October 2012 Vol. 54 No. 7

CONSTRUCTION CANADA

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CSC The official magazine of Construction Specifications Canada

www.constructioncanada.net
$7.95

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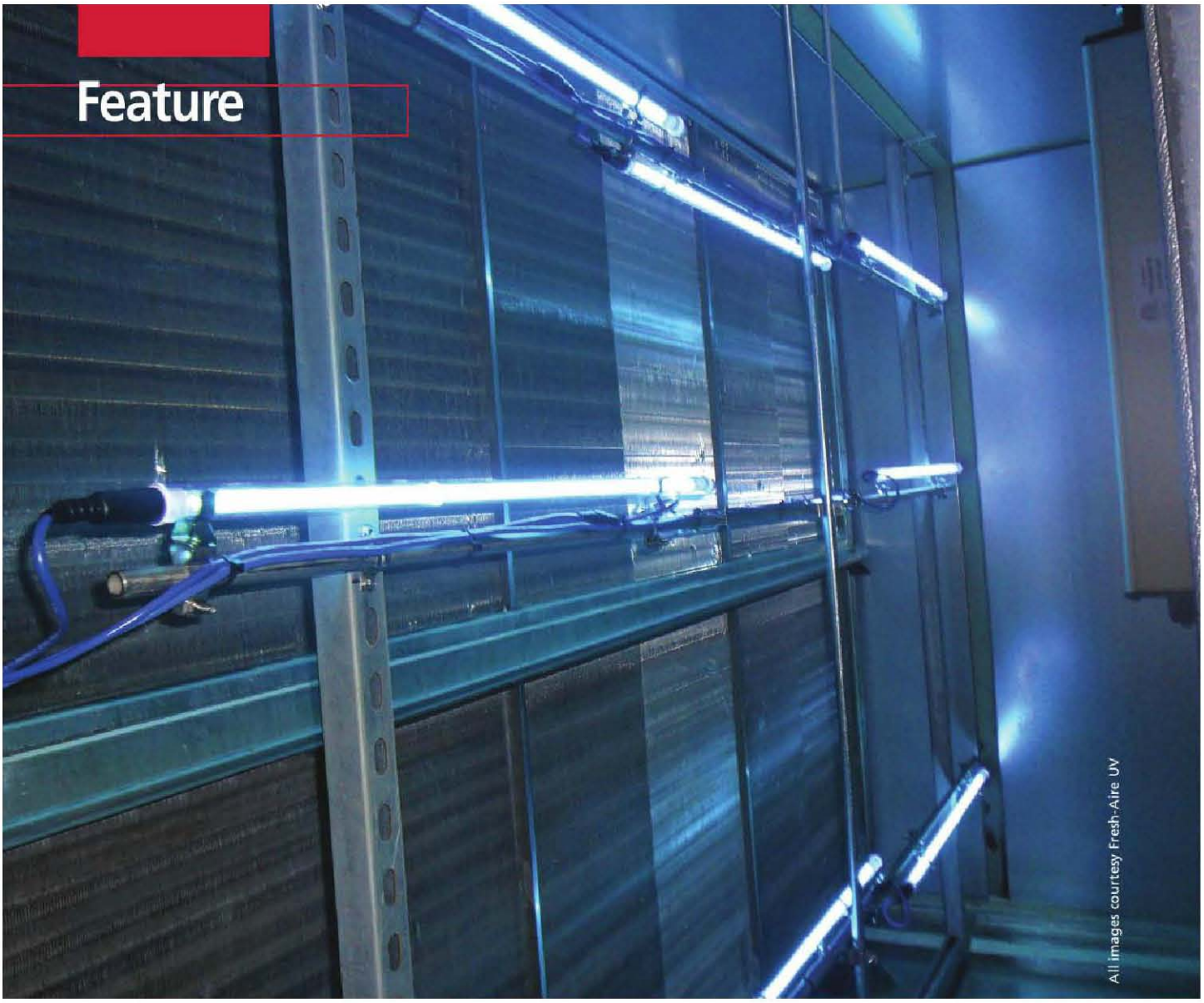
Feature



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Saving Energy Through AIR FILTRATION

By Chris Willette

Indoor air quality (IAQ) technologies combining ultraviolet germicidal irradiation (UVGI) and gas-phase purification allow engineers and facility managers to reduce energy consumption while ensuring a safe environment for building occupants.[1] Now, the latest approach is to combine these systems with photocatalytic oxidation (PCO)—a chemical reaction caused by shining UV light onto a reactive medium, usually titanium dioxide.

