The cross-calibration of radiometers in the field by the use of miniature spectroradiometers – towards better control

by

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1 Abstract

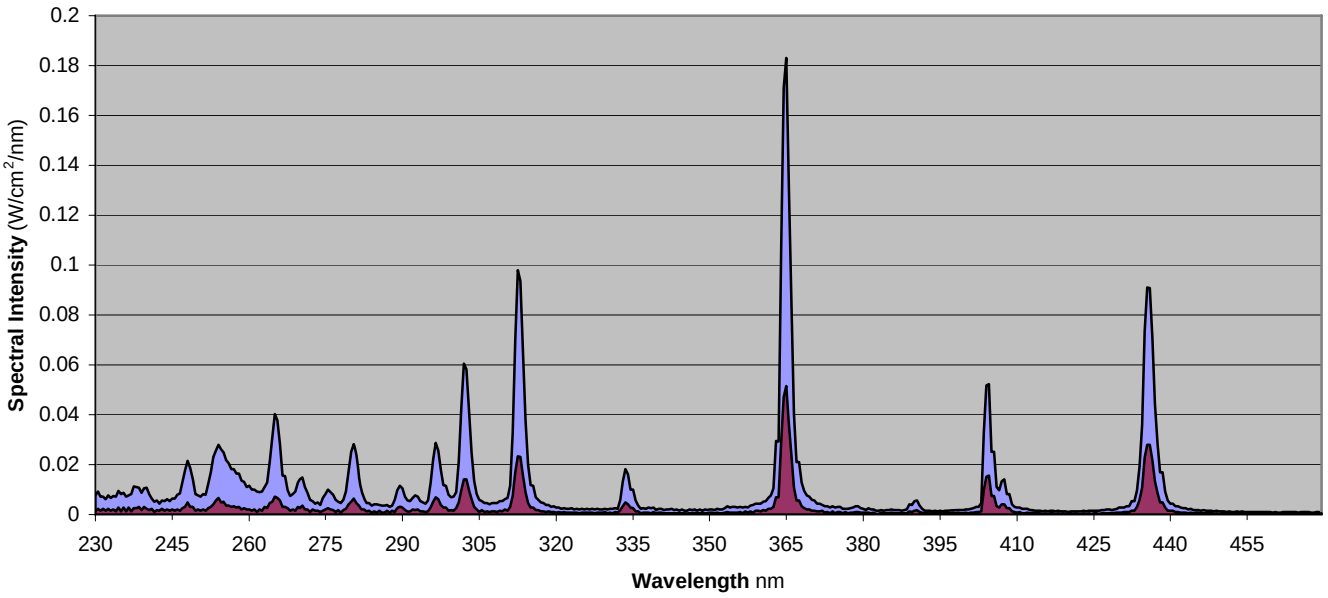
UV radiometers (UV light meters) vary widely in their calibration. The UV radiometer, being a broadband light measuring device **can** be quite accurately calibrated on a known light source of known spectrum, traceable to national standards. However, it is well known, but not generally well acknowledged, that as soon as a different light source of differing, or unknown spectrum is to be measured in the field (as is often the case), the UV radiometer instrument becomes effectively **uncalibrate**d. This explains the reasons no two radiometers are likely to measure the same in the field when **not** measuring a conveniently smooth calibration lamp – the spectra differ. Often it can be the case that radiometers differ in their readings by as much as a factor of 10, despite claims of 'accuracy' of 5 to 10%.
This paper points the way for some of the deficiencies of UV radiometric measurements in the field to be redressed by the use of newly available, diffraction grating based, handheld UV spectroradiometers to cross–calibrate the radiometer in front of the unknown light source to be measured. The UV spectroradiometer's purpose is to accurately measure the spectrum and intensity distribution of the UV irradiance, and to give a calculated total irradiance in the pass band of the radiometer. An adjustment factor can then be applied to the readings of the radiometer for that light source.
The process of cross-calibration can be automated to quite a large extent and such a method is described. The complimentary aspects of both the UV radiometer (cost, speed) and the UV spectroradiometer (accuracy, detail) are effectively brought together to allow much more reliable field measurements to be made of 'unknown' UV light sources using radiometers. Progress in both these types of instrument is allowing the possibility of better regulation of the use of UV sources in the workplace and by the public, with new standards, working practices and also new laws emerging in different application areas. Some recent examples are given.

It is now recognised throughout the UV industry that to expand the applications and effectiveness of the UV process there is a fundamental need for effective and well-understood process control. To achieve this it is essential to effectively measure the UV source under the varying field conditions which can be encountered.

