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Let there be light

Can UV-c stop COVID-19?

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Can ultraviolet light help limit the spread of COVID-19? Ecolibrium assembled a panel with diverse opinions to discuss UV-c technology in HVAC systems. Our panel members are **Andrew Watson, Patrick Chambers, Affil.AIRAH, Dion M Froes, M. AIRAH, Daniel McCaffrey M.AIRAH**, and **Scott Summerville, M. AIRAH**.

Danny Chan reports.

This roundtable is part two of a two-part series.

Andrew Watson, CBE director

Patrick Chambers, Affil.AIRAH, Stantec associate mechanical project engineer

Dion M Froes, M.AIRAH, chair and general manager of ecoHVAC

Daniel McCaffrey, M.AIRAH, AFPRO Australia

Scott Summerville, M.AIRAH, managing director of Opira and of Air Restore, and a director of Labstar

Concerns surrounding the airborne transmission of SARS-Cov-2 have helped contribute to a renewed interest in ultraviolet germicidal irradiation (UVGI). UVGI is a long-established means of disinfection that can be used to effectively inactivate airborne microbes that transmit tuberculosis, measles and SARS-CoV-1, a close relative of the novel coronavirus.

Since the pandemic began, this century-old technology, known alternatively as GUV or UV-c, has received the kind of attention usually reserved for a novel method or device. Some within the built environment industry have also been mulling over the deployment of germicidal UV HVAC systems as an additional measure to curb infection risks.

In part one of this roundtable we asked participants about different presentations of the tech (coil- vs duct-mounted), factors determining uptake, mainstream adoption, reliability, and the efficacy of using UV-c to provide continuous air disinfection.

Q: Are there cost-benefits of incorporating germicidal ultraviolet light (UV-c) technology in HVAC systems?

Dion Froes: In the Australian market, the "cost-benefits" equation is really only valid when UV-c is used in an "on-coil" situation and the UV-c lamps are incorporated in the AHU/FCU to ensure the coil remains clean. ROI is typically 12 months, which is when the normal coil clean would be performed.

Keeping coils clean with UV-c not only reduces (possibly eliminates) the need for manual coil cleaning, but also preserves the efficiency of the AHU as designed by preventing clogged and thermally inefficient coils, thus the blower doesn't have to work harder to move air through the coil, extending useful system life. It must be noted that UV-c does not replace filtration.

Patrick Chambers: The true cost benefits of UV-c need to consider the economics of indoor air quality. The application of UV-c in HVAC systems can provide benefits relating to enhanced air quality (by virtue of reduced pathogens and colony forming units), and to minimise the maintenance burden associated with microbial build-up inside HVAC systems. The latter example has clear and measurable fiscal benefits, and we have seen examples in the healthcare sector where clients have indicated that maintenance costs relating to coil cleaning and ductwork cleaning have dropped significantly due to the installation of on-coil UV-c technology.

In the instance of providing enhanced air quality, this is very difficult to measure, as generally speaking, the economics of clean air inside buildings is multi-faceted and an evolving space of research.

Andrew Watson: There may be an energy benefit in the lowered cost of running the UV-c versus pushing air through a filter. However, the full cost of a UV-c may vary according to the application.

The decision would need to be made whether it is a "front-line device" (primary contamination control) or as an "add on" or "nice to have". If it is a front-line device you would need to add the cost of testing on installation, alarm device in case of unit failure and yearly tube replacement and re-testing. However, if it is a front-line device, why wouldn't you just use a HEPA filter?

A HEPA filter is a common device that can be tested to a NATA-accredited procedure on installation and regular recertification. If installed in a well-designed system, it should provide high-level (almost absolute) protection for 10 to 15 years.

Daniel McCaffrey: Purchase/installation/maintenance/replacement costs would need to be compared with disinfection protocols already in play with legacy systems.

Scott Summerville: A lot more studies need to be conducted on the costs and benefits. There will be plenty of similar data coming out over the next few years, as we are seeing a greater uptake in UV-c in in-duct systems due to the coronavirus.

Looking at hospital-acquired infections where Victoria had hundreds and more than 1,000 in isolation at times and the growing evidence of aerosol transmissions, it also seems negligent not to spend the money on this type of air disinfection. If in-duct air disinfection can save one life or prevent an ICU bed being occupied for a week, you would think that the benefits far outweigh the costs.

Q: How is UVC currently being used in a hospital setting?

DF: To my knowledge, Australian hospitals only use on-coil or duct-mounted UV-c. Some hospitals also utilise mobile room disinfection. The mobile room disinfection is for surface sterilisation and can only be run while the areas are unoccupied. In the US they use UV-c in operating theatres, mainly orthopedic surgery, before, during and after surgeries.

