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Graphic technology — Testing of prints — Visual lustre

Technologie graphique — Examen des imprimés — Lustre visuel

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Contents

Page

Foreword

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

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

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member 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 shall not be held responsible for identifying any or all such patent rights.

ISO 15994 was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

Introduction

There is a large number of national and International Standards covering gloss measurement. However, no existing measure of gloss provides a measure of the visual lustre as perceived by the human observer over the wide range of materials used in printing and publishing. This International Standard defines a measure of surface appearance, identified as “visual lustre”, which is not intended for process control but rather for communication amongst designer, client and the printer of products for which the visual perception of the surface lustre is important.

The visual lustre as specified in this International Standard is a measure of the specular reflection from a sample with the diffuse component of the reflection minimized, and it should therefore correlate with the lustre as perceived by an observer. The test method specified makes it possible to compare the perceived lustre of a wide range of differently coloured prints in a meaningful way. A 45:45 geometry coupled with a 45:0 geometry (preferably, but not necessarily in the same instrument) is sufficient for the entire range that spans from the ideally diffusive surface to a highly reflective glass surface. It is recognized that the the specular component of the total reflectance can also be determined using an instrument with spherical geometry, which can measure total (specular included) and diffuse (specular excluded) reflectance. However, the present 45/0:45/45 method is preferred because it is close to the geometry used for densitometers and colorimeters in graphic technology.

Comparative studies of the lustre of various printed and unprinted samples (see CIE Publ. 17.4) showed that the visual lustre defined in this International Standard correlates well with the lustre as perceived by an observer group, whereas the specular gloss (measured in accordance with ISO 2813 and ISO 8254-1 shows a much smaller correlation coefficient. An important prerequisite for such a comparison is that the geometric conditions for illuminating and observing the samples are identical to those realized in the measuring instrument.

Graphic technology — Testing of prints — Visual lustre

1 Scope

This International Standard defines a measure of the apparent lustre of printed materials, termed “visual lustre”, which is intended for communication amongst designer, client and the printer of products for which the visual perception of the surface lustre is important.

This International Standard is not intended for process control in the printing industry, or in the papermaking and boardmaking industry, nor is it intended for the measurement of fluorescent materials or those which show metallic or pearlescent effects.

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 186, *Paper and board — Sampling to determine average quality*

ISO 2813:1994, *Paints and varnishes — Determination of specular gloss of non-metallic paint films at 20 degrees, 60 degrees and 85 degrees*

ISO 8254-1:1999, *Paper and board — Measurement of specular gloss — Part 1: 75 degree gloss with a converging beam, TAPPI method*

ISO/CIE 10527, *CIE standard colorimetric observers*

CIE Publ. 15.3:2004, *Colorimetry*

CIE Publ. 17.4:1987, *International Lighting Vocabulary*

CIE Publ. 38.5:1977, *Radiometric and Photometric Characteristics of Materials and their Measurement*

3 Terms and definitions

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

3.1
visual lustre
L
quantity characterizing the visually perceived lustre as defined in this International Standard and having a unit of 1

3.2
reflectometer scale
scale defined in relation to the specular reflection of a polished, flat, black glass with a refractive index of 1,567 at a wavelength of 546,1 nm which has a reflectometer value of 100 under the geometrical conditions (45/45) of measurement defined by this International Standard

3.3
reflectometer value
R
value on the defined reflectometer scale

3.4
photopic vision
vision by the normal eye when it is adapted to a level of luminance of at least several candelas per square metre

[CIE Publ. 17.4]

3.5
measurement beam plane
plane defined by the influx and efflux light beams

3.6
area under test
part of the sample surface determined by the angular field of sensitivity of the receiver

3.7
diffuse reflection
d
reflection in which the incident flux is reflected in many directions by diffusion at or below the surface of the material

3.8
specular reflection
s
reflection of light from the surface of a material according to the laws of optics, excluding diffuse reflection

3.9
total reflection
r
reflection of light from the surface of a material, including both the specular and diffuse components of reflection, as used in this International Standard

NOTE Total reflection is approximately equivalent to the sum of the specularly reflected flux and the diffusely reflected flux relative to the flux from the perfect reflecting diffuser.

4 Principle

A test piece is illuminated at an angle of 45° to the normal and measurements of the reflected light are made under standardized conditions at the angle of specular reflection, 45°, to obtain the total reflection (the sum of specular and diffuse reflection) and at an angle of 0° (diffuse reflection only). The result of the latter measurement is subtracted from that of the former to yield a value of the specular reflection. The logarithmic value of this specular reflection is calculated in order to obtain a quantity which correlates with the visual perception of lustre.

5 Apparatus

5.1 Instrument or instrument combination, in conformance with the requirements of Annex A.

5.2 Black glass reference standard, polished, optically flat, black-coloured idealized glass with a refractive index of 1,567 at 546,1 nm, which is assigned a reflectometer value 1,0.

