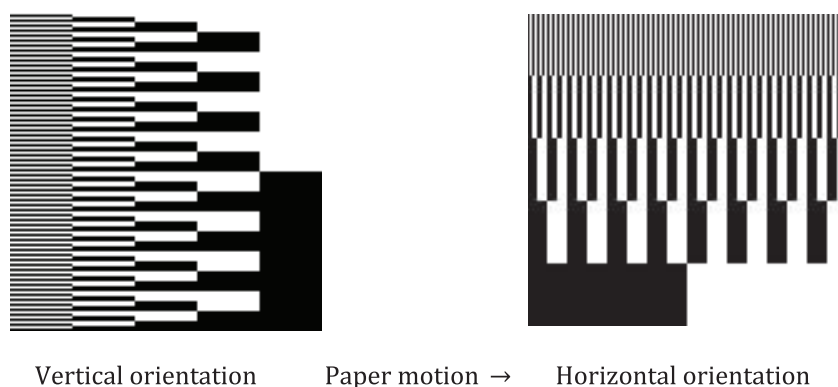


Figure 6 — Line characteristics test page

4.5.5 Method for measuring printer SFR from 1-D repeating pattern characteristics

Print the test page file TP4V_SquareWaveSFR.eps according to Annex A. The elements used to provide an estimate of a printer's SFR characteristic are illustrated in Figure 6. It is critically important in printing the test page for square-wave SFR evaluation that the addressability of the test page exactly matches the printing system addressability. Annex E provides an illustration of the aliasing that

occurs if test page and printing system addressabilities do not match. A bitmap version of this test page (TP4B_SquareWaveSFR.eps) is provided for use if the vector code of TP4V_SquareWaveSFR.eps is mis-interpreted by the printer RIP. Preset test page files are distributed for 600 dpi and for 1 200 dpi printing systems. The context for printing and for evaluation of the SFR characteristics from the square-wave test page is summarized in [Table 5](#).

If the printing system being assessed has an addressability different than 600 spi, editing a copy of the distributed TP4V_SquareWaveSFR.eps test page is required.

- 1) Open a renamed copy of the TP4V_SquareWaveSFR.eps file or the TP4B_SquareWaveSFR.eps file in a text editor and edit the /SetDPI line in this PostScript text file that is used to over-ride use of the RIP queried values for in-track and cross-track native addressability values to reflect the actual addressabilities of the printing system. The /SetDPI line of the PostScript text file is illustrated below.

Table 5 — SFR from line characteristics

Test page:	TP4V_SquareWaveSFR.eps (use latest Test pages.zip)
	TP4B_SquareWaveSFR.eps (bitmap version)
Test page editing:	(Required) To specify addressability
Printing method:	According to the procedure specified in Annex A
Samples to print:	Single printed sample (horz and vert, at least five instances each)
Scanner conformance:	According to the procedure specified in Annex B
Scanner OECF:	Reflectance
Measurement conformance:	According to the procedure specified in Annex C
Measurement method:	ISOIEC29112_SquareWave_PrinterSFR (.exe or .m) (use latest version)

```
/SetDPI 0 def      % You can set the DPI that the program will adapt to. When
                  % set to zero, this will be done automatically, by checking the
                  % number of addressability steps per inch of the output device.
```

- 2) Print and evaluate the edited and saved test page. When the bars of the square wave elements all print uniformly, proceed with the evaluation.

Scan the set of sample prints created by printing the test page file, at a resolution greater than or equal to the native addressability of the printing system being assessed or 1 200 ppi, whichever is greater.

The scanner characteristics at this resolution shall conform to the requirements specified in [Annex B](#) to provide valid lossless image files for analysis.

Alignment of the printed page on the platen is critical for correct assessment using this measurement method. An edge of the printed page shall be aligned with an edge of the platen.

- Misalignment by 0,25° or more can affect the measurement results.
- The reference implementation specified in [Annex C](#) verifies alignment.

Analyse the scanned image files using the square-wave SFR measurement method specified in [Table 5](#). The results reported by this measurement method provide measurements of the SFR characteristic of the printer based on line characteristics for the selected test page orientation.

From the printer SFR characteristic estimates provided by the square-wave SFR method:

- The spatial frequency at 50 % modulation provides an estimate of the perceived sharpness of repeated detail, and the spatial frequency at 10 % modulation provides an estimate of the limiting resolution of repeated detail. Sampling efficiency provides a Nyquist frequency normalization of the 10 % modulation frequency measure.

