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Photography and graphic technology — Density measurements —

Part 3: Spectral conditions

Photographie et technologie graphique — Mesurages de la densité —

Partie 3: Conditions spectrales

Reference number
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Foreword

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

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 5-3 was prepared by ISO/TC 42, *Photography*, and ISO/TC 130, *Graphic technology*, in a Joint Working Group.

This third edition cancels and replaces the second edition (ISO 5-3:1995), which has been technically revised. This technical revision takes into account, in particular, computation of ISO 5 standard density from spectral data, as well as graphic arts considerations. In the course of this technical revision, all parts of ISO 5 have been reviewed together, and the terminology, nomenclature and technical requirements have been made consistent across all parts.

ISO 5 consists of the following parts, under the general title *Photography and graphic technology — Density measurements:*

— *Part 1: Geometry and functional notation*

— *Part 2: Geometric conditions for transmittance density*

— *Part 3: Spectral conditions*

— *Part 4: Geometric conditions for reflection density*

Introduction

0.1 General

The ISO 5 series comprises four International Standards that specify the spatial and spectral conditions for optical densitometry for use in black-and-white and colour imaging applications, as practised in photographic and graphic technology applications. The term "ISO 5 standard density" is used within the ISO 5 series to refer to such specified conditions. The more general term "density" is used in its traditional sense when the basic optical principles and concepts are being discussed.

To define an ISO 5 standard density value fully, it is necessary to specify both the geometric and spectral conditions of the measuring system. Geometric conditions are described in ISO 5-2 for transmittance ISO 5 standard density, and in ISO 5-4 for reflection ISO 5 standard density. This part of ISO 5 specifies the spectral conditions for both transmittance and reflection ISO 5 standard density measurements. For many of these conditions, the term "status density" is used to identify them.

0.2 Density measurement

In photography, optical density is a measure of the modulation of light or other radiant flux by a given area of the recording medium. The measurement of density can be of interest for various reasons. It might be necessary to assess the lightness or darkness of an image, to predict how a film or paper will perform in a printing operation, or to determine a measure of the amounts of colorants in the image for the purpose of controlling a colour process. If the visual effect is of interest, the spectral conditions of measurement need to simulate an appropriate illumination and the spectral sensitivity of the eye. For photographic printing operations, the spectral power distribution of the source to be used in the printing operation and the spectral sensitivity of the print material need to be simulated. In evaluating original material for colour separation, the illuminant, the spectral sensitivity of the separation medium, and the spectral transmittance of the tricolour separation filters (and other optical components) need to be simulated.

In order to provide measurement data that can be properly interpreted by the various users who need to do so, the provision of standard specifications for the measurement procedure is necessary. ISO 5 provides that specification. In this part of ISO 5, a number of spectral conditions are specified, including a definition of the spectral response for each.

NOTE Spectral response is a function of the spectral sensitivity of the photodetector and the spectral modifications by any of the optics and filters between the plane of the specimen and the photodetector.

In many applications, it is considered desirable for the spectral response to match the spectral sensitivity of the intended receiver (eye, photographic paper, etc.) used in the practical applications of the product as described above. However, in other applications, the spectral response is defined somewhat arbitrarily (though frequently with some regard to the spectral characteristics of the media being measured) to facilitate unambiguous communication for issues of process control and thus the spectral product also becomes arbitrary in those instances.

The various spectral conditions specified in this part of ISO 5 have each been shown to be useful to the application identified. For example, certain types of density measurements are often made to generate sensitometric curves which are used to characterize the photographic properties of films and papers. Densities can also be used to perform a photographic tone-reproduction analysis or to monitor operations like photoprocessing. In graphic technology, reflection density measurements are used for the control of the ink film thickness, or, more generally, the amount of colorant per area and the determination of the tone values or other quantities.

