OPPORTUNITIES FOR THE REDUCTION OF SUBSTANCES AND EQUIPMENT IMPACT ON PERSONNEL IN PENETRANT AND MAGNETIC PARTICLES TESTING

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***ABSTRACT -** Penetrant testing (PT) and magnetic particles inspection (MPI) are widespread methods of non-destructive testing which are not required a lot of investments for manual application and are simple in terms of discontinuous interpretation. On the other hand, work with chemicals requires special precautions, safety instructions and disposal limitations. Growing demand among customers to decrease impact of consumables and equipment on personnel and environment, shift producers' priorities to develop new, safer solutions. This work offers to consider some results of MR Chemie company in development of free of dangerous components consumables for PT and MPI and to look closer at aspects of ultraviolet irradiation, as part of fluorescent PT and MPI methods, which affect on personnel safety.*

***Keywords:** penetrnant and magnetic inspection, safety,precosions, ultraviolet irradiation, protection of human health and the environment, ultraviolet hazard aspects, UV equipment*

1.1. TEST MEDIA PERFORMANCE AND HAZARD CONSEQUENCES

When we consider parameters which influence the probability of discontinues detection by Penetrant testing (PT) and Magnetic particles inspection (MPI), besides process variables and conditional variables, professionals stress the importance of test media properties. Chemical composition of the test media brings on the top of tests' performance such qualitative parameters as wetting ability, which is responsible for parts coverage by test media in PT and MPI; viscosity, which links to magnetic particles mobility during magnetization in MPI; washing ability – parameter affecting on background during interpretation in PT, etc.

From the beginning of PT and MPI methods invention, consumers and producers of test media were focused on achieving highest qualitative parameters of the test media. In that times kerosene, naphtha and AZO dye pigments were widely used in test media production, as they were the simplest and easiest way to maximize test media's performance. On the other hand, these substances were (and are) distinct risk factors, initiating such serious diseases like skin cancer, genetic damage and other fatal impacts, as well as they were subject of disposal limitations.

1.2. REACH REGULATION

In order to ensure a high level of protection of human health and the environment from the risks that can be posed by chemicals, so called REACh regulation by European Chemical Agency (ECHA) was found. Since 2007, the regulation has been regularly updated, bringing more restrictions for the chemicals circulation and better transparency in dangerous substances identification for the end user.

Upcoming version of REACh, which is awaited for release at the end of 2015, is bringing more changes (below are listed some of these changes):

- Candidates list of carcinogen, mutagenic and toxic substances continues to expand and draw up 161 substances (on Dec 2014)
- Threshold concentrations, when substance counted as hazard, are being decreased for a lot of products
- Health and other hazard phrases are being rephrased with greater emphasis on the danger impact
- Hazard pictograms graphical conversion to GHS (Globally Harmonized System of Classification and Labeling of Chemicals)

As result, much more substances should be declared by producers as dangerous and labeled accordingly.

1.3. ACHIEVEMENTS AND APPLICATION CHANGES

MR Chemie company were eager to meet this challenge and alongside with our standard products (which do not have AZO-dye pigments, and most of them counted as bio-degradable) to develop line of consumables which are recognized as free of dangerous components according to the upcoming new version of REACh regulation. These products are labeled as ECO LINE and have additionally such properties as:

- Not hazard (even not irritant)
- Not flammable
- Do not contain volatile organic compounds (VOC)
- Have optimal removability and wetting ability
- Have no foaming effect and have high particles mobility
- Have increased fluorescence brightness

It is worth mentioning, that development of such properties ought to change recipes substantially, which result in several changes in application of the test media. Products, which are in aerosol cans supplied, have narrower and not homogeneous spraying pattern; for application of aqueous developer and white contrast paint pneumatic spray guns are necessary, also increased application and dryness time should be taken into account; Pre-cleaning procedures before water-based test media application should be handled thoroughly. Nevertheless, more and more customers adapt these changes in favor of safer operation.

