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Arup Live Event

How lighting can help fight COVID-19

Questions and answers

What is the relationship to the WELL standard on air quality and UVGI?

Brian Stacy (Arup): WELL has existing guidance about the use of UVGI inside air handlers which pertains primarily to employing UV applied to the system cooling coils for microbe and mold control, thus enhancing indoor air quality and reducing fan energy use. We would recommend looking at the recently updated ASHRAE position document on infectious aerosols as this is more specific to HVAC system design to mitigate COVID-19.

See specifically: https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf

We are a museum, is UV safe to expose to fine art and special collections?

Renee Thomas (Arup): No, direct and sustained UV irradiance will photodegrade most artworks and thus direct irradiance should not be utilized in museums and conservatory centers. A better application to reduce the risk of infection is to employ upper room air volume UVGI. The direction and intensity of the radiant energy can be better directed and controlled to deliver UV-C fluence while preventing damage to artwork or inadvertent exposure to building occupants.

Would "heavier air" i.e. air containing more moisture, be harder to mix and bring up to light source?

Joseph Hewlings (Arup): The moisture content of air doesn't significantly impact its density (temperature is much more important where this is concerned), so there's not really any impact from humidity on mixing. The impact is more so on the vulnerability of the pathogen to the UV light.

Nathaniel Jones (Arup): On the scale of typical rooms, moisture will diffuse evenly in the space, so we don't expect humidity to inhibit mixing. Furthermore, supply air from the HVAC system, movement of occupants, and rising heat generated by people and equipment will tend to mix air. Thus, moisture in air generally does not prevent that air from reaching the UV-C source. Incidentally, humidity can also be helpful in preventing COVID-19 spread, as respiratory droplets in a humid environment can gain mass, making them more likely to fall to the ground. In very large spaces, or spaces with large humidity gradients (e.g. aquariums), we could use computation fluid dynamics analysis to find areas with poor mixing and propose appropriate solutions.

Do you have an opinion as to whether UVGI with a mixed environment is better than a low level air supply to control COVID-19?

Joseph Hewlings (Arup): Good question. I think it depends. We have usually thought of low-level air supply as better for indoor air quality generally, and in general that may still be the case. But an upper room UVGI system probably won't work very well with low level air supply, because that type of air supply depends on <not> mixing the air too much. Low level air supply is just not that common in most existing buildings, and if you are designing a new building there are so many other factors that will tend to drive a decision on whether to use underfloor air supply or not – like flexibility, floor to floor heights, marketability, climate and cost.

How would a floor air system impact air mixing? My building has all supply air coming from floor registers.

Nathaniel Jones (Arup): Displacement systems, where air is supplied at the floor level and exhausted at the ceiling level, can theoretically reduce pathogen spread. In computational fluid dynamics simulations of rooms with these systems, we observe that exhaled air rises into the upper part of the room, and concentrations of pathogens in the breathing zone remain lower than in fully mixed rooms. Displacement systems should not be considered to eliminate the risk of disease transmission entirely, though, as movement of occupants can still mix air from the upper room volume back into the breathing zone. UVGI can still be applied, and practices such as social distancing, mask wearing, and proper hand hygiene should still be adhered to.

Is there any evidence that visible, UV-A or UV-B spectrum can help suppress the spread of pathogens in buildings if applied at a sufficiently high dosage (with sunlight, for example)?

Renee Thomas (Arup): Thank you for your question Galen. The radiant energy contained within the UV-A and UV-B spectra will over time (measured in hours) breakdown the RNA or DNA genomic material of infectious pathogens. UV-C energy is shorter in wavelength, highly energetic and more efficient at rapidly inactivating infectious pathogens. Additionally, given the short wavelength of UV light, all glazing materials are of sufficient thickness to block UV energy from entering the interior of buildings via horizontal and vertical glazing systems.

Given the specific needs for ventilation to support effective use of UVGI, are there applications for transportation facilities with limited ventilation, especially subway stations?

Renee Thomas (Arup): Great question! In such occupancies, ceiling mounted fan systems (in combination with upwardly directed and shielded UV-C fixtures) can be installed to draw air containing infectious viral particles into the upper room UV-C irradiance zone where they can be effectively and continuously deactivated without posing a risk to building occupants below.

If the application of UVC in this context requires multidisciplinary study and approach, how can it be applied on a broader basis when 90% of building client or public would not have access to this type of consultancy? Or is this type of approach only applicable to larger scale clients/ buildings?

Renee Thomas (Arup): We believe that the use of this technology should be carefully regulated and that product safety, installation and use instructions should be provided by UV-C fixture manufacturers. Both the Illuminating Engineering Society (IESNA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have recently published important guidelines for the use of UV-C technologies for infection control. Furthermore we at Arup support the development of specific and consolidated product testing, design and use guidelines under the auspices of the American National Standards Institute (ANSI), European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) to ensure safety and efficacy in the manufacture and use of these products.

