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NEWSLETTER

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Editor: Thomas P. Coohill, Depts. of Biology and Physics,
Western Kentucky University, Bowling Green, KY 42101 tel.: (502) 745-3697

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ASP - Newsletter

Timing

This list will help insure that members are aware of the time delay between receipt of material by the Editor and its appearance in the Newsletter. The delay is due to two factors - a) the Editor needs three working days to prepare a copy-ready submission by the end of each month and b) the printer needs four weeks to receive, print, and send the Newsletter out to the membership. Week-ends and holidays are accounted for in this list.

Material received by Editor	Will appear in Newsletter issue
Feb. 23	April
March 28	May
April 26	June
June 13	July-August (joint issue)
July 26	Sept.
August 26	Oct.
Sept. 27	Nov.
Oct. 26	Dec.
Nov. 25	Jan.
Dec. 20	Feb.
Jan. 26	March

Please retain this sheet for your information. Feel free to call me at (502)745-3697 should you have any questions. Don't forget that we will publish photographs.

Proceedings Available

The proceedings of a workshop entitled "Biological Effects of UV-B Radiation" sponsored by the EPA (U.S.) and the German Ministry of Research and Technology that was held in Munich in May of 1982 are now available. Free copies can be obtained from Dr. H. Bauer, Gesellschaft fur Strahlen -und Umweltforschung, Bereich Projektträgerschaften, Josefsphitalstr. 15, D-8000 Munich 2 (FRG)

Meetings

March 3-6, 1983, Environmental Mutagen Society, San Antonio Hyatt, San Antonio, TX

June 19-23, 1983, Health Physics Society, Baltimore Convention Center, Baltimore, MD

July 31-August 3, 1983, Society for Risk Analysis, Grand Hyatt Hotel, New York, NY

Sept. 13-16, 1983, Visual Pigments, Univ. of Bristol England. Sponsored by the British Photobiology Society and the Association for Research in Vision and Ophthalmology. Contact Dr. Aubrey Knowles, Dept. of Biochemistry, Univ. of Bristol, Bristol BS8 1 TD, England.

UV Dosimetry: Physical Units

by: Ronald E. Davies - Temple University

The literature describing the exposure of a target to a source of non-ionizing radiation contains a jumble of terms intended to indicate the parameters of such exposure. Many of these terms are at best uninformative, and at worst misleading. For at least five decades there have been serious and commendable efforts to produce consistent, standardized measurement descriptions and units, culminating in the widely accepted SI terminology elaborated for photophysical applications by Rupert and Latarjet. Aside from some rumblings over etymology, difficulties have arisen in the photobiologic use of this terminology for two unrelated reasons: one concerns the availability of information implicit in the descriptive units; the second relates to use of "input" terminology to indicate consequences. Difficulties of the first type are simply ignored in the substitution of the term "fluence" for the older (admittedly imperfect) term "surface dose" as if the newer term required no further qualification. Problems of the second type arise when effectiveness descriptions are quantified in physically accurate input terms which lack defined transfer functions relating input to consequences. By analogy, predictions of the <u>impact</u> of a projectile require knowledge of projectile parameters (mass, velocity, direction); predictions of <u>effect</u> require knowledge of target parameters unrelated to the impact description.

If a collimated beam of radiation is incident on a surface, the intensity per unit surface area is proportional to the <u>sine</u> of θ, the angle of incidence on the surface (or the <u>cosine</u> of $90 - \theta$, the deviation from normal incidence). For a perfect flat-plate detector the intensity from an omnidirectional source is the sum of all directional components, each weighted by the sine of its angle of incidence to the detector. To the extent that a detector exhibits this type of directionality it is said to have a "cosine-law response." The unfortunate term "cosine-corrected" is sometimes used to describe a detector; whether this is incorrect or only misleading depends on its interpretation. Since the response of most detectors is an integral containing no directional information, it is not possible to "correct" for deviations from flat-plate response (such a correction would require specific information from several directional detectors). What is actually meant, in almost all cases, is that the detector has been designed and engineered to minimize critical-angle reflection losses and to maximize its effective acceptance angle. To the extent that the design is successful, directional response will approximate the "cosine-law" ideal. To achieve this result the design may involve relative overweighting of near-tangent radiation by the use of a dome-shaped receiver. It is even possible to design such a receiver to be equally responsive to radiations from all directions (or, more frequently, from 2 pi radians): such a system would <u>not</u> exhibit a cosine-law response. The term "cosine correction" actually connotes the application of empirical design criteria to create a detector which adequately mimics an ideal flat detector.

