UV and EB Equipment Safety Topics

[RadTech Equipment Safety Task Force]

This document is intended as a concise overview of the topics related to safety and safe use of industrial UV (Ultraviolet) and EB (Electron Beam) curing equipment. It may also serve as a "checklist" for users, designers and operators of UV or EB equipment. The topics are not intended to be covered in detail -- but only as limited guidance that must be used in conjunction with adequate training and education, which would include further, detailed explanations in published materials and manufacturer's documentation.

UV Equipment

UV Hazard

Ultraviolet light can be harmful to unprotected skin and eyes if exposure exceeds recommended levels. Eyes and skin must be protected from direct exposure to UV. As with "snow blindness" or "welder's eye" which occurs when too much UV is absorbed by the outer surface of the cornea, direct radiation from a UV lamp can also cause this condition. ***Never look directly at the bulb or cure zone.***

Different Safety Concerns for UVC, UVB, UVA

Ultraviolet radiation is divided into wavelength bands A, B, C, V and VUV (vacuum UV). Although the ranges for wavelength bands will vary depending on the source, the following may be used as a guide.

- **VUV (100-200 nanometers)** - absorbed by air and poses no danger to humans.
- **UVC (200-280 nanometers)** - Also called "far UV" and includes the 'germicidal' wavelengths. Although solar UVC is absorbed by the earth's ozone layer, UVC from UV lamps can be a serious hazard. Fortunately, most materials (plastics and glass) will filter out UVC.
- **UVB (280-315 nanometers)** - most responsible for reddening and burning of the skin and damage to the eyes. This is the range for which most safety threshold levels are stated.
- **UVA (315-400 nanometers)** - represents the largest portion of UV energy and is most responsible for human skin aging and increased pigmentation. UVA is at the lower limit of sensitivity of the human eye. Also called "near UV."
- **UVV (400-450 nanometers)** – UV wavelengths that extend into the visible range.

UV Radiation Exposure Regulations or Guidelines

The National Institute for Occupational Safety and Health (NIOSH) document *Criteria for Recommended Standard. Occupational Exposure to Ultraviolet Radiation* (PB214 268) establishes guidelines for the safe use of and exposure to UV radiation in the workplace. These exposure guidelines are based on and are similar to the American Council of Governmental Industrial Hygienists (ACGIH) *Threshold Limit Values*. Different wavelengths have different levels of allowable exposure. Generally, a lower threshold limit is allowed for longer exposure. For example, 0.1 μW/cm² at 270 nm is the limit level for 8-hour continuous exposure. Allowable exposure increases in inverse proportion to shorter duration of exposure. Commercial UV exposure meters are available to determine UV radiation levels in the workplace.

UV Exposure Meters

UV exposure meters or UV survey meters are typically hand-held meters used to evaluate the UV exposure field to which workers will be exposed. These meters are different from process radiometers in that they usually measure in the μW/cm² irradiance range with carefully calibrated responsivity in the UVB range. Further, they may be calibrated in units of minimal erythemal dose (MED) or in hours (allowable exposure time).

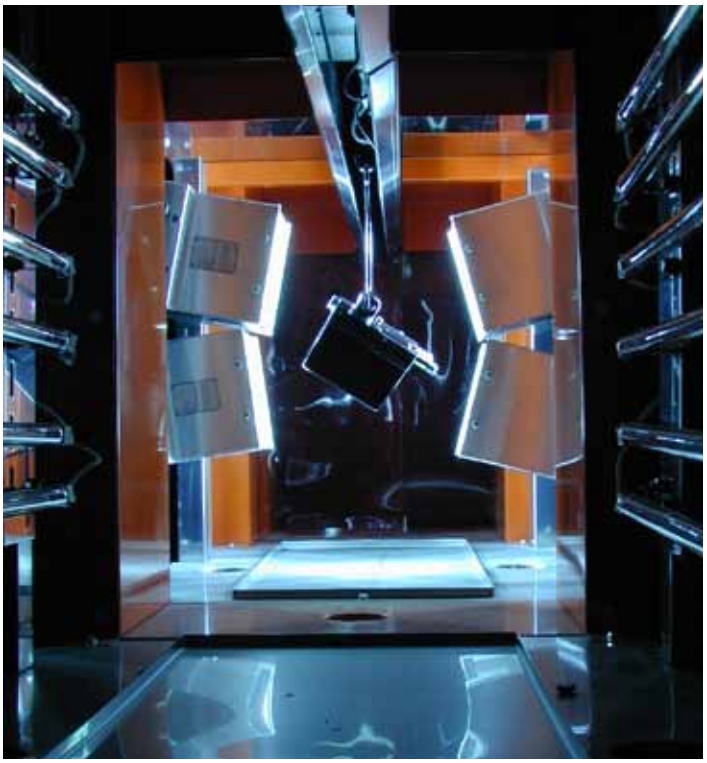
Personal Protective Equipment and Safety Glasses

Proper protection of eyes and skin is necessary when working with UV equipment. This includes UV blocking safety glasses, gloves, long sleeve shirts and possibly face protection in areas where high levels of exposure are likely. Safety glasses should be worn at all times when working with any UV sources. Only "UV-rated" clear glasses are recommended ("Tinted" adds no benefit of UV protection and may or may not effect visual acuity). "ANSI Z87" may be imbedded into the frames to verify that they are "UV-rated."

