

Alternate Methods for USING GERMICIDAL UV-C Disinfection Lamps TO SUPPLEMENT HEPA Filtration

By Dave Shagott

Today, healthcare facilities must be prepared to face potential large-scale threats from chemical, biological, and nuclear contaminants that were almost unthinkable in the past. HRSA Critical Benchmark #2-2 has significantly increased the surge isolation room capacity requirements for hospitals and clinics in an effort to handle a potential influx of potentially infectious patients.

Existing capacities have been further strained by the recommendations in the 2003 CDC Guidelines against the use of dual-purpose (positive/negative) isolation rooms in either new or existing facilities, because these rooms can be “unreliable.”

Should Your Facility Consider UVGI?

HEPA filtration, air changes, containment, and negative room-pressurization are the time-proven engineering measures for successful patient isolation and infection control. They remain the primary recommended controls under current and proposed standards for Airborne Infectious Isolation (AII) rooms and Protective Environments (PE).

Because of the unknown nature and toxicity of the pathogens that may be involved, an increasing number of facilities are also considering the use of UVGI (Ultraviolet Germicidal Irradiation) lamps, also called UV-C lamps, as an additional measure. Others remain wary because of safety and efficacy concerns.

Common questions from infection control and facility engineering professionals regarding this technology include the following:

- ▶ Do UVGI lamps really increase the level of protection?
- ▶ How much UVGI output is needed?
- ▶ Where should the lamps be located for maximum effectiveness?
- ▶ Can UVGI be used safely?

The purpose of this article is to help provide some of the answers.

The short answer is that UVGI disinfection can complement these other infection control measures. Leading hospital applications include:

- ▶ Providing an additional level of protection for patient isolation rooms.
- ▶ Continuous air disinfection in areas where the infectious status of patients may be unknown, such as ER, outpatient clinics, or waiting areas.
- ▶ Controlling airborne pathogens and odors to improve worker safety and comfort in areas such as laboratories, autopsy or morgue.

2003 CDC Guidelines and UVGI

Additional answers to most of the above questions can be found in the 2003 CDC *Guidelines for Environmental Infection Control in Health-Care Facilities*, which take a more positive view toward the use of UVGI than some previous guidelines. Specific references to and recommendations include:

“As a supplemental air-cleaning measure UVGI is effective in reducing the transmission of airborne bacterial and viral infections in hospitals, military housing, and classrooms.”

“UVGI can be placed in the ducts as an adjunct measure to HEPA filtration, but it cannot replace the HEPA filter.”

“Where supplemental engineering controls for air cleaning are indicated from a risk assessment of the AII area, install UVGI units in the exhaust air ducts of the HVAC system, to supplement HEPA filtration, or install UVGI fixtures on or near the ceiling to irradiate upper room air.”

“The use of fans or HVAC blowers to generate air movement may increase the effectiveness of UVGI if airborne microorganisms are exposed to the light energy for a sufficient

length of time. In duct irradiation systems, UV lamps are placed inside air ducts to disinfect the air before it is recirculated. When properly designed, high levels of UVGI can be attained in the ducts with little or no exposure of persons in the rooms.”

Maximizing UVGI Effectiveness

UVGI “kills” microorganisms primarily by destroying their DNA, in addition to taking away their ability to replicate. Doing this effectively requires direct exposure to a high-intensity UVGI energy source, because the lamp(s) can’t “kill” what they can’t “see.”

From an infection control perspective, there is no such thing as too much UVGI exposure; the higher the dosage (level of UV-C radiation exposure), typically measured in microwatts per square centimeter, the higher the “kill” rate. This is especially true with pathogens such as most fungi, which typically require 10 to 50 times more energy to destroy than is required for bacteria.

