Specific Accreditation Criteria
Calibration ISO/IEC 17025 Annex

Optical metrology

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Optical Metrology

This document provides interpretative criteria and recommendations for the application of ISO/IEC 17025 for both applicant and accredited facilities conducting optical metrology.

Applicant and accredited facilities must also comply with ISO/IEC 17025 andthe NATA ISO/IEC 17025 Standard Application Document (SAD) and the Calibration ISO/IEC 17025 Appendix. The clause numbers in this document follow those of ISO/IEC 17025. However since not all clauses require interpretation, the numbering may not be consecutive.

This appendix is divided into two sections; the first provides additional guidance and recognition of the general requirements that are applicable to all types of measurements in this discipline, while the latter provides additional guidance and recognition of the requirements that are specific to individual types of measuring equipment. For ease of use and to avoid fragmentation of the guidance, the clauses of ISO/IEC 17025 have not been applied.

General requirements

Dark rooms

Dark rooms used for photometric measurements commonly have matt black painted walls and provision for screening stray radiation, particularly from ceiling and floor. Baffles are a more effective means of reducing stray radiation. The amount of stray radiation present must be measured and be accounted for.

Power supply

Power supplies matching the requirements of reference standard lamps and with a current stability of better than 0.1% should be provided.

Specific requirements for types of measurement equipment

Optical Glass Filters

Colour and neutral density glass filters change the spectral properties of optical radiation. These filters allow investigations to be conducted using optical and radiometric equipment. For example, in the areas of photometry and radiometry, optical filters are used for:

- checking the spectral response and linearity of photocells, photomultipliers, and radiometers;
- checking the accuracy and precision of colour measuring systems (e.g. spectrophotometers and colorimeters).

Since filters are often used as laboratory standards, only glass filters (dyed in the mass) are recommended. Plastic, gelatine or coated filters are not acceptable due to their inferior stability in terms of optical parameters. Various qualitative and quantitative descriptions assist in determining whether a particular glass filter is suitable for a certain use. For example, relevant parameters may include:

- chromaticity co-ordinates;
- luminous transmittance (T);
- chemical resistance;
- bubble quality;
- homogeneity and polish, thickness uniformity;
- tempering and strengthening;
- handling and storage;

Recommendations for each of these parameters are given below:

Chromaticity co-ordinates

Filters should be chosen that have chromaticity co-ordinates in the desired colour region. The usual system used for specifying chromaticity co-ordinates is the CIE 1931 *x*, *y,* Y system. Selected filters should be calibrated by a suitable calibration authority (e.g. a facility accredited with NATA for filter measurements and capable of measuring with a least uncertainty of ±0.005 units of chromaticity or better).

Any conditions or precautions stated in the calibration report should be strictly adhered to, for example:

- test geometry;
- illuminant source used;
- test area(s);
- sampling interval and bandwidth used;
- ambient environmental conditions.

Chromaticity should be constant over the surface of the filter or, as a minimum requirement, any variations should be known and clearly documented.

Luminous Transmittance (T)

In many applications it will be necessary to know both the luminous transmittance (T) and the spectral transmittance T(λ) of optical filter standards.

Optical radiation filters, regardless of their structure or mode of action, are characterised by their spectral transmission (i.e. their transmittance as a function of wavelength). The luminous transmittance is calculated by integrating the spectral transmittance values with the visibility function and source.

Transmission values quoted for filters are usually for the reference thickness only - this is typically a nominal value of 1 mm, 2 mm or 3 mm. Once selected, optical filters should be sent to a suitable calibration authority for measurement of spectral transmittance over the appropriate wavelength interval and calculation of luminous transmittance. An uncertainty of ±0.2% or better is desirable for transmittance values.

Chemical resistance

Optical glass filters should be resistant to chemical attack by acids, alkalis and other chemical agents. Under normal conditions of use, no change in optical properties should occur. Only under extreme conditions, such as when subjected to a continuous spray of sea water, or when used in rain or water, could a change in optical properties be expected to occur.

