Yuriy Yaremenko*
MR Chemie GmbH, Germany

Ultraviolet irradiation hazard aspects and proactive ways of its impact reduction on personnel performing penetrant or magnetic particles testing

Aspekty zagrożenia napromieniowaniem UV oraz aktywne sposoby redukcji jego oddziaływania na personel wykonujący badania penetracyjne lub magnetyczne

ABSTRACT

Ultraviolet (UV) irradiation is a part of interpretation process in fluorescent sub-methods of penetrant testing (PT) and magnetic particles inspection (MPI). Therefore exposure to UV and its hazard consequences should be considered by Health and Safety Executives inherently with test media hazards.
UV filtered spectacles, masks and clothing which covers exposed parts of the body are essential part of protective measures for operators. Alongside with the operator, the risk of exposure for surrounding personnel is always existent. Therefore, comprehensive approach to protective measures is needed, and UV basics, UV harmful impact and types of artificial sources should be studied more thoroughly.
This work analyzes hazard aspects of UV irradiation, compares UV irradiation influence emitted from different UV sources and offers to consider UV LED sources as proactive measure of UV exposure reduction on personnel.

Keywords: *fluorescent penetrant testing, magnetic-particles inspection, UV irradiation, personnel safety*

STRESZCZENIE

Promieniowanie ultrafioletowe (UV) jest stałym elementem w procesie interpretacji wyników badań penetracyjnych (PT) oraz magnetyczno-proszkowych (MP). Dlatego konieczne jest rozważenie skutków zagrożeń spowodowanych ekspozycją na promienie UV przez służby BHP. Okulary, maski i odzież, która obejmuje odsłonięte części ciała, są istotną częścią środków ochronnych dla operatorów. Ryzyko narażenia personelu uczestniczącego w badaniach istnieje zawsze. Dlatego kompleksowe podejście do środków ochronnych UV jest potrzebne, a szkodliwe oddziaływanie i rodzaje sztucznych źródeł promieniowania powinny być zbadane bardziej dokładnie.
Ta praca analizuje aspekty zagrożenia napromieniowania UV, porównuje wpływ promieniowania ultrafioletowego emitowanego z różnych źródeł promieniowania UV i oferuje do rozważenia UV LED jako źródła aktywnego środka redukcji narażenia pracowników na promieniowanie UV.

Słowa kluczowe: *fluorescencyjne testy penetracyjne, badania magnetyczno-proszkowe, promieniowanie UV, bezpieczeństwo personelu*

MSc
Yuriy Yaremenko

1. Ultravioulet irradiation in non-destructive testing

UV light is electromagnetic radiation with a wavelength shorter than visible light, but longer than X-rays. Whole UV spectrum lies in the range of 100 – 400 nm and typically cannot be seen by human eye. Basically, UV is classified in 3 wavelength bands. Short wavelength UV-C [100…280nm], middle wavelength UV-B [280…315nm] and long – UV-A [315…400nm]. In non-destructive testing, UV-A spectrum is permissible with a peak at 365 ± 5 nm. According to [2] and [3] particular requirements to the UV spectrum profile are prescribed as well. Such strict approach to standardize and limit UV spectrum is caused by the fact that different UV wavelength bands have different influence on human health. Let us look at these main differences.

2. Ultravioulet hazard aspects

Parts of human body affected by UV are eyes and skin. The lens of the eyeball is more sensitive to UV-A and part of UV-B bands. Starting from 300 nm this and higher wavelength of the UV are absorbed by lens and cause protein changes. On the other hand, the layer of the skin called epidermis is more sensitive to UV-B irradiation, whereas UV-A is passing by to deeper layer, i.e. the dermis. UV-B spectrum plays a key role in DNA changes in epidermis cells, and both UV-B and UV-A contribute to skin aging (photoaging). It is worth mentioning that alongside with UV spectrum, there is another harmful light band belonging to visual spectrum, namely violet light [400 … 490 nm]. This light band affects the back wall of the eyeball and its element called macula.