In the early years of densitometry, the spectral responses of instruments were specified only in terms of the colour filters used in the construction. Although it was seldom the case, it was assumed that the spectral responses of the detector and the source spectral energy distributions, as well as all intervening optical components, were the same in all instruments. In more recent times, densitometry standards have specified that the combination of all these components equals a given set of published “documentary” values. If each of these components is approximated by a mathematical function, then their combination could be approximated by simply multiplying the spectral characteristics, wavelength by wavelength, and compiling the results into a table of numbers known as the spectral products. Such a specification allows flexibility to the manufacturer while providing for improved accuracy and precision. It also allows for reference materials to be manufactured and certified based on fundamental measurements.

0.3 Calculation of density

In this revision of this part of ISO 5, it has been recognized that the use of simple filter instruments is in decline. The more common method of “measuring” ISO 5 standard density makes use of computations based on measurements of the spectral reflectance factor or spectral transmittance of the specimen under study. Many users have achieved this calculation in the past by summing, over the full wavelength range, the product of the spectral reflectance factor or transmittance and the spectral products provided in previous editions of this international standard (defined at 10 nm intervals), after converting them to the linear domain. However, such a procedure is not strictly accurate. The spectral products are assumed to be the specification, at 10 nm intervals, of the physical spectral characteristics of a device obtained by combining spectral data pertaining to its illumination source and its optical components. Where measurements of samples made with a device conforming to this specification were compared to those computed from spectral data of the same samples, calculated by summing over the full wavelength range the product of the spectral data and the linear form of the 10 nm spectral products, small differences would be found. Although such errors are likely to be very small with the typical samples encountered in photography and graphic technology (probably in the third decimal place), such a situation is still undesirable.

Thus, for computation purposes, the older, coarsely sampled tables of spectral products have been supplemented in this revision with the concept of spectral weighting factors. To achieve these, the 10 nm spectral products defined in this and previous editions of this part of ISO 5 have been interpolated in the log domain to 1 nm intervals, using the method defined in Annex D, converted to the linear domain, and normalized to a peak value of 1. Additional sets of spectral weighting factors have then been derived from these for use with data measured at intervals greater than 1 nm and any densities calculated from these weighting factors, using the methodology defined in Annex B, will exactly match those obtained with filter instruments conforming exactly to the 10 nm spectral products. Of course, the values for the 10 nm spectral weighting factors differ slightly from those for the 10 nm spectral products, when converted to the linear domain, because the computation of ISO 5 standard density (as opposed to the direct measurement of ISO 5 standard density) is a convolution of spectral weighting factors and spectral reflectance factor (or transmittance) at discrete intervals over the appropriate wavelength range. Since the spectral weighting factors include both the densitometric spectral products and the coefficients of a polynomial for interpolating the spectral reflectance factor or transmittance, the table entry at a given wavelength might occasionally be a small negative value. This will not result in negative densities for any typical media, nor does it imply negative spectral products. The sums will always be positive and the logarithms will have the appropriate magnitude for the spectrally integrated readings.

It is important to note that the relative (normalized to the peak value) values for the spectral products have not changed. The interpolation to 1 nm intervals in all cases has left the 10 nm values for relative spectral products unchanged, except for a linear scaling. These data are still considered to be the primary definition of the spectral products in this part of ISO 5. Therefore, the spectral products that a filter instrument is expected to match are still the same, but they have now also been defined at finer data intervals. The assumption is made that at a data interval of 1 nm, the spectral products can also be used as weighting factors for computation from spectral data recorded at, or interpolated to, that same spectral resolution. However, for practical work, where the spectral data are usually sampled more coarsely than this, weighting factors have been calculated from these 1 nm tables. Such an approach is consistent with more recent practice in colorimetry and provides the “best” approximation to calculations made with finer resolution data. These weighting functions will also provide data that are consistent with those made with a “filter” instrument conforming to the 10 nm spectral products defined in this part of ISO 5. Thus it is recommended that the weighting factors, rather than the spectral products, are to be used when calculating ISO 5 standard density from spectral reflectance factor or transmittance data collected by practical instruments at 10 nm or 20 nm wavelength intervals.

See Annexes B, C and D for further discussion of spectral weighting factors and how they were calculated for this revision of this part of ISO 5.