Are we seeing LED based bulbs as a UVC light source?

Renee Thomas (Arup): More efficacious UV-C LED products are currently under development by numerous semiconductor manufacturers around the world. The challenge to widespread adoption of UV-C LEDs at this time is that the power output (“wall-plug efficiency”) of LEDs, which is the ratio of electrical power in - to optical power out, still under-performs low-pressure mercury and flash xenon emitter tube technologies. To deliver germicidally effective levels of UV irradiant flux over the distances needed for air volume disinfection, LEDs must be able to overcome the limitations of the inverse square law. That will require more powerful UV-C LEDs with higher internal photon delivery efficiencies. Currently blue LEDs (used for white light LED products) have an internal quantum efficiency, the fraction of electrons injected into the LED die that result in the generation of photons, of about 90 percent. For current UV-C chips it’s about 30-40 percent. Boosting those numbers will take significant improvements both to the LED fabrication process and to epitaxy, the growth process of the semiconductor crystal that LED fabrication is based upon. Defects in the crystal are currently the main limiter to LED performance, thus improving the epitaxy process provides a path to more powerful UV-C LEDs.

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Do you use or can indicate any Code-Standard to follow, in order to spec UVGI systems?

Dan Lister (Arup): The International Commission of Illumination (CIE) have guidance on Ultraviolet Air Disinfection, but this document was last revised in 2003. Both the Illuminating Engineering Society (IESNA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have recently published updated guidelines for the use of UV-C technologies. The National Institute for Occupational Safety and Health (NIOSH) also have a useful guide for basic upper room application in Healthcare Settings, but this is focused around the environmental control of Tuberculosis.

At the time of writing (Sept 2020) there is no agreed technical safety standards for UV-C devices. Standards are expected to be developed by the International Electrotechnical Commission (IEC), Underwriters Laboratories (UL) and other standards organisations; though this will take time. In the interim the Global Lighting Association (GLA) has proposed an interim guidance document to draw attention to safety measures associated with UV-C products and suggest guidance for their safe use. During the absence of formal standards, we would recommend following the guidance presented by the GLA as a minimum safety requirement.

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Do you specify a typical uplight and then it is just a matter of selecting a lamp with the right wavelengths? or is this a separate type of light that is not also lighting the space?

Nathaniel Jones (Arup): Great question, Doug! It is possible to find some light fixtures that incorporate both visible and UV-C light (with a separate emitter for each). However, it’s not as simple as putting a UV-C bulb into a regular fixture. UV-C wavelengths will be absorbed by the plastic and glass elements that are meant to diffuse visible light in typical fixtures. Instead, most UV-C fixtures feature exposed lamps with metal grills or louvers to direct the output radiation.

How would the energy consumption compare for two strategies of high ventilation vs using UVGI?

Nathaniel Jones (Arup): While I don’t think there’s a one-size-fits-all answer for this, the energy requirement for UVGI will typically be similar to the lighting energy use. This is generally less energy than is used by the HVAC system.

Joseph Hewlings (Arup): The energy consumption from ventilation depends to a large extent on the climate. In California, for example, there is a much lower energy burden from increasing ventilation rates than in New York, Miami or Calgary. Further, the potential to do so often depends on the HVAC systems that are popular in any real estate market: buildings in milder climates tend to have airside economizers that make this easier, whereas many existing buildings in the Midwest, for example, do not have the ability to provide any additional outside air. Depending on the jurisdiction, increasing outside air rates may conflict with energy efficiency codes and so it’s not always straightforward to design a new building with high ventilation rates. But assuming it is practical to provide increased ventilation in your building, this will usually consume more energy than a UVGI system – especially in summer and winter.

Are there any currently available 222nm options for occupied spaces? Eden Park and Ushio come to mind, but both seem to be producing only for manufacturers, not for custom installs etc. LED or excimer.

Renee Thomas (Arup): As the question implies, currently available non-mercury excimer lamp technologies operating at germicidally active spectra are produced and marketed by both Eden Park and Ushio. Excimer lamps, emitting at 222nm (with the addition of spectrally selective low-pass filters), utilize a sealed KrCl (Krypton & Chlorine) gas discharge lamp to create an energetic UV-C plasma. These excimer lamp technologies are typically being manufactured for OEM UV-C fixture providers for inclusion in their germicidal lighting product lines. For example, Acuity Brands Inc. recently announced a strategic alliance with Ushio to utilize its Care222® Excimer lamp module in Acuity’s soon to be released

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far UV-C fixture product line. Additionally, and as noted previously, semiconductor manufacturers are working to develop highly efficacious solid-state UV-C emitters that can be utilized to create LED products to replace current low-pressure (mercury-based) gas discharge lamps. The introduction of both excimer and LED UV-C emitters has the potential to allow for new and useful product form factors which exhibit greater lamp-life, lower operating cost and remove mercury from the manufacturing supply chain.