Light Shield (Enclosure) Design

A properly designed light shield should prevent the operator, or anyone in the vicinity, from looking directly at the bulb or at the

cure zone (where the focused light and UV from the lamp strikes the substrate being cured). Secondary reflections can contain a significant amount of UV so they also need to be controlled. As a general rule of thumb, any bright visible light that is uncomfortable to the eye should not escape from the light shield because it will



be accompanied by a substantial amount of UV.

Interlocks

All equipment or areas where UV radiation is used must be adequately shielded and access covers, doors, etc., must be interlocked to prevent accidental exposure to UV or high voltage. "Interlocked" means that if an interlock switch is tripped while the lamps are operating, they will be turned off and cannot be restarted without two reset actions. This prevents accidental exposure to UV or high voltage.

Ozone Hazard

Ozone (O3) is a colorless gas that is generated by the reaction of short-wave UV (around 180-220 nm) with air. Ozone is also produced whenever high-energy electrical discharge is present. Ozone exposure can cause headaches and fatigue. The concentrations of ozone found in UV-curing systems can possibly irritate the mucous membranes of the eyes, nose and throat.

Ozone Exposure Regulations or Guidelines

The United States Occupational Safety and Health Administration (OSHA) 8-hour permissible exposure limit (PEL) for ozone is 0.1 parts per million (ppm). This is also the ACGIH recommendation. This means recommended levels of ozone in the atmosphere of a factory cannot exceed 0.1 ppm averaged over an 8-hour workday. However, most people can smell ozone at substantially less than the maximum allowable 0.1 ppm level. Proper exhaust of the UV system will prevent ozone from escaping the light shield.

Exhaust/Ventilation Design

UV systems are designed to discharge exhaust air outside the work area or building to eliminate the possibility of the presence of ozone or any volatilized material in the work area.

Heat

Light shielding should be designed to reduce or eliminate hot exterior surfaces. Although the interior of a shielded system may be hot, any exterior surfaces hotter than 120°F should be labeled to prevent contact. Bulbs must be allowed to cool before cleaning or replacing.

High Voltage

Most UV equipment operates at high voltages up to 5,000 volts dc and is therefore potentially dangerous. Interlocks and EPO (Emergency Power Off) controls should never be over-ridden or disabled.

Electrical

Electrical equipment should be labeled to meet NFPA, NEC, UL, CSA or CE codes or standards. Service to the power supply should be conducted only by a trained technician.

RF (Microwave)

Microwave-powered lamps operate on the same frequency as microwave ovens. The lamp system is safe provided that the RF screen and gaskets are intact. Any damage such as rips or holes in the screen may cause leakage of microwave radiation. The power to the lamp is interlocked to an RF detector and will shut down the system if microwave leakage is detected.

Hazardous Environments

Some systems require very specialized design if there are flammable or combustible vapors present. These are called "Purged & Pressurized" systems (NFPA Class I, Division I, Group D). [They are not referred to as "explosion-proof".] Discuss the need for this design with your equipment supplier.

Mercury, Spills and Cleanup

Medium-pressure and low-pressure mercury vapor lamps contain small amounts of mercury. Mercury is a hazardous substance. There is no exposure to mercury during routine operation of UV equipment. When a bulb in these lamps breaks, however, there is potential for exposure which must be prevented with proper ventilation, protective equipment and by following the correct spill procedures. Bulb breakage is considered a small spill. Windows and doors in the area of the spill should be opened

to ventilate the area. While wearing appropriate protective equipment, small amounts of mercury can be collected with adhesive tape or an eye dropper and stored in a sealed plastic container until disposal. **Do NOT use a broom. Do NOT use a vacuum cleaner to clean up the spill.** After all visible mercury has been collected use a mercury cleanup kit to clean the spill area. Dispose of mercury as per your company policy and federal, state and local regulations.

Disposal of Bulbs

In most jurisdictions, local codes allow UV lamps to be disposed of in the same way as florescent lamps. Some jurisdictions require disposal as hazardous waste. Also, all lamp manufacturers will accept used bulbs returned for disposal. Dispose of bulbs as per your company policy and federal, state and local regulations.

Electron Beam Equipment

Ozone

E-beam energy can directly convert oxygen into ozone. For this reason (and for curing reasons), all e-beam systems are flooded with nitrogen (or "inerted") to eliminate the production of ozone or are properly ventilated to prevent worker exposure to ozone.

Nitrogen

Air is approximately 78% nitrogen. Nitrogen is a hazard only when in such high concentrations that oxygen is displaced. E-beam equipment should be used in well ventilated areas to prevent nitrogen used in the curing chamber from displacing oxygen in the surrounding workspace.

High Voltage

E-beam systems are interlocked so that when the interior is accessed for service, all high voltage is removed. Service to the high-voltage equipment should be conducted only by a trained technician.

X-rays

E-beam electrons have high enough energy to produce X-rays when they strike a solid material. All commercial e-beam systems are shielded with an appropriate amount of lead shielding to eliminate x-rays exterior to the system. EB equipment includes continuous monitors that will not allow the equipment to operate if X-rays are present. Periodic surveys and personal monitoring of operators may also be part of the site safety program.

Heat

Some areas around the process zone can be hot to the touch and must be labeled as such.

Safety Certification

State and local regulations apply to equipment emitting ionizing radiation (similar to medical/dental X-ray equipment). The manufacturer will provide written documentation that must be provided to local regulatory authorities. The documentation includes a radiation map and verification of the radiation monitors to ensure safe use of the equipment. The manufacturer can provide assistance in verifying safe installation and use.

Information and material provided by

Alcoa, Inc.
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