A small change in transmittance may occur with the growth of surface films (blooming). This can be reversed by carefully cleaning the surface of the filter.

Bubble quality

This parameter is usually characterised by stating the total cross-sectional area of any bubbles in mm^2, relative to 100 cm^3 of glass volume, calculated from the sum of the cross-sectional areas of any bubbles in the glass. Inclusions in the glass, such as stones or crystals, are treated in the same way as bubbles of the same area.

It is recommended that the projected area (in mm^2) of all bubbles/inclusions, having a dimension greater than 0.05 mm diameter, be less than 0.10 mm^2/100 cm^3 of glass volume.

Homogeneity and polish, thickness uniformity

Optical filters should be homogenous, with respect to optical properties, over their entire area. The variation in refractive index within a filter glass is a good measure of the optical homogeneity. The better the homogeneity is, the smaller the variation in refractive index. Optical filters should have maximum variation of the refractive index (nd) value of $\pm 5 \times 10^{-6}$. This should be verified by the glass filter supplier or by calibration.

The two sides of the filter must be adequately polished and accurately parallel to obtain uniformity of transmittance over the working aperture.

Tempering and strengthening

Absorbing filter glass is generally heated unevenly by illuminating radiation. Rapid thermal equilibrium is prevented by the low thermal conductivity of glass.

This results in temperature differences between the front and rear and, in particular, between the centre and the edge of the filter glass. Consequently, different rates of thermal expansion within the filter occur, generating high flexural stress in the glass (and ultimately leading to crystallisation, embrittlement and fracturing).

Improved resistance to large temperature gradients or rapid temperature changes can be obtained by tempering (or strengthening) the glass. Heat tempering glass leads to birefringence in the material and is not appropriate for spectrophotometer measurements where the beam is partially plane polarised.

Constructional methods and illuminator design must ensure that the filter glass is subjected to minimal temperature gradients. This is the sole method of achieving high reliability in operation.

Handling and storage

The following precautions should be observed:

- if there exists a possibility of filters being exposed to moisture or water during transport, it is advisable to use a desiccant when packaging the filters. Prolonged exposure to intense light sources which have a high proportion of ultraviolet (UV) radiation can cause permanent changes in the transmission of some filter glasses. This effect is called ‘solarisation’ in glass technology. Solarisation depends on the intensity and spectral distribution of radiation (i.e. the shorter the wavelength of radiation, the greater the solarisation effect in most cases).

In most optical filter glasses, solarisation is characterised by a shift of the short-wavelength edge towards longer wavelengths and a reduction of transmission in the pass band region.

In practical terms, this means filters should never be exposed to bright sunlight or intense UV sources for extended periods;

- filters are obviously very fragile items and should be treated with due care. It is advisable only to handle filters by their edges and store them in a soft, lint-free container that can be locked tight to prevent the entry of moisture and light.

  If filters are subjected to any agents or processes that could be expected to change their optical properties, it is highly recommended that they be re-calibrated by a suitable calibration authority.

Distribution photometers

Any mirror on a distribution photometer must be checked for flatness and uniformity of reflection factor. The light path length and the accuracy of angular settings should be established. An accuracy of better than 30 minutes of arc is recommended for angular settings.

Goniophotometers

The accuracy of angular settings must be established. Type ‘A’ Goniometer must be used for ADR testing, traffic signal lanterns or where testing at large horizontal angles is undertaken. The type of goniometer must meet the requirements of the standards.

Illuminance meters

The accuracy to which the detector matches the V (λ) function must be corrected for and/or accounted for in the uncertainty calculations. Correction may be performed by:

- using a spectral mismatch correction factor (if the spectral response of the detector is known);
- using a correction factor from the manufacturer (if supplied for a particular source); or
- using filters.

This is particularly important for measurement of sources with narrow spectral features.

The linearity of response and cosine response must be checked initially with additional linearity checks to be performed as required. Linearity of response checks may be performed by the inverse square law, multiple aperture or neutral density filter techniques. Glass neutral density filters are recommended; plastic and gelatine filters are not acceptable.

