



Illuminating
ENGINEERING SOCIETY

RECOMMENDED PRACTICE:
ULTRAVIOLET GERMICIDAL
IRRADIATION (UVGI)

AN AMERICAN NATIONAL STANDARD

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ANSI/IES RP-44-21

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Publication of this document
has been approved by IES.
Suggestions for revisions
should be directed to IES.

**Prepared for IES
IES Photobiology Committee**



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1.0 Introduction and Scope

1.1 Introduction

The 2014 outbreak of the Ebola virus and the recent global spread of the SARS-CoV-2 virus (and its resulting disease, COVID-19) have renewed interest in the use of ultraviolet irradiation for disinfection. UV radiant energy was first used for disinfecting surfaces in 1877,^{1,2} for water in 1910,³ and for air in 1935.⁴ Ultraviolet germicidal irradiation (UVGI)'s use in recent decades has been largely limited in the U.S. to water treatment facilities, applications where it is hidden (shielded) in heating and air-conditioning ductwork, and use in biological laboratories. UVGI is being used in many countries to control airborne transmission of tuberculosis (TB). In addition, some U.S. healthcare facilities are now using autonomous mobile units ("robots") to add enhanced hygiene to patient rooms in order to reduce hospital-acquired infections. More-widespread use of UVGI is often limited by safety concerns, but these are relatively manageable. UVGI related injuries typically resolve within 24 to 48 hours, and potential increased risk for skin cancer is relatively insignificant and minor compared to a true sunburn⁵ and to potential infection prevention. Most of the public are not aware of its unique value in disinfection of air and contaminated surfaces.⁶ More widespread use of UVGI technology in a wide range of applications should be encouraged in the battle against the COVID-19 pandemic, and this is an urgent matter. At the same time there is a longer-term interest at stake, as UVGI technology can be a vital tool in mitigating and preventing many more current and future viruses. COVID-19 will not likely be the last pandemic.

The term *germicidal UV* (GUV) is sometimes used to refer to ultraviolet radiant energy that can be used to inactivate bacteria, protozoa, mold spores, fungi, or viruses. When the process is applied in a given location, it has generally been referred to as ultraviolet germicidal irradiation (UVGI). Because of the public's concern about *ionizing* radiation (e.g., X-rays and gamma rays), the term *GUV* is sometimes used to avoid needless concerns about a link with that type of radiation, although there are other potential safety concerns (see **Section 5.3**). Another non-technical term is *germicidal light*, although

"light" is usually considered only visible radiation.⁷ Others may refer to the spectral band and term it *germicidal UV-C*.

1.2 Scope

This document addresses the use of germicidal ultraviolet radiation for disinfection of room air and surfaces; potential dangers for humans; potential effects on materials and plants; UVGI technologies; and safety measures and precautions. It does not address photobiological safety with respect to emission or exposure limits; those topics will be addressed in an update to *ANSI/IES RP-27-20, Recommended Practice: Photobiological Safety for Lighting Systems*.⁸

2.0 Definitions and Abbreviations

2.1 Definitions

air changes per hour (ACH): A measure of the clean air volume added to or removed from a space in one hour divided by the volume of the space. Sometimes called air exchange rate.

equivalent air changes per hour (eACH): The number of ACHs that would be needed in order to provide the equivalent inactivation rate of airborne bacteria or viruses using an upper-room UV-C system.

excimer lamp: A discharge source of ultraviolet radiation produced by excited dimer† ("excimer") molecules as they transition to their ground state. The wavelength of UV radiation emitted depends on the type of noble gas, which is, depending on the type of source, combined with a halogen gas. Krypton-chloride excimer (chemical symbol: KrCl*) lamps emit primarily at 222 nm, with lesser emissions at longer UV wavelengths. (The asterisk in the symbol indicates that the molecule is an excimer.)

fluence (radiant fluence): The omnidirectional radiant energy externally incident on an elementary sphere about the point, per unit cross-sectional area

† A dimer is a molecule or molecular complex consisting of two identical molecules linked together.