IEC 60068-2-87

Edition 1.0 2024-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Environmental testing –
Part 2-87: Tests – UV-C exposure of materials and components to simulate ultraviolet germicidal Irradiation or other applications

Essais d'environnement –
Partie 2-87: Essais – Exposition des matériaux et composants aux UV-C pour simuler l'irradiation germicide aux ultraviolets ou d'autres applications

IEC 60068-2-87:2024-10(en-fr)

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ENVIRONMENTAL TESTING –

Part 2-87: Tests – UV-C exposure of materials and components to simulate ultraviolet germicidal irradiation or other applications

FOREWORD

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IEC 60068-2-87 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
104/1067/FDIS	104/1073/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

UV-C radiation (with wavelength ranging from 100 nm to 280 nm) emitted by the sun is known to destroy DNA and RNA in living cells, but it is filtered entirely by the atmosphere, so that none reaches Earth's surface. Because of its effects on cells, artificial light sources that emit UV-C radiation are used to kill or deactivate pathogens in air, water, and on material surfaces, a process known as ultra-violet germicidal irradiation (UVGI). Although UVGI systems for disinfection of water have been in use for decades, the technology's use on surfaces and in air has become common more recently and has accelerated in response to the COVID-19 pandemic.

UV-C radiation is potentially harmful to polymers, textiles, and other materials. Consequently, UVGI treatments can degrade material properties, especially when frequently performed.

The test procedure set out in this document is intended as a standardized method of evaluating the effects of UVGI on either samples of material or components, subsystems or complete systems of electrical equipment.

The severities are listed in order from lowest to highest expected UV-C radiation dose. A low severity environment represents materials exposed to UVGI treatments infrequently. Higher severity environments represent materials with more frequent exposures, including materials used within a UVGI system's components.

The majority of UVGI systems in use rely on low pressure mercury lamps, which emit most of their output at a single wavelength of 254 nm. This type of lamp is available in several power levels and in many physical configurations, but the spectral output is the same regardless of these factors. Other light sources are used in some UVGI systems, including excimer lamps with output at 222 nm and LEDs with output at 265 nm.

This document will be limited to applications using low pressure mercury lamps because the technology is very well known and commercial testing equipment using it is available.

ENVIRONMENTAL TESTING –

Part 2-87: Tests – UV-C exposure of materials and components to simulate ultraviolet germicidal irradiation or other applications

1 Scope

This part of IEC 60068 describes exposures of materials and components to UV-C radiation during ultraviolet germicidal irradiation (UVGI) treatments or other processes that require UV-C exposure and test procedures to simulate those environments. Severities representing various frequencies and intensities of UV-C exposures are described. Test conditions are described and limited to devices that utilize low pressure mercury lamps which emit most of their radiation at a single spectral line at 254 nm.

NOTE A more precise characterization of the wavelength of the spectral line is 253,7 nm. The ability for a laboratory to determine the wavelength to this resolution is rare. Therefore, this spectral line is often quantified to the resolution of 1 nm.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4892-1, *Plastics – Methods of exposure to laboratory light sources – Part 1: General guidance*

ISO 9370:2017, *Plastics – Instrumental determination of radiant exposure in weathering tests – General guidance and basic test method*

ASTM G130, *Standard Test Method for Calibration of Narrow and Broad-Band Ultraviolet Radiometers Using a Spectroradiometer*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
low pressure mercury lamp
discharge lamp of the mercury vapour type, with or without a coating of phosphors, in which during operation, the partial pressure of the vapour does not exceed 100 Pa

Note 1 to entry: For the purposes of this document, low pressure mercury lamps do not contain any phosphors.

3.2
UV-C
ultraviolet C
electromagnetic radiation in the wavelength range of 100 nm to 280 nm, which is completely filtered by the atmosphere before reaching Earth's surface

4 Background

4.1 Overview

Ultraviolet C radiation is effective in deactivating, or killing, pathogens in air and water or on surfaces. Germicidal effectiveness curves are published which show peak effectiveness at 265 nm. Low pressure mercury lamps, without a coating of phosphors, emit most of their irradiance at a single wavelength of 254 nm. The proximity of this spectral line to the peak of the germicidal effectiveness curve has resulted in wide deployment of this lamp type in commercial ultraviolet germicidal irradiance (UVGI) systems. During UVGI exposures, irradiance in the UV-C region can degrade non-metallic materials including paints, plastics, and textiles.

4.2 Exposures to UV-C irradiation

Literature describes UV-C dose levels required to deactivate specific pathogens. In addition, different levels of disinfection are defined for various applications, with the highest levels called sterilization. Defining the service environment of materials exposed to repeated UVGI exposures requires knowledge of the target disinfection level, UV-C dose required to deactivate the target pathogen(s) and expected frequency of UVGI exposures. In addition, in some situations, UV-C exposures are continuous or nearly so, which results in significantly higher UV-C dose levels. Table 1 represents four UV-C radiant dose levels for different UVGI requirements and the total annual dose level experienced by a material or component for weekly, daily, or eight UVGI cycles per day. In addition, a fixed dose is included as specified by IEC 60335-1:2020, Annex T.

