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Graphic technology and photography — Certified reference materials for reflection and transmission metrology — Documentation and procedures for use, including determination of combined standard uncertainty

Technologie graphique et photographie — Matériaux de référence certifiés pour la métrologie par réflexion et transmission — Documentation et procédures à utiliser, y compris la détermination d'une incertitude normale combinée

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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 15790 was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

Introduction

The International Organization for Standardization (ISO), in ISO Guide 30 [1], defines a certified reference material (CRM) as a “reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence”. Thus, CRMs are well-characterized materials with values traceable to stated references (see 3.1.12). They may be used to calibrate or to determine the performance characteristics of measurement systems in order to facilitate the exchange of data and to assist in quality control. Their use will help to assure the long-term adequacy and integrity of the measurement and quality control processes.

Densitometers, colorimeters and spectrophotometers are widely used to make measurements for quality and process control in the graphic arts, photographic and other imaging industries. The intent of this International Standard is to establish documentation requirements that describe characteristics of reflection and transmission certified reference materials that may be used for verifying performance of these instruments. In many areas (e.g. cyan, magenta, yellow colorants) there are no readily available reference materials that are traceable to international and national standards. This International Standard can still provide guidance in such circumstances by showing how to determine the reproducibility of the results of measurements, even in the absence of CRMs.

Although the calibration reference materials provided with many reflection and transmission instruments used in graphic arts and photography are not identified as CRMs, they could often meet the requirements as such. Instrument manufacturers are encouraged to document the characteristics of their calibration materials as CRMs where appropriate.

This International Standard describes practical procedures to determine values that represent components of the uncertainty of measurements for the graphic arts, photography and other image-technology industries. A computational procedure is also provided to combine these components to determine “combined standard uncertainty” (see 3.1.3). A more rigorous and detailed approach is described in the *Guide to the expression of uncertainty in measurement*.

Furthermore, general procedures are identified for the use and maintenance of these certified reference materials. Through use of this International Standard, manufacturers of CRMs can provide consistent general-use information for the verification of measurement-system performance described above. This International Standard lists appropriate documentation that should accompany CRMs, including the following:

a) areas where a CRM is and is not applicable;

b) physical characteristics of CRMs for density, colour values, uniformity, etc. (see Annex A);

c) traceability of CRM values to stated reference;

d) expected lifetime of a CRM;

e) care and storage of a CRM;

f) general procedures on how to use a CRM.

Other useful documents providing guidance in metrology and the uncertainty of measurement can be found in the Bibliography.

This International Standard provides guidance and is a resource for manufacturers and users of CRMs. Using CRMs as part of quality assurance activities is essential for verification and calibration of measurement systems and can increase confidence in data obtained from measurement instruments. It provides a useful tool in support of ISO 9001 [15] registration and ISO/IEC 17025 [22] accreditation by providing information relevant to graphic technology, photographic and other imaging industries.

Graphic technology and photography — Certified reference materials for reflection and transmission metrology — Documentation and procedures for use, including determination of combined standard uncertainty

1 Scope

This International Standard specifies the documentation requirements for certified reference materials (CRMs), procedures for the use of CRMs, and procedures for the computation and reporting of the combined standard uncertainty of reflectance and transmittance measurement systems used in graphic arts, photographic and other imaging industries.

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 reference document (including any amendments) applies.

Guide to the expression of uncertainty in measurement, published jointly by BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, 1995

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
calibration
set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards

[adapted from *International vocabulary of basic and general terms in metrology*] [2]

NOTE Contrary to a common misconception, calibration is not the process of adjusting a measurement system such that it produces values that are believed to be correct. Calibration permits either the assignment of values of measurands to the indications (creating a reference table) or the decision to reset or adjust the device. Following the resetting or adjusting of the device, a calibration is normally repeated to ensure that the new device setting(s) provide indications within the accepted ranges.

3.1.2
certified reference material
CRM
reference material, accompanied by a certificate, one or more of whose property values are certified by a procedure which establishes traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence

[ISO Guide 30] [1]

3.1.3
combined standard uncertainty
u_c
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[*Guide to the expression of uncertainty in measurement*]

3.1.4
coverage factor
k
numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

[*Guide to the expression of uncertainty in measurement*]

3.1.5
CRM reference value
value of the certified property of a CRM, reported in the documentation supplied with it

3.1.6
expanded uncertainty
U
quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[*Guide to the expression of uncertainty in measurement*]

NOTE Expanded uncertainty is the product of the combined standard uncertainty, u_c, and the chosen coverage factor, k.

3.1.7
experimental standard deviation
s
quantity characterizing the dispersion of the results for a series of n measurements of the same measurand and given by the following formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where

n is the number of measurements;

$\bar{x}$ is the arithmetic mean of the n results considered;

x_i is the result of the ith measurement.

[adapted from *International vocabulary of basic and general terms in metrology*] [2]

NOTE According to ISO 3534-1:1993 [7], 2.34, the standard deviation is the positive square root of the variance.

