Committee Report

Report of Special Research and Investigation Comittee on Ultraviolet Iraddiance Measurement

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1. Introduction

Ultraviolet radiation has been applied to a wide range of industries, and since it is pollution-free, the demand is sprea-ding toward sterilization and cleansing. Method to measure the ultraviolet irradiance, however, has not been established yet, and there is no unified standard to specify the measuring device; these have caused various confusions.

Under the circumstances, the industries concerned requested the Illuminating Engineering Institute of Japan to study and survey the methods to measure ultraviolet irradiance; the Research and Investigation Committee for Ultraviolet Irradiance Measurement started 1991, which was graded up to a special research committee with a special budget of the society in 1993, and has had vigvigorous activities. The committee had nineteen members as mentmentioned later and had fifteen meetings. It carried out a number of experiments, measurements and surveys, andprepared a report. The average attendance rate at the fifteen meetings. was as high as 88%, which is worth attention and indicates the vigorousness of the participants.

Activities of the committee are classified into the following two categories, and accordingly, we divided the report into the following two parts:

(1) Status of applying ultraviolet irradiation to industries (types, examples, etc.), and the measured radiometric quantities(regarding wavelength and space), environment of measurement, and status of corresponding measuring device for industrial use (eg., ultraviolet irradiance meter), specification for measuringdevices based on analysis of users' requirement and comparison of specifications based on opinions of the measuring device manufacturers (Part 1, 87 pages).

(2) Type of standard device to measure irradiance, selection of standard device, graduation of standard device, change with lapse of time, skill and means to measure spectral irradiance using standard device, etc. (Part 2, 71 pages).

The contents are outlined in chapter 4 of this paper, while the report is separately prepared and distributed by the Illuminating Engineering Institute. We appreciate it, if the people concerned make full use of it.

2. Outline of Activity

The committee studied and surveyed two classified items as mentioned earlier.

2.1 Surveys on applying and measuring ultraviolet irradiance in industries.

We summarized ideal measuring devices, their required specifications, etc., surveying the examples of applying ultraviolet irradiation in industries, including measuring devices and methods, as well as the performances of current measuring devices and specifications and the users' satisfaction. For these purposes,we had twelve presentations and discussions, approximately one hour each, with the specialists in the related areas. We also visited the Japan Electric Meters Inspection Couporation to study the current status, and obtained information through a questionnaire.

The presentations and discussions consisted of the following subjects: medical care (1), semiconductor (1), printing (5), water purification (5), sterilization (5), sun and sky light (1), light sources(1), and measuring method and devices(3).The resultshowed that water treatment, surface cleanup, and sterilization occupy a considerable share of ultraviolet irradiation in indus-tries. The irradiation was featured by a long radiation source and an extremely short distance (less than a few centimeters), which confirmed that measuring the irradiance from an extremely near source and with a large incident angle was to be studied. Also, the ultraviolet irradiance meter used in industries werepointed put to have the following problems:

(1) Differences between devices and between calibration methods, especially, different types of the radiation source causing considerably different levels of error,

(2) Insufficient performance depending on the incident angle, and so forth. Regarding these issues, we exchanged vigorous discussions with the measuring device manufacturers to summarizethe numerical values into Table 1; according to the manufacturers, these values may almost satisfy the requirements excluding the receptor thickness. On the other hand, unifying calibrationmehods is the greatest issue, requiring further investigation, and the committee will arrange to make a proposition to the industries including the Japan Electric Lamp Manufacturers Association.

