



BY JOHNSON CONTROLS

SOLUTION® AIR-HANDLING UNITS UV-C LIGHT



INTRODUCTION

New technologies are constantly being introduced to our marketplace. As the leading supplier of air handling/controls equipment worldwide, Johnson Controls is constantly evaluating these technologies to determine if by applying these technologies there will be a benefit derived by our customers. One technology in particular appears to have significant upside benefits to our customers is UV-C light options.

The UV-C light options, through a process known as UVGI (Ultraviolet Germicidal Irradiation) will save your customer money and at the same time protect a major investment, the HVAC equipment.



Background

One of the fastest evolving technologies to be introduced into the HVAC industry in the past 30 years is ultraviolet disinfection. Building design and construction have been impacted by ever evolving ASHRAE standards, and owners are becoming more and more focused on not only heating/cooling/moving so much air, but also making sure the HVAC design provided is energy efficient. Along with energy efficiency, many owners are also looking for HVAC designs which will maintain and/or enhance indoor air quality. Today people spend more time indoors than ever before. It has been proven that the air we breathe can make us feel unhealthy, deficient and tired. This in fact does affect our well-being along with productivity. People expect the air they breathe to be reasonably safe and comfortable. Yet indoor air can be laden with mold, mildew, dander, bacteria, and viruses. As a result of those paradigm shifts, many owners and engineering firms are turning to ultraviolet disinfection to meet the new and emerging requirements.

Where Utilized

Traditionally, ultraviolet has been utilized to disinfect surfaces as well as a variety of liquid applications including drinking water. The UVGI process is utilized on make up water for juices, sports drinks and a variety of beverages which you encounter every day. Another popular application for ultraviolet disinfection is treatment of process water utilized in a variety of industries, including pharmaceutical processing, semiconductor rinsing and boiler feed.

Ultraviolet

The power of ultraviolet has been observed as far back as the early 1900's. It has been well known for these many years in the scientific community that viruses, bacteria and molds are susceptible to ultraviolet. Germicidal disinfection is delivered at 254 nanometer wavelength in the light spectrum and is known as UV-C.

Note: The amount of UV energy required to inactivate any one of the many microbiological agents is expressed as dosage.

$$\text{Dosage} = \text{Intensity (x) Time}$$

Example: 50 micro watt per square centimeter per second (intensity)
x 60 sec. (time)
x 60 min. (time)
x 24 hours (time)
= 4,320,000 micro watt-seconds per square centimeter/day

By understanding the capabilities of ultraviolet, and properly applying the technology to air handling units, we will be employing a technology to our air handling units which will allow constant maintenance of the cooling coil/drain pan and, if required, disinfecting the moving air stream as well. See below.



MICROBIOLOGICAL AGENTS

Nature has provided the earth with an abundance of living, breathing and reproducing microbiological agents. These microbiological agents exist all around us, some plainly visible, some too small for the naked eye to see. When not kept in check, these stealth-like unwanted invaders can begin to cultivate, populate and be transmitted throughout a facility leading to odors, illnesses, allergies, and associated allergy symptoms. As long as there is a food source, moisture and acceptable environmental conditions, microbiological growth will flourish and can cause significant problems.

For the purpose of this guide, we will focus on viruses, bacteria and fungi (mold) – these are all challenges within the air handling unit.

The following are some of the most common microbes found in any air handling units. If left unattended, these microbes can adversely affect the performance of the air handling unit.

Airborne Microbial Agents

Viral and bacterial microbes account for 60-80% of indoor air quality problems. The Solution AHU software, for either the surface decontamination or the airborne inactivation, will take into account these microbes and particle sizes. The following is a list of some common microbiological agents typically found in air handling units.

Two thirds (2/3) of the Viruses and Bacteria listed here are vulnerable to a single pass kill rate. The remaining one third (1/3) become more susceptible with each additional air change as the kill rate percentage quickly increases to 99.98%.