NOTE 1 Such glasses are not commercially available. A practical working standard is a polished, optically flat, black-coloured glass whose specular reflectance has been characterized relative to the ideal standard.

NOTE 2 The black glass serves as a standard for specular reflectance.

5.3 White reference standard, matte, non-glossy surface produced by pressing calibrated $BaSO_4$ powder or substitute of sufficient purity as referred to in CIE Publ. 15.3.

NOTE In the application of this method it is assumed that the reference white is a perfectly diffusing and perfectly reflecting surface. Other commercial materials such as Spectralon[1)] manufactured by Labsphere may be appropriate for use instead of $BaSO_4$ powder.

5.4 Black cavity, hollow body with a highly absorbing inner surface and an orifice so that it can be positioned in the measuring instrument in a reproducible way. The diffuse reflectance of this cavity shall be less than 1 %.

6 Determination of instrumental constants

6.1 General

Two instrumental constants, k and N, shall be determined.

Constant k is a measure of the imbalance of the two signal channels, which may be caused by differing responsivities/emissivities and/or unequal beam apertures.

Constant N is the difference between the intensity signals detected with the 45:45 and the 45:0 measurements on black glass, after the 45/0 signal has been corrected for channel imbalance by multiplication by the constant k.

6.2 Zero adjustment

The black cavity (5.4) serves as a substitute for the perfectly absorbing surface, it is used for zeroing the intensity signals. Measure the black cavity and set the intensity signals of the 45:45 and the 45:0 measurements to zero.

1) Spectralon is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

6.3 Determination of k

Place the white reference standard (5.3) in the instrument and measure the intensity of the signal detected with the 45:45 and 45:0 settings as I_{ws} and I_{wd} respectively. Calculate the constant k by use of Equation (1):

$$k = \frac{I_{ws}}{I_{wd}} \quad (1)$$

where

I_{ws} is the intensity signal of the 45/45 measurement of the reference white;

I_{wd} is the intensity signal of the 45/0 measurement of the reference white.

6.4 Determination of N

Place the black glass standard (5.2) in the instrument and measure the intensity of the signal detected with the 45:45 and 45:0 settings as I_{gs} and I_{gd} respectively. Calculate the constant N by use of Equation (2):

$$N = I_{gs} - \left(k \times I_{gd}\right) \quad (2)$$

where

I_{gs} is the intensity signal of the 45/45 measurement of the black glass;

I_{gd} is the intensity signal of the 45/0 measurement of the black glass.

7 Sampling and preparation of test pieces

Select samples in accordance with ISO 186.

Avoiding watermarks, dirt and obvious defects, cut rectangular test pieces approximately 75 mm × 150 mm. Ensure that the test piece to be measured is flat, clean and undamaged. Take care to avoid touching the test piece area to be measured.

8 Test procedure

Make sure that the instrument settings have not been changed since the values of k and N were determined.

Position the test piece and measuring instrument (5.1) such that the base of the measuring instrument and the test piece lie in the same plane. Measure the intensities of the reflected light for both the 45:0 and 45:45 geometries. The average of a minimum of three measurements is required taking into account paper surface variation.

For materials with a strongly structured (textured) surface it is recommended to average readings at three different azimuthal orientations of the measurement beam plane. Alternatively, the visual lustre may be reported for measurements parallel to and perpendicular to the preferential direction of the structure.

9 Calculation

Calculate the visual lustre, L, by use of Equation (3):

$$L = 50 \times \lg\left[1 + 99\,\frac{\left(I_\text{s} - k \times I_\text{d}\right)}{N}\right] \qquad (3)$$

where

I_s is the intensity signal of the 45:45 measurement of the test piece;

I_d is the intensity signal of the 45:0 measurement of the test piece.

NOTE The term ($I_\text{s} - k \times I_\text{d}$) in Equation (3) is a measure of the difference between the total reflection at 45° (regular and diffuse) and the diffuse background reflection measured at 0°. Since the reflection of an ideally diffusive surface does not depend on the angle, this latter term is an expression for the specular component of reflection. The other numbers in Equation (3) are scaling parameters which assure that the black glass and the reference white are assigned visual lustre of 1,0 and 0 respectively. The 10-base logarithmic function serves to reduce the sensitivity of the visual lustre to high levels of specular reflection in comparison to low levels, in an effort to simulate the visual perception.

10 Precision

The limited amount of comparative information so far available, indicates that the within-laboratory precision is less than 0,05 and that the between-laboratory precision is less than 0,15.