IAQ equipment manufacturers have combined UVGI, gas-phase air purification, and PCO in a combined filtration unit that can be installed into new or existing HVAC systems. The result offers commercial building owners the potential for significant energy savings.

This new approach can improve energy efficiency in three ways. First, UVGI can cut HVAC coil maintenance costs and retain optimal heat transfer of the coils allowing the mechanical system to run at peak design efficiency.

Secondly, gas-phase air purification, while better known for filtration, can contribute to energy efficiency. The recently approved Indoor Air Quality Procedure (IAQP) from American Society of

Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 62.1, *Ventilation for Acceptable Indoor Air Quality*, allows for reduced outdoor air requirements when an 'air-cleaning' system is used to remove gaseous airborne contaminants in the re-circulated indoor air. Reducing outdoor air, and the costs for conditioning it, promise significant energy savings, says Dean Tompkins, PhD, P.Eng., an air purification and IAQ consultant, and past chair of the ASHRAE Technical Committee 2.3, "Gaseous Air Contaminants and Gas Contaminant Removal Equipment."

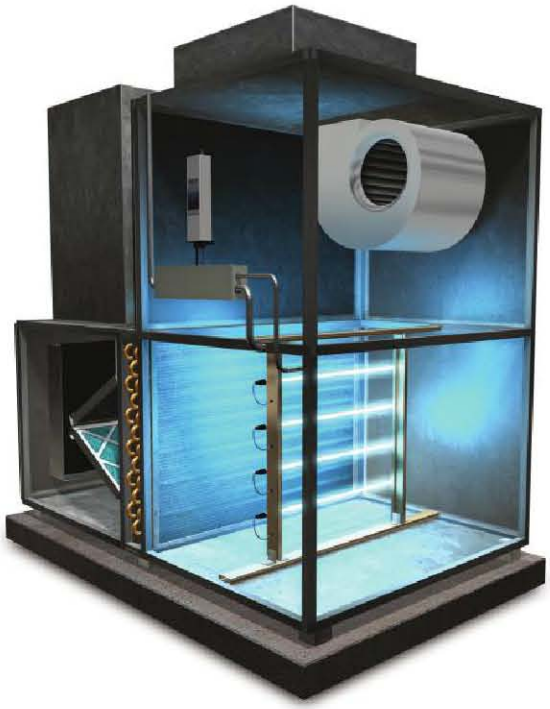
Further, photocatalytic oxidation links UVGI and gas-phase air purification and enhances their efficiency. It regenerates the gas-phase-activated carbon media, keeping its adsorption capacity and efficiency high, and energy consumption low.

UV-C increases HVAC coil efficiency

UVGI is an established technology for both surface and airborne disinfection in HVAC systems. The technology works by scrambling the DNA of micro-organisms—like mould, bacteria, viruses, and allergens—that prevents them from reproducing. The UVGI lights are typically positioned downstream, facing the coils in air-conditioning systems.

Although effectiveness depends on exposure time and micro-organism type, all viruses, bacteria, mould, and other microbes are destroyed by UVGI light. Microbial growth affects HVAC system efficiency by fouling interior surfaces. Biological contaminants adhere to HVAC coils, which offer ideal environments for microbial growth. If left unchecked, microbial growth can coat air conditioning coils with multiple layers. This hinders the heat-transfer process and increases static pressure, which causes longer HVAC system run-times to satisfy set-point temperatures.

