Photonet National Managed Clinical Network

Dosimetry Protocols for Photonet*
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* This guideline is not intended to be construed or to serve as a standard of care. Standards of care are determined on the basis of all clinical data available for an individual case and are subject to change as scientific knowledge and technology advance and patterns of care evolve. Adherence to guideline recommendations will not ensure a successful outcome in every case, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgement must be made by the appropriate healthcare professional(s) responsible for clinical decisions regarding a particular clinical procedure or treatment plan. This judgement should only be arrived at following discussion of the options with the patient, covering the diagnostic and treatment choices available. It is advised, however, that significant departures from the national guideline or any local guidelines derived from it should be fully documented in the patient’s case notes at the time the relevant decision is taken (this disclaimer applies to all protocols listed above)
1. **Dosimetry Protocol No. 1 Meter Calibration**

Meter calibration should take account of the Scottish UV Dosimetry Guidelines (*Photodermatology, Photoimmunology & Photomedicine* 17:230-233, 2001) and the Guidelines on the measurement of ultraviolet radiation levels in ultraviolet phototherapy: report issued by the British Association of Dermatologists and British Photodermatology Group 2015 (*British Journal of Dermatology*. 2015;173:333-350). The meter may be sent to a calibration laboratory or calibrated in-house using either a lamp-based or detector-based technique. Calibration must be traceable to SI units via a National Measurement Institute (for example the National Physical Laboratory in the UK).

(a) **Calibration Laboratory**

1. The Calibration Laboratory should perform the calibration as described in the outline below. These are not detailed protocols and it is essential that calibration is overseen by a competent physicist who is knowledgeable in ultra-violet radiation dosimetry.
2. The laboratory should have a quality assurance system compliant with ISO / IEC 17025 – General requirements for the competence of testing and calibration laboratories.

(b) **Lamp-based Calibration**

1. Calibration should be traceable to SI units via a National Measurement Institute (for example the National Physical Laboratory in the UK).
2. The meter must be calibrated using the same type of lamp as used clinically.
3. The meter should be positioned at a reproducible distance from a bank of the appropriate type of UV lamps.
4. Meter reading should be compared with that from a calibrated double grating spectroradiometer with cosine angular response ($f_2$ error less than 5%) at a bandwidth of 1 nm.
5. The meter display should be adjusted or a correction factor applied to give the true UV irradiance as measured by the spectroradiometer over the desired wavelength interval.
6. For a UVA meter specify UVA (315-400 nm); for a broad-band UVB meter specify UVB (280-315 nm); for TL01 specify extended UVB (280-320 nm). Alternatively, total UV (250-400 nm) may be specified provided this is clearly stated.
7. Overall uncertainty in the calibration should be less than 15%.
8. The calibration should be performed annually.

(c) **Detector-based Calibration**

1. Calibration should be traceable to SI units via a National Measurement Institute (for example the National Physical Laboratory in the UK).
2. The meter and calibrated detector should be positioned at a reproducible distance from an irradiation spectroradiometer.
3. The meter reading should be compared with that from the calibrated detector at each wavelength.
4. The angular response of the meter should be determined.
5. Meter correction factors should be determined using appropriate spectra for the required type of lamp and angular response for an extended source, typical of a treatment cabin.
6. For a UVA meter specify UVA (315-400 nm); for a broad-band UVB meter specify UVB (280-315 nm); for TL01 specify extended UVB (280-320 nm). Alternatively, total UV (250-400 nm) may be specified provided this is clearly stated.
7. Overall uncertainty in the calibration should be less than 15%.
8. The calibration should be performed annually.
2. Dosimetry Protocol No. 2 Designated Patient Irradiance

Meter calibration should take account of the Scottish UV Dosimetry Guidelines (Photodermatology, Photoimmunology & Photomedicine 17:230-233, 2001) and the Guidelines on the measurement of ultraviolet radiation levels in ultraviolet phototherapy: report issued by the British Association of Dermatologists and British Photodermatology Group 2015 (British Journal of Dermatology. 2015;173:333-350). Overall responsibility for UV dosimetry at each treatment centre should be ascribed to a Responsible Person. This should be a Medical Physicist who is knowledgeable in the evaluation of ultra-violet radiation measurements and risks.

At an Institute of Physics and Engineering in Medicine conference in 2018, the Health and Safety Executive provided written information:

Staff should not enter UV cabins when they are turned on. There are other methods, which are considered reasonably practicable, such as using jigs and stands, to do QA measurements.

