

Future Healthcare IAQ Will Combine Many HVAC Filtration Methods

An in-duct UV installation

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Introduction

Today's hot yoga is not exactly the yoga that the famous Indian sage Pantanjali helped develop nearly 2,000 years ago. While a typical yoga space might require HVAC specifications similar to a common fitness room or gymnasium, hot yoga demands a myriad of different HVAC design practices that will not be found in ASHRAE standards.

Hot yoga is a yoga genre requiring up to 250°F furnace discharge temperature and 100°F to 130°F indoor air temperature, and a hot yoga studio is one of the toughest designs and installations in the HVAC industry, according to Chad Clark, president of the Hot Yoga Studio Design & Services, a division of Cavalry Services, Inc., Scranton, Pennsylvania, USA. Clark has consulted, constructed or retrofitted more than 2,000 hot yoga studios around the world since 1997, including several studios in Bengaluru and Delhi.

Few mechanical engineers specify the correct equipment and even fewer contractors escape unscathed from a host of installation challenges inherent in any hot yoga studio project. Consequently, hot yoga studios have been responsible for fires, code infringements, infectious disease outbreaks and studio evictions. Clark recalls several hot yoga studio owners who called

him for consultation after their furnace vent assembly caught fire or just completely melted because of an engineer's specification or a contractor's installation errors. While the correct equipment is important, achieving a healthy, sanitary and odorless indoor air quality (IAQ) dominates the HVAC concerns of the hot yoga industry. For example, a Florida hot yoga studio was experiencing such severe IAQ challenges that the owner faced eviction charges and the facility's foul odors were detected literally blocks away from its front door.

If the conventional fitness, yoga and health club industries generally have reputations for potential airborne biological contaminants, the high temperatures and uncontrolled humidity potential at hot yoga studios – which are required for blood vessel dilation, muscle stretching and cell healing – generally produce what is best described as microbes on steroids.

About the Author

Mike Walrath is an HVAC industry veteran of 14 years with the commercial products division of Fresh-Aire UV, a division of Triatomic Environmental Inc., Jupiter, Florida, USA. He handles sales of indoor air quality products, such as the APCO, an IAQ system which incorporates germicidal UV light irradiation, gas-phase air purification technology and photo catalytic oxidation. The other products handled by him include the Blue-Tube UV®, a low-voltage germicidal UV light for HVAC.

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Handling Airborne Biological Contaminants

Because expelling body contaminants for total body cleansing is critical to hot yoga's success, an ultraviolet germicidal irradiation (UVGI) light system for airborne biological disinfection is essential for disinfecting re-circulated air laden with microbes. Typically, Clark uses an in-duct system (see *Photo 1* and *2*), which comes in an easily-to-install kit that is also suitable for hospitals, schools and other commercial buildings. While most UVGI lamps are installed perpendicular to airflow and parallel to air conditioning coils where microbes thrive in a condensation-rich atmosphere, Clark prefers in-duct system installations configured with multiple 32-inch lamps oriented in-line with the airflow. These comparatively long lamps create an extended UVGI field and consequently an increased exposure time for the most effective microbe sterilization. In traditional HVAC systems, in-duct UV lamps are typically installed in the supply air duct. However, because of the significantly hotter supply air discharge temperatures of hot yoga studios, Clark recommends the cooler 130°F return air duct as a more suitable environment for UVGI equipment. Likewise, components such as steam humidifier air switches, high limit switches and any other HVAC devices survive only about one week in a hot yoga supply air duct.

Besides in-duct systems, UVGI power supplies that are remotely mounted outside the duct are preferred instead of inside where the humid, hot environment causes potential reliability issues. Because of its reliability, some UVGI manufacturers offer a lifetime warranty with an externally mounted power supply because they experience few failures.