VIRUSES

Adenovirus
Vaccinia (Poxvirus)
Coxsackievirus
Influenza A virus
Echovirus
Reovirus Type 1

BACTERIA

Serratia marcescens
Escherichia coli
Staphylococcus aureus
Streptococcus pyogenes
Pseudomonas aeruginosa
Mycobacterium tuberculosis
Corynebacterium diphtheriae
Haemophilus influenzae
Legionella pneumophila
Bacillus anthracis (plates)
Bacillus anthracis spores (Air)
Bacillus subtilis spores

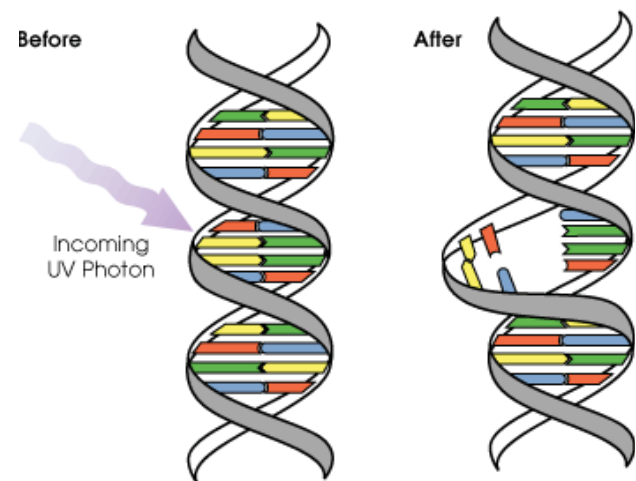
Surface Microbial Agents

Fungi (Spores) on the other hand are typically identified with surface decontamination since they require a longer time factor. A spore (such as mold) is a reproductive structure that is adapted for dispersion and surviving for extended periods of time in unfavorable conditions. In environmentally controlled situations, spores have very little stored food resources and therefore die.

FUNGI

Cryptococcus neoformans spores
Mucor racemosus spores
Aspergillus niger spores
Aspergillus glaucus spores
Rhizopus nigricans spores
Fusarium oxysporum spores
Fusarium solani spores
Penicillium italicum spores
Penicillium digitatum spores
Penicillium expansum spores
Cladosporium spores
Scopulariopsis spores
Blue-green algae
Bacillus subtilis (average)
Listeria monocytogenes
Salmonella enteritidis
Giardia lamblia
Shigella paradysenteriae

NOTE: All microbiological agents are susceptible to ultraviolet. The Solution UV-C lighting options are able to penetrate the cell wall of microorganisms, and alter the DNA structure such that the microorganism becomes non-viable; unable to reproduce or infect. See below:



EFFECTS ON DNA

Surface Decontamination Option

This option is designed to treat the surface of the cooling coil and drain pan of the air handling unit. UV-C lights are attached to mounting brackets installed in the coil segment in such a way that the coil and drain pan are continuously exposed to the UV-C lights.

UV-C lights in this option are normally placed downstream of the cooling coil/drain pan. Figure 1 shows a typical mounting rack and light configuration for this option.

In this application, reflectivity of the UV-C light is of dominant importance. Any increase in reflectivity enhances the UV effectiveness and efficiency. The kill rate increases dramatically with this option since exposure time is unlimited. This is important since mold and other spore size micro-organisms have a much higher kill threshold than bacteria and viral contaminants and require a longer exposure time to kill them.