During the surgery, it operates at a low intensity and all medical staff are completely covered.

PC: The predominant application we are seeing is on-coil technology, followed to a lesser degree by in-duct applications. We are also starting to see in-space products which act to sterilise environments when they are not occupied, such as operating theatres as part of overnight set-back-mode operation.

AW: I regularly review hospital pharmacies and get any UV light devices to be removed at the earliest opportunity. One, UV light and drugs do not mix; exposure of a vial or bag to a UV light has the potential to degrade the active ingredient, making the drug less effective. Two, staff can use the UV light as a back-up for poor hygiene and cleaning practices. The same can occur in operating theatres. If there is a proper, controlled, blind study that demonstrates a tangible CFU/m^3 reduction in airborne viable particles, I'd be very interested to see it. Until then, I think proper HEPA filtration, and robust cleaning, gowning and hygiene practices are far more effective.

DM: Aside from instrument and equipment sterilisation in central sterile services departments (CSSDs) and biology analysis and pathology departments, to my knowledge, it is not so widespread. The implementation into HVAC systems is in its early days of implementation.

SS: In Australia, our experience is that it is mostly coil systems. Since COVID-19, there are a number of projects specifying in-duct. However, in-duct is only now being considered even though there are a number of TB (spread by aerosol) patients across Australian healthcare institutions long before COVID-19. In-duct UV-c has the potential to save lives of frontline healthcare workers and the general public in a healthcare setting. In-duct should be a minimum standard for all HVAC systems serving any areas of high-risk patients or areas used to treat infected patients where these patients are infected with an airborne infectious disease. Surface sterilisation of bathrooms and mobile units are available but these are not utilised in an Australian infection control program, whereas in Europe and US this is very common.

Q: Can the knowledge or implementation of UV-c in a hospital setting be easily transferred to other indoor environments such as office buildings or schools?

DF: If being implemented in HVAC systems and/or upper-air irradiation, then yes. The "surface-mount" or mobile units are not easily transferrable due to the harmfulness of exposure to UV-c, but can be implemented following the manufacturers' safety guidelines.

There are also "in-room" products, such as the upper-air irradiation system on the market, which would be suitable for these environments, as they are safe to use.

PC: The concept of using photon energy to disrupt DNA of pathogens is completely transferrable from sector to sector. That being said, there are obviously different circumstances which might lean the decision one way or another. For example, if utilising the technology to target microbial growth inside AHUs, it is far more appropriate for high-latent conditions such as high-occupancy applications.

AW: For these areas, traditionally there was much less at stake. With COVID-19, not anymore. If this technology is to be introduced into other environments as a primary control, then much more work and assurance is required before I would recommend any UV-c device. So, at the moment, as a front-line device – no.

SS: I would say "yes" but you need to be aware of its limitations in each application and choose the type of technology that is likely to give positive results.

Q: What are the guidelines to make sure the public is sufficiently informed before buying UV products and what more can be done?

DF: I don't believe that Australia has specific guidelines around UV-c but would strongly encourage that guidelines are implemented, if they do not yet exist. Warning labels on the risk of exposure should be an absolute minimum.

In addition, we should have some sort of standard guide for certification as well as how the required intensities or outputs are displayed. There should be guidelines on the ballast requirements, and these should be AS/NZ certified. A typical US specification on lamps requires them to "have a minimum of 11.7µW/cm² per linear inch (25.4mm) of lamp arc length at a distance of one meter as per IES Test Standards.

"Output shall be independently tested in airstreams of 400 feet per minute (2.03 m/s) velocities at temperatures of 45°F (7.22°C)." The key words are "independently tested".

PC: There are limited guidelines that I am aware of to inform how designers will specify products.

AW: The Therapeutic Goods Administration (TGA) has a system for the review and approval of devices that can rightly claim effectiveness on SARS-CoV-2, particularly in a medical setting. The evaluation process is robust and non-compliance or using a false claim will lead to a hefty fine.

Further guidelines on design, construction, commissioning, use and ongoing testing would be welcome, but would need an active community of suitable devices, and an industry that is willing to utilise guidelines.

DM: Apart from information in the industry group advisories mentioned previously, unsure. More can be done in the demonstration and publication of proven benefit and case studies.

It is important that to minimise dust settling and being distributed via HVAC&R systems, the dust-penetration, air filters in AHUs should be assessed using current best practice in selection, and ISOePM1/ASHRAE 52.2 >MERV13-A/EN779.2012 >F7 classifications should be used as a measure to significantly reduce the risk of biological transfer within the AHU system. Current advice from ASHRAE as well as leading manufacturers is that product performance sheets confirm the distinction between >F7 filters as both ISOePM1 and ISOePM10 depending on filter type.