11 Test report

The test report shall include the following information.

a) date and place of testing;

b) precise identification of the sample;

c) reference to this International Standard, i.e. ISO 15994;

d) the visual lustre for each specimen or the mean of multiple determinations and, if the sample shows texture, whether the visual lustre was obtained by averaging over various azimuthal angles or, if not, the angle between the measurement plane and the preferential direction of the texture;

e) type and manufacturer of the instrument used;

f) any deviation from this International Standard or any circumstances or influence that may have affected the results.

Annex A
(normative)

Apparatus for measuring visual lustre

A.1 General

While the laws of optics prescribe the possibility of reversing the flow of energy through an optical system by interchanging the source and detector, this law can only be applied if careful consideration has been given to the control and capture of the incident and received light fluxes. In the apparatus described in A.2, only one geometry has been described. While it may be possible to interchange the light source and the detector, such a simple interchange will not result in identical or even equivalent light fluxes in both the specular and diffuse beams. This lack of reciprocity is due, in part, to the need to have limiting apertures that define the influx and efflux beams explicitly. Simply reversing the optical path may not result in equivalent efflux and influx beams. Since visual lustre involves combining and comparing readings from two different light fluxes, changes in the optics which affect one flux more than the other will result in a change or distortion in the scale of visual lustre. This International Standard does not recommend constructing instruments with variations on the recommended geometry unless it can be shown that such variations will not produce a bias in the readings.

A.2 Geometry and aperture angles

Two measurements are required to compute visual lustre, both in a plane that includes the normal to the sample plane. One measurement is made with the illuminating beam at – 45° to the normal and the sensing beam centred on the specular angle, 45°, designated as the 45:45 measurement. Another measurement is made with the illuminating beam at – 45° and the sensing beam normal (0°) to the sample plane, designated as the 45:0 measurement (see Figure A.1). The corresponding intensity signal of the 45:0 measurement is a measure of the lightness of the sample.

Figure A.1 shows the instrument geometry which meets the requirements of this International Standard.

In Figure A.1, the sample is illuminated by a light beam centred at an angle of 45° to the normal to the sample plane. The reflected light flux is detected with two sensors mounted in the plane defined by the incoming beam and the normal to the specimen plane.

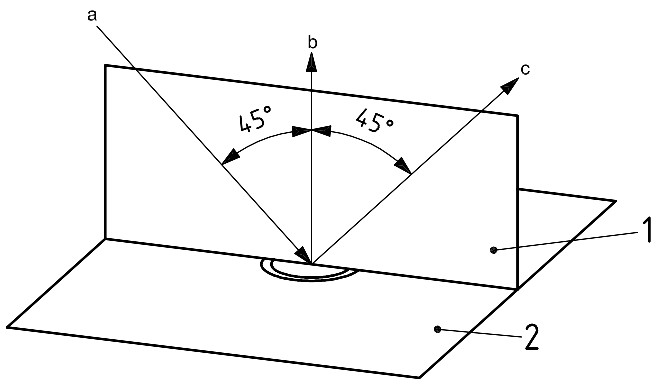
The target values for the geometry and aperture angles of the influx, efflux and sensing cones shall be as given in Table A.1. Note that the aperture angle is here defined as twice the angle between the beam or cone centroid and the beam edge.

Both the specular and the diffuse measurements shall be made on the same region of the test piece and with the same test piece orientation. However, the measurements need not be made at the same time or with the same instrument.

The tolerances for the geometry and aperture angles shall be as given in Table A.1. The tolerance of the sensing beam angle in the 45:45 geometry refers to the specular angle of the illuminating beam centroid.

EXAMPLE If the actual angle of the influx beam is 45,1° then the centroid of the sensing beam shall be at (45,1 ± 0,1)°.

NOTE In the same plane, the sensitivity should be minimal at angles that deviate by more than 0,85° ± 0,05° from the centroid of the specularly reflected beam.



Key

1 measurement plane
2 sample plane

[a] Illumination.
[b] Diffuse sensor.
[c] Specular sensor.

Figure A.1 — Measurement geometry with a common illumination source

Table A.1 — Target values and tolerances for the geometry and aperture angles (in degrees)

Action	Geometry angles	Aperture angles	
		parallel	perpendicular
		to the measurement plane	
Illumination	− 45° ± 0,2°	0,75° ± 0,1°	2,5° ± 0,1°
Sensing	− 45° ± 0,1°[a]	4,4° ± 0,1°	11,7° ± 0,2°
	0° ± 0,1°	4,4° ± 0,1°	4,4° ± 0,1°

[a] Specular angle of the illumination beam centroid (nominally 45°).

A.3 Sampling aperture and illuminated area

The area under test shall be not less than 7,2 mm^2.

The illuminated area of the sample surface shall contain the tested part of the sample surface with a margin of at least 0,5 mm around the latter's circumference.

NOTE The minimum aperture size was chosen in relation to the screen frequencies of typical half-tones used in the graphic arts.