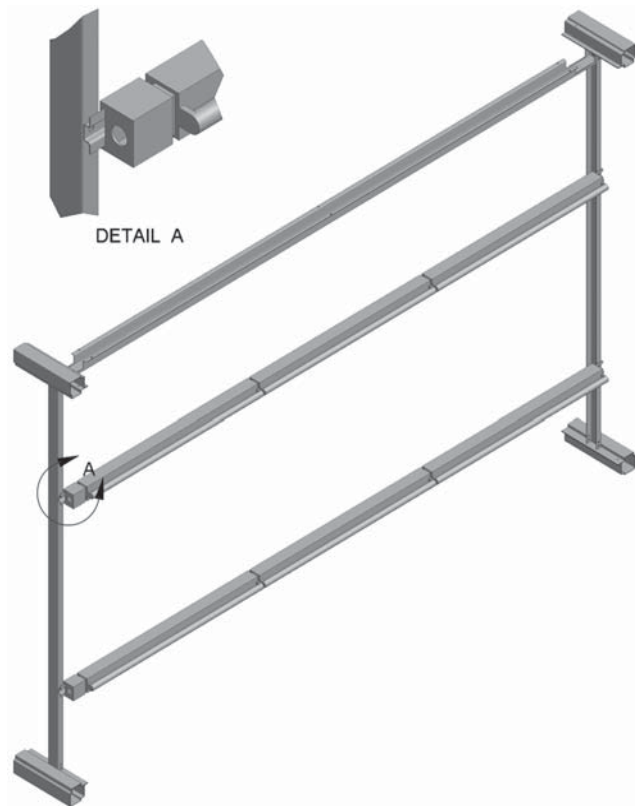


Figure 1 – Surface Decontamination Mounting

Airborne Inactivation Option

The Airborne Inactivation Option is a stand-alone segment specially designed to attack airborne viruses in moving air streams. This segment can be installed upstream and or downstream of all cooling coil segments. The UV-C lights are configured in such a way so as to kill or disinfect microbial agents “On-the-fly” as the air moves past the UV-C lights. Figure 2 shows typical mounting rack and light configuration for the Airborne Inactivation option.

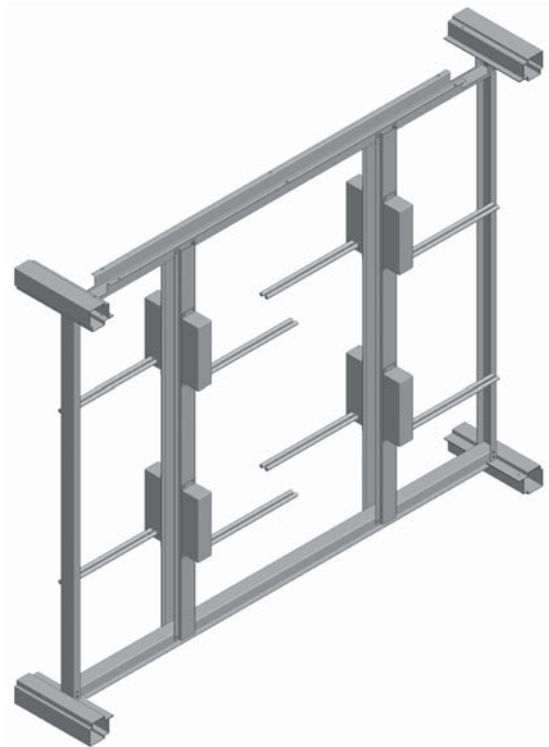


Figure 2 – Airborne Inactivation Mounting

The principal differentiating factor between surface treatment and “on-the-fly” kill is that higher UV output is required. To ensure adequate disinfection, a software modeling program was used to properly calculate the output needed. Remember: **Dosage** (amount of UV energy delivered to disinfect a particular virus, bacteria or mold) **equals Intensity** (amount of UV being emitted from the lamp) **multiplied by time**.

For a moving air stream, we only have a limited amount of time to attack the microbes, so we must adjust the UV intensity. We do this by applying higher output UV-C lamps to increase the intensity/output. For an “on-the-fly” kill application, many more variables must be identified before it can be determined which UV design will properly treat the moving air stream. These variables

are taken into consideration with a software program designed for that purpose. Contact the factory for sizing applications involving infectious disease particles. Also see “Selection Software” section to the right.

Using this option, a reduction in airborne organisms can be rapidly achieved. Air entering the air handler is subjected to radiation at time of entry. The air-flow can be disinfected up to 99.99%, depending on the number of lamps installed, length of time of exposure and the dimensions of the air duct. A key aspect of this option is the fact that some pathogens may be too small to be trapped by a HEPA filter with 99.99% efficiency, but they are very susceptible to the effects of UV. The full air cleaning provided by this combination of HEPA filtration and airborne inactivation also achieves a disinfecting effect on local surfaces. Typical applications of this option are found in laboratories, food and beverage, cosmetics and pharmaceutical industries.

Surface + Airborne Option

If both Surface Decontamination and Airborne Inactivation options are used together, they can virtually clean your unit and the air you breathe. Working together with various filtration systems and complying with the requirements of ASHRAE Standard 62.1 will assure the best possible IAQ when a designer combines all of these technologies.

A typical configuration for high risk health-care and government applications places the UV-C lights downstream from the cooling coil to deal with the spore size micro-organisms and upstream of a high efficiency HEPA (High Efficient Particle Arrestance) filter to eliminate airborne bacteria and viral contaminants. See Figure 3 below for a typical example of this.

SELECTION SOFTWARE

For either a surface decontamination, airborne inactivation or using both options simultaneously, Johnson Controls utilized a proprietary, third party validated

math modeling tool to scientifically select the appropriate UV-C options needed for your Solution air handling systems design. The guess work has been taken out of the selection process. Every time you select a UV-C application you can be assured of the appropriate ultra-violet design. No additional outside software needed to make the best possible selection.