UVGI is steadily becoming popular for microbial disinfection in all types of health and fitness facilities. Customers in all genres of yoga studios are increasingly interested in UV's proven sterilization effects not only on airborne body secretions, but also on influenza and common cold viruses that are commonly passed among classmates.

UVGI is a Proven Technology

UVGI has been known for decades as a successful tool in reducing infectious airborne contaminants. However, nobody knew for sure how well it worked in an actual building environment until a recent third-party laboratory test in a simulated HVAC system.

A 2012 study by one of the top five international air cleaner equipment test labs, Airmid Healthgroup (AHG), Dublin, Ireland,

actually proved what engineers suspected all along. UVGI was proven effective against mold, bacteria and viruses in a simulated HVAC unit environment. The study simulated airstream microbe inactivation in an ASTM/AHAM style environmental test chamber. AHG built the chamber (see *Photo 3*) to simulate the indoor environment of a typical building with an HVAC air handler providing a 73°F (23°C) temperature, a 55-percent relative humidity and airflow velocity of 492 fpm (0.93m³/sec). A single pass test was also performed on an *ASHRAE Standard 52.2* test duct system.

The UVGI light single-pass inactivation results of the test were: Bacteria (*S. epidermidis*): 98.85 percent; virus (*MS₂ coliphage*): 99.03 percent; and Mold (*A. niger*): 78.80 percent. While someone unfamiliar with these biological contaminants might interpret anything less than 100 percent as unsatisfactory, the test was only a single pass. Multiple passes, as simulated in a typical HVAC system producing several room air changes hourly, would have produced a greater microbial inactivation, according to Dean T. Tompkins, Ph.D., P.E., a Milwaukee, Wisconsin-based independent IAQ consultant who reviewed the AHG test results.

UVGI equipment complements Clark's outdoor air specifications, which typically surpass *ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality*. Clark specifies the 20 cfm/person outdoor air recommendation of *Standard 62*, which is automatically overridden by outdoor air dampers activated by humidity, VOC or CO₂ sensors.

Combining UVGI, Gas-Phase Air Purification and PCO

The future trend of IAQ in yoga studios, as well as other facilities like hospitals, offices and other occupied spaces, will soon combine several filtration methodologies such as UVGI, Gas-Phase Air Purification and Photo Catalytic Oxidation (PCO). The amalgam of all three technologies offers facility managers a complete IAQ solution that disinfects airborne microbes and adsorbs volatile organic compounds (VOCs) out of the supply air stream and regenerates the adsorption media itself using new PCO methodology.

While progressive engineers aware of both UVGI and gas-phase air purification previously combined both technologies on projects with separate components from different manufacturers, both technologies plus PCO are now available in a single unit

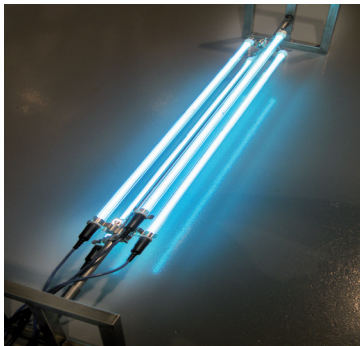


Photo 1: In-duct UV system used in hot yoga

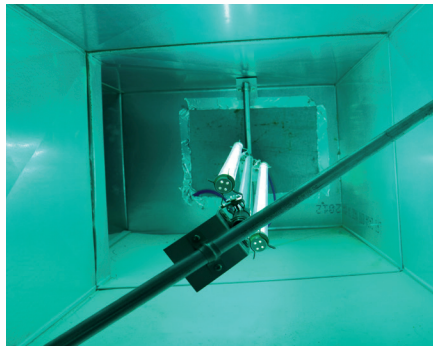


Photo 2: UV light in a hot yoga HVAC system ducting



Photo 3: Airmid's APCO test chamber

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that can be installed in new or existing HVAC systems. They have the potential of advancing the IAQ of any facility well past just UVGI.