- The cascaded modulation transfer acutance, CMTA^[2], based on a weighting of the printing system SFR by the modulation response function of the human eye, provides an overall figure of merit for printing system sharpness.
- These measured characteristics shall be entered into the printer resolution test report as described in [6.3](#).

4.6 ROI size and shape variation

The size and shape of the ROI chosen for use in the measurement methods specified in this document can affect the measurement result. Windowing techniques have been developed to minimize similar sensitivity in traditional Fourier analysis.

An effective compensation technique utilized in this document is to perform analysis on an ensemble of ROI positions and sizes, then utilize the mean value of the resulting distribution as the reported value from the analysis.

- An ensemble of 81 variations (three variations in X position, three variations in Y position, three variations in ROI width and three variations in ROI height) has proven effective in driving this sensitivity from an approximately 10 % noise level to well below a 2 % level. More detail can be found in [E.1.2](#).
- Averaging of the analysis results from this ensemble of variations is implemented in the reference implementations of the measurement methods for scanner SFR, edge blurriness, edge raggedness, slanted-edge printer SFR and square-wave printer SFR.

5 Test set-up, configurations and procedure

5.1 Printer set-up and configuration

The printer shall be set up on a level surface according to the installation guide provided by the printer manufacturer. The most recent software (printer driver, etc.) available from the manufacturer shall be used. Check the manufacturer's website for the most recent printer driver that is compatible with the computer operating system that will be used for testing. The printer driver version should be documented in the test report.

Printer maintenance shall be performed according to the printer manufacturer's user's manual. All printing device consumables and operating components shall be those specified as acceptable for use by the manufacturer (or otherwise noted).

Prior to the start of the test, the state of the replaceable printing system components, usually toner cartridges, shall be documented in the component condition field of the test report. This usually takes the form of the percentage of expected life remaining or the total number of prints made using a cartridge.

The operating configuration in which a printing system is assessed is as important as the measurement. A particularly important operating configuration is the manufacturer's default configuration.

- This configuration provides an assessment representative of the majority of a printer's usage. Many manufacturers also define a "best practice" configuration for achieving optimal print quality.
- The "best practice" configuration can utilize specialty substrates or operate more slowly than the default configuration, but an assessment of this configuration is apt to evaluate the optimized capability of a printing system.
- The printer configuration used in testing shall be documented in the test report.
- Conditions and settings that differ from the printing device defaults shall be documented in the test report.

To assure that the test pages utilized in an assessment of printer resolution are printed correctly, no page size modifiers such as “Fit to Page” shall be used and font substitution shall be turned off.

- The test pages shall be printed using the fonts embedded in the file and shall be rendered on the page in a size corresponding to the dimensions specified in the test page description.
- Page placement modifiers such as page centring can be used to place the image properly on the page.

5.2 Printer testing environment

The test environment, including temperature and humidity, shall be within the ranges recommended by the manufacturer for operating the printer. If no recommendation is available, the following ranges shall apply:

- Temperature: 18 °C to 25 °C
- Relative humidity: 30 % to 70 %

The printer, all supplies, consumables, etc. shall be acclimated to the test environment for a minimum of 24 hours. Record the temperature and relative humidity at the time of the assessment in the test report.

The printer shall be connected to a supply of power that is within the manufacturer specified operating voltage and operating frequency range.

5.3 Substrate

The substrate used in printer resolution assessment shall represent a compatible substrate for the printer and shall conform to the manufacturer's list of approved substrates.

- The substrate weight, coating and surface characteristics shall be documented in the test report.
- The substrate manufacturer and substrate name should be documented in the test report.

5.4 Test platform connection to the printer

Connection to the computer serving as the platform for printer resolution testing should be determined by the manufacturer's targeted usage.

5.5 Printing process

One of the procedures specified in [Annex A](#) shall be used to submit the printer resolution assessment test pages to the printer being assessed for use with this document. For reference, the name, version and settings of the low-level printing application used to submit the test pages should be recorded in the test report.

- The printing process specified in [Annex A](#) avoids the re-interpretations of test page content provided by many imaging or graphics applications.
- This assessment method is most independent of application features and is therefore most representative of the inherent capability of the printer.

One or more pages shall be printed prior to an assessment to ensure that the printer is properly warmed up.

5.6 Test pages

The test pages for use with this document are specified in [Clause 4](#). These test pages are available from <http://standards.iso.org/iso-iec/29112/ed-1/en>, in the ZIP file Test pages.zip.

- The latest collection of these test pages shall always be used.

- The test page name and version used in printer resolution assessment shall be recorded in the test report.
- Test page names referred to in this document are base file names without a version number suffix. Version numbers will be incremented in later collections of test pages.