In addition, the modeling software, used for airborne inactivation analysis, allows Johnson Controls to offer the customer a cost effective design based on air changes per hour. The charts and graphs on page 5 show a “Typical Filtration Analysis” of an airborne inactivation using influenza A as a target microbe. This application illustrates the software modeling of a Solution cabinet with 11458 CFM @ 401 FPM. Combinations of different mechanical filters & UV lamps are shown.

This filtration analysis allows the customer to better understand the use of UV technology with mechanical filtration and choose the most appropriate technology for the application, be it UV alone, filtration alone, or UV in combination with filtration. The results are based on a single pass with UV effectiveness @ 50%, 75%, or 90% + kill rate efficiencies for a mixed air system. Using more UV-C lamps increases the light intensity, increasing the kill rate.

Table 1 is the Good – Better – Best summary of the analysis and illustrates the effects of the dosage formula.

When selecting a UVC lamp option for Airborne Inactivation, the first step is to be aware of the type of contaminants and airborne viruses in circulation through-out the system and building. The next step is to consider how many system air changes there may be per hour. Some microbes require a greater UVC dosage before they are completely inactivated; the more air changes the faster the disinfection. For example, the chart below illustrates a kill rate percentage based on a single-pass air change. This simply means that with each air change passing through the UVC illumination, the microbes listed will be inactivated at the percentage listed.

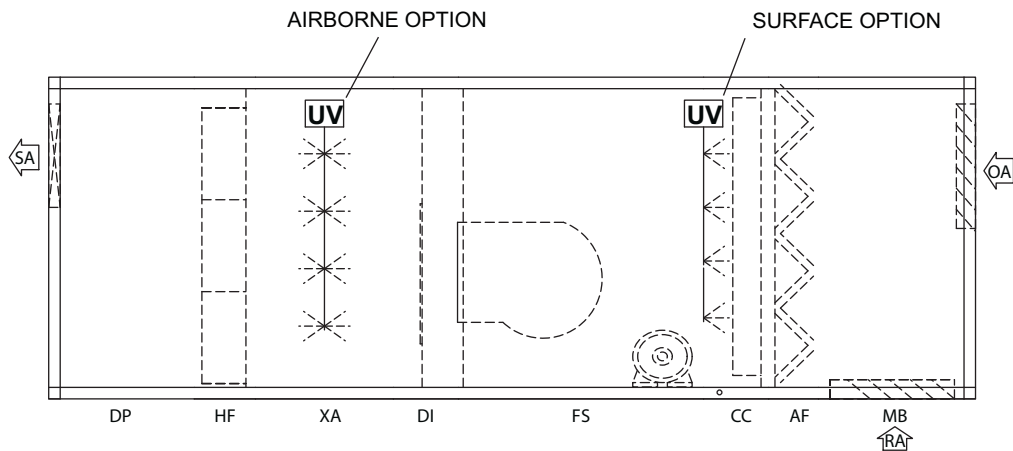
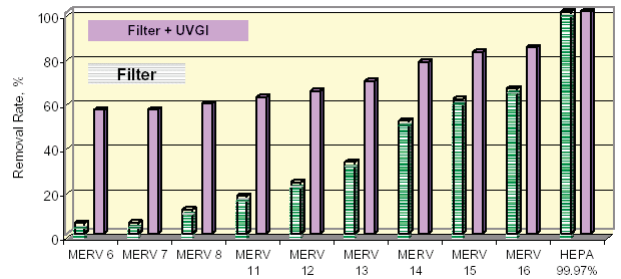


Figure 3 – Combining Both Options

TYPICAL FILTRATION ANALYSIS - (Airborne Inactivation Options shown for Solution AHU)