0.4 Sources of illumination

The traditionally specified spectral power distribution of the incident flux for transmittance ISO 5 standard density measurements differs from that specified for reflection ISO 5 standard density measurements, although both are based on a Planckian radiation at a temperature of approximately 2 856 K as defined in ISO 11664-2. This is the spectral distribution known as CIE standard illuminant A, adopted by the CIE in 1931, and it can be approximated by an incandescent tungsten-filament lamp operated at a distribution temperature of 2 856 K. The spectral distribution for transmittance density measurements is modified by a heat-absorbing filter to protect the specimen and optical system from heat. The requirement to provide in densitometers a spectral power distribution close to that specified is particularly important because many graphic arts materials, especially print substrates, and some photographic materials contain optical brightening agents (OBAs) and exhibit significant fluorescence. If fluorescence is not an issue, the spectral power distribution of the incident flux is less significant and can deviate from that specified, so long as the specified spectral product is maintained. Furthermore, when fluorescence is not an issue, the same spectral reflectance factor data can be used for calculating both colorimetric quantities and reflection ISO 5 standard density.

In this edition of ISO 5, the requirement to use CIE standard illuminant A for reflection measurements and the modified illuminant A for transmittance measurements is maintained for photographic products. However, in an attempt to maintain compatibility with colorimetric measurements made in accordance with ISO 13655 in the graphic arts industry, three additional illumination conditions are introduced for graphic arts use. These are based on the conditions specified in ISO 13655 and are as follows:

— M1: illuminant D50,

— M2: source that only contains substantial radiation power in the wavelength range above 400 nm, and

— M3: addition of a polarization filter to condition 2.

For materials without optical brighteners, these variations in illumination have no effect, but because the level of OBAs present is often unknown it is important that the illumination condition used be clearly identified. Some process control density measuring devices are also being introduced that use a light emitting diode (LED) as the illumination source and meet the requirements of illumination condition M2. Care is advised when comparing measurements made with differing illumination conditions, particularly when used to compare process control measurements between colorants with significantly different spectral characteristics.

0.5 Calibration standards

Many older standards for reflection density specified the use of barium sulfate ($BaSO_4$) as the reference standard. However, pressed barium sulfate ($BaSO_4$) is fragile, variable from batch to batch of powder, variable from pressing to pressing, and its reflectance changes appreciably in the first few days after pressing. In 1969, the CIE recommended that all reflectance factors and, by inference, the corresponding reflection densities be reported relative to a perfectly reflecting and perfectly diffusing material. This is specified to be the reference for calibration in ISO 5.

In day-to-day operation, reflection densitometers are usually calibrated with materials from the instrument manufacturer or with certified reference materials (CRMs) available from a number of sources. These working standards need to be calibrated with respect to primary standards that are calibrated with respect to the perfect reflecting diffuser by absolute methods in national standards laboratories.

Photography and graphic technology — Density measurements —

Part 3: Spectral conditions

1 Scope

This part of ISO 5 specifies spectral conditions and computational procedures for the definition of several types of ISO 5 standard densities used in imaging applications in photography and graphic technology.

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 5-1, *Photography and graphic technology — Density measurements — Part 1: Geometry and functional notation*

ISO 5-2, *Photography and graphic technology — Density measurements — Part 2: Geometric conditions for transmittance density*

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

ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

ISO 14807, *Photography — Transmission and reflection densitometers — Method for determining performance*

IEC 60050-845:1987[1)], *International Electrotechnical Vocabulary. Lighting*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5-1, IEC 60050-845:1987 | CIE 17.4:1987 and the following apply.

3.1
CIE standard illuminant A
Planckian radiation at a temperature of approximately 2 856 K, as defined in ISO 11664-2

NOTE 1 The radiation of a gas-filled coil tungsten filament lamp operated at a colour temperature of 2 856 K will approximate this spectral distribution, and thus can serve as a practical realization of this standard illuminant.

1) IEC 60050-845:1987 is a joint publication with the International Commission on Illumination (CIE). It is identical to CIE 17.4:1987, *International Lighting Vocabulary*.