*Corresponding author. E-mail: yaremenko@mr-chemie.de

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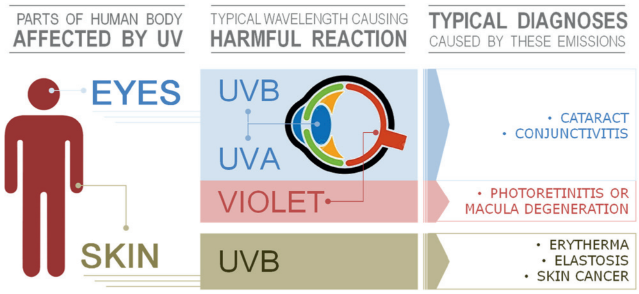

Fig. 1. Infographic of UV irradiation hazard aspects.
Rys. 1. Schematyczny podział zagrożeń promieniowaniem UV.

Typical diagnoses caused by each band of wavelength are: conjunctivitis and cataract for the eyes affected by UV-A and UV-B; Macula degeneration for the eyes affected by violet light emission; erytherma, elastosis (photoaging) and skin cancer for the skin – mainly by UV-B.

After the overview of causes leading to the most harmful consequences to the human health, it is important to consider the relationship between the wavelength of the light emitted and power of its effects.

3. Wavelength and the power of exposure correlation

[1] set requirements regarding personnel protection exposed by the artificial optical radiation to the eyes and to the skin. UV exposure limits values for 8 hours shift draw up: 30 J/m2 for the general UV spectrum (180-400 nm) and 104 J/m2 for UV-A band only.

These values demonstrates that biophysical impact of the UV-B and UV-C spectrum dose is seen as a lot more harmful than UV-A. Graphical interpretation, as shown on Figure 2, describes detailed relationship between biophysical impact of different UV bands, using Action spectrum Index, S(λ).

When we impose on this graphic Xenon, Mercury or other type of conventional UV source (Fig. 3) and compare the overlay with the spectrum of UV Light Emitted Diodes (LEDs) (Fig. 4), it clearly shows that conventional UV sources have much more intensive effects on operator than UV based on LED source. Taking into account logarithmic Selective example of Xenon UV Lamp spectrum with built-in UV filter rscale of action spectrum index S(λ), the harmful influence becomes sizable even at UV bands with low intensity.