A.4 Spectral properties

The spectral energy distribution of the flux incident on the specimen surface shall be equivalent to that of CIE standard illuminant A. The spectral sensitivities of the sensor(s) comprising the transmission factor of the detection optical system shall be adjusted to conform to the spectral luminous efficiency function for photopic vision as given in CIE Publ. No 17.4:1987 (item 845-01-22), so that Equation (A.1) holds for each possible combination of source and sensor used:

$$V(\lambda) \times S(\lambda, \mathrm{A}) = c \times S(\lambda) \times s(\lambda) \quad \text{(A.1)}$$

where

$V(\lambda)$ is the spectral luminous efficiency function for photopic vision;

$S(\lambda, \mathrm{A})$ is the spectral energy distribution of CIE standard illuminant A;

c is a proportionality constant;

$S(\lambda)$ is the spectral energy distribution of the flux incident on the specimen surface;

$s(\lambda)$ is the spectral sensitivity of the sensor.

The deviation from proportionality shall not exceed 10 %, when determined as the characteristic error parameter f_1 in accordance with CIE Publication 38.5.

The spectral luminous efficiency function for photopic vision Is defined in CIE Publ. 17.4 where the data are tabulated at 10 nm intervals. Data for this function at 5 nm intervals are given in Table 2.1 of CIE Publ. 15.3:2004, as the $y(\lambda)$ component of the CIE 1931 standard colorimetric observer, and data at 1 nm intervals are similarly given in ISO/CIE 10527.

Annex B
(informative)

Visual lustre and gloss values

Table B.1 gives examples of the specular gloss values of typical printed materials at different specular angles and their visual lustre values. These are for information only, and were collected as part of a one-off research project for illustrative purposes. They do not represent the achievable gloss or lustre levels of commercial products or the performance of commercial instruments.

Table B.1 — Visual lustre of various prints and their gloss measured at some common angles

Position	Visual lustre	Specular gloss			
Measurement beam angle(s)	45° and 0°	20° [a]	60° [a]	75° [b]	85° [a]
Unit	1	1	1	1	1
Specimen type					
Sheet-fed, SBS, C	71		41,7	63,8	73,6
Sheet-fed, SBS, M	79		53,8	70,5	74,8
Sheet-fed, SBS, Y	77		50,9	68,7	74,9
Sheet-fed, SBS, K	77		52,2	70,8	75,1
Newsprint, C	14		3,3	6,6	5,9
Newsprint, M	15		4,2	7,5	6,6
Newsprint, Y	17		5,2	7,7	6,5
K, B 1	48		20,1	40,8	38,5
K, B 2	48		23,2	39,1	41,9
K, B 3	51		22,1	42,5	42,9
K, B 4	56		24,4	42,2	39,8
Sheet-fed 70, uncoated, C	11		2,4	4,6	5,2
Sheet-fed 70, uncoated, M	11		2,5	3,6	3,1
Sheet-fed 70, uncoated, Y	6		4,1	4,5	3,4
Sheet-fed 70, uncoated, K	9		1,8	3,3	3,1
Sheet-fed 80, coated, C	64		30,6	48,2	60,4
Sheet-fed 80, coated, M	76		46,5	65,3	64,4
Sheet-fed 80, coated, Y	75		47,8	58,5	66

Table B.1 (*continued*)

Position	Visual lustre	Specular gloss			
Measurement beam angle(s)	45° and 0°	20° [a]	60° [a]	75° [b]	85° [a]
Unit	Units	%	%	%	%
Specimen type					
Sheet-fed 80, coated, K	74		43,5	61,6	63,2
Laminate proof, high gloss, C	101	92,9	98,9	98,2	97,3
Laminate proof, high gloss, M	98	94,8	100,7	99,8	98,9
Laminate proof, high gloss, Y	101	96,2	101,4	100,3	98,6
Laminate proof, high gloss, K.	109	132,7	122,2	108,4	100,7
Laminate proof, high gloss, substrate.	100	94,3	100,4	99,4	97,9
Laminate proof, medium gloss, C	85		58,9	69,9	84,7
Laminate proof, medium gloss, M	88		58,6	68,3	83,3
Laminate proof, medium gloss, Y	86		61,7	70,4	86,7
Laminate proof, medium gloss, K.	94		73,6	76,3	88,9
Laminate proof, medium gloss, substrate	86		61,9	71,1	84,2
Laminate proof, low gloss, C	64		25,4	38,9	65,3
Laminate proof, low gloss, M	64		25,7	38,4	63,7
Laminate proof, low gloss, Y	64		26,6	38,7	65,2
Laminate proof, low gloss, K.	69		30,8	40,6	66,8
Laminate proof, low gloss, substrate	61		26	37,8	64,1

[a] Measurement in accordance with ISO 2813.

[b] Measurement in accordance with ISO 8254-1.

Bibliography

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