INTERNATIONAL STANDARD

ISO/IEC 13660

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Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Binary monochrome text and graphic images

Technologies de l'information — Équipement de bureau — Mesurage des attributs de qualité d'image pour copies papier — Texte monochrome binaire et images graphiques

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. 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 International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 13660 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

Annexes A and B form a normative part of this International Standard. Annex C is for information only.

Introduction

This International Standard is designed to help a quality control engineer evaluate the quality of prints from office imaging systems.

In traditional imaging systems (such as ink-on-paper printing), an image is evaluated by comparison to an original or master version of that image. In many electronic imaging systems, however, the image is created digitally within the system. There is no hardcopy master and so there can be no evaluation by comparison in the ordinary way.

Often, those who operate electronic imaging systems ensure good image quality by controlling the imaging process. They use test targets and reference images to evaluate the performance of the system.

If it is not possible to control image quality by controlling the imaging process and if no test target or reference image is available, we can rely only on direct evaluation of properties of the image itself.

To perform intrinsic evaluations of image quality, we must consider the nature of an image that is output. An image is some organization of information in space. We assume that these signals have some purpose or are making some attempt at communication. Good image quality means that the image is legible (the organization and information can be interpreted) and that it has a pleasing appearance.

Our goals in developing this International Standard were to compile a list of image attributes that (taken together) correlate to human perception of print quality and to develop measurement methods for these attributes that can be automated and carried out on a simple system.

Legibility and appearance have several aspects:

- Detail can be detected easily.
- Image elements are well isolated from the background.
- The image has a minimum of gross defects.
- The imaging system has good geometric fidelity.

Not all these factors can be covered by evaluation of intrinsic, quantitative image quality attributes. Many of them have a large psychological or cultural component that is difficult to evaluate.

A print made with large optical reduction or one that is out of focus might still have excellent edge quality (and be totally lacking in gross defects, banding, noise, etc.) and yet be illegible. This could occur primarily because of the high process gamma (contrast) that is characteristic of many xerographic processes. Thus, the process can produce apparently sharp edges in spite of the loss in resolution. Without a resolution target of some kind, the extent of the resolution loss, and hence legibility, may not be known.

The purpose of this International Standard is to present a set of objective, measurable attributes that give some correlation to the perceived quality of an image to a human observer at a standard viewing distance. The standard will allow a user of printed material to sort samples into several groups, from excellent to bad.

The attributes and methods for their assessment are based on several assumptions:

- The image represents an attempt at communication.
- There is uniformity within identifiable image elements.

- Character images, symbols, and graphic elements are regular (that is, they are intended to be identical when they have multiple, similar occurrences).

- Samples with extreme gross defects have been screened out.

This International Standard applies to images made up of text, graphics, and other image objects with two-tone levels of a single colour (typically black image on white paper). This International Standard does not cover halftones or images with more nominal gray levels, continuous tone images, colour images, and so on.

Image quality measurement can be thought of as divided into diagnostic (high resolution), and visual scale (low resolution) procedures. Diagnostic measurements typically use precision test targets and instrumentation and are key to much engineering work. The present procedure, by contrast, is limited to phenomena visible to the naked eye and does not permit test patterns.

The working group has taken the approach of selecting simple and (in our judgment) effective metrics, rather than attempting to prove that our method of doing a given job will always be the most exact.

How will this International Standard actually be implemented? A complete evaluation system has three components: an image capture device, evaluation software, and application-specific quality standards and sampling plan. The end user may choose to develop all these parts himself or he may choose to purchase one or more components from a commercial supplier.

Any equipment capable of gathering data appropriate to these measurements is understood to have a complex instrument function. Rather than attempting to explore the relationship among these instrument functions, the working group has defined reference images, and target values for them. If these target values are achieved by an instrument, calibration will be acceptably good.

This is not an attempt to break new ground in image science. It is an attempt to provide suppliers and customers for copies/prints with a practical and objective way to communicate about basic image quality parameters.

Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Binary monochrome text and graphic images

1 Scope

This International Standard specifies device-independent image quality attributes, measurement methods, and analytical procedures to describe the quality of output images from hardcopy devices. This International Standard is applicable to human-readable documents composed of binary monochrome images produced from impact printers, non-impact printers, and copiers.

The attributes, methods, and procedures rely on intrinsic properties of the image. Targets or reference images are not required. The International Standard is not applicable to images on media other than hardcopy (e.g. images on a VDT) or to images that are intended to be machine readable only (e.g. bar codes).