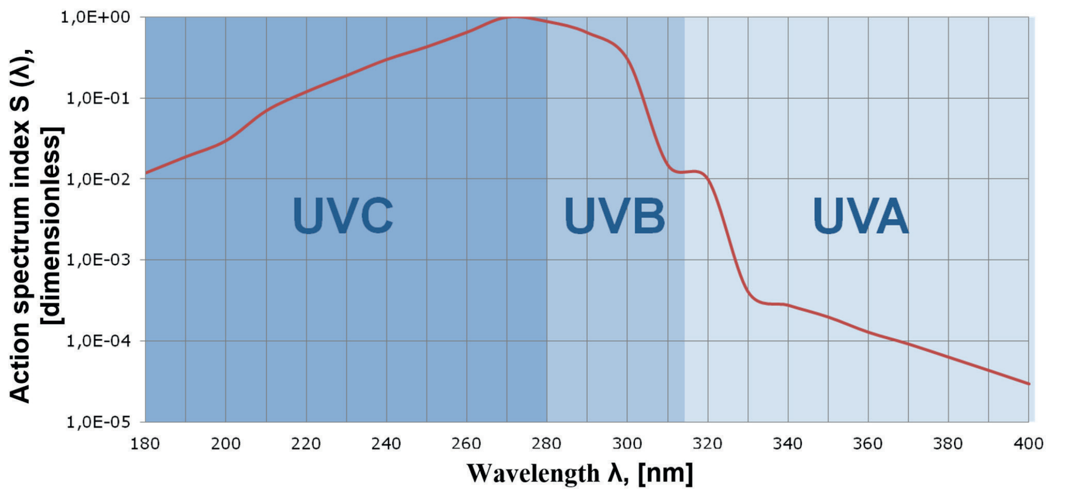

Fig. 2. Biophysical impact of UV irradiation as a function of wavelength. Graphical interpretation of the data obtained from 2006/25/EC Directive.
Rys. 2. Biofizyczny wpływ napromieniania UV, w zależności od długości fali. Graficzna interpretacja danych uzyskanych z Dyrektywy 2006/25 / EC.

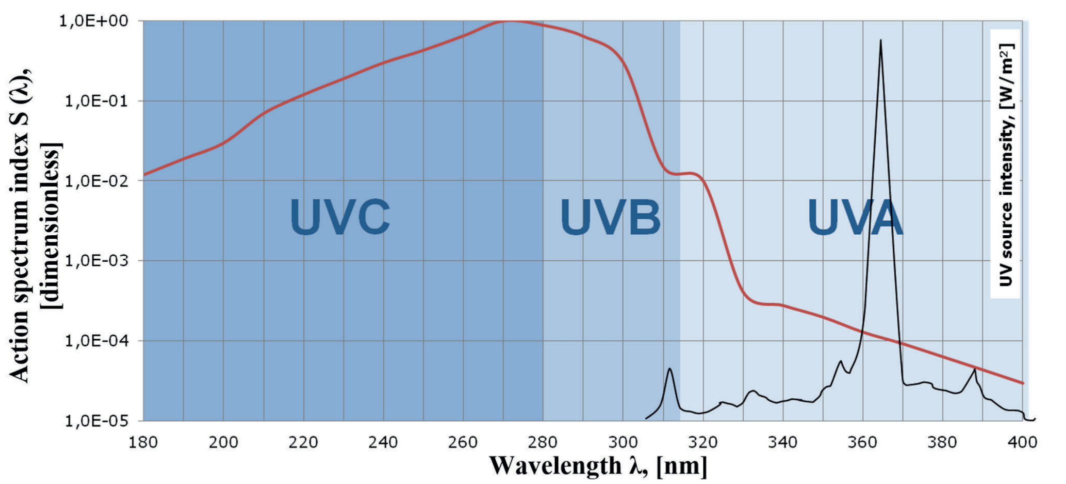

Fig. 3. Selective example of Xenon UV Lamp spectrum with built-in UV filter.
Rys. 3. Przykład widma ksenonowej lampy UV z wbudowanym filtrem UV.

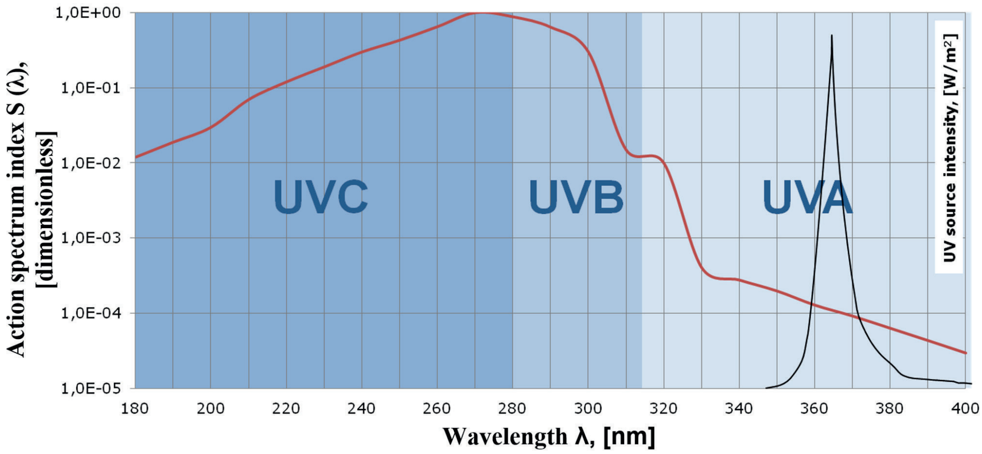

Fig. 4. MR 974 UV LED Lamp spectrum.
Rys. 4. Widmo lampy UV LED MR 974.