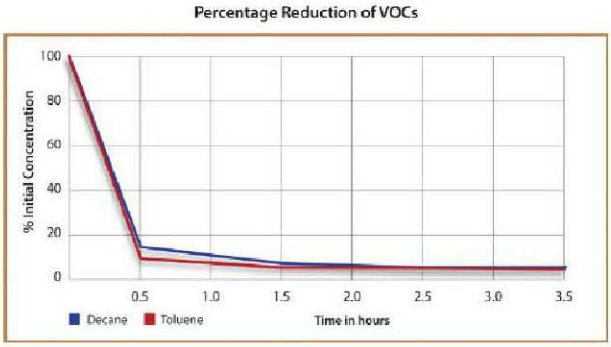
Keeping coils clean might be considered a maintenance and IAQ expense, but it pays back in energy efficiency. Small amounts of coil surface dirt, debris, or biological growth can significantly decrease operating efficiency.



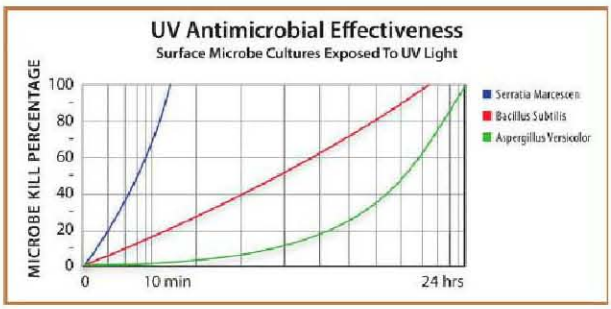
Ultraviolet germicidal irradiation (UVGI) is an established technology for both surface and airborne disinfection in HVAC systems. The technology uses ultraviolet (UV)-C light to scramble the DNA of micro-organisms—such as mould, bacteria, viruses, and allergens—and prevents them from reproducing. The UVGI lights are typically positioned downstream in an air-handling unit (AHU) facing the coils.

Florida Hospital, an Orlando-based healthcare system with more than 2800 beds in locations throughout the state, documented the maintenance-reducing effects of UVGI installed in air-handling units (AHUs). The facility's chief mechanical engineer (CME) Firouz Keikavousi, suggests use of UVGI improved static pressure, air velocity, and temperature in a test HVAC system.[2]

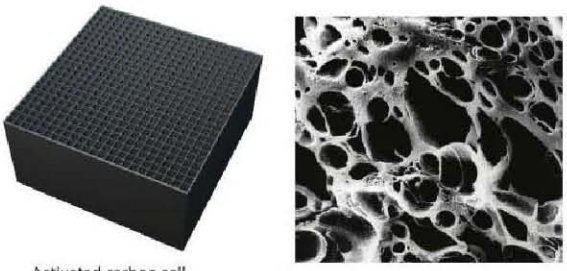
A tubular rack UVGI system is a quick and easy method of installing UV lights as a retrofit or new installation in any brand and size of commercial HVAC equipment. The installation kit uses common electrical conduit and brackets so maintenance departments and contractors can custom build a system into an AHU.



Studies indicate that gas phase air purification is effective in reducing concentrations of volatile organic compounds (VOCs). This test graph shows the timeline reduction of two VOCs—decane and toluene.



Studies also indicate UVGI is effective in disinfecting microbes. This test graph shows the timeline of exposure that is required to disinfect common microbes found in hospitals and other commercial buildings.



New methods of air purification combine gas-phase air purification carbon media with UVGI.

In Florida Hospital's test, Keikavousi revealed static pressure over the coil decreased from 1.8- to 0.7-wg. within weeks of installing UV-C lamps. Air velocity doubled from 70 to 158 m (230 to 520 f) per minute and exiting wet-bulb air temperature decreased from 14 to 11 C (57 to 53 F).

The improvement resulted in a capacity increase of 95,245 Btuh of air-conditioning. In dollar savings, the calculation was:

1(kW/ton) x 24 (hrs/day) x 365 (days/year) x $0.07 (electric rate)

The total savings per AHU—$4867—did not include the reduced maintenance costs. The total savings are approximately twice the cost of a UVGI system for the coil, which results in payback in less than one year. Considering the hospital's many other facilities and HVAC systems, the estimated annual savings of using UVGI in all of them is significant. Similar systems are installed in hospitals throughout Canada.

Not every facility has the funding to periodically test IAQ, but most maintenance departments contend UV-C lights minimize mould growths on air-conditioning coils and AHU interior surfaces. As a result, biological growths and their distribution via the ventilation system is minimized.