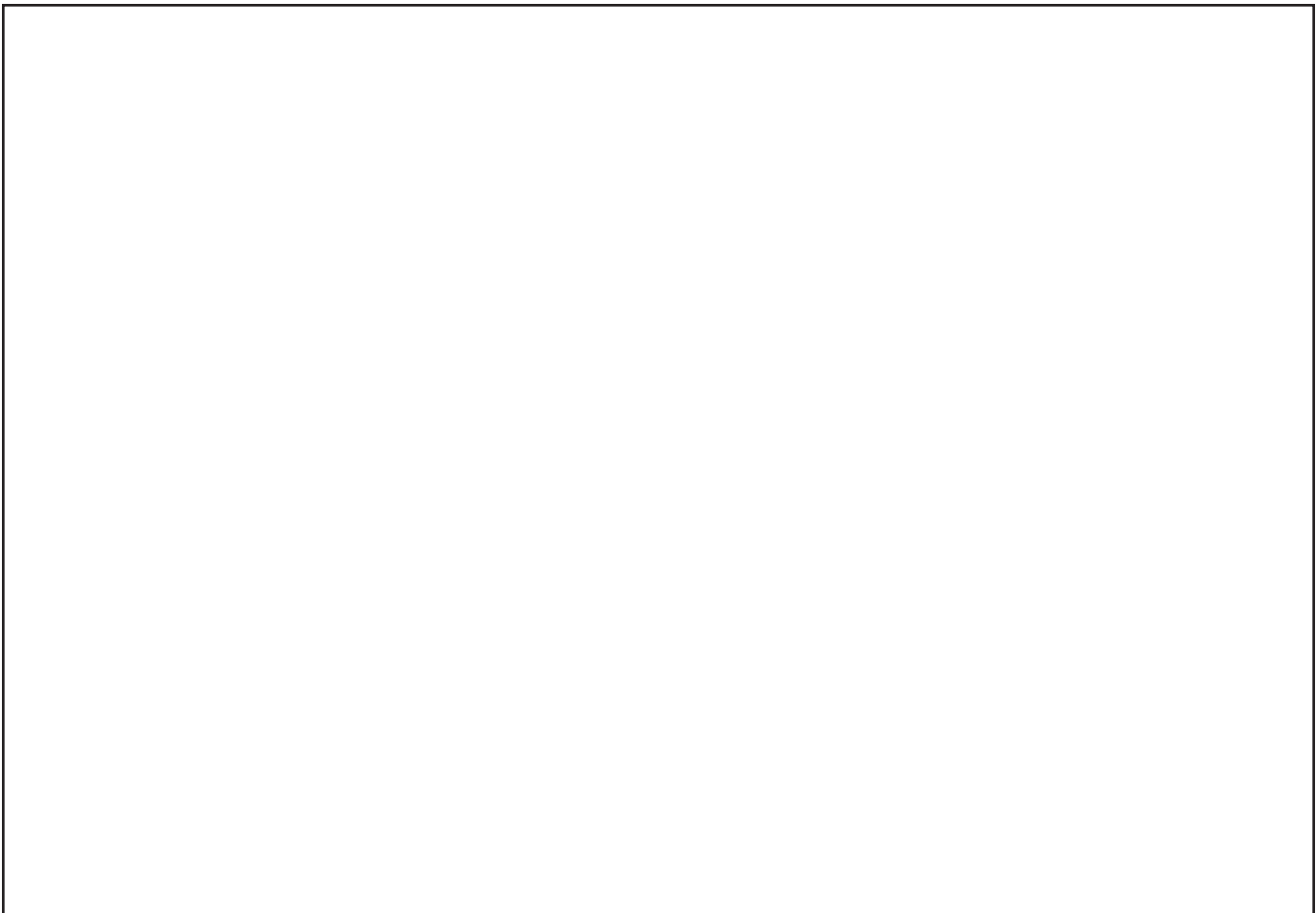
Three primary factors determine dosage:

- ▶ **Distance between the UVGI lamp(s) and the pathogen**

The distance is an extremely important factor. Studies have shown that dosage decreases by approximately the square of the distance from the lamp. Based on this formula, dosage of “X” at one inch away from the lamp is reduced to X/4 at two inches away, X/64 at eight inches away, and X/144 at 12 inches away.
- ▶ **Intensity of the UVGI lamps**

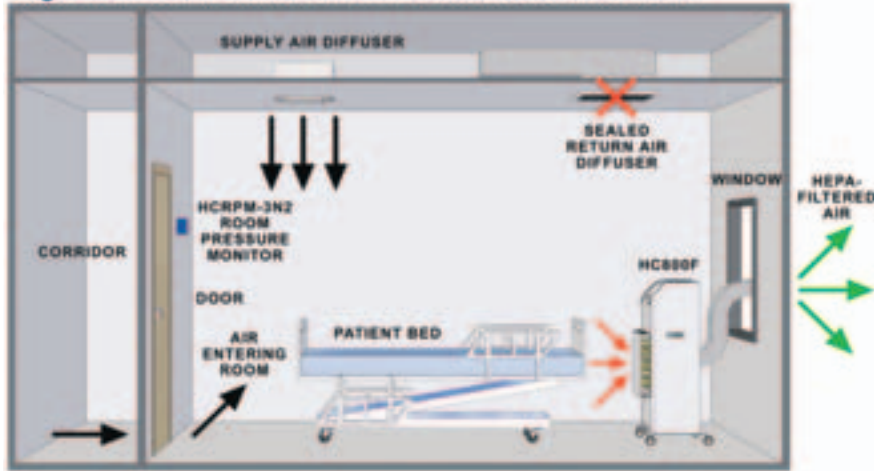
The intensity of UVGI lamps can vary significantly from one product to another, based on the sizes (length and diameter), designs, construction, and quality of the lamps. Total output can also be increased by the use of multiple lamps.
- ▶ **Duration of exposure to the UVGI lamp(s)**