NOTE 2 It is important to note the distinction between an illuminant and a source. An illuminant is defined by a table of relative spectral power distribution that might not be precisely realized in practice. A source is an object that produces radiant flux.

3.2
efflux spectrum
spectral power distribution of the radiant flux collected by the receiver from the reference plane

NOTE This is a function of the influx spectrum and the spectral reflectance or transmittance characteristics of the standard or specimen.

3.3
influx spectrum
S
spectral distribution of the radiometric quantity, such as radiance, irradiance or radiant flux, incident upon the sampling aperture

NOTE This is a function of the source and optics used for the illumination.

[ISO 5-1:2009, definition 3.11]

3.4
ISO 5 standard density
density value obtained using an instrument conforming to one of the geometries specified in ISO 5-2 or ISO 5-4, and one of the spectral definitions in ISO 5-3

[ISO 5-1:2009, definition 3.12]

3.5
peak wavelength
wavelength at which the spectral product or weighting factor is a maximum

3.6
receiver
portion of the densitometer that senses the efflux, including the collection optics and detector

[ISO 5-4:2009, definition 3.3]

3.7
sideband rejection
degree to which radiant flux outside a desired spectral bandwidth is blocked or suppressed

NOTE It is usually expressed as the ratio of the integrated energy within the desired bandwidth to the integrated radiant flux outside the bandwidth.

3.8
source
object that produces radiant flux

3.9
spectral bandwidth
wavelength interval between which the spectral product has decreased to a designated percentage of its maximum

3.10
spectral product
Π
product of the influx spectrum and the spectral responsivity

3.11
spectral reflectance factor
ratio of the reflected flux to the absolute reference reflected flux under the same geometrical and spectral conditions of measurement, as a function of wavelength

NOTE Adapted from ASTM E284.

3.12
spectral responsivity
s
output signal of a receiver per unit input of radiant flux as a function of wavelength

NOTE Adapted from ASTM E284.

[ISO 5-1:2009, definition 3.20]

3.13
spectral transmittance
ratio of the transmitted flux to the incident flux under specified geometrical and spectral conditions of measurement

3.14
spectral weighting factor
factor obtained from the spectral product, tabulated at specified wavelength intervals

NOTE To compute density values from spectral weighting factors, see Annex B.

4 Requirements

4.1 General

ISO 5 standard density is the logarithm to the base 10 of the ratio (see Annex B) of the integration of the spectral products and either spectral reflectance factor or spectral transmittance of the material under examination, and the integration of the spectral products alone. The spectral conditions for the various types of ISO 5 standard density specified in this part of ISO 5 are given by the various spectral products, defined at 10 nm intervals, specified in this, and previous editions, of this part of ISO 5. However, these have been extended to provide greater precision by means of tabulated values spaced at 1 nm intervals and normalized to a value of 1 at the peak wavelength. These data are directly equivalent to the 10 nm data, although defined in the linear domain. In addition, abridged weighting factors are provided for convenience in determining ISO 5 standard density using instruments where spectral reflectance factor or transmittance data are available at intervals of 10 nm or 20 nm. Further information pertaining to these weighting factors, and their derivation, is given in the Introduction and in Annexes B, C and D.

4.2 Influx spectrum

4.2.1 General

To unambiguously define the determination of ISO 5 standard density in the presence of materials which may fluoresce, it is necessary to also specify the spectral characteristics of the influx spectrum, S, as well as the spectral products.

The historic radiation source for densitometry has been an incandescent lamp with a relative spectral power distribution that matches CIE standard illuminant A as defined in ISO 11664-2 and as specified in 4.2.2.1. This source will continue to be used for measurements of ISO 5 standard reflection density for photographic applications and as one option for ISO 5 standard reflection density for applications in graphic technology. Other illuminant conditions that may be used and shall be noted when reporting ISO 5 standard reflection density in graphic technology are specified in 4.2.2.2.

For ISO 5 transmittance density, the radiation source shall be an incandescent lamp with a relative spectral power distribution that matches CIE standard illuminant A modified as specified in 4.2.3.