Elimination of the risk is the first priority in the hierarchy of controls. Even if they were wearing full PPE it is not acceptable. There is a high risk of significant skin burns and potential for eye damage if PPE were not suitable or adequate.

All risks should be considered when performing dosimetry, including the risk to the patient from inaccurate or inappropriate dosimetry. Use of jigs and stands needs to be justified with evidence that the reported values are equivalent to the Designated Patient Irradiance.

(a) Designated Patient Irradiance

1. Designated Patient Irradiance (DPI) is defined as the mean irradiance incident on a patient of average height and build in a whole body treatment unit at chest, waist and knee level. At each level, irradiance should be determined on the anterior, posterior, right and left surfaces, that is at 12 body sites.
2. Measurements should be carried out on the investigator / phantom in the treatment cabin in the same position as adopted by the patients.
3. It is desirable that the patient should turn during treatment to average out any areas of high or low irradiance. The investigator / phantom should seek to reproduce the practice adopted at the treatment centre.
4. Lamps should be operated for a 5-minute warm-up period before irradiance measurements are made. The DPI may be measured by the direct or indirect method.
5. The dose received by the patient in the treatment unit is taken to be the product of the DPI and duration of exposure.
6. Measurements may be carried out using different direct or indirect methods provided they can be related to the DPI as defined above. If the method used introduces a discrepancy <5% this is acceptable without correction to the DPI, provided this is documented.

(b) Direct Method
1. The investigator / phantom must measure the irradiance at the specified sites, whilst standing in the unit.
2. Care must be taken to ensure that the field of view of the meter is not restricted by any part of the body or clothing.
3. The investigator / phantom should take readings in more than one orientation if the practice is for the patient to turn during treatment.
4. The DPI should be calculated from the mean irradiances.
5. All measurements should be properly documented.

(c) Indirect Method
1. The irradiance from each bank of lamps in the treatment unit should be measured, in a reproducible manner, while the unit is unoccupied.
2. The mean value of these measurements is multiplied by a correction factor to obtain the DPI.
3. The investigator should determine the appropriate correction factor, either by direct measurement or reference to published values.
4. Determination of the correction factor should be properly documented.

(d) Safety
1. Ultra-violet radiation is potentially harmful.
2. A risk assessment should be carried out.
3. Safety guidelines should be issued to cover all staff working in the vicinity of the treatment units.
4. Staff should exercise prudent avoidance and ensure that skin and eyes are not exposed unnecessarily to ultra-violet radiation.

(e) Lamp Replacement
Refer to Photonet Lamp replacement protocol available on Photonet website www.photonet.scot.nhs.uk
3. Dosimetry Protocol No. 3 Calibration of Handheld MED Testers

Below are a list of acceptance and / or quality control tests for UV handheld MED / MPD testers.

1) Determine the spectrum of the handheld MED tester
2) Determine the change in output with time
3) Determine warm-up, exposure and cool down periods
4) Determine the percentages of the apertures on the handheld MED tester
5) Check the surface temperature of the MED tester during the exposure period.

It is important to test the handheld MED tester in the manner in which it will be used - without disassembling or removing any components. Often the apertures of these handheld devices are small and therefore a small input optic (diffuser) to your measurement equipment is critical. In these circumstances, the light being measured should always overfill the input optics of the measurement device, otherwise the accuracy and repeatability of measurements will be poor. Appropriate measurement devices are described in the Guidelines on the measurement of ultraviolet radiation levels in ultraviolet phototherapy: report issued by the British Association of Dermatologists and British Photodermatology Group 2015 (British Journal of Dermatology. 2015;173:333-350). These tests do not need to be performed in the order given here and indeed it may be possible for multiple checks to be performed simultaneously.

3.1 Determine the spectrum of the handheld MED tester
Ideally the handheld MED tester spectrum should be measured with a calibrated spectroradiometer, either a double grating scanning system or an array spectrometer. Details of using these devices for UV measurements can be found in the Guidelines on the measurement of ultraviolet radiation levels in ultraviolet phototherapy: report issued by the British Association of Dermatologists and British Photodermatology Group 2015 (British Journal of Dermatology. 2015;173:333-350). This check may be performed with a scanning system after a sufficient warm-up time such that a stable output of the lamp has been achieved (see 2. Determine the change in output with time) or during the anticipated exposure period if using an array spectrometer (see 4. Determine warm-up, exposure and cool down periods).