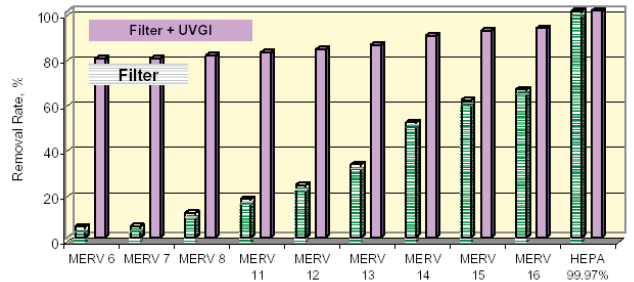
50% Single Pass Kill Rate (Good) 4-Lamp

FILTRATION ANALYSIS SUMMARY		
Target Microbe	Influenza A virus	
Logmean Diameter	0.1 microns	
Filter Type Nominal MERV Rating	Removal Rate Filter Only %	Removal Rate, % Filter + UVGI %
MERV 6	4.6	55.7
MERV 7 (~25-30% DSP)	4.8	55.8
MERV 8 (~30-35% DSP)	10.7	58.5
MERV 11 (~60-65% DSP)	16.85	61.37
MERV 12 (~70-75% DSP)	23.010	64.229
MERV 13 (~80-90% DSP)	32.110	68.457
MERV 14 (~90-95% DSP)	50.792	77.137
MERV 15 (~>95% DSP)	60.525	81.659
MERV 16	65.345	83.899



75% Single Pass Kill Rate (Better) 8-Lamp

FILTRATION ANALYSIS SUMMARY		
Target Microbe	Influenza A virus	
Logmean Diameter	0.1 microns	
Filter Type Nominal MERV Rating	Removal Rate Filter Only %	Removal Rate, % Filter + UVGI %
MERV 6	4.6	78.9
MERV 7 (~25-30% DSP)	4.8	78.9
MERV 8 (~30-35% DSP)	10.7	80.2
MERV 11 (~60-65% DSP)	16.85	81.59
MERV 12 (~70-75% DSP)	23.010	82.952
MERV 13 (~80-90% DSP)	32.110	84.967
MERV 14 (~90-95% DSP)	50.792	89.104
MERV 15 (~>95% DSP)	60.525	91.259
MERV 16	65.345	92.326



90+% Single Pass Kill Rate (Best) 20-Lamp

FILTRATION ANALYSIS SUMMARY		
Target Microbe	Influenza A virus	
Logmean Diameter	0.1 microns	
Filter Type Nominal MERV Rating	Removal Rate Filter Only %	Removal Rate, % Filter + UVGI %
MERV 6	4.6	97.2
MERV 7 (~25-30% DSP)	4.8	97.2
MERV 8 (~30-35% DSP)	10.7	97.4
MERV 11 (~60-65% DSP)	16.85	97.54
MERV 12 (~70-75% DSP)	23.010	97.720
MERV 13 (~80-90% DSP)	32.110	97.990
MERV 14 (~90-95% DSP)	50.792	98.543
MERV 15 (~>95% DSP)	60.525	98.831
MERV 16	65.345	98.974

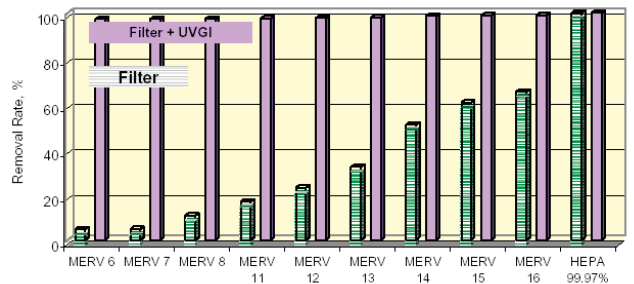


Table 1 – Good, Better, Best Summary (UV Only)

Application	Lamp Qty	Air Changes per hour	Kill Rate Efficiency
Good	4	SINGLE PASS	50%
		6	99.98%
Better	8	SINGLE PASS	75%
		3	99.98%
Best	20	SINGLE PASS	90% (+)
		3	99.999%

FREQUENTLY ASKED QUESTIONS

Terminology Questions

1. What is UV-C?

The letters “UV” relates to the entire UltraViolet spectrum. This spectrum is broken down into four frequency ranges:

- Vacuum (VUV)
- Short Wave (UV-C)
- Middle Wave (UVB)
- Long Wave (UVA)

UV-C is the frequency that is the most germicidal. Optimum damage to microorganisms occurs at 254 nanometers.

2. What is UVGI?

The term UVGI refers to Ultraviolet Germicidal Irradiation.

- Federal Agencies such as OSHA, NIOSH and the CDC use the term when directly referring to the process of killing surface and airborne microorganisms.

3. What is deactivation?

Doses of UV-C energy may not cause immediate cell death but the microbe may be “deactivated”.

- Some function may still exist but replication is impossible so the organism is not viable and soon dies.
- Continuous doses over time have been shown to hasten cell death.