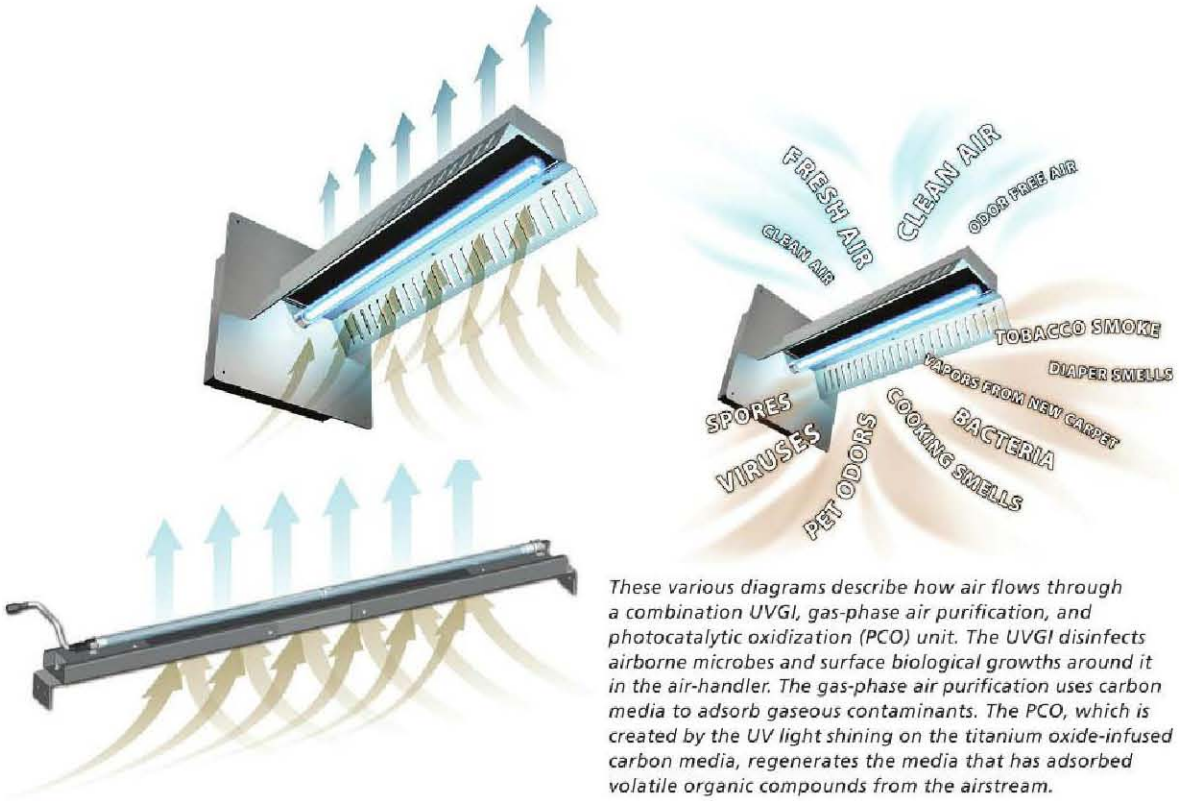
For example, Geary Community Hospital in Junction City, Kan., has been using UVGI in new HVAC air-handlers supplying common areas, a patient tower, and operating rooms as part of a recent multi-million dollar expansion. While it is difficult to compare new technology to the hospital's older HVAC units (installed before UVGI was available), the new AHUs with UVGI require no cleaning based on periodic visual inspections.

"We pressure-clean the original units' coils annually, but the new units with UVGI have not required any maintenance cleaning in more than three years," says Steve Rippert, the facility's director of maintenance.

Gas-phase air purification and ASHRAE's IAQP

The Indoor Air Quality Procedure provision has been added to AHSRAE 62.1 and gives gas-phase air purification an entirely new scope beyond purifying outdoor air of gaseous contaminants. Specifically, building owners now have the ability to reduce the outdoor air cubic feet per minute (cfm) per person.