NOTE In transmittance densitometers, it is necessary to add a heat-absorbing filter to the influx side to protect the specimen and optical elements. If the absorber does not change the spectral power distribution of the source below 550 nm, as specified in 4.2.3, no significant effect on the measurement due to fluorescence is expected to be observed or be of concern.

4.2.2 Reflection ISO 5 standard density

4.2.2.1 Photographic applications

For reflection ISO 5 standard density measurements used in photographic applications, the relative spectral power distribution of the flux incident on the specimen surface should conform to CIE illuminant A (corresponding to a correlated colour temperature of 2 856 K). In practical instruments used to measure reflection ISO 5 standard density, the relative spectral power distribution of the flux incident on the specimen surface shall conform to a correlated colour temperature of (2 856 ± 100) K.

NOTE 1 The influx spectrum of CIE illuminant A is given in the “sources.csv” file that forms an integral part of this part of ISO 5, under the heading S_A (which is the symbol used in functional notation). For reference, an abridged version of the full definition is included in Table 1.

NOTE 2 For an instrument that does not precisely match CIE illuminant A, but is within the tolerance cited, the influx spectrum will not be significantly different from that of CIE illuminant A.

NOTE 3 The requirement to provide an influx spectrum close to S_A can be relaxed if samples to be measured do not exhibit fluorescence, so long as the specified spectral product is maintained.

4.2.2.2 Graphic technology application

For reflection ISO 5 standard density measurements used in graphic technology applications, four options are provided for the relative spectral power distribution of the flux incident on the specimen surface. The first, and historic source, is CIE illuminant A as defined in 4.2.2.1.

To maintain compatibility with instrumentation used to make colorimetric measurements in accordance with ISO 13655, three additional illumination conditions (M1, M2, and M3) defined in ISO 13655 may be used. The requirements specified in ISO 13655 shall be met if these conditions are used for the computation of density.

Measurements made using these influx spectra shall be accompanied by an identification of the particular condition used. These conditions are limited to measurements based on computation of reflection density from spectral measurements made for graphic arts applications. The influx spectrum notation used as identification for these conditions shall be M1, M2 or M3.

Measurement condition M1 requires that the instrument manufacturer provide either a spectral match of standard illuminant D50 (which is valid for both the measurement of fluorescence of optical brighteners in the substrate and fluorescent printing inks) or a compensation technique (valid only for the measurement of fluorescence of optical brighteners in the substrate).

Measurement condition M2, to exclude variations in measurement results between instruments due to fluorescence of optical brightening agents in the substrate, requires that the illumination only contain substantial radiation power in the wavelength range above 400 nm.

NOTE 1 If the specimen (substrate and marking materials) contains any fluorescent additives, then measurements under conditions M1 or M2 possibly will not report ISO 5 standard densities that will equal the values obtained from a traditional filter densitometer matching exactly the spectral product for the desired status density. When the only fluorescent additives are optical brightening agents in the substrate, the measurements under condition M2 are expected to be very similar to those of a traditional filter instrument.

NOTE 2 For density measurements in M2 mode, it is sufficient that the light source has no substantial radiation below 400 nm. Continuous spectral illumination above 400 nm is not required. Narrow-band LED instruments can be applied, if their spectral products match the density filter specification in this part of ISO 5.

Measurement condition M3 has the same general requirements as those of M2 but, in addition, requires the use of a means for polarization in order to suppress the influence of first-surface reflection on the reflectance factor measured.

4.2.3 Transmittance ISO 5 standard density

For transmittance ISO 5 standard density, the relative spectral power distribution of the flux incident on the specimen surface should conform to that given in the “sources.csv” file that forms an integral part of this part of ISO 5, under the heading S_H (which is the symbol used in functional notation). Practically, in measurements of transmittance ISO 5 standard density, the relative spectral power distribution of the flux incident on the specimen surface shall conform to the distribution temperature of (2 856 ± 100) K, with the modification in the region above 560 nm specified in S_H.

NOTE 1 This spectral power distribution is based on that of CIE standard illuminant A, modified in the region above 560 nm to protect the sample and optical elements from excessive heat that is typical for most transmittance densitometers. For reference, an abridged version of the full definition is included in Table 1.