2.1. ULTRAVIOULET IRRADIATION AS PART OF INTERPRETATION PROCESS

Ultraviolet (UV) irradiation is a part of interpretation process in fluorescent sub-methods of PT and 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.

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, there is UV-A spectrum permissible with a peak at 365 ± 5 nm. According to EN ISO 3059, particular requirements to the UV spectrum profile are prescribed as well. Such strict approach to approved UV wavelength is caused by the fact that different UV wavelength bands have different influence on human. Let us look at these main differences.

2.2. 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.

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 wavelengths of the light emitted and power of its effects.

2.3. WAVELENGTH AND THE POWER OF EXPOSURE CORRELATION

European Directive 2006/25/EC 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/m^2 for the general UV spectrum (180-400 nm) and 10^4 J/m^2 for UV-A band only.

These values shows 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 in Figure 1, describes detailed relationship between biophysical impact of different UV bands, using Action spectrum Index, S(λ)

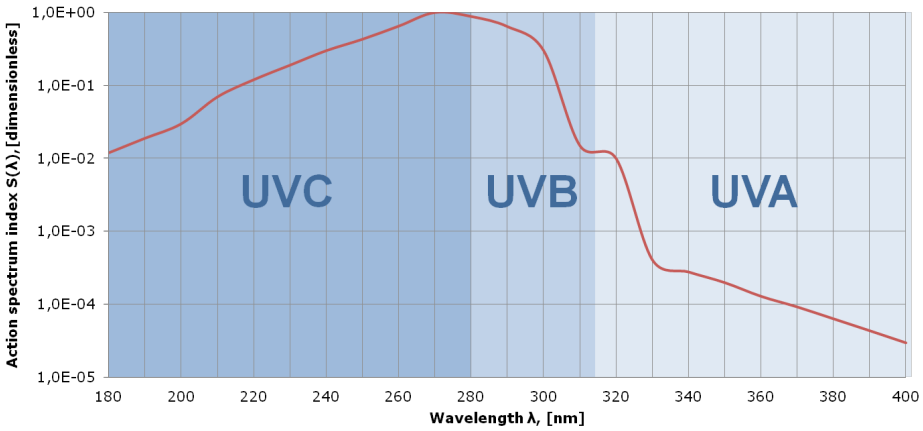

Figure 1 *Biophysical impact of UV irradiation as a function of wavelength. Graphical interpretation of the data obtained from 2006/25/EC Directive*

When we impose on this graphic Xenon, Mercury or other type of conventional UV source (Figure 2) and compare the overlay with the spectrum of UV Light Emitted Diodes (LEDs) (Figure 3), it clearly shows that conventional UV sources have much more intensive effects on operator than UV based on LED source. Taking into account logarithmic scale of action spectrum index S(λ), the harmful influence becomes sizable even at UV spectrum with low intensity.