4. How does UV-C affect germs and mold?

- UV-C destroys a microorganism’s nucleus or DNA causing cell death or making replication (cell division) impossible.
- UV-C also degrades simple organic material at the molecular level.

5. Does UV-C work?

Yes, thousands of references to this effectiveness can be found in literature and in actual applications.

- Extended Abstract from NIOSH and the University of Cincinnati wherein UV-C was tested against the heartiest of bacteria.
- Tulsa University study conducted at the Public Service Company of Oklahoma wherein a 2log (99%) reduction of surface and airborne mold was achieved using UV-C lighting.

UV-C is used worldwide, more in other countries per capita than in the US.

6. Why doesn’t JCI use an anti-microbial coating on Solution AHU’s?

Anti-microbial coatings, such as AgION™, are not an effective method of deterring microbial growth.

- The life expectancy of the coating is greatly reduced because the silver ions released by the coating are catalyzed by the moisture that travels through the drain pan.
- Secondly, the coatings do not kill airborne microbes.
- Thirdly, the coatings do not keep surfaces from getting dirty. Coatings are not a substitute for regular maintenance and cleaning which are required regardless.

Filter Questions

1. Don't filters remove Microorganisms?

Not all mechanical filtration removes all microorganisms. Some filters are capable of “catching” or eliminating them from the air stream but they do not effectively “kill” the microbes.

- Antimicrobial treated filters rely on direct contact to kill the microbes. As the filter builds a layer of dirt on it, this direct contact is eliminated and the microorganisms will not be affected by the chemical treatment.
- Treated filters will not accomplish the task of eliminating the growth on the coil and the subsequent contamination of the breathing zone by those bio-contaminants.
- UV-C options kill microorganisms in the air and on the surfaces.
- More important is the fact that filters do not abate microbial growth on surfaces of the air handling components.

2. Do I need UV-C if I use treated filters?

Treated filter media in no way addresses the growth of microorganisms on other surfaces and in drain pans, which lead to the eventual buildup of organic material.

- In these latter and more important issues, UV-C is the only non-chemical continuous source of control.

3. Do UV-C lights replace filters?

No, a UV-C option is an air conditioning component that works in conjunction with mechanical filtration and is not intended to replace components such as filters, etc.

Sizing Questions

1. How do I size my UV-C option?

For either a surface decontamination or airborne inactivation application, Johnson Controls utilizes a proprietary, third party validated math modeling tool to scientifically design UV-C options. The guess work has been taken out of the selection process. Every time you select a UV-C option you can be assured that it is the appropriate size for your particular application.

- No additional outside software needed to make the best possible selection.
- The factory should always be consulted for sizing applications involving infectious disease particles.

2. What are the recommended UV-C operating limits- temperature, humidity and velocity?

Unlike conventional UV-C fixtures, our fixtures are designed to UL specifications such as being of drip-proof construction and perfect electronic function at 55-135°F.

- Essentially, our UV-C fixtures have no limits in HVAC equipment as they were designed specifically for that use.
- Rules of thumb are 55-135°F, 99% RH and 1000 fpm respectively.
- Please contact the factory for safety requirements when operating outside these boundaries.

Questions About Lamps

1. Are All UV Lamps The Same?

Not all UV-C lamps are created equal.

- Our product uses germicidal UV lamps (UV-C) which utilize a protective coating on the inside of lamps minimizing the effect of mercury absorption into the surface of the glass.
- Non-coated glass or a quartz tube absorbs the mercury faster and thus minimizes the output of UV.
- Non-coated glass or quartz tubes also require more mercury within the lamp to compensate for loss of mercury into the glass wall.

2. How much mercury is in a lamp?

Our UV-C lamps utilize 5.5 or less mg of mercury per lamp compared to quartz UV-C lamps which can exceed 100 mg's of mercury.

- Extensive testing has been done on the long-term performance of both soft coated glass UV-C lamps and quartz glass UV lamps. The results show that after 9,000 hours of operation, the quartz lamps tested were producing only 53% of their original output, whereas the coated soft-glass lamps averaged above 80%.

3. How do you dispose of the used tubes?

UV-C tubes fall into the same category as fluorescent lights.

- All users should dispose of them the same way they dispose of their fluorescent lights and follow any EPA and state guidelines.
- Large users should already have a fluorescent light program in place that simply includes the germicidal lights.

