

## **Title: Towards documentary standards for BRDF based quantities**

### **Abstract**

The commercial success of a product can be dependent on its aesthetic appearance. For this reason, industrial manufacturers are continuously looking to develop new attractive visual effects. The control and characterisation of these effects requires the development of a traceability chain based on the Bidirectional Reflectance Distribution Function (BRDF). Primary references and standard artefacts have recently been established at the NMI level and commercial measurement devices have also been developed. However, the field of BRDF measurements still suffers from the lack of standardisation. Proposals in response to this SRT should address this issue by developing, in the framework of CIE normative activity, guidance on the measurements of BRDF, gloss and sparkle.

### **Keywords**

Goniospectrophotometry, gloss, goniochromatism, iridescence, BRDF, colour, appearance, sparkle, materials

### **Background to the Metrological Challenges**

The appearance of a product is important in a wide range of industrial sectors e.g. automotive, cosmetics, paper, 2D and 3D printing, packaging and plastics. Therefore, within the last 20 years, substantial effort has been undertaken by industrial manufacturers to create attractive and sophisticated visual effects, typically using paints with very glossy appearance or deep matt finishes, or pigments that produce iridescence, pearl lustre and texture visual effects such as sparkle, glitter or graininess. Classical colorimeters or glossmeters with few fixed geometries are not adequate for characterising these effects. Manufacturers of spectrophotometer systems are thus developing a new generation of instruments with an increased number of fixed measurement geometries (multi-angle spectrophotometers) and devices able to scan across arbitrary geometries using rotating stages (goniospectrophotometers). Both types of devices usually work in relative mode, by comparison of the measured signal from the sample against that from a calibrated standard. In order to meet the growing demand of calibrations for the instruments mentioned above, calibration laboratories and NMIs have developed absolute goniospectrophotometers.

From a normative point of view, there two issues:

- Existing standards for colour and gloss measurement (ISO 11664 and ISO 2813, respectively) are not totally adequate to characterise sophisticated visual and goniochromatic effects;
- Standards or recommendations do not exist for BRDF and sparkle calibrations.

At a European level there are currently no normalisation activities taking place in the field of spectrophotometry and all the work is being undertaken at the international level, in particular by the CIE (Commission Internationale de l'Eclairage). CIE emphasises the need, provides the international forum for discussion and delivers standards, guidance and procedures that can become international and national standards.

In July 2011, May 2012, and May 2015, the CIE opened the following three reporterships:

- R1-53 "Gloss Perception and Measurement";
- R2-65 "Multigeometry colour measurement of effect materials and metrics for evaluation";
- R2-74 "New visual effects in the field of appearance of materials".

In 2015, CIE Div 2 activity report pointed out the need of new metrics on the topic of BRDF and appearance. In January 2016, in view of the urgent need from industry, CIE has opened a Technical Committee (TC) to initiate this work of standardisation on reflectance-based quantities. In September 2016 CIE will hold an expert

symposium on the topic of BRDF measurement and visual appearance. In 2013, ASTM published the standard E2175-01, "Standard Practice for Specifying the Geometry of Multiangle Spectrophotometers" showing the importance of the subject from the US point of view.

## Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on metrology research necessary to support standardisation on BRDF based quantities.

The specific objectives are:

1. To propose standard parameters for the measurement of the BRDF of particular materials and optical surfaces in the visible range in order to improve the traceability to the SI between users and NMLs, and therefore to allow for better agreement between commercial goniospectrophotometers. The focus should be on i) settings of apertures, ii) illuminated and measured areas, and iii) convergence of light beams.
2. To provide guidance on how to sample the BRDF space efficiently and to propose a minimum number of measurement geometries according to the appearance properties of the specimen. In addition, to propose arrangement for data handling and processing for BRDF measurements when a large amount of data is obtained.
3. To propose a new method for gloss measurement that correlates with visual perception. The contribution should be based on i) reflectance measurements, ii) visual evaluations and iii) definition of a standard gloss observer.
4. To propose a consensual definition of sparkle and graininess measurands and to define procedures for their measurement in correlation with visual scales for sparkle and graininess.
5. To facilitate the uptake of the technology and guidance developed in the project by the measurement supply chain e.g. instrument manufacturers and end-users e.g. automotive, cosmetics, pigments, packaging and 3D printing industries. In addition, to contribute to the standards development work of international standardisation bodies e.g. CIE. Dissemination of project results should take place as early as possible to establish a standardised approach.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP project IND52 xDReflect and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.6 M€, and has defined an upper limit of 0.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

## Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the "end user" community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,

- Transfer knowledge to the industrial sector e.g. automotive, cosmetics, paper, 2D and 3D printing, packaging and plastics.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

### **Time-scale**

The project should be of up to 3 years duration.