The fundamental parameters of the UV to be measured are the intensity and the wavelength. These parameters, usually uniform in the laboratory, are never thus over time and in field conditions. There is a great deal of difference between making UV measurements in the uniform and controlled conditions of the laboratory bench compared to carrying out variable UV sources in the field under difficult and often hostile UV process environments

Inherent degradation over time of UV sources is the most obvious variable but many others come in to play when the UV source is used in the field environment. Contaminations of the UV Optics, variable cooling, change in the substrate in process all contribute to variable, **effective** UV in the process.

Figure 1. Comparison of spectral data from new U.V. lamp
to a used lamp (lower graph). Especially shows the loss of critical shortwave range
of 240 - 280nm a key area monitored by SOLA-CHECK on press



There are a number of instruments developed over the years which can be employed to measure the UV source. The Spectroradiometer is highly accurate and provides detailed spectral and intensity information. However, being large, cumbersome, complex in operation and expensive, their usefulness has been confined to the laboratory. They are impractical for use in the field environment of the UV process.

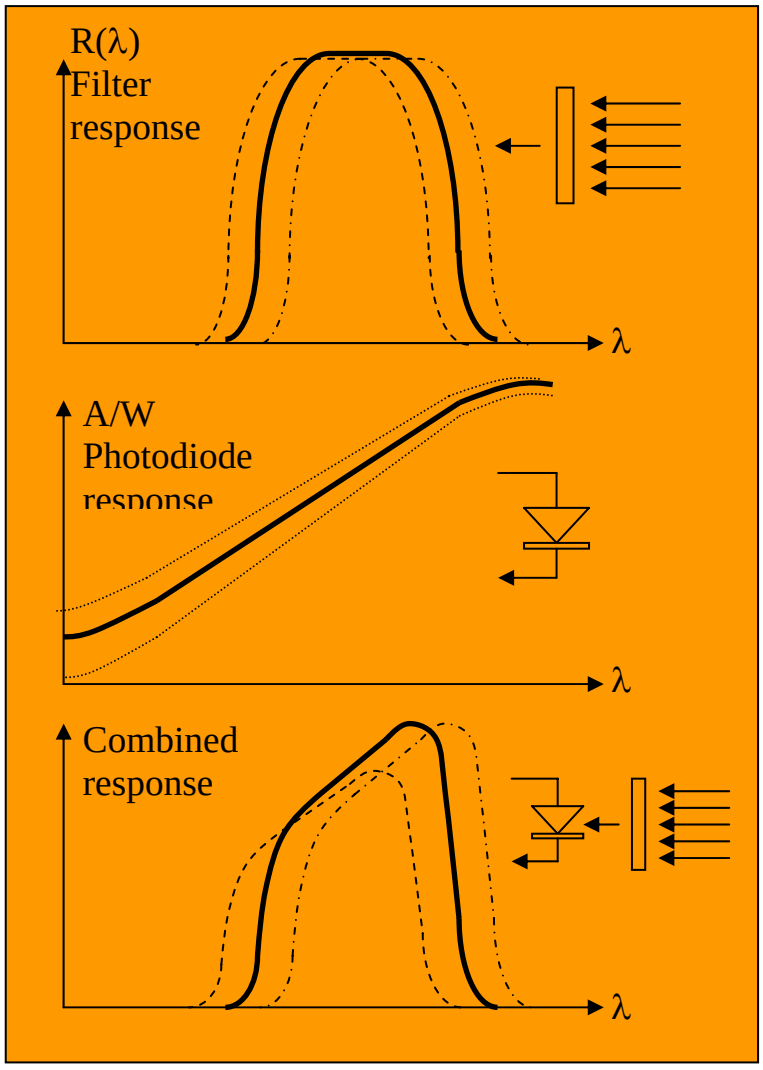
For this reason the Band Pass Radiometer has become ubiquitous for field UV measurements. It is small, simple to operate and low cost. However, to achieve these

desirable traits the Radiometer compromises in accuracy and detail. It remains, for field purposes, a simple indication of relative output of unknown wavelength.

UV radiometers vary widely in their calibration. Being a broadband light measuring device it **can** be quite accurately calibrated on a known light source of known spectrum, traceable to national standards. However, it is well known, but not generally well acknowledged, that as soon as a different light source of differing, or unknown spectrum is to be measured in the field (as is usually the case), the UV radiometer instrument becomes effectively **uncalibrated**. This explains the reasons no two radiometers are likely to measure the same in the field when **not** measuring a conveniently smooth calibration lamp – the spectra differ. Often it can be the case that radiometers differ in their readings by as much as a factor of 10.

Figure 2.

Elements of Radiometer wavelength variability resulting in unknown spectral response against an unknown UV light source.



NEW DEVELOPMENTS IN UV FIELD MEASUREMENT

Since a Spectroradiometer measures the precise intensity and spectral distribution of a UV source this would appear to be the best solution for measuring the UV source as it does in the laboratory. However, for field measurements this can be impractical due to size, complexity and cost of the equipment.