Table 1 – Radiant dosages received by materials in one year of UVGI cycles

Target UV-C dose (per UVGI cycle)	Application	Frequency of UV-C exposures and resulting annual radiant doses (J/cm^2)		
		Weekly	Daily	8 × per day
20 mJ/cm^2	Materials exposed to UVGI in non-medical settings	1,0	7,3	58,4
80 mJ/cm^2	Materials exposed to UVGI in medical settings	4,2	29,2	234
250 mJ/cm^2	Materials exposed to whole room UVGI systems, average	13	91	730
1 J/cm^2	Disinfection of medical devices and personal protective equipment (PPE) by UVGI; materials exposed to whole room UVGI, typical maximum	52	365	2 920
3,6 kJ/cm^2	Safety of electrical insulation in UVC devices or frequently exposed to UVC, IEC 60335-1:2020, Annex T	Dose fixed 3 600		

4.3 Temperature

UVGI exposures occur mostly in indoor environments where the temperature is controlled. In other instances, exposures can occur outdoors or inside of vehicles where temperatures can be elevated. Specimen tests should consider the service environment where UV-C exposures occur.

4.4 Humidity

Relative humidity is not typically factored into UVGI exposures. Theoretically, very high relative humidity can attenuate the amount of UV-C radiation reaching a surface, due to the absorption of photons by water vapour. For specimen testing, humidity should not be added by the test chamber.

5 Test chamber for performing UV-C exposures

5.1 General

Test chambers shall be constructed of materials capable of withstanding the exposure conditions. Chambers that conform to ISO 4892-3 requirements are suitable, provided they are equipped with the proper lamp as described in 5.2. Moisture functions described in ISO 4892-3 are not necessary to perform tests described in this document. Other chamber designs are possible provided they meet the specific requirements.

For safety reasons, the chamber shall be designed so that operators are shielded from UV-C irradiance during testing and maintenance.

NOTE Some commercially available test apparatus designed for ISO 4892-3 have been adapted to perform UV-C exposures of materials.

WARNING UV-C irradiance causes inflammation of the eyes and sunburn of skin. See CIE Technical Report 187 for information on health and safety concerns related to exposure to UV-C lamps.

5.2 Source of UV-C

The light source shall be one or more low pressure mercury lamps without a phosphor coating, designed so that ozone is not produced. Approximately 90 % of the irradiance of this lamp type is concentrated in a single spectral line at 254 nm.

NOTE Ozone is produced when UV-C wavelengths dissociate oxygen molecules, some of which recombine into ozone. Longer wavelength UV-C (250 nm to 280 nm) essentially reverses this process. Low pressure mercury lamps can produce, in addition to the 254 nm spectral line, a spectral line in the UV-C band at 185 nm, which produces ozone molecules faster than they are consumed by the 254 nm line. However, the 185 nm line is blocked by certain glass types so that there is no net ozone produced by the lamp.

5.3 Irradiance monitoring and control

5.3.1 General

Irradiance at wavelength 254 nm shall be measured and should preferably be controlled during the exposure. At a minimum, irradiance shall be measured and adjusted before the exposure, after approximately half of the intended exposure duration, and at the conclusion of the exposure, or as described in the relevant specification. Continuous irradiance control as described in ISO 4892-1 and ISO 4892-3 is preferred.

5.3.2 Common sources of UV-C measurement error

5.3.2.1 General

Two common sources of UV irradiance measurement error are spectral mismatch between the light source used during calibration and that being measured, and deviation from true cosine response.

NOTE In a study of commercially available UV-C radiometers conducted by the National Institute of Standards and Technology (NIST), several devices demonstrated significantly lower readings than the reference measurements. One device measured approximately one-third of the actual value. The report concludes that poor cosine response was the primary reason for the errors. However, spectral mismatch between the detector sensitivity and calibration source versus the measured source has been shown to be a common problem.

5.3.2.2 Spectral mismatch errors

Spectral mismatch issues are discussed in CIE 220 and ASTM G130. UV-C radiometers used to measure irradiance shall be calibrated to measure the 254 nm spectral line emitted by low pressure mercury lamps in accordance with ASTM G130 or an equivalent procedure.

5.3.2.3 Deviation from true cosine response

Errors caused by deviation from true cosine responses can be very significant when the distance between the specimen plane and lamp is smaller than the length of the light source. Irradiance sensors shall comply with the requirements for cosine response in ISO 9370:2017, Table 2.

NOTE In the case of many chambers designed for ISO 4892-3, the distance between the specimen plane and lamps is typically less than 10 % of the lamp length.

5.4 Temperature

Temperature shall be measured and controlled in accordance with ISO 4892-1 by a black panel thermometer. Alternative means of temperature control, such as an insulated black panel or black standard thermometer may be used when specified by the relevant specification.

NOTE Black panel thermometers as described in ISO 4892-1 are not insulated, while black standard thermometers are. Black standard thermometers have a very specific construction and are not typically used in chambers designed for ISO 4892-3 tests. By adding insulation to a black panel thermometer, the resulting measurement is very similar to a black standard thermometer, however.

6 Test procedures

6.1 General

Specimens are exposed to a UV-C radiant dose equal to that expected during the service life of a component or material, or a significant portion of the service life. After exposure, and, when specified, at intermediate intervals during the test, specimens are evaluated to determine their change in relevant properties (Clause 7).

6.2 Test conditions

6.2.1 General

Table 2 describes test conditions representing a range of exposure severities. Each test duration represents the nominal UV-C dose during one year of service life, with a minimum total dose.

The maximum allowable operational fluctuations, which are defined as the positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions, shall be for black panel temperature ±2 °C and irradiance ±0,1 mW/cm^2.

6.2.2 Irradiance

6.2.2.1 General

Irradiance levels in Table 2 are intended to provide a balance between achieving realistic simulation of operating conditions and minimizing test durations for the most demanding applications. Any deviations from the specified conditions shall be indicated in the test report.