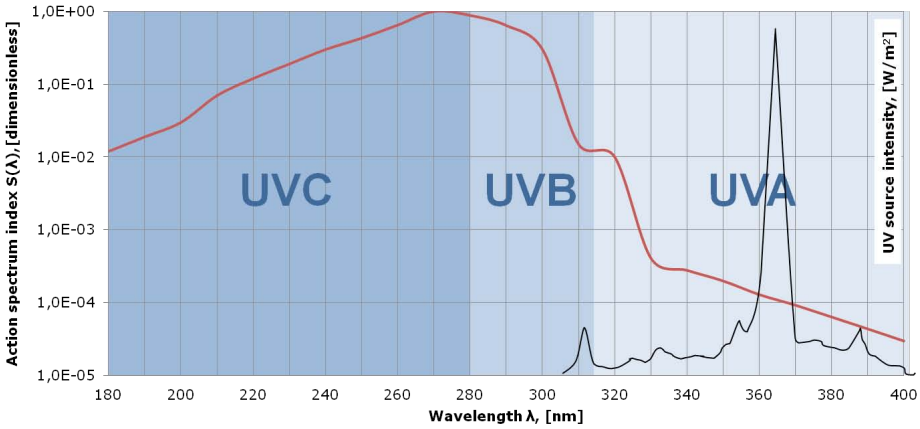

Figure 2 *Selective example of Xenon UV Lamp spectrum with built-in UV filter*

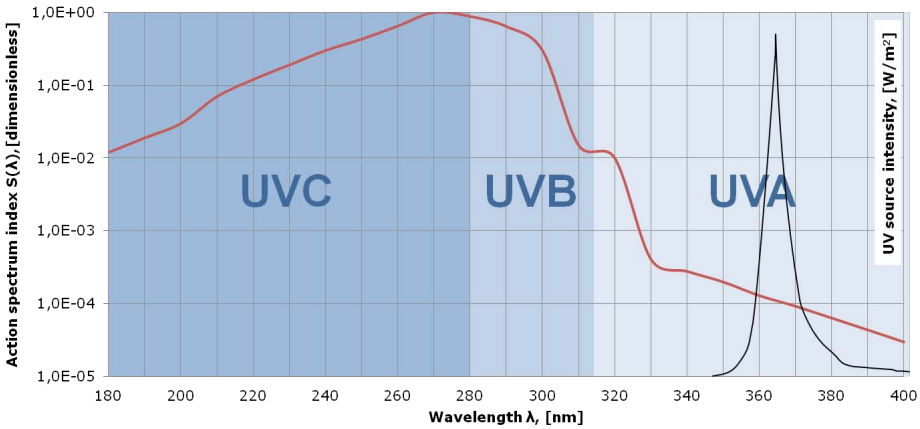

Figure 3 *MR 97 UV LED Lamp spectrum*

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 4 shows difference in action of Violet light spectrum in association with Macula degeneration diagnosis.

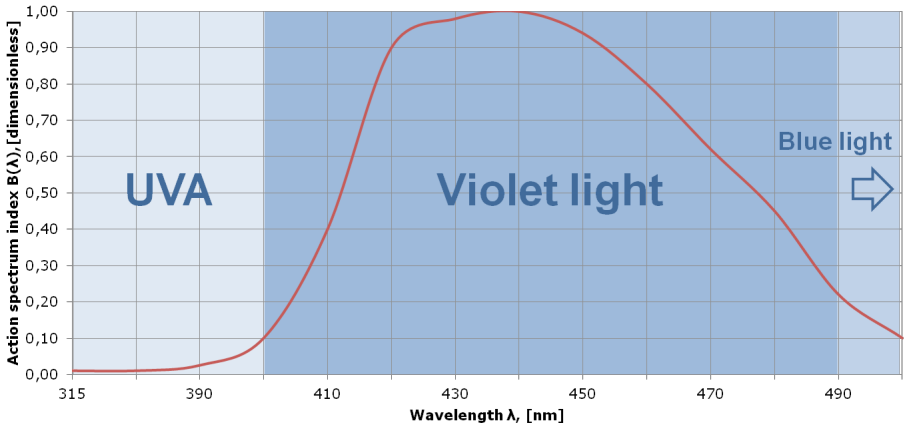

Figure 4 *Photochemical impact of Violet light spectrum. Graphical interpretation of the data obtained from 2006/25/EC Directive*

Alongside with the 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, violet background is typically registered on inspected surface, during its exposure under permissible 365 nm UV. The higher the concentration of UV beam, the more intense the violet light emissions back to the operator.

3. SUMMARY

Thus, there are a list of preventive measures, which have to be taken into account for the impact reduction of consumables and UV equipment when perform PT or MPI.

For consumables:

- Pay attention to symbols and hazard phrases labeled on product AND mentioned in Safety Data Sheets (SDS)
- Avoid products with carcinogenic, mutagenic, toxic and other serious harmful effects
- Consider products free of hazard symbols

For UV equipment:

- Use protective equipment against UV irradiation
- Avoid UV sources with any portion of UVB spectrum
- For conventional UV sources, as mercury, xenon, etc., 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 high intensity and concentrated UV beams