There is a direct correlation between time and dosage. If all other factors are equal, a pathogen exposed for one second will receive double the dosage of a pathogen compared to a pathogen exposed for half a second.



Three Typical Operational Modes for HEPA-CARE Air Purification Systems

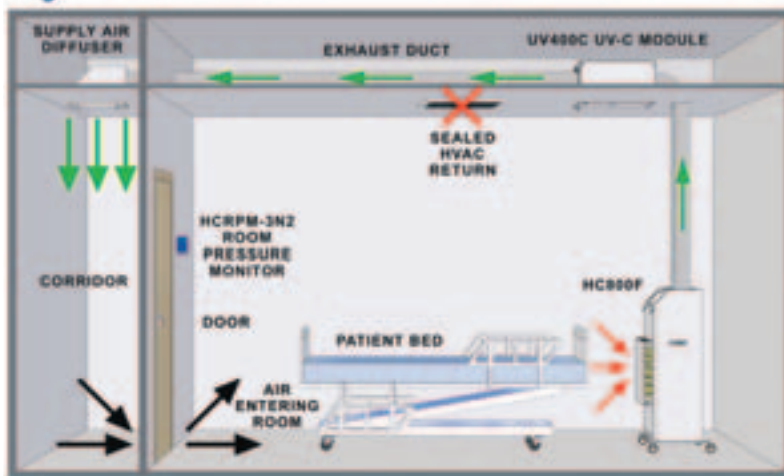
Negative Pressure Isolation With Direct Outdoor Exhaust



Negative Pressure Mode With Unit Located Inside the Isolation Room and Direct Outdoor Exhaust

The unit pulls in contaminated air, filters out contaminants and propels the filtered air outside the environment to negatively pressurize room.

Negative Pressure Isolation With UV Module & Indoor Exhaust

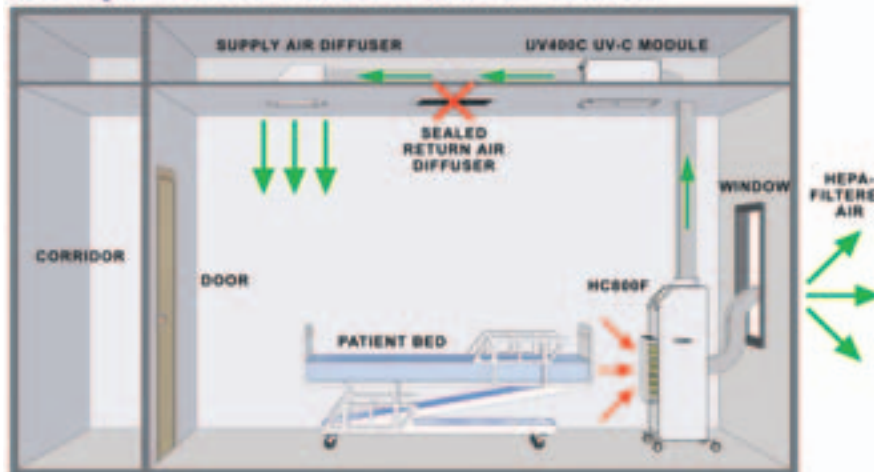


Negative Pressure Isolation with UV Module & Indoor Exhaust

In this configuration, filtered air from a portable unit in the room is ducted out the top exhaust port through a germicidal UV module and into the exhaust ducting above the drop ceiling.

If a ceiling-mounted fixed model is used, the unit can simply exhaust out one or both of the exhaust grills directly into the ducting above the drop ceiling.

50% Negative Pressure Exhaust & 50% Recirculation



50% Negative Pressure Exhaust and 50% Recirculation

In this mode, air is ducted to the outdoors from one outlet, creating negative pressure, and recirculated into the room from the other outlet. Running an HC800F or HC800C unit in this configuration at high speed provides the ability to clean the air in smaller rooms up to 30 times or more per hour, without having to exhaust that much conditioned air from the building.