Gas-phase air purification uses activated carbon-based material derived from coconut shells, charcoal or wood chips to adsorb and hold VOCs through a chemisorption process.

Like UVGI, there are studies proving gas-phase air purification effectiveness, such as *Predicting Gaseous Air Cleaner Performance in the Field* by C. Howard-Reed, S.J. Nabinger, and S.J. Emmerich of the Building and Fire Research Laboratory, National Institute of Standards and Technology (NIST), USA. The filtration tests, which were performed in a house using decane as the gaseous pollutant, demonstrated that gas-phase air purification reduces the contaminant by 30 to 44 percent in a single pass. Many facilities, such as hospitals, already use gas-phase air purification, according to Tompkins, who is also a past chairman of the ASHRAE Technical Committee 2.3, *Gas Phase Control and Removal Equipment*.

Indoor re-circulated air typically distributes a variety of VOCs throughout the facility. The VOCs include cleaning chemicals such as chlorine and d-limonene, and interior furnishings off-gassing of formaldehydes, acetones and other toxic chemicals. These materials are likely to release more VOCs in a high temperature environment such as a hot yoga studio.

Using PCO to Regenerate Gas-Phase Media

Eventually gas-phase air purification carbon media reaches 100-percent adsorption capacity. Replacing the media can be costly. However, combining the UVGI lamps with titanium dioxide-infused carbon media regenerates the media using a PCO process to extend its useful life indefinitely.

PCO is a self-cleaning process. The carbon cells adsorb VOCs, but before they reach their adsorption capacity, the same UVGI light disinfecting the aforementioned airborne microbes and interior HVAC system internal surfaces, also assist in regenerating



Photo 4: Ultraviolet ductwork

the carbon media. Thus the carbon media is continually reused and never needs replacement.

The regeneration occurs in this way: UVGI light illuminates titanium dioxide to produce hydroxyl radicals, which react with and decompose organic matter to form non-toxic inorganic matter. Specifically, PCO breaks down toxic gaseous contaminants into common water molecules and carbon dioxide. Hydroxyl radicals are among the strongest oxidizing agents and have stronger disinfecting capabilities than chlorine, ozone and even hydrogen peroxide, but are much safer for building occupants.

Unlike many conventional air purification and adsorption methods, the addition of PCO destroys contaminants rather than just transferring them to an adsorption substrate.

Going Beyond IAQ in Hot Yoga

While IAQ is the major issue in hot yoga studios, their required high temperatures also necessitate unique installation techniques, materials and equipment. For example, improperly sealed HVAC ductwork in cooler unsealed ceiling spaces attracts condensation