The measurement concept embodied in the terms "fluence" and "fluence rate" specifically provides for omnidirectional irradiation. The fluence rate is the integral of all radiations arriving at a target (of small but finite cross-section), divided by the cross-sectional area of the target. Since no directional weighting is applied to any of the components, and since the denominator is constant, the target must be spherical, presenting a constant cross-section to all input radiation. Such a measurement clearly does not exhibit "cosine-law" adherence. As mentioned previously, it is possible to design omnidirectional integrating detectors; the readings from such detectors will correspond to the definition of fluence rate. On the other hand they will not indicate the intensity of irradiation of a <u>surface</u> at the detector location, and will not be affected by changes in source location (at fixed distance).

Fluence and fluence rate measurements involve important and valuable descriptions of an irradiation source. They are not, however, equivalent to the target-specific concepts of surface dose (more correctly, incident dose on a plane) or intensity. The total load on a three-dimensional target is properly described by concepts derived from fluence; for two dimensional targets such as skin or leaves, the cosine-law weightings embodied in planar surface dose are more appropriate. Regardless of preference, however, it should be recognized that most detectors are not uniformly omnidirectional and many sources are not unidirectional; thus most irradiance measures are not of "fluence rate." Most specifically, measurement of "fluence rate" with a "cosine-corrected detector" is a conceptual impossibility for anything but collimated radiation at normal incidence.

For most practical sources, the spectral region effective for biological responses represents only a tiny fraction of the total energy distribution. Changes in quantitative or qualitative distribution in this region could produce major alterations in efficacy but be virtually undetectable in measures of total energy. An obvious answer is to measure the composition as well as quantity of radiation, but this can be technically complex and expensive. Practical solutions require compromises and approximations. Difficulties arise if the investigator is unaware of the nature and limitations of these approximations, and presents "measurement" data which are inappropriate or inadequately defined.

A common approach is to use a spectrally selective detector, usually with maximum sensitivity in the region of interest. If the spectral quality of the source is constant (and if geometry is reproducible) the readings of such a detector will be related to input energy by a transfer function (the spectral sensitivity function or response spectrum). Typically the user is unaware of the transfer function; instead, the manufacturer will employ the detector response spectrum and an emission spectrum representative of the intended source to compute calibration factors. These calibration factors may be applied by the user to convert arbitrary detector response units to energy units, sometimes restricted to particular spectral regions and sometimes "full-spectrum", almost always in recognized physical units of intensity (e.g. watts per square meter) or its time integral (e.g. Joules per square meter). In a common refinement the calibration factor is incorporated directly into the metering system, providing a direct readout in physical units.

Assuming that such a system is appropriately designed, accurately calibrated and correctly used, the results will still need to be described with qualifications. If, for example, the instrument calibration is intended to provide intensity measurement of watts per square meter of UVA, the implication is that the readings are scaled to represent what would be obtained if the detector response was absolutely flat with "vertical" cutoffs at the limits of UVA (320-400 nm). This qualification is minor if the source emission is largely confined to the UVA region (e.g. fluorescent BLB lamps with blackglass envelopes); the reading equally well describes UVA emission and total emission. On the other hand, if an appreciable amount of emission is at other wavelengths (e.g. cool white fluorescent sources) it is imperative to specify the spectral region implied in the calibration. It should be obvious that the "absolute" energy readings of such detectors will be meaningful only if the source spectrum corresponds to that used for calibration. Small, though occasionally important, errors can be introduced by sampling variation of individual sources from the "typical" spectrum used in calibration. Larger errors may occur if the source spectrum differs systematically from the calibration spectrum: a detector calibrated for a BLB source will give erroneous readings for a BL lamp, and the amount of the error will depend on the relative sensitivity of the detector to the visible output of the BL. Much greater errors will result if the source is substantially different from that used for calibration: "blacklight" meters specifically intended for use with a "Wood's Light" (a mercury arc with a Wood's filter, a nearly monochromatic source of 366 nm radiation) are not calibrated to give accurate readings with BL (fluorescent blacklight) sources, or any broad-spectrum source. Such detectors can provide useful relative information concerning the energy delivered from any specific source under various conditions (provided that the delivered spectrum is not altered), but the nominal physical units of such readings will be erroneous by an amount which is not usually known.

Thus as a general rule, literature values expressed as energy units of intensity or time-integrated intensity must be regarded with suspicion unless it is clear that the detector was calibrated specifically for the source spectrum, or unless the author provides a defined basis for subsequent calculations. Furthermore, if the energy units are intended to describe only a portion of the source spectrum the limits of that portion and the basis for its estimation should be presented. Source spectral characteristics should also be presented either explicitly or by accessible reference, not merely by manufacturer and model number. Finally there should be sufficient geometric information about source and detector to classify the measurements as either point oriented (fluence or fluence rate) or plane oriented (surface dose or surface intensity). With this information the reader knows something about impact; whether or not he can predict effect will be considered in a subsequent discussion.

Note: Please address any responses to this article to Ron Davies directly - not to the Editor.

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