NOTE 2 For an instrument that does not precisely match S_H, but is within the tolerance cited, the spectral power distribution will not be significantly different from that of S_H.

NOTE 3 The requirement to provide a spectral power distribution close to S_H can be relaxed if samples to be measured do not exhibit fluorescence, so long as the specified spectral product is maintained.

NOTE 4 The reference transmittance for the heat-absorbing filter can be found by taking the ratio of S_H and S_A of Table 1.

4.3 Types of instruments

Density measurements can be performed using two types of instrument, denoted as filter and spectral. A fully conforming filter instrument realizes the spectral product for the desired type of ISO 5 standard density, specified by Tables 2 to 7, by the appropriate combination of influx spectrum, given in 4.2, and spectral responsivity, usually achieved with a filtered detector. A filter instrument measures density directly. A spectral instrument measures the spectral transmittance or reflectance factor of a specimen and the desired type of ISO 5 standard density is calculated using the procedure specified in Annex B and the appropriate spectral weighting functions from Tables 8 to 13.

4.4 Spectral products

4.4.1 General

Spectral products, Π, are obtained at each wavelength by multiplying the influx spectrum, S, by the spectral responsivity, s.

4.4.2 Conformance

The spectral product of the densitometer (whether produced directly by a filter instrument or indirectly by calculation from a spectral instrument) shall be one of those specified in Tables 2 to 7. However, where greater accuracy is required, the 1 nm tables in the “Specprod.csv” file that forms an integral part of this part of ISO 5 may be used.

The spectral products at 10 nm intervals defined in Tables 2 to 7 provide the information necessary to define the spectral response of a “filter” instrument which claims conformance to this part of ISO 5. However, these data are not appropriate for calculation of ISO 5 standard density from spectral data. For this application, the methods specified in 4.5 shall be used.

NOTE The 10 nm spectral products specified in Tables 2 to 7 are defined in terms of logarithmic spectral product values specified at intervals of 10 nm, in order to be consistent with previous editions of this part of ISO 5. These are normalized to a peak value of 100 000. The logarithms to the base 10 of these values are used in this part of ISO 5 to define the various spectral types. The 1 nm spectral products are specified in the linear domain, normalized to a peak value of 1.

4.5 Computation of ISO 5 standard density from spectral data

4.5.1 General

When calculating ISO 5 standard density from spectral data, the measured spectral reflectance factor or spectral transmittance shall be multiplied by the spectral weighting factors appropriate for the measurement interval at which the data were collected.

4.5.2 Computation procedures

Computation of ISO 5 standard density shall be based on Simpson's rule of numerical integration at 1 nm intervals, using the tables of spectral weighting factors identified in Annex A and contained in the "Specprod.csv" file. However, for practical measuring instruments, this result may be sufficiently approximated by using the abridged spectral weighting factors specified at 10 nm and 20 nm intervals contained in Tables 8 to 13 (and electronically in the "10nmWeights.csv" and "20nmWeights.csv" files) together with the computational techniques defined in Annex B. For the computation of abridged tables at other intervals, the method described in Annex D shall be used.

NOTE 1 Spectral weighting factors for all of the types of ISO 5 standard density defined in this and previous editions of this part of ISO 5 are included in the "Specprod.csv", "10nmWeights.csv" and "10nmWeights.csv" files and Tables 8 to 13. The definitions and applications of these various types of ISO 5 standard density measurements are contained in Clause 6.

NOTE 2 Although the actual sum of the individual weighting factors in Tables 8 to 13 can vary because of rounding issues, the value shown as the sum is used in all calculations.

4.6 Sample conditions

The density of some materials changes with variations in temperature and relative humidity. Therefore, to avoid ambiguity, such materials should be at 23 °C ± 2 °C and 50 % ± 5 % relative humidity when determining ISO 5 standard density.

4.7 Reference standards

4.7.1 General

Reflectance factor or transmittance, and corresponding reflection or transmittance densities, are measured relative to a reference standard, which may be real or ideal. When working standards are required (usually only for reflection measurements) these are customarily calibrated relative to this reference standard by a basic standards laboratory.

