Developments in electronic UV dosimeters

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Abstract. The Scienterra personal UV dosimeter was introduced in 2010, and has been extensively used for scientific research. The instrument has been refined, and significant improvements are listed. Temperature dependence is characterised and the possibility of temperature compensation is raised. A new method to perform quality control tests and determine calibrations is discussed. A new user interface will be released soon.

Description and discussion

This personal UV dosimeter is a small electronic device manufactured by Scienterra. It consists of an integrated UV sensor and a datalogger, with wireless communication to a small interface box, or cradle. The cradle connects to a computer via USB, and all configuration and data handling are accomplished through this route.

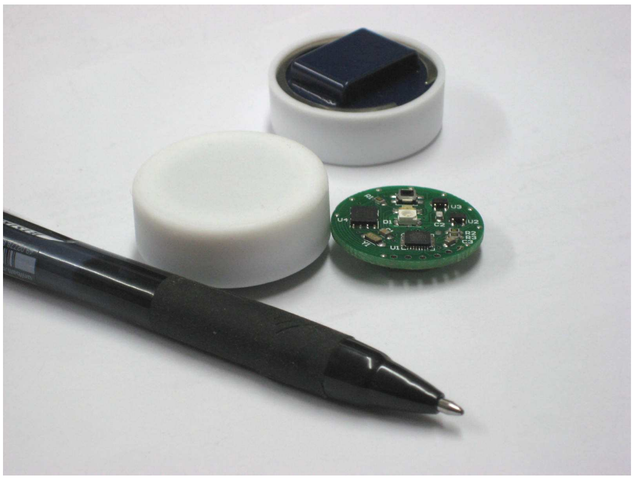

Figure 1. Scienterra personal UV dosimeter

The dosimeter is lightweight and easily worn on a wrist strap or pinned to clothing. It holds 2 megabytes of flash memory, allowing more than one million data points. A data compression technique stretches this figure further, so in practice, the size of the data array is not a limitation.

The device is powered by a CR1632 button-cell battery, which lasts for approximately one year. There is some variation amongst units. While some units have failed after nine months, most have lasted for 500-600 days. More precise statistics are not available.

The dynamic range of the dosimeter is configurable, which allows the dosimeter to be adjusted for various UV environments. The measurement resolution is 1/1024 of the full dynamic range. Because of the adjustable dynamic range, a dosimeter can make full-resolution measurements in both summertime and wintertime conditions. The output values are arbitrary units, which require calibration.

The temporal resolutions of the three measured parameters (UV, temperature, and battery voltage) can be adjusted independently. Measurement intervals can be configured to any value between one second and eighteen hours.

UVA and UVB options are currently available. It is also possible to fit different sensors that operate in a photovoltaic mode.

Worldwide use

This product is being used in many locations around the world. In figure 2, the area of the circle indicates the number of instruments at that location. Some nearby locations have been merged for clarity.

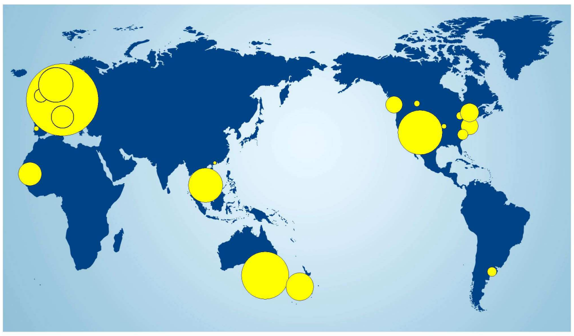

Figure 2. Worldwide distribution of dosimeters in use.

Improvements

Researchers require the ability to install firmware updates, so feature enhancements can be applied as the product evolves. The first major improvement (2010) allows dosimeters to be updated through the USB cradle.

Subsequent updates improved the measurement linearity, the reliability of the wireless communication, and the battery management. Metadata is now embedded into the data file, which ensures that configuration changes are self-documenting.

Electrostatic discharge (ESD) in arid climates has caused instrument failures. In an attempt to fix this problem, a static-dissipative material was tested, but its optical properties were incompatible with UV measurements. The latest firmware update (version 26) allows the dosimeter to recover from ESD events, as the clock and configuration are stored in non-volatile memory every four minutes. To accomplish this without exceeding the stated endurance of the memory, advanced non-volatile memory techniques were implemented.

All structural components have been refined. The original rubber gasket, cut from material of inconsistent thickness, has been replaced with a standard O-ring. The optical qualities of the diffuser have been improved. Production of the metal backplate was brought in-house to improve quality. Powder-coating techniques have also been refined.

Following reports of dosimeters coming apart in the field, it was found that the diffuser was changing shape over time. The diffuser is tooled from extruded PTFE bar stock, which has internal residual stresses. Tooling releases these stresses, resulting in dimensional creep. Revisions to the tooling, together with the other structural refinements, have resulted in a much tighter closure system that is both reliable and waterproof.

Temperature dependence

The temperature dependence of the instrument was measured with a simple experiment. Several dosimeters were placed on a heater and illuminated by a 295nm source. The source was assumed to be thermally uncoupled from the heater. Dosimeters were heated, and allowed to cool to ambient temperature. This was repeated for various levels of UV illumination.

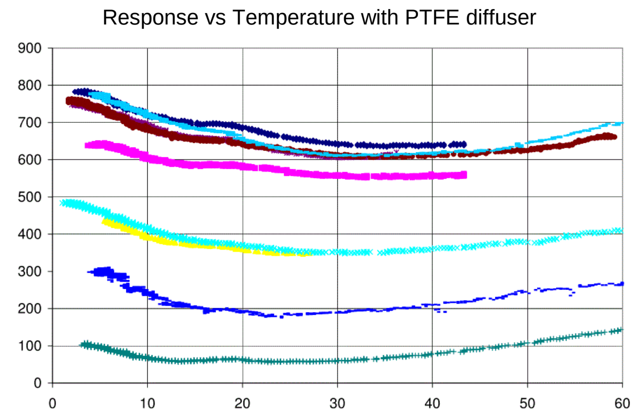

Figure 3. Preliminary results showing how measured UV readings are affected by temperature. The temperature was measured by the on-board temperature sensor.

Preliminary results in Figure 3 show a significant pattern that seems reasonably consistent regardless of the illumination. It is therefore possible to compensate the data for temperature effects. The effect of temperature is perhaps insignificant for dosimetry, as other errors are large; however, if the instrument is used for other purposes, temperature compensation should be considered.

Quality assurance and calibration

New data visualisation tools make it easy to examine each dosimeter for linearity and repeatability. Non-linear dosimeters are identified and removed from distribution. The same data visualisation tools can be used to determine calibrations, when used together with a reference data source. (See Figure 4.)

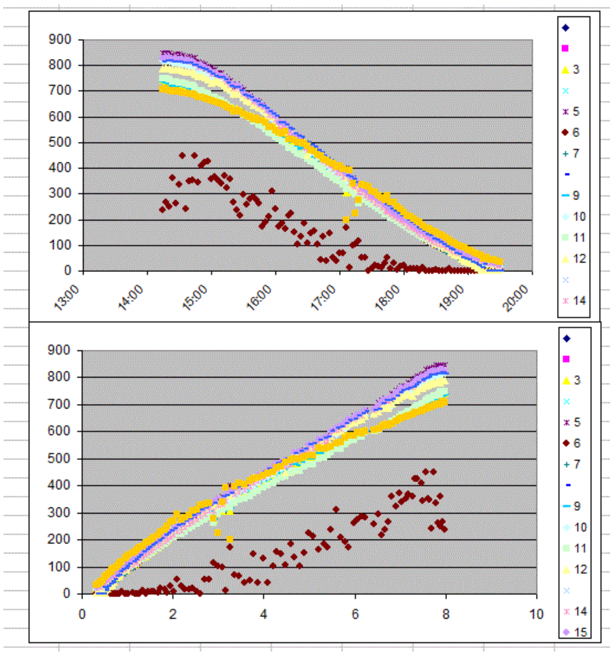

Figure 4. Data visualisation tool used in production shows histograms (top pane) and calibrations (bottom pane). The red and orange lines reveal qualities that would cause rejection.

User interface

The lack of a dedicated user interface has been a hindrance for non-technical users. A new user interface is now available for beta-testing. This interface is more intuitive to use, provides faster data transfer, and includes more automation. Data read from the dosimeter is represented graphically, and data files can be generated automatically in several formats.

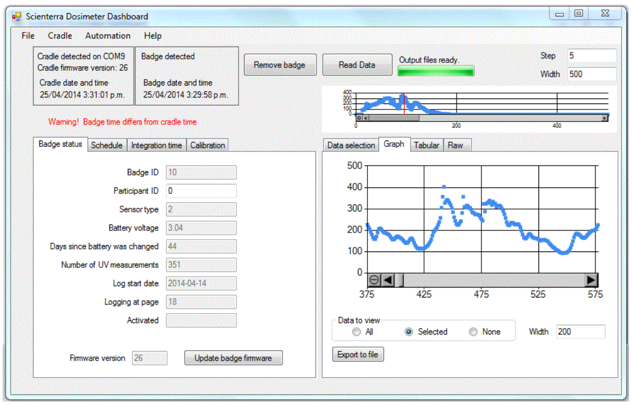

Figure 5. User interface shows cradle and dosimeter general status. Left pane shows dosimeter configuration parameters. Right pane shows detailed dosimeter data.

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