



AEROSPACE INFORMATION REPORT

AIR4964™**REV. A**

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Superseding AIR4964

(R) Exposure Levels of UV Radiation in
Nondestructive Inspection Processes

RATIONALE

AIR4964A is the result of a Five-Year review and update of the report. The revision introduces material covering ultraviolet LEDs (Light-Emitting Diodes), updates the technical content, and significantly expands recommended practices when working with ultraviolet lights.

INTRODUCTION

Ultraviolet (UV) radiation may be used within several Non-Destructive Test (NDT) methods to excite fluorescent materials and cause them to emit light at a visible wavelength. Where these fluorescent materials are concentrated around a discontinuity and are viewed in low ambient light conditions under UV irradiation, this serves to enhance the visibility of the discontinuity. This phenomenon is most often utilized to enhance the sensitivity of penetrant testing (Fluorescent Penetrant Inspection - FPI) and Magnetic Particle Inspection (MPI).

The fluorescent materials used typically have a strong peak in their fluorescence when irradiated with UV at around 365 nm (which lies within the UV-A range). There are various types of sources used in NDT: UV LEDs (Light-Emitting Diodes), mercury vapor lamps, metal-halide-lamps, or Xenon bulbs. Historically, mercury vapor lamps were used predominantly; however, in recent years, they have widely been replaced by UV LEDs.

UV radiation exposure can be hazardous to humans, with the hazard dependent on the exposure time, intensity of the radiation, wavelength of the radiation, nature of the exposure, and sensitivity of the exposed person. Depending on jurisdiction, there may be legal limits on acceptable exposure to UV radiation, or limits may be recommended by appropriate national bodies in the absence of legislation.

The aim for these NDT methods should be to achieve appropriate UV irradiation of the fluorescent material (and manage ambient light levels) for an effective inspection, while managing any risk to personnel to be as low as reasonably achievable/practicable and within any applicable legal limits.

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1. SCOPE

Long wave ultraviolet or UV-A irradiation (between 320 and 400 nm) is used for fluorescent inspections in magnetic particle and liquid penetrant examinations. UV-A irradiation is obtained from either LED, fluorescent, or high intensity discharge lamps that are stationary or portable. Commercially available UV-A lamps possess a large variation in intensity output that may introduce a legitimate concern for possible health hazards. This document reviews the nature of UV-A irradiation emitted by lamps and acceptable UV dosage limits adopted by the American Conference of Governmental Industrial Hygienists (ACGIH®) and European Union and recommendation of proper practices when working with UV-A irradiation.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 ACGIH® Publications

Available from ACGIH®, 3640 Park 42 Drive, Cincinnati, OH 45241, Tel: 513-742-2020, www.acgih.org. ACGIH® and TLV® are registered trademarks of the American Conference of Governmental Industrial Hygienists, Inc.

Introduction to TLV® Physical Agents: <https://www.acgih.org/science/tlv-bei-guidelines/tlv-physical-agents-introduction/>

2.1.2 EU Publications

Available from the Publications Office of the European Union.

2.1.2.1 Law

Available online at <https://eur-lex.europa.eu/>.

Directive 2006/25/EC of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation), <http://data.europa.eu/eli/dir/2006/25/oj>.

2.1.2.2 Health and Safety Authority

Available online at <https://op.europa.eu/>.

Non-binding guide to good practice for implementing Directive 2006/25/EC, amended 2019, “Artificial Optical Radiation”

2.1.3 IEC Publications

Available from IEC Secretariat, 3 rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland, Tel: +41 22 919 0211, www.iec.ch.

IEC 62471 Photobiological safety of lamps and lamp systems

2.1.4 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, Tel: +41 22 749 01 11, www.iso.org/store.

ISO 16321 Eye and face protection for occupational use

ISO 19734 Eye and face protection — Guidance on selection, use and maintenance

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Information Report.

2.2.1 UK Legislation

Available online at <https://www.legislation.gov.uk/>.

The Control of Artificial Optical Radiation at Work Regulations 2010

3. POTENTIAL HEALTH HAZARDS FROM OVEREXPOSURE TO ULTRAVIOLET RADIATION

Humans do not have the same aversion responses to UV radiation as they do for bright, visible light, which can increase the risk of overexposure, particularly for the eye. For healthy human beings with intact natural lenses in their eyes the health hazards to the eye from overexposure to ultraviolet radiation may include Photokeratitis (inflammation of the cornea - often referred to by names that reflect its usual cause: e.g., snow-blindness when caused by sunlight reflecting off snow and ice; or arc-eye/welder's flash when caused by UV exposure from welding), Photoconjunctivitis (inflammation of the conjunctiva), Cataracts (protein changes in the lens of the eye), or Photoretinal damage. For people with artificial lenses in their eyes there are additional risks, due to the fact that the UV radiation can reach the retina, which can cause critical photoretinal damage, increase the risk of age-related macular degeneration (AMD) as well as accelerated retinal aging, when not wearing eye protection.

The health hazards to the skin may include Erythema (reddening and swelling of the skin), Elastosis (photoaging), Immediate Pigment Darkening, or Skin Cancer.

IEC 62471 and European Union (EU) Directive 2006/25/EC (and associated non-binding guidance document) on artificial optical radiation show the relative hazard potential of wavelengths between 180 and 400 nm for the skin and eyes. Medical data indicates that radiation between 180 and 319 nm (UV-B and UV-C) can cause severe skin and eye burns. The sensitivity of the skin to such radiation is a function of the incident UV wavelength and its dosage. Normally, the erythema effectiveness is strong between 180 and 300 nm, with a rapid fall-off to 1% at 320 nm.

The wavelengths relevant for fluorescent stimulation within NDT applications (UV-A range between 350 and 380 nm) have a hazard potential that is up to a factor of 2500 to 15000 lower than for UV-B and UV-C radiation. While the UV radiation typically used in NDT applications is at the lower end of the risk scale, there is still a hazard to both the skin and eyes, and overexposure may result in acute or chronic issues. There may also be a hazard from any other UV wavelengths present.

4. THRESHOLD LIMIT VALUES FOR UV-A EXPOSURE

The American Conference of Governmental Industrial Hygienists (ACGIH®) recommends threshold limit values (TLVs®) for UV radiation in the spectral region between 180 and 400 nm. These values represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. For the long wave UV spectral region (UV-A), the total irradiance incident upon the unprotected eye should not exceed 1 mW/cm² (1000 uW/cm²) for periods greater than 1000 seconds (approximately 16 minutes). For exposure times less than 1000 seconds, the total UV-A dosage should not exceed 1 J/cm² (Joule = Watts x seconds). However, these values do not apply to photosensitive individuals or to individuals concomitantly exposed to photosensitizing agents such as special medication. Such individuals must seek doctor's advice prior to further UV exposure. The TLV for occupational exposure to UV-A radiation within an 8-hour period should be used as a guide and not be regarded as a fine line between safe and dangerous levels.

EU Directive 2006/25/EC covers workplace exposure to artificial optical radiation and states radiation limits for skin and eyes and weighting factors to apply for various wavelengths of radiation. The directive has been adopted into national laws across the EU and United Kingdom (UK). Users should refer to the applicable regulations for their country or local.