Following is a summary of the features and benefits of three design options that meet the CDC-recommended installation criteria for using UVGI to provide supplemental room air disinfection.

Upper Room GFCI

Upper room UVGI fixtures, which generally look like an upside-down fluorescent light fixture, have been around for many years. They are designed to irradiate the air at or near the ceiling, without exposing persons below. Because the lamps are used in ambient air, exposure time can be much longer than with lamps located in moving airstreams.

There are two significant disadvantages to this approach. First, it primarily relies on ambient air currents to bring the contaminants in close enough proximity to the lamp(s) to provide sufficient UVGI dosage. Second, because the fixtures really can't be integrated with the HEPA filtration unit and exhaust ducting, they can't ensure that all the air exhausted from an AII is first irradiated.

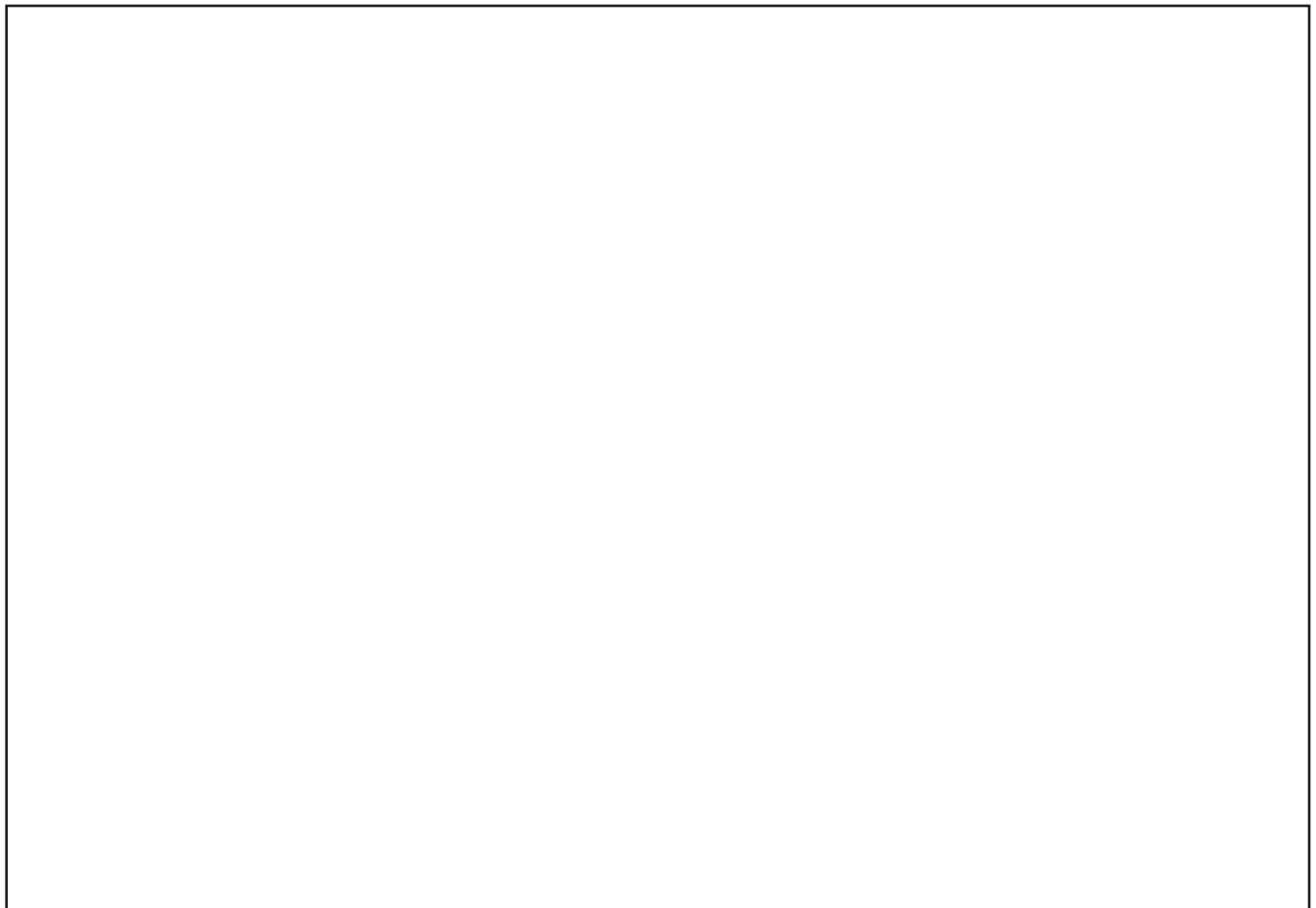
Induct UVGI Lamps

Also in use for many years, in-duct systems feature a bank of UVGI lamps installed inside of HVAC exhaust ducts (AII rooms), or HVAC supply air ducts (PE). These installations can be designed to provide several advantages compared to upper-air UVGI: extremely high UV-C output; a higher level of protection against eye or skin exposure; irradiation of 100% of the air the exhausted from or supplied to a room; and, pathogens are brought into fairly close proximity to the lamps, to offset the shorter exposure duration.