If these measurement systems are not available, it may be sufficient to confirm with the manufacturer the spectrum of the handheld device. For extra reassurance often the lamp within these units can be accessed and the model and manufacturer of lamp determined. Details of the lamp spectrum can then be obtained from the lamp manufacturer. However it is important to highlight that the spectrum that is clinically relevant is not just that of the lamp but the lamp combined with any material that the light passes through prior to impacting the skin.

3.2 Determine the change in output with time
It is important to determine how the light output of the handheld MED tester varies with time, this will influence the determination of the warm-up and cool-down period. Position a detector over one of the apertures, switch on the unit and record the readings at regular intervals (without moving the detector) – for example every 30 seconds. Recording the readings can either be done manually, with a data logger attached to the UV meter or with the UV meter’s own in-built data recording function. Record measurements until the readings become stable, however be careful not to exceed the manufacturers recommended “on” time which should be detailed in the user manual.
3.3 Determine the warm-up, exposure and cool down periods

After it has been determined how the output varies with time the warm-up period, exposure time and cool-down period can be determined.

a) Warm-up period

You may wish to allow a warm-up period long enough that the lamp’s output becomes stable. This has the benefit that when the device is used clinically, the timing of placing the unit on the skin is not overly critical. The disadvantages are that the surface of the unit can become very hot and the device “on” time may exceed the manufacturer’s recommended “on” time.

Alternatively you may wish to shorten the warm-up period and use the device before the output is stable. This has the benefit of a lower surface temperature of the unit and a faster turn around time for the user. However the disadvantages are that timing of placing the unit on the skin is critical when used clinically and you must satisfy yourself that the dose delivered to the skin is repeatable.

b) Exposure period

If the warm-up period has been chosen such that the lamp’s output is stable then the exposure period can be determined by measuring the irradiance (mWcm$^{-2}$) of the highest output aperture after the warm-up period. The exposure time is then equal to the prescribed dose divided by the irradiance. Ensure that the input optics of the measurement device are in the same position that the skin would be and that they are being overfilled by the light from the MED tester.

If the warm-up period has been chosen such that the lamp’s output is not stable, then the exposure period should be determined by measuring the radiant exposure (mJcm$^{-2}$) of the highest output aperture. Most UV meters will have a function that allows measurement of the radiant exposure. Once again ensure the input optics of the measurement device are in the same position that the skin would be and that they are being overfilled by the light from the MED tester. Position the detector over the highest output aperture, immediately upon reaching the end of the warm-up period, begin the measurement of radiant exposure on the UV meter and start a timer. When the radiant exposure reaches the prescribed dose, stop the timer. The timer result is the exposure time required to deliver the desired dose / radiant exposure.

c) Cool-down period

The cool down period should be selected at a length of time such that, following cool down, the unit can be switched on again and, following warm-up, the exposure period measurement repeated and the same result achieved. Determination of the cool down period will require trial and error. Start with a 10 minute cool down period, if the exposure period result is not the same as the first run then increase the cool down period and repeat. If the exposure period result is the same as the first run then decrease the cool down period and repeat. Continue until you have reached the shortest cool down period acceptable.

Once the warm-up, exposure and cool-down periods have been determined cyclical testing should be performed to ensure consistency each time the unit is switched on.
4. **Determine the percentages of the apertures on the handheld MED tester.**

It is most likely that the aperture percentages will need to be determined individually.

a) If you have chosen a warm-up period such that the output of the lamp is stable, it may be possible to take irradiance measurements from each aperture consecutively, without switching the unit off and being mindful that the lamp will have drifted slightly between the first and last aperture. It may be useful to repeat the test moving the detector in the opposite direction and then take an average of the results.

b) If you have chosen a warm-up period such that the output of the lamp is not stable, then only one aperture can be measured per warm-up, exposure, cool-down period. Measure the radiant exposure of each aperture with a fixed exposure period as determined in 3.

Various researchers are attempting to determine the aperture percentages simultaneously, the most common method being the use of UV sensitive film. However, to date, there is no published literature on such a technique.

5. **Check the surface temperature of the MED tester during the exposure period.**

The surface temperature of the handheld MED testers has been reported to reach high temperatures (up to 70 degrees Celsius). It is therefore important to measure this surface temperature for the warm-up and exposure period determined previously. Various temperature recording methods can be used including the use of thermocouples or thermal cameras. This test can be performed at the same time as earlier tests and may assist with your decision of the warm-up period.