5.7 Sample size

The residual noise of the printing process is substantially reduced in the assessment analysis by averaging measurements over a number equivalent test elements. The residual noise is further reduced with the use of larger numbers of sample prints (at the expense of measurement and analysis time).

- For most printing systems, multiple prints from the same run provide the most stable printing condition.
- The number of test elements and sample prints utilized in the analysis of the print quality characteristics contributing to attribute measures of perceived resolution shall be documented in the test report.

It is imperative that printing artefacts are avoided for an accurate assessment of printer resolution. Cleanly printed samples with properly reproduced test elements are essential.

For each different printer set-up and configuration:

- A single cleanly printed sample test page is recommended for visual evaluation of native addressability.
- A single cleanly printed sample test page is recommended for the measurement of effective addressability.
- At least five equivalent, cleanly printed test elements are recommended for the measurement of edge characteristics (edge blurriness, edge raggedness and slanted-edge SFR) and for the measurement of square-wave SFR. These can be provided in the layout of a single cleanly printed sample test page.

5.8 Set-up procedure

- 1) Qualify the reflection scanner and the scanner control application that will be used for assessment measurement according to [Annex B](#).

Re-qualification is not required for each assessment.

- 2) Qualify the ISO/IEC 29112 measurement method implementations used to analyse scanned data from printed test pages according to [Annex C](#).

Re-qualification is not required for each assessment.

- 3) Obtain, install and verify the appropriate low-level printing application as specified in [Annex A](#).
- 4) Perform printer maintenance according to the printer manufacturer's user's manual.
- 5) Set up and configure the printer according to [5.1](#) to [5.5](#). Record the printer configuration.
- 6) Configure the printing application according to [Annex A](#) and record the printing method used. For reference, the name, version and settings of the low-level printing application should be recorded.
- 7) Obtain test pages (Test pages.zip) from: <http://standards.iso.org/iso-iec/29112/ed-1/en>.

5.9 Testing procedure for visual evaluation

- 1) Print at least one copy of the visual evaluation test page to ensure that the printer is properly warmed up.

- 2) Print a copy of the visual evaluation test page specified in this document, using the configured low-level printing application, the configured printer driver and the configured printer, according to the printing process specified in [Annex A](#). A single clean print is all that is required for visual evaluation. Record the orientation of the test page through the printing system paper path.
- 3) Evaluate the printed test page visually according to the method specified in [4.2.2](#).
- 4) If required, edit the copy of the visual evaluation test page according to the method specified in [4.2.2](#).
- 5) Iterate steps 1), 2) and 3) until an unambiguous visual evaluation result is obtained.
- 6) Record the results of the visual evaluation printer native addressability.

5.10 Testing procedure for scanner-based measurement

- 1) Print at least one copy of the visual evaluation test page to ensure that the printer is properly warmed up.
- 2) Configure the scanner control application according to [Annex B](#) and record the application settings.
- 3) Print and use at least the recommended number of samples (see [5.7](#)) of each of the instrumental measurement test pages specified for use with this document, using the low-level printing application, the printer driver and the printer, according to the printing process specified in [Annex A](#). Record the orientation of the test page through the printing system paper path.
- 4) Warm-up the scanner by scanning at least one full-size page at the desired resolution prior to scanning any printed samples for evaluation.
- 5) Scan each of the printed samples of the test pages using a qualified scanner with the configured scanner application and save lossless image files of each print sample according to [Annex B](#).
- 6) Analyse the image files of each print sample using the qualified analysis methods specified in this document. Record the analysis results. Record whether scanner SFR normalization is employed or not. Ensure that multiple samples are properly averaged in the analysis to create a single, more accurate result.

6 Presentation of results

6.1 General

A report presenting the results of a printer resolution assessment according to this document shall include the information specified in [Clause 6](#). Guidelines for assessment, dealing with workflow issues and representative samples of test reports can be found in [Annex D](#).

The information required in an assessment report of printer resolution according to this document can be divided into two categories:

1. Assessment configuration documentation is specified in [6.2](#) and [Table 6](#).
2. The requirements for reporting assessment measurement results are specified in [6.3](#) and [Tables 7](#) and [8](#).

The operating configuration in which a printing system is assessed is as important as the measurement results. Each change in the printer settings represents a new printing system configuration and requires a separate assessment.

NOTE Two particularly useful printing system configurations for resolution assessment are:

- the printer manufacturer's default printer configuration, which is representative of the majority use of a printing system, and