A visual inspection of the photometer detector is recommended every 6 months.

Luminance meters

The accuracy to which the detector matches the V (λ) function must be corrected for and/or accounted for in the uncertainty calculations. Correction may be performed by:

- using a spectral mismatch correction factor (if the spectral response of the detector is known);
- using a correction factor from the manufacturer (if supplied for a particular source); or
- using filters.

This is particularly important for measurement of sources with narrow spectral features. The linearity, sensitivity, spectral responsivity, scattered light and optical alignment must be checked. The size and location of the measurement field, at an appropriate distance, must be determined.

Photodetectors

The sensitivity and spectral responsivity of the photodetector and filter, if fitted, and associated electronics combination must be checked regularly. Linearity of response must be checked initially with additional linearity checks to be performed as required. A visual inspection of the photodetector and filter, if fitted, is recommended every 6 months.

Where the photodetector is designed to have a spectral responsivity matching the V (λ) function, e.g. photometer heads, the accuracy of the spectral response to V (λ) must be corrected for and/or accounted for in the uncertainty calculations. Correction may be performed by:

- using a spectral mismatch correction factor (if the spectral response of the detector is known);
- using a correction factor from the manufacturer (if supplied for a particular source); or
- using filters.

For all visible range detectors, including V (λ) detectors, the stability of the spectral response should be checked periodically, and this may performed using glass colour filters. The following types of filters are recommended:

- Blue filter Schott type BG28 (1 mm or 2 mm)
- Green filter Schott type VG6 (1 mm)
- Red filter Schott type RG610 (3 mm)

As glass filters are subject to aging, filters must be calibrated before each use or the facility must determine a suitable calibration interval depending on accumulated history of stability.

Laser Power Meters

The sensitivity of the photodetector and filter, if fitted, and associated electronics combination must be checked regularly.

Linearity of response must be checked initially with additional linearity checks to be performed as required.

A visual inspection of the laser power meter detector receiving surface must be performed regularly due to the risk of laser induced damage.

Radiometers

The spectral response, over the region of interest, and linearity must be checked.

If fitted with a diffuser device, the cosine correction must be checked. Band pass should be verified.

Spectrophotometers

The wavelength accuracy, band pass, stray radiation, linearity of response, repeatability and optical alignment of a spectrophotometer must have been checked within six months prior to its use for the ranges of use.

Glass colour filters should be used to check the spectral characteristic of the spectrophotometer and the accuracy of colour measurements. Configuration changes will require recalibration.

Spectroradiometers

The wavelength accuracy, band pass, stray radiation, linearity of response, spectral response and repeatability must be checked regularly. Configuration changes will require recalibration.

Standard lamps – discharge

A group of at least three reference lamps plus three working lamps is recommended for each type of discharge lamp tested with ballast in matching pairs. Unfortunately, there is a great variety of types of these lamps which also exhibit poor stability. Lamps must be shown to be stable before nominating as standards. Alternatively, discharge lamps may be compared with reference incandescent lamps. This procedure reduces the number of lamps needed, but requires a knowledge of the spectral properties of each lamp type tested, as well as a knowledge of the photometric integrator and of the V (λ) correction of the photocell used.

Standard lamps – incandescent

A group of at least six lamps is recommended for each calibration type, three reference and three working. Lamp current and voltage must be measured and recorded using instruments with accuracies of ±0.1% or better. There must be an appropriate warm-up time and the burning times of lamps must be recorded.

References

This section lists publications referenced in this document. The year of publication is not included as it is expected that only current versions of the references shall be used.

Standards and other references

AS 1000 *The International System of Units (SI) and its application*

Amendment Table

The table below provides a summary of changes made to the document with this issue.

AMENDMENT TABLE	
Section or Clause	**Amendment**
New document	This document represents a direct adoption of the former Calibration Application Document Appendix F. The document has been reviewed and updated to reflect the new accreditation criteria documentation structure.