This International Standard is not intended to apply to pictorial art. It is optimized for black colourant forming the image on a white substrate; it is not intended to be used for dropped out or reversed type or for transparencies. The evaluation of an image with any other colour of colourant or substrate will be sensitive to changes in illumination. In this case, the procedures of this International Standard may not be applicable and should be used with caution.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 5-1:1984, *Photography — Density measurements — Part 1: Terms, symbols and notations*

ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*

ISO 5-4:1995, *Photography — Density measurements — Part 4: Geometric conditions for reflection density*

CIE 15.2:1986, *Colorimetry*

TAPPI T480 om-92, *Specular gloss of paper and paperboard at 75 degrees*

TAPPI T452 om-92, *Brightness of pulp, paper, and paperboard (directional reflectance at 457 nm)*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply. The image quality attributes themselves are defined in Clause 5.

binary— any system based on exactly two possible values, such as 0/1 or black/white.

binary image— an image with only two fundamental tones: the substrate and the colourant.

boundary— the region of an edge within which the reflectance factor makes the transition from 10% to 90% of the difference between image and substrate reflectance factors. See also *threshold contour.*

character image— a specific physical representation of a character glyph.

colourant— the material used to make an image visible. In copying and electronic printing, the two main colourants are dye and pigment.

density, optical— log10 (1/*R*), where *R* is the reflectance factor, measured according with 0/45-degree geometry, Illuminant A, and ISO visual density calibration.

distortion— undesired change in the shape of an image.

edge threshold— the points in the gradients of an edge that define the location of the edge. This is the threshold contour corresponding to R_{60} for the ROI. See also *threshold contour.*

gradient, edge— the relative reflectance value gradient along a line normal to the edge of an image segment.

hardcopy— a document on a substrate.

human-readable— designed to be interpreted by a standard human viewer.

image element— a single, evidently intentional, object not connected to other objects.

image segment— a collection of image elements that are treated as a unit.

inner boundary edge— the point in the gradient of an edge that is at 90% of the transition from the substrate reflectance factor to the image reflectance factor: $R_{90} = R_{max}–90\%(R_{max} – R_{min})$.

line width— width of the line measured normal to the line from edge threshold to edge threshold.

monochrome image— an image in one colour or shades of one hue.

nominal— a value used as a reference value. This value is obtained by assumption, by calculation, or by some other means and then treated as the actual, intended value.

normal edge profile— the reflectance factor gradient along a line normal to the edge of an image segment.

outer boundary edge— the point in the gradient of an edge that is at 10% of the transition from the substrate reflectance factor to the image reflectance factor: $R_{10} = R_{max}–10\%(R_{max} – R_{min})$.

page— a collection of text, graphics, and other image objects intended to be printed on one side of a sheet of hardcopy.

pixel— a contraction of the term “picture element”; the smallest geometric unit of information in a digital representation of an image.

pseudorandom— a sequence which is generated by a predictable process, but which has all the measurable properties of a truly random sequence that are required for a particular application.

random— a sequence that is generated by a process in which each element is unrelated to the preceding element, which has no pattern, and which is completely unpredictable.

reflectance factor— the ratio of radiant flux reflected from the sample to the radiant flux incident on the sample.

relative reflectance value— percentage of the transition from the substrate reflectance factor to the image reflectance factor at a particular point in the image.

region of interest (ROI)— area (inside defined boundaries) that the user wants to analyse.

R_{max}— maximum reflectance factor in the ROI, typically of the substrate. This is taken to be the centre of the higher peak in the bimodal reflectance distribution across the ROI.

R_{min}— minimum reflectance factor in the ROI, typically of the colourant. This is taken to be the centre of the lower peak in the bimodal reflectance distribution across the ROI.

ROI— see *region of interest.*

sharpness, edge— the inverse of blurriness. (See 5.3.1.)

spi (spots or samples per inch)— spots or samples per 25,4 millimetres.

standard viewing distance— 300 millimetres, assuming standard visual acuity.

substrate— the material on which a hardcopy document is produced, usually paper.

threshold contour— the points in the gradients of an edge that are at some specified percentage of the transition from the substrate reflectance factor to the image reflectance factor: $R_p = R_{max} - p\%(R_{max} - R_{min})$.

tile— a plane figure used for a tiling.

tiling, regular— to cover the plane (or region of the plane) with identical plane figures so that there are no gaps and there is no overlap of the figures.

4 Report of results and sampling scheme

This clause contains the three possible image sampling schemes (4.3) and a description of the report of an evaluation carried out under this International Standard (4.1).

4.1 Report of results

4.1.1 Test identification information

The report shall include the date of the measurements, the identity of the test operator, lot identifications, etc.

4.1.2 Instrument system

The report shall include a description of the instrument system used, noting any of the specifications (see Clause 6) that are emulated or deviated from in any way.

4.1.3 Compliance

Report the results of the compliance tests. (See Clause 6 and Annex B.)

4.1.4 Sampling scheme

The report shall include a complete description of the sampling scheme (4.3) used to select the pages and images.

4.1.5 Results

For each attribute, the report shall include the number of samples per page and the mean, standard deviation, and range of the results for each page and for the entire lot.