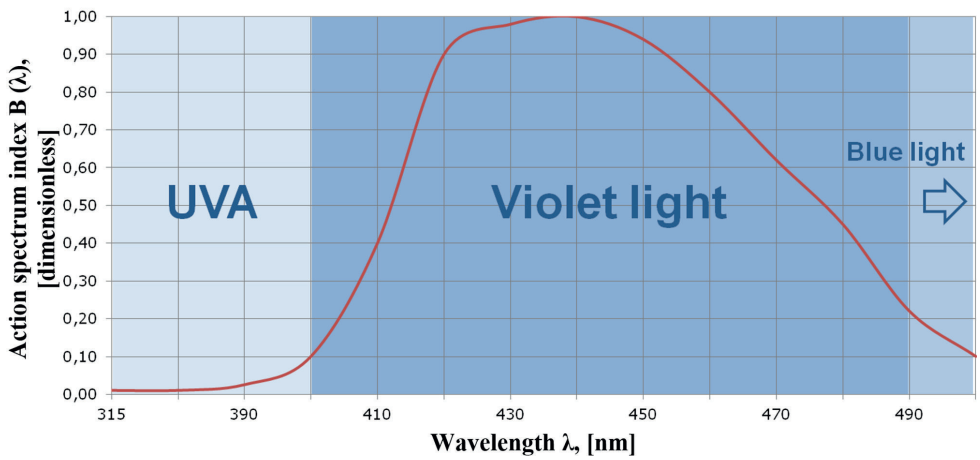

Fig. 5. Photochemical impact of Violet light spectrum. Graphical interpretation of the data obtained from 2006/25/EC Directive.
Rys. 5. Spektrum działania fotochemicznego światła fioletowego. Graficzna interpretacja danych z Dyrektywy 2006/25 / EC.

Moreover, in course of time, UV filter age and the borders of intercepted spectrum expand, and unwished UV wavelengths (which emitted unfiltered conventional UV source) are amplified. On the other hand, LEDs produce narrower UVA spectrum and do not irradiate UVB spectrum at all, no matter whether these irradiations are filtered additionally or not.

Besides UV spectrum, Health and Safety executives need to pay attention to violet light band, whose harmful spectrum sometimes underestimated. Figure 5 illustrates the difference in action of Violet light spectrum in association with Macula degeneration diagnosis.

Alongside with conventional UV sources, UV lamps with any kind of UV source, which produce spectrum of visible light in wavelength 400 – 490 nm should be avoided. Furthermore, background with the same violet band is typically registered on examination surface, during its exposure under permissible 365 nm UV. Consequently, the higher the concentration of UV beam generates UV lamp, the more intense the violet light emissions reflect from examination surface to the operator.

4. Summary

Thus, there is a list of preventive measures, which have to be taken into account for reduction of UV irradiation impact on personnel when perform PT or MPI.

- Use personal protective equipment against UV irradiation
- Avoid UV sources with any portion of UVB spectrum
- If conventional UV sources, as mercury, xenon, etc. are still in operation, replace UV filter regularly
- Avoid any UV sources with violet light irradiation [400…490 nm]
- Consider UV sources based on LED technology
- Avoid UV sources with intensive and concentrated UV beams

5. References/Literatura

[1] European Directive 2006/25/EC
[2] EN ISO 3059: 2012 Penetrant testing and magnetic particle testing – Viewing conditions
[3] ASTM 3022-15 Standard Practice for Measurement of Emission Characteristics and Requirements for LED UV-A Lamps Used in Fluorescent Penetrant and Magnetic Particle Testing