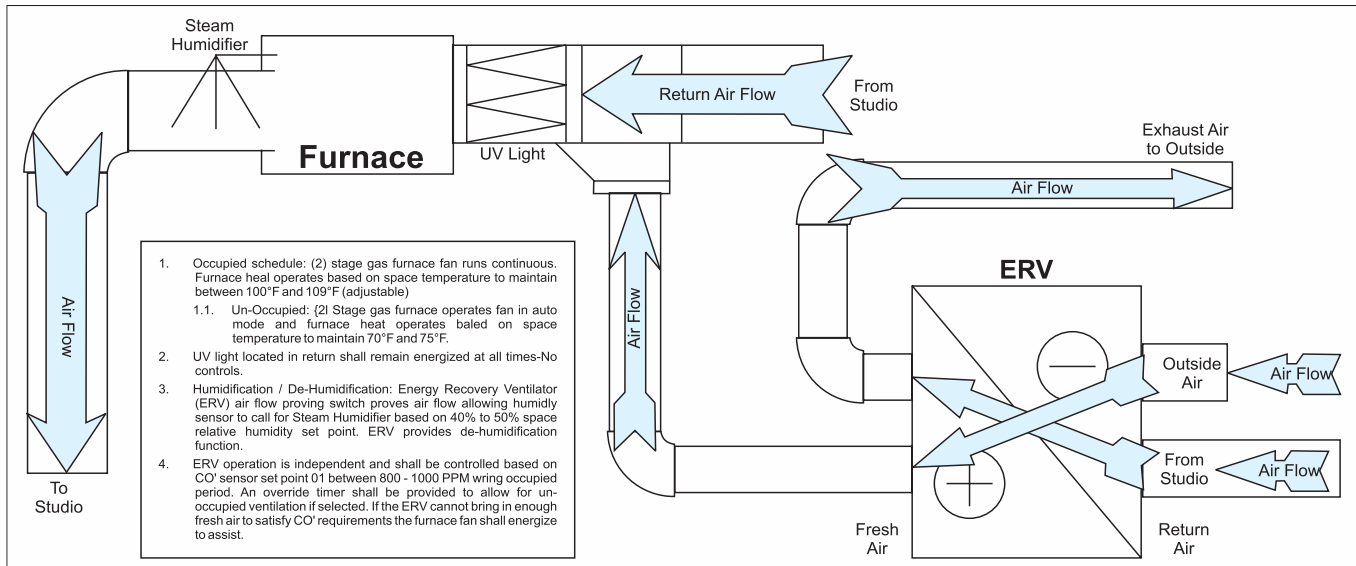


Figure 1: Clark's typical hot yoga HVAC system design

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that promotes growth of biological contaminants such as mold, fungus or Legionnaires' disease. Condensation on piping and steel roof structures can also lead to building deterioration. An Arizona shopping center roof collapse was allegedly caused by a hot yoga studio tenant.

Enveloping the entire studio in a vapor barrier is critical (see *Photo 4*), according to Clark, who also consults on every aspect of studio construction as outlined in his new e-book *How to Build a Hot Yoga Studio* (CreateSpace, 2012, Scranton, Pennsylvania). Then to withstand the 70 degree operating differential, Clark builds the walls and ceiling with structurally insulated panels (SIP), which are similar to refrigerated walk-in coolers. The equipment is equally robust to withstand high temperatures. Clark recently developed his own OEM type of building automation system that senses all environmental conditions plus standard items such as temperature.

Hot yoga studios are so problematic that major furnace manufacturers neither recommend their equipment nor risk the liability of custom-building equipment to suit the torrid environment. Consequently, Clark was forced to design his own OEM electric furnaces, gas furnaces, thermostats and circuit boards.

Consequently, his modulating furnaces are approximately twice the size and capacity of conventional space units. If a hot yoga studio does not have a 400 amp service available for the preferred electric heat, Clark specifies a gas-powered furnace. Most HVAC manufacturers want nothing to do with occupied spaces above 92°F, which puts them into more stringent code

classifications.

Many contractors are ill-prepared because they perceive a hot yoga studio heat requirement as just a supplemental heater putting 3,000 cfm in a 1,500 square foot space. For example, using a conventional heater and bringing in code mandated outdoor air could be problematic for reaching the 130°F set point. Consequently, the studio owner runs the ill-suited equipment 24/7 to try and reach set point temperature and stresses out the equipment.

When a contractor does happen to get the correct capacity equipment, the space typically has no blueprints. So the contractor sets it up like regular heating/ cooling equipment with items like ceiling returns instead of floor returns, which are essential. Three months later, the contractor is still fielding complaints and the system never works up to hot yoga standards.

Conclusion

Hot yoga studio design is not to be taken lightly by engineers or contractors, either in equipment or in respect to IAQ. However, the disinfection of biological contaminants with UVGI is the most important element in keeping occupants healthy and advancing the growth of not only the hot yoga industry, but also any active and occupied environment.

The aforementioned hot yoga studio that could be smelt blocks away was only a momentary challenge. After installing a UVGI system, the biological contaminants and foul odors disappeared within three days. The studio operator's pending eviction notice was rescinded, and another IAQ solution had once again been provided to the hot yoga industry. ❖