3.1.8
manufacturer's calibration reference material
physical device or material, certified or non-certified, supplied by the instrument manufacturer, which may be used to calibrate a specific instrument

3.1.9
measurand
particular quantity subject to measurement

[*International vocabulary of basic and general terms in metrology*] [2]

EXAMPLES Density, lightness, transmittance, and reflectance factor.

3.1.10
reference material
material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for the calibration of an apparatus, for the assessment of a measurement method, or for assigning values to materials

[ISO Guide 30] [1]

3.1.11
reproducibility
⟨results of measurements⟩ closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement

[adapted from *International vocabulary of basic and general terms in metrology*] [2]

NOTE Reproducibility is distinct from repeatability. Repeatability is the closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions, e.g. using a single instrument, by the same observer, in the same location and in a short period of time.

3.1.12
traceability
property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons, all having stated uncertainties

[adapted from *International vocabulary of basic and general terms in metrology*] [2]

3.1.13
uncertainty of measurement
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[adapted from *International vocabulary of basic and general terms in metrology*] [2]

NOTE 1 For the purposes of this International Standard, each component of the uncertainty is assumed to have a normal distribution. The concepts and rules for cases where this assumption may not be valid are considered in the *Guide to the expression of uncertainty in measurement*.

NOTE 2 The result of a measurement is only an approximation or estimate of the value of the measurand and thus is complete only when accompanied by a statement of the uncertainty of that estimate (see 3.1.3 and 6.1.7).

3.1.14
uncertainty of CRM
U_{CRM}
measurement uncertainty that is attributed to the reported value of a CRM in the certificate supplied with it, often expressed as an expanded uncertainty with a coverage factor

3.1.15
variance
a measure of dispersion, which is the sum of the squared deviations of observations from their average divided by one less than the number of observations

[adapted from ISO 3534-1:1993] [7]

3.2 Symbols

b_{max} maximum value of the known correction

D_R reflection density

k coverage factor

s experimental standard deviation

S_A influx spectrum based on CIE illuminant A

T_R status T red response

U expanded uncertainty

u_c combined standard uncertainty

u_r uncertainty of reproducibility of results of measurements

U_{CRM} uncertainty of CRM reference values

U_{max} maximum expanded uncertainty

$Y(t)$ measurand function

4 General guidelines for CRM application

CRMs may be used for several purposes:

— to verify the accuracy of a measurement device or system;

— to verify measurement system performance on a routine basis;

— to estimate the uncertainty of reported measurements;

— to improve agreement between/among independently calibrated measurement systems and to determine correlation.

The manufacturer's calibration reference material normally includes properties and values that are designed to work with a specific instrument and for a specific application. A manufacturer's calibration reference material is a CRM if it provides the documentation conforming to 5.1 to 5.3 of this International Standard.

A CRM that is not the instrument manufacturer's calibration reference material should not arbitrarily be used for physically readjusting the instrument. The user of a CRM should first contact the instrument manufacturer regarding the use of a specific CRM for that purpose.

A CRM is usually designed to verify some but not all attributes of a measurement system. It is, therefore, important to understand and follow closely the application information provided with a CRM.

5 Required documentation for CRMs

5.1 Identification of CRM

The following information shall be supplied with a CRM:

— manufacturer's name;

— product identification;

— serial number;

— certification date;

— expiration date or useful life.

This information shall be affixed to a CRM or uniquely associated with it.

5.2 Reporting of CRM reference values

The reference values of CRMs shall be properly identified and reported, with either the combined standard uncertainty u_c (see Example 1), or the expanded uncertainties U and coverage factor k (see Example 2).

EXAMPLE 1 $D_R(45; S_A; 0; T'_R) = 1{,}25$ with $u_c = 0{,}01$; notation for densities according to ISO 5-3 [5]

where

D_R is reflection density;

S_A is the influx spectrum based on CIE standard illuminant A;

T'_R is the status T′ red spectral response.

EXAMPLE 2 $D_R(45; S_A; 0; T'_R) = 1{,}25 \pm 0{,}02 = 1{,}25 \pm U$ [$u_c = 0{,}01$, ($k = 2$)]

where the variables are the same as for Example 1.

Alternatively, the reference values of CRMs may be expressed in some other form such as a table; however, the certificate accompanying a CRM shall clearly show either the combined standard uncertainty or the expanded uncertainty and the coverage factor.

5.3 Traceability

A statement of traceability shall be provided with CRM reference values. A detailed description of this traceability shall be available upon request.

Information about the instrumentation and procedures used to determine CRM reference values shall also be supplied.

5.4 Cautions for use

The manufacturer of a CRM shall provide documentation for those characteristics of a CRM that can affect the stability of the values measured on a CRM. See Annex A for a sample list of characteristics.

The use of CRMs having characteristics that differ from those of materials whose properties are to be measured may yield erroneous measurement results. Consideration should be given to these characteristics when selecting and using a CRM in order that unintended effects are minimized. Documentation should be provided regarding any properties that can adversely affect instrument calibration.