Table 1 Severest Specifications for Radiometer Head of UV Detector

	Required specification	Objective of device
Size of radiometer head (Size of recieving surface, circular/square,etc)	Recieving surface: ϕ20 mm	UV irraidance measurement of microwave operating radiation sources for printer
Thickness of radiometer head (Distance from bottom to reccieving surface)	1.5mm	UV irraidance measurement of microwave orerating radiation sources for printer
Incident angle range (1) absolutely grasping irradiation	0 - 80°	Sterilization of water, food packaging material and food container; Optical oxidation and optical CVD
Incident angle range (2) satisfying cos θ characteristics	80°	UV hardening of resin, surface coating
Upper limit of service temperature	80°C	General industries
Measurement time at service temperature	Continuous use possible	Controlling printer exposure; controlling rradiation to cure resin, paint and ink

2.2 Practical ultraviolet irradiance standards

The second issue is to measureng the ultraviolet irradiance, especially to arrange a standard device, which is essential to the measurement, for the use at the industrial site. One of thestandard irradiation sources in Japan is the halogen lamp supplied by the Japan Electric Meters Inspection Couporation, while its ultraviolet irradiance is very weak, demanding too high levels of skill and device for a practical measurement at site. GL-15, a practical standard of bectericidal lamp for 254 nm line irradiation frequently used in industries, is generally extremely difficult to graduate using a halogen lamp. The committee, therefore, set the following measures regarding 254 nm irradiance standard:

(1) Setting a detecter standard (S1337-1010BQ silicone photodiode) as a practical standard to calibrate the 254 nm line irradiance and the spectral responsivity of UV irradiance meters.

(2) Recommending the use of radiation source (GL-10, 15, etc.) through the method specified to graduate an radiation source using a standard detector, since the past experience shows that a standard radiation source is more convenient as a 254 nm irradiance standard used at site. Methods described in reference 1 were used to select and to age the radiation source.

(3) Examining the accuracy in graduating spectral responsivity, which is necessary for setting a detector standard; the responsivities obtained at four laboratories (two national and two private institutes) in Japan were compared, which were confirmed tocoincide practically (reference 2).

As a standard for the wavelengths other than 254 nm, a continuous spectrum was considered to be convenient, and thus a 150 W Xe lamp was selected as a candidate. Stability and reproducibility in a repeated on-and-off test in a short period of time, which is required for the standard, were tested with the attendance of almost all the committee members. The result confirmed that L2273 (Hamamatsu Photonics) could be a standard with a ultraviolet irradiance change of approximately 2% or lower for one hundred on-and-off's during a test period of one hundred hours. It was authorized that the Japan Electric Meters Inspection Couporation is to graduate spectral distribution of the lamps, and to supply them.

2.3 Supply and maintenance of standard

The graduation must, as a practical standard, be free from technical problems, and also must be maintained to become a national standard. For the total luminous flux of fluorescent lamps, the industry has established an authorized system, and has ensured the users' reliance. The same effort is demanded for a further progress of the ultraviolet irradiation applications.

The Electrotechnical Laboratory can provide the spectral responsivity characteristics, specified by the committee, on a standard detector of 250 nm-1100 nm, wavelength range whileas mentioned earlier, the Japan Electric Meters Inspection Couporation will be able to provide a practical spectral irradiance standard, based on that of a halogen lamp, of a Xe lamp. On the other hand, a system should be organized whithin the industry to maintain and control the 254 nm standard, or thepractical standard values of the ultraviolet irradiance meters. This should be discussed by the industrial groups such as the lamp manifactures. We are making efforts to realize the idea in the near future with a sympathy of the people concerned.

3. Reports

Under the circumstances mentioned above, we divided the committee report into two parts: (1) Industrial Applications of Ultraviolet Irradiation and Updates of Practical Measuring Devices and Methods, and (2) Standards and Measurement of Ultraviolet Irradiance.

4. Conclusion

We wish that the research and survey by the committee may contribute to a further progress of ultraviolet irradiation application. We also would like to express our gratitudes toward the committee members who cooperated with us, and toward Ushio Electric Inc. and Hamamatsu Photonics Ltd., who willingly offe red us their experimental facilities.

References

(1) Takashi Azuma: J. Illum. Eng. Japan 57-4, 196 (1973)
(2) Nakagawa et al.: J. Illum. Eng. Japan 77-10, 658 (1993)