Gas-phase air purification has been used for decades in heavy industries such as petrochemical, wastewater processing, and



These various diagrams describe how air flows through a combination UVGI, gas-phase air purification, and photocatalytic oxidization (PCO) unit. The UVGI disinfects airborne microbes and surface biological growths around it in the air-handler. The gas-phase air purification uses carbon media to adsorb gaseous contaminants. The PCO, which is created by the UV light shining on the titanium oxide-infused carbon media, regenerates the media that has adsorbed volatile organic compounds from the airstream.

paper/pulp to minimize process-generated gaseous contaminants affecting equipment, electronics, employees, and the surrounding environments. More recently, engineers have specified gas-phase air purification in HVAC system retrofits and new equipment as a result of the IAQP provision. During the gas-phase process, the air stream is directed through activated carbon, which is a porous material with the capability to adsorb most volatile organic compounds (VOCs). The carbon changes the contaminants from a gas to a solid phase.

Gas-phase air purification can remove chemicals that particulate filters, such as conventional pre- and final-filter media commonly used in HVAC systems, and even higher capture methods such as high-efficiency particulate arrestor (HEPA) and ultra-low particulate arrestor (ULPA) filters.

The original ASHRAE 62.1 was considered a superior advancement for indoor air environments. It prescribed the ventilation rate procedure (VRP) of flushing out indoor contaminants. Whereas VRP was the status quo for engineers over the last few decades, IAQP is expected to become a more favoured method.

VRP has two significant limitations that have become more critical due to today's energy costs and environment:

1. Outdoor air, depending on the season, must be heated, air-conditioned, and sometimes dehumidified before mixing with the air supply of a commercial building. This puts an extra energy burden on operating budgets.
2. Outdoor air is typically more polluted than air inside a building. Therefore, introducing outdoor air needs additional filtration, especially in highly populated or industrial areas.

In light of these factors, IAQP may be a better methodology because its calculations are derived from ventilation, air-cleaning,

UVGI lights can be grouped together to provide proper coverage of large air conditioning coils in commercial air handlers.

and source control, whereas VRP only considers ventilation. Energy used to condition the outdoor air can be significant depending on location. For example, in winter, preheating –23 C (–10 F) outdoor air to 21 C (70 F) is a major expense even if it only accounts for 15 to 20 per cent of the supply air.

Summer operation can also be costly. A hot humid day of 32 C (90 F) requires cooling the outdoor air down to 24 C (76 F) and reducing the relative humidity (RH) to 55 per cent. ASHRAE 62.1 helped spur a growing outdoor-air-dehumidification equipment segment in the HVAC industry 20 years ago, because conventional air-conditioning equipment cannot always handle the high humidity loads of outdoor air in the summer.

The impurity of today's outdoor air is also a factor. Outdoor air concentration of 0.14 m^3/minute (5 cfm) per person might have been adequate decades ago when outdoor air was cleaner, but as the outdoor air has become more polluted with carcinogenic poly-aromatic hydrocarbons (PAH), benzene, and rising ground ozone levels, upgrades to 0.28, 0.42, and 0.57 m^3/minute (10, 15, and 20 cfm) per person were seen as remedies to provide acceptable IAQ.

Even in areas with cleaner outdoor air, IAQ is affected by contaminants generated from indoor sources, such as cleaning chemicals, furnishings off-gassing, and other gaseous pollutants commonly found in buildings. When calculating the IAQP, engineers consider a variety of different parameters beyond the VRP. Potential outdoor air contaminants (based on government-funded research documents from many countries around the world) are included with off-gassing indoor air contaminants referencing the material safety data sheets (MSDSs) of building materials and furnishings, air changes, and other factors.

Once IAQP is calculated, the procedure allows for the addition of air-cleaning equipment to remove gaseous contaminants from both indoor and outdoor air. Ultimately, IAQP reduces the high outdoor air flow prescribed by VRP while simultaneously complying with ASHRAE 62.1.

