APMP PR-S1 comparison on irradiance responsivity of UVA detectors

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Abstract. The APMP PR-S1 comparison on irradiance responsivity of UVA detectors has been carried out in seven national metrology institutes since 2002. Two quantities, the narrow band UV (365±5nm) irradiance responsivity and the broad band UVA (315-400nm) irradiance responsivity of the traveling detectors, have been compared. The results from most participating labs lie within ±5% against the weighted mean.

Introduction

Broadband UVA radiometers are widely used in a variety of industrial, medical, environmental and other applications. There are so far no internationally agreed standard procedures for the calibration of such radiometers and this has caused unacceptable discrepancies in measurement results.

The aim of this comparison is to assess the equivalence of the standards and techniques used for calibration and measurement of UVA irradiance responsivity of photo-detectors among the participating laboratories.

Seven national metrology laboratories (SPRING Singapore, NMIA of Australia, NMIJ of Japan, CSIR of South Africa, ITRI of Chinese Taipei, KRISS of South Korea and NIM of China) have participated in this comparison. SPRING Singapore is the pilot laboratory.

Method, Measurands and Conditions

The comparison was carried out through the calibration of a group of two traveling UVA detectors (Combination of a UV enhanced silicon photodiode, a UVA filter and a quartz wide eye diffuser manufactured by International Light) under irradiation of a UV source provided (a medium pressure mercury lamp with a liquid light guide manufactured by EFOS). The comparison took the form of a star comparison through six phases. Each phase consists of one participating lab plus the pilot lab. The artifacts were first measured by the pilot lab then sent to one lab for measurements then returned to the pilot lab for repeat measurements to check the drift.

There are two measurands in the comparison, the narrow band UV (365±5nm) irradiance responsivity (s_{365}) and the broad band UVA (315-400nm) irradiance responsivity (s_{UVA}) of the traveling detectors with respect to the provided UV source according to their definitions as shown in equations (1) and (2) respectively.

$$s_{365} = \frac{i}{E_{365}} = \frac{i}{\int_0^{\infty} E(\lambda)T(\lambda)d\lambda} \qquad (AW^{-1}cm^2) \qquad (1)$$

where i is the photocurrent of a detector under the narrow band (centre wavelength: 365nm, bandwidth: ±5nm FWHM) UV irradiance (E_{365}) produced by the UV source through a 365nm interference filter. $E(\lambda)$ is the spectral irradiance of the UV source and $T(\lambda)$ is the spectral transmittance of the filter.

$$s_{UVA} = \frac{i}{E_{UVA}} = \frac{i}{\int_{315}^{400} E(\lambda)d\lambda} \qquad (AW^{-1}cm^2) \qquad (2)$$

where i is the photocurrent of a detector under the broad band radiation from the UV source and E_{UVA} is the UVA irradiance produced by the UV source at the detector surface .

The measurement was made under specified conditions using the setup shown in Fig.1. The traveling detectors were overfilled and irradiated normally by the UV beam of divergence smaller than 5° at irradiance levels of ≤0.5 mW/cm^2 for narrow band UV (365nm) radiation and ≤2.0 mW/cm^2 for broad band UVA radiation on the plane of measurement respectively.

Preliminary Measurements

Preliminary measurements were carried out by the pilot lab for characterizing the artifacts (UVA traveling detector, UV source and 365nm filter), before the comparison. These included the spectral responsivity (see Fig.2), spatial uniformity, linearity and temperature effect of the traveling detectors, the spectral transmittance and spatial uniformity of the 365nm filter, and the spectral power distribution, (see

Fig. 2), spatial uniformity of the UV beam as well as short term stability of the UV source.

Correction and Transfer Uncertainty

Corrections were made for the measurement results under different measurement conditions (room temperature, irradiance level) in different laboratories. The experiments showed that the temperature effect and non-linearity effect in the comparison are less than 0.1%.

The measurement uncertainty of each lab and the transfer uncertainty in each phase were combined together as the combined uncertainty of the results of the lab. The transfer uncertainty includes the drift of irradiance responsivity of the traveling detectors before sent to the lab and that after returned to pilot lab, and the spatial non-uniformity of a UV beam.

The drifts of irradiance responsivity are different in different phases (0.01-1.1%). The transfer uncertainty caused by the spatial non-uniformity of a UV beam is less than 0.4% according to the experiment with different aperture radius from 3mm to 10mm in SPRING Singapore.

Results and Conclusion

The preliminary analysis of the comparison results show most of the results lie within ±5% against the weighted mean with a few exceptions.

The degree of agreement of such comparison depends not only on the base scales of spectral responsivity and spectral irradiance of a laboratory, but also equally important on the method used for such measurement. A number of major uncertainty sources have been identified for discrepancies observed in the comparison (e.g. the uncertainty caused by stray light in the measurement of spectral irradiance or spectral power distribution of the UV source). Detailed results and discussions will be reported in the paper.

This comparison also allowed some labs to improve their experimental method and arrangement so as to eliminate previously undetected errors.

Acknowledgements

The pilot lab wishes to thank all the participants for their cooperation which allowed the comparison to be completed in time.

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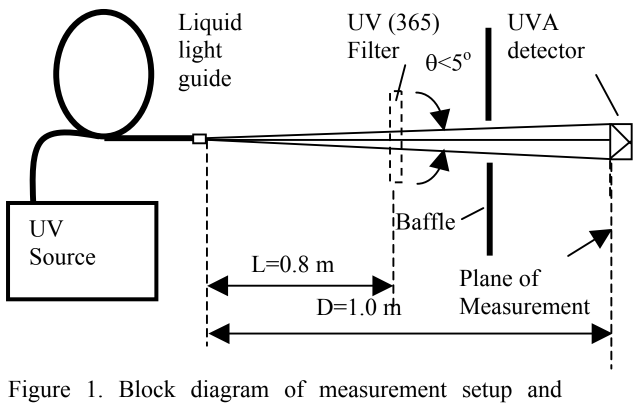

Figure 1. Block diagram of measurement setup and measurement conditions

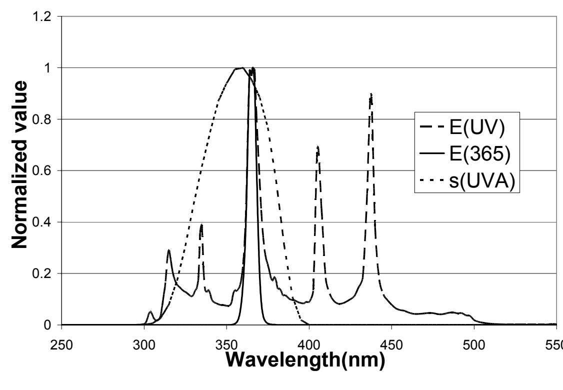

Figure 2. Spectral power distributions of UV source with and without 365 filter, E(365) & E(UV) and spectral responsivity of UVA detector, s(UVA)