The main disadvantage is that accessing the lamps for inspection, service or replacement may be difficult. If access requires disturbing ceiling tiles, temporary containment procedures may be required to isolate any airborne contaminants that may be disturbed.

Ducted UVGI Modules

A more recent development in in-duct UVGI technology is the introduction of products that mount a bank of UVGI lamps into an enclosed module, which can be installed in a much more accessible location. In AII rooms, these units are used to irradiate HEPA-filtered air, and then exhaust the air out of the room through an



If access requires disturbing ceiling tiles, temporary containment procedures may be required to isolate any airborne contaminants that may be disturbed.

exhaust duct that connects to the unit's outlet collar. In PE, they can be used to irradiate all of the supply air to the room.

Added advantages of ducted modules compared to traditional in-duct systems include safe and easy access to the lamps from within the room, without having to disturb ceiling tiles; and internal diverters, to increase dosage by slowing down the air, and guiding it even closer to the lamps.

Two types of UVGI modules are available, each with specific advantages.

Portable UVGI Modules

These modules are typically designed to mount directly onto the clean air outlet of a HEPA filtration unit, so they can be moved easily from room to room, as needed, along with the HEPA unit. They are an excellent choice for: shorter-term, emergency requirements, such as bioterrorism response; temporary patient isolation; continuous air cleaning, deodorization and disinfection; and, for disinfecting the air in isolation rooms and treatment rooms between patients.

Ceiling/Duct-Mounted UVGI Modules

These modules mount into drop ceiling grids, in place of existing HVAC supply air diffusers or return grills, where they are completely out of the way. They are a great choice for permanent or longer-term patient isolation applications. They can be installed as a stand-alone device, to irradiate and disinfect HVAC supply or exhaust air in almost any area of the hospital.

Using UV Lamps to Irradiate a HEPA Filter

This option, which is not one of the CDC recommended designs, places a UVGI lamp or lamps inside of a HEPA filtration unit, to continuously irradiate the inlet surface of the HEPA filter. While it does provide some air disinfection capability, several significant potential disadvantages and limitations make it a less desirable option to the CDC-recommended methods:

Contaminant Visibility

HEPA filters are designed with very closely spaced pleats, with typical pack depths of three to 12 inches, and typically load from back to front. It's highly unlikely that a lamp or lamps shining on the inlet face of a filter could effectively irradiate the media much beyond the first inch of depth, particularly pleats farthest away from the lamp(s).

UV Dosage

Depending on the size of the HEPA media surface and the number of lamps used, organisms that pass the lamps or are trapped on the media can be as far as 12 to 36 inches away from the lamp.

Component Protection

UV can virtually disintegrate cotton or synthetic prefilter media, and can weaken or destroy unprotected internal components, such as wire insulation, gasket material, or plastics.

VOC Off-Gassing

High levels of UVGI exposure can also potentially break down binders and adhesives used in some HEPA filters, and off-gas volatile organic compounds.

Safety

Extra precautions and design considerations are required, to ensure that workers and patients won't be exposed to UV radiation if the prefilter is not in place, or during filter replacement.

A Word About Electrical Safety

U.S. (OSHA) and Canadian (CSA) safety standards require testing and certification of electrical devices by a Nationally Recognized Testing Laboratory (NRTL), such as UL, ETL or CSA, to ensure that the device provides the necessary level of safety. This requirement applies even if all of the electrical components used in the product are NRTL listed.

Facilities may be surprised to learn how many indoor environmental control products available on the market today do not meet this requirement. The bottom line is to make sure that products are properly listed by an NRTL before purchasing them. †

Dave Shagott is an engineer who has served as the president of Abatement Technologies, Inc. since the company was founded in 1985. Abatement specializes in manufacturing and marketing IAQ products, and has HEPA filtration and UVGI products in use today in several thousand hospitals and clinics throughout North America. More information on the company's products, CDC guidelines, and the potential uses for UVGI can be found at www.hepacare.com.