4. Should the tubes be cycled with the fan or run continuously?

Like fluorescent lights they run better and longer when running continuously.

- For maximum effectiveness, always run them continuously.

5. How do you know when to change the Tubes?

IAQ or mold control, require changing the lamps when their output decreases by 20% is common. This usually occurs in about 12 months.

- For infectious disease applications, change-out should be performed using a radiometer and following factory specifications.

6. Do the lights need cleaning?

UV-C lamps do not normally require cleaning as part of normal operation (high levels of mineral particulate may be an exception).

- Cleaning is recommended if the glass lamp has been touched during installation.
- The lamp tubes will usually degrade common organic debris that may accumulate on the glass, thus periodic cleaning may not be required.
- When cleaning simply use 99% pure alcohol or a mild liquid window cleaner and a lint free cloth. It is best not to leave too many impurities behind

Miscellaneous Questions

1. If I can't see UV-C energy, what do I see?

The blue color comes from an inert gas in the tube.

- The tube can be lit (and blue) yet not produce much if any UV-C energy at all.

- Remember that UV-C is in the non-visible part of the light spectrum.

2. Can UV-C options be used at 50Hz?

Yes, all of our voltage options can, as they are independent of line frequency.

3. Is UV-C expensive?

In commercial, industrial or institutional buildings, the costs for lost heat exchange efficiency; air horsepower, surface cleaning and drain pan tablets far exceed the cost of a UV-C factory installed option.

- This excludes routine labor, downtime, complaint service, absenteeism, loss work and litigation and the costs of duct cleaning, service calls and system change-out.
- Replacement lamp tubes are far less expensive than all the above.

4. Can UV-C save energy?

Yes, Energy savings are through increased heat absorption (transfer), reduced air horsepower (or increased air volume) and/or reduced run time, including the condenser.

- Reductions and increases always manifest themselves in some ultimate form of energy saving.

Is UV-C Safe Questions

1. Is UV-C harmful?

Yes, UV-C is harmful to all organic matter including human beings.

- Even brief exposure can result in skin irritation and/or eye irritation that could lead to serious consequences after prolonged exposure.
- We take great pains to provide the utmost in safety precautions and designs that incorporate meticulously designed safety interlocks.

2. Does UV-C produce ozone?

No. As the lamp ages and the intensity decreases, the lamp will not change its wavelength, hence will not fall below 200nm and will not produce ozone.

- Our lamps are made with soft glass (soda barium) where the mercury vapor produces spectral lines at 254nm.
- The soft glass eliminates the production of 185nm wavelengths no matter what age the lamp is; in short, as the lamp ages, the spectral range does not change.

3. Are UV-C options UL Listed?

Yes. For complete safety, our fixtures shall have been tested and Listed as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively, no exceptions.

RECOMMENDED FILTRATION

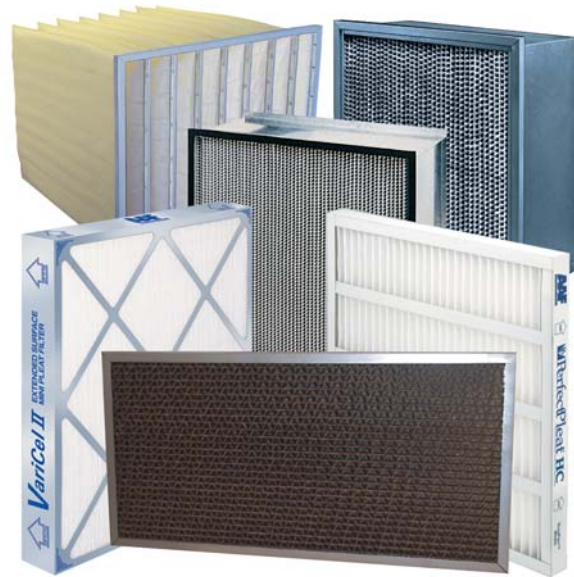
UV-C lights are an ancillary piece of equipment and should always be used in conjunction with an air filter or air filtration system. The air system should be provided with substantial high efficient pre-filters to ensure the cleanest operation.

NOTE: The UV-C lights zap the micro-organisms but, they do not remove the dead flakey solid particles they leave behind. For that, filtration is required. See below for recommended filtration:

'Mechanical Air Filtration' using various dry-media filters (including HEPA)

Dry-media filters exhibit an increase in efficiency as they collect dirt and dust. