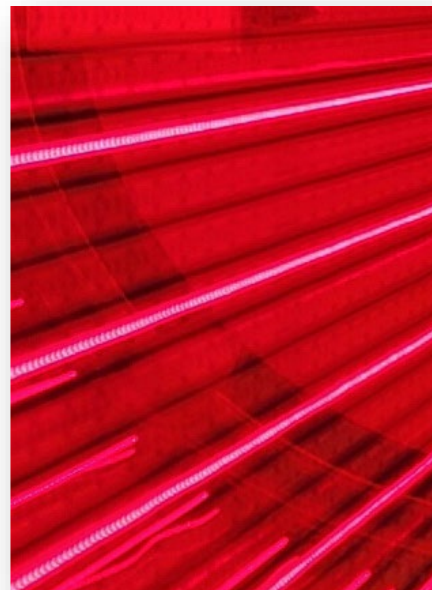
LightLab INTERNATIONAL ALLENTOWN LLC

Verification of Average Irradiance Measurements for PhotoBioModulation Therapy (PBMT) Beds



One of the main purposes of PhotoBioModulation Therapy (PBMT) is to recreate conditions that have been found to be effective and safe in clinical studies so that the subjects of the treatment can maximally benefit. The measurement typically associated with this treatment is irradiance (mW/cm^2) and its time-integrated relative, energy density (J/cm^2). The measurement of irradiance within a PBMT bed, however, is not a simple task and requires measurement instruments that mitigate certain challenges that are inherent to the measurement subject and environment.

Likely Sources of Error in Irradiance Measurement

- Cosine Correction: high-quality cosine correction is required due to the close proximity of the measurements to the source LEDs.
- Spectral Mismatch Error: broadband irradiance meters need a flat spectral response since LED sources have a SPD which is typically very different from the calibration source.
- Calibration traceability: error can be introduced directly by the calibration of the meter.
- Other sources of error: including, for example, linearity of the meter response, thermal stability, and out-of-band rejection.

It is therefore recommended that only high quality, spectral irradiance meters with calibration traceable to a National Metrological Institute (NMI) be used for PBMT bed measurements.

Verification of Results Based on Expected System Radiant Efficiency

In order to verify that irradiance measurements (or claims) are reasonable with respect to expected physical limitations, it is possible to consider the overall system efficiency; that is, the ratio of the total radiant power to the input electrical power. This system radiant efficiency includes the efficiency of the LED driver(s), the radiant efficiency of the LEDs, the optical losses inherent in the optical design (reflectivity of reflectors, transmissivity of the bed surface, etc.), and the overhead of the control systems, fans, and any additional electronics. In general, this system radiant efficiency is typically in the range of 20-40% as a general guideline.

Examples:

***Example 1*:** A PBMT bed is measured and found to have an average bed (bottom surface) irradiance (E_{bed}) of 30mW/cm², and an average lid irradiance (E_{lid}) of 35mW/cm². If the surface area of the bed (A_{bed}) is 13,000cm² and the surface area of the lid (A_{lid}) is 22,000cm², the total radiant power (P_{rad}) emitted by the bed is:

$$P_{rad} = A_{bed} * E_{bed} + A_{lid} * E_{lid}$$

$$P_{rad} = 13{,}000cm^2 * 30mW/cm^2 + 22{,}000cm2 * 35mW/cm^2$$

$$P_{rad} = 390{,}000mW + 770{,}000mW = 1{,}160W$$

So, assuming a radiant efficiency (η_{rad}) of 30%:

$$\eta_{rad} = 100 * P_{rad} / P_{elec}$$

$$P_{elec} = 100 * P_{rad} / \eta_{rad} = 100 * 1{,}160W / 30 = 3{,}867W$$

If this projected electrical power is within a reasonable range of the rated (or preferably measured) electrical input power of the system, it can be used to support the validity of the average irradiance measurements.

Another way to look at the same calculations is to use the irradiance measurements (or claims) and the input electrical power of the system to calculate the system radiant efficiency (η_{rad}) and use it to decide if the result is reasonable:

Example 2: A PBMT bed is claimed to have an average irradiance of 100mW/cm². The surface area of the bed is 13,000cm² and the surface area of the lid is 22,000cm². If the input electrical power of the bed is measured to be 3,200W, the system radiant efficiency of the bed would have to be:

$$P_{rad} = A_{bed} * E_{bed} + A_{lid} * E_{lid}$$

$$P_{rad} = 13{,}000cm^2 * 100mW + 22{,}000cm^2 * 100mW/cm^2$$

$$P_{rad} = 1{,}300{,}000mW + 2{,}200{,}000mW = 3{,}500W$$

So, the radiant efficiency (η_{rad}) would be:

$$\eta_{rad} = 100 * P_{rad} / P_{elec}$$

$$\eta_{rad} = 100 * 3{,}500W / 3{,}200W = 109\%$$

Since there is no physical way that the efficiency of the system can be greater than 100% (and it's probably not even likely to be greater than 50%), it's likely that the claim of 100mW/cm² is incorrect.

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