The 2012 version of the now-withdrawn EN779 excluded many previously classified >F7 filters. This is not the case with filters classified as >F7 to AS1324.1.2001. HEPA filters will prevent transfer of bacteria carrying particles, but they are subject to failure, and this can often occur between scheduled certification and should not be relied on as a single-step measure of biological/viral security. So the application of in-duct UV-c/UVGI in the supply air, in combination with effective air filtration at the air handing unit and/or the return-air points, would do no harm and provide a further risk-reduction strategy.

SS: There should be the development of an Australian standard, as the technology is becoming more common and a number of products don't comply with the RCM electrical certification for Australia. There is also an issue with UV-c leakage from different products and there is really no guidance here in Australia. A good place to start is ASHRAE Chapter 62 Ultraviolet Air and Surface Treatment. ∎

Would you like to know more?

Part one of this article ran in the summer 2020 issue of Ecolibrium.
Go to www.airah.org.au/ecolibrium to check it out.

THE PHARMACEUTICAL PERSPECTIVE

CBE director Andrew Watson provides insight on the use of UV light as a sanitising or disinfection agent in the pharmaceutical industry.

The most common use of UV light is in systems that deliver highly purified water for non-sterile and sterile drug products. They are located in storage tanks and installed in-line in water-recirculating distribution systems. These devices are there more as a maintainer of sterility, where the purified water is subjected to a constant dose. The heavy lifting is performed through heat, filtration and occasional chemical dosing with materials such as ozone. They are considered good practice at most, and "do no harm" at least.

UV is also used in transfer devices, and in specialist devices such as biological safety cabinets where injectable drug products must be prepared in a sterile environment. Unfortunately, these devices can do more harm than good.

The use in transfer devices is for decontamination of surfaces where materials are being passed from a less-clean to a "more clean" environment. There are two key problems with this. One, it is almost impossible to sanitise all surfaces by UV, particularly when materials are sitting on another surface. Two, the UV will penetrate through glass or plastic and therefore irradiate what is inside. This can be your microbiological samples, or worse, your $20,000 life-saving chemotherapy drug.

For specialist devices, the UV light has been traditionally used as a post-use sanitisation device, where the front of the device is covered, and the internal sterile space is irradiated between sessions. However, this can lead to problems.

There can be a reliance on the use of the UV light, as opposed to proper cleaning practices and good aseptic techniques. There can be a deterioration of some materials within the space, which can lead to brittleness or discolouration. Then there are the left-field problems, such as the pharmacist who once confessed that she liked to work "under the nice blue light". Finally, poor maintenance meant that tubes were rarely replaced or check to confirm they were still delivering a suitable dose.

A fundamental problem with the UV light is that while it is straightforward to test a UV light on a flat surface, it is difficult to determine and replicate a specific kill rate across an entire device or even a container.

The Australian Standards committee that oversees the standards for biological safety cabinets and similar devices, ME-060, has decided not to recommend the use of UV lights. However, guidelines on how they may be used and tested are still included.

In the less-regulated industries that support the pharmaceutical industry, I see a range of devices on the market that make all manner of claims using plasma, electrostatic or ionised fields, carbon filters, activated surfaces and UV. I'm yet to see one of them that can make and maintain a claim that can be made by a HEPA filter.

With a HEPA filter, you have a device that is certified in the factory, is certified on installation and is regularly re-certified for the life of the installation. The aforementioned devices may give you a claim, usually based on some limited research work, but no way of actually demonstrating that it can achieve the claim on installation, or during the life of the installation. This is why most of these technologies, UV-c included, are unlikely to find a proper foothold in the pharmaceutical industry, and therefore a proper critical mass for wider acceptance.

However, there are some caveats to this:

- There is no reason why an in-duct UV-c device could not operate in the same manner as they operate in purified water. The question is cost, dwell time, maintenance and a defined net benefit.
- Contamination, colonisation and "grow through" in filters are a significant issue. Perhaps an in-duct filter could limit the opportunity for initial filter contamination, but so could good maintenance practices, humidity control and proper pre-filtration.
- In large systems, it may be cheaper to run an in-duct UV-c light than to push air through an F7 pre-filter.
- There is increasing evidence that SARS-CoV-2 can persist on surfaces at low temperatures for extended periods of time. Could we find AHUs holding viable virus particles that could infect maintenance staff, or disruptions during maintenance that could release viable virus particles into a populated area? Could UV-c provide a control, or would chemical or heat-based disinfection be much more effective? ∎