To overcome this difficulty there have been 2 recent developments in UV measurement. When combined these 2 developments can achieve the twin objectives of calibrated spectral intensity with simplicity of use and low cost. These 2 new developments are as follows:

1. UV Process Sensor. This can be installed on-line for continuous UV monitoring

2. Programmable Spectroradiometer. This is a compact, fully portable instrument with spectroradiometric optics used for cross-calibration in the field of the Process Radiometer above.

Figure 3.

On-line, UV Process Sensor with UV probe for access to UV source

Figure 4.

Programmable Spectroradiometer providing wavelength and intensity data for cross-calibration of the On-line Process Radiometer. Includes UV probe to replicate the measuring point.

METHODOLOGY

The On-line Sensor (for continuous monitoring the UV process)

The new optical system of this unit eliminates the use of interference band pass filters which degrade with time and are temperature dependent. 2 channel measurement is provided by wide band gap photodiodes for full UV waveband (220nm to 390nm) and UVC (220 to 280nm) solar-blind. The radiation source can be captured using a probe and cosine diffuser.

Used as a simple radiometer the unit provides 0 to 10 volt analogue output signals for each waveband proportional to the UV radiation seen in the process. Measurements can be related to a programmable baseline of 100% and trip points set when the UV is outside limit.

In addition, the unit is provided with full digital, serial communications via RS485, 2 wire network. Up to 32 sensors can be networked for multi UV source processes and Visual Basic software is provided to suit current Windows platforms.

The Programmable Spectroradiometer (for calibrating the On-line Sensor)

This instrument has spectroradiometer optics measuring the full UV range from 230nm to 470nm. It is equipped with an identical probe as the On-line Sensor. In this way both instruments can replicate the identical UV measurement.

The Spectroradiometer can be programmed to integrate the UV intensity in the same sensing ranges as the On-line Sensor. This calibrated measurement can then be transferred to the CPU of the On-line Sensor to calibrate it on the UV Process.

Effective UV Process Control

By combining these 2 elements of an On-line Sensor with a portable Programmable Spectroradiometer, the twin objectives can be achieved of providing a calibrated on-line measurement with a simple, low cost sensor.

The goal is in sight of achieving effective UV process control in the field by continuous monitoring of the spectra and intensity of UV sources across the very varied fields of UV applications. Typical data produced by such a monitoring system are shown in the graph below. This data can be used to define, characterise and control the UV process

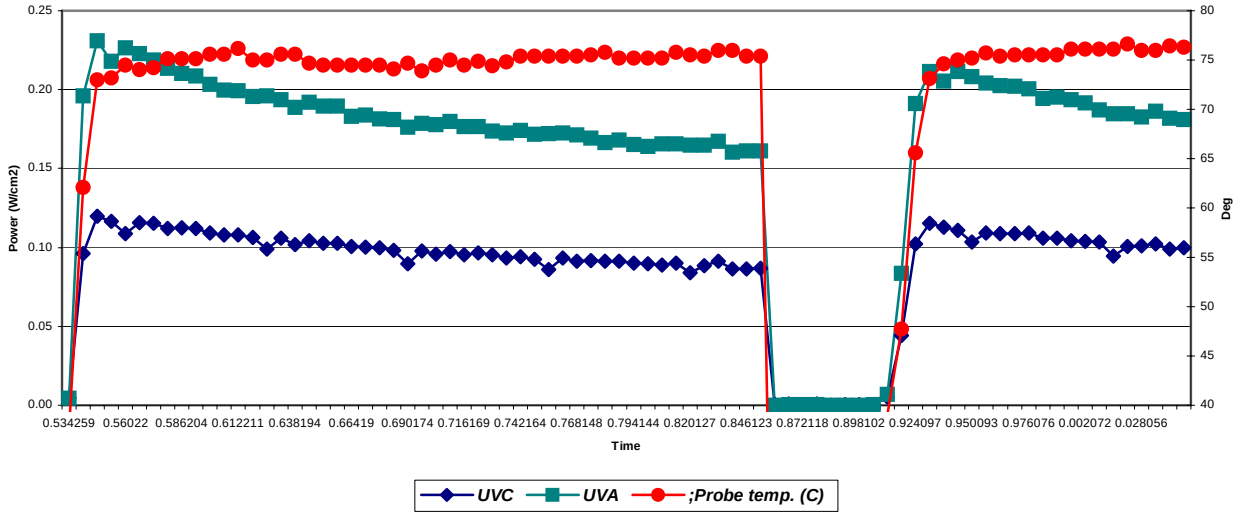


Figure 5. Time series from a UV process tracking the UV intensity in UVC and UVA ranges. Temperature at the probe tip is also monitored.