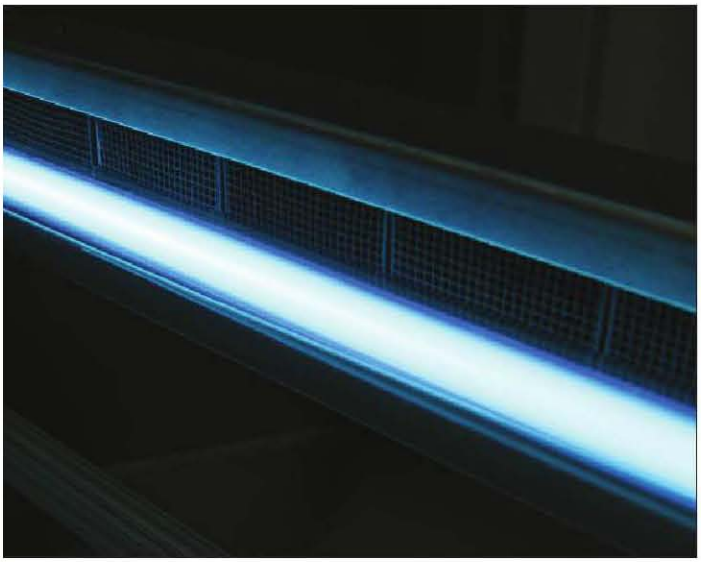
Conclusion

The disadvantage of traditional gas-phase air purification is the fact its media must be periodically tested to determine the remaining adsorption capacity. Replacing media that has become 100 per cent adsorbed with contaminants is expensive.

However, adding the PCO process can regenerate gas-phase media and negate periodic replacement, because it energizes a catalyst such as titanium dioxide, which is a popular coating infused into gas-phase media. The oxidization process of shining UV-C light onto the media degrades the adsorbed gaseous organic contaminants and can also oxidize bacteria and viruses.

When illuminated by UV light, the titanium dioxide produces hydroxyl radicals, which react with and decompose organic matter to mineralize, under conditions of complete oxidation,

This photo shows an all-in-one unit that combines UVGI and gas-phase air purification, which is titanium oxide-infused carbon media. The placement of the light near the gas-phase air purification media creates PCO, a process that regenerates the carbon media to allow it to continuously adsorb gaseous contaminants without replacement. Also pictured is the power supply that energizes the unit.



The gas-phase carbon media adsorbs gaseous contaminants and the UVGI disinfects biological contaminants. Mounting the UV light source in close proximity regenerates the carbon media through a PCO process when it is infused with titanium dioxide.

common gas-phase water molecules and carbon dioxide. Hydroxyl radicals are among the strongest oxidizing species and have stronger disinfecting capabilities than chlorine, ozone, and even hydrogen peroxide, while being much safer for building occupants. PCO destroys or mineralizes contaminants rather than simply sequestering them onto an adsorption substrate or media. Additionally, the PCO process requires no custom or artificially produced temperatures or pressures.

A good analogy of the PCO effect occurs naturally with beach sand and the sun's UV rays. In the daytime, there are rarely foul odours, because the sun's UV rays penetrate the sand and generate clean,

This photo shows an air-handler installation that uses a combination of UVGI, gas-phase air purification, and PCO in one unit for total air purification.

oxidizing molecules. At night, without sunlight and its UV effect, 'fishy' odours dominate the air quality. Likewise, the same UV light used to disinfect the HVAC system's interior surfaces, coils, and airstream, can also perform double duty by regenerating the carbon media and converting the adsorbed chemicals into harmless carbon-dioxide and water vapour. Therefore, the gas-phase carbon media is continually reused.

Advances in IAQ technology are bringing all three technologies—germicidal UV light, gas phase air purification, and photo catalytic oxidation—together into one cost-effective add-on unit for HVAC systems. Commercial building owners can now benefit by combining these three technologies.

Notes

[1] For more on gas-phase technology, see the article "Improving Indoor Pool Air Quality" by Harry Topikian, P.Eng., in the March 2010 issue of *Construction Canada*. To read it online, visit www.constructioncanada.net and select "Archives."

[2] This can be found in the article "UVC: Florida Hospital Puts HVAC Maintenance Under A New Light," published in an issue of *Engineered Systems* in February 2004 by Firouz Keikavousi.

Chris Willette is president of Fresh-Aire UV, a division of Triatomic Environmental Inc. He is an engineer and a designer/developer of indoor air quality (IAQ) products such as the Fresh-Aire APCO. Willette holds several patents/pending on ultraviolet (UV) lights and photocatalytic oxidation (PCO) for commercial and residential HVAC systems. He can be contacted via e-mail at chris@freshaireuv.com.