4.7.2 Absolute reference standards

The reference standard for determining ISO 5 reflection density shall be an ideal, perfectly reflecting and perfectly diffusing material. Any working standard used shall not contain fluorescent additives or be intrinsically fluorescent, as this fluorescence will corrupt both the scaling of reflectance and the determination of the absolute zero level of ISO 5 standard density.

The reference standard for determining ISO 5 transmittance density shall be when no media is present (often known as "calibrating to air").

4.7.3 Relative density reference standards

In some reflection density applications, the reference white is the base on which an image may be produced, such as unexposed but processed photographic printing paper, or unprinted paper in graphic technology applications. In such cases, the measured density is called "relative reflection density" and the density of the reference white shall be stated. Great care should taken if the printing paper contains fluorescent brightening agents, as these will distort the scale of reflectance and the zero density calculation. Use of an instrument conforming to illumination condition M2 will minimize these issues.

In some transmittance density applications, the reference medium is the base on which an image may be produced, such as unexposed but processed photographic film. In such cases, the measured density is called "relative transmittance density" and the density of the reference medium shall be stated.

NOTE It is preferable to provide spectral data for the reference media where possible.

5 Notation

ISO 5-1 specifies functional notation of the form $D(G;\, S\colon g;\, s)$, where G and g symbolize the illuminator and receiver geometry, respectively, and S and s symbolize the influx spectrum and spectral responsivity, respectively. Since this part of ISO 5 is concerned only with spectral conditions, the notation is abbreviated to $D(S\colon s)$. To distinguish between ISO 5 transmittance density and ISO 5 reflection density, a subscript may be used. The subscript for transmittance density is the lower case Greek letter tau (D_τ) and that for reflection density is the upper case roman letter R (D_R).

While the spectral product, Π, is the product of the influx spectrum, S, and the spectral responsivity, s, in this part of the ISO 5 standard, the spectral responsivity s is given a subscript indicating which spectral product is to be realized. The actual spectral responsivity will be adjusted or modified so that the product of the actual instrument influx spectrum and the actual spectral responsivity will produce the specified spectral product when combined, wavelength by wavelength. This process is true for instruments with incandescent sources that approximate the standard CIE illuminant A spectrum, S_{A}, or any of the graphic arts influx spectra, S_{M1}, S_{M2} or S_{M3}. The various spectral responsivities are not equal to or identical with any set of spectral products.

6 Types of ISO 5 standard density

6.1 ISO 5 standard visual density

The notation for ISO 5 standard visual density is $D_T\,(S_{\mathrm{H}}\colon s_{\mathrm{V}})$ or $D_R\,(S_{\mathrm{A}}\colon s_{\mathrm{V}})$.

ISO 5 standard visual density is used to evaluate the darkness of an image which is to be viewed directly or by projection. Measurements of ISO 5 standard visual density are most often made on black-and-white images, but can be made on other types of images.

Where filter instruments are used to measure ISO 5 standard visual density, they shall comply with the spectral products of Table 2. Where ISO 5 standard visual density is computed from spectral data at 10 nm or 20 nm intervals, the weighting factors of Table 8 shall be used.

NOTE 1 These data are also included in the "10nmWeights.csv", "20nmWeights.csv" and "Specprod.csv" files that form an integral part of this part of ISO 5.

NOTE 2 Spectral products and weighting factors for ISO 5 standard visual density are chosen to match the product of the spectral luminous efficiency function for photopic vision, V_λ, (as defined in CIE 18) and the relative spectral power distribution of the influx spectrum specified for reflection measurements, S_{A}. This is essentially the CIE tristimulus Y function of illuminant A.

6.2 ISO 5 standard printing density

6.2.1 General

The notation for ISO 5 standard printing density is $D_T\,(S_{\mathrm{H}}\colon s_{\mathrm{P}})$ or $D_R\,(S_{\mathrm{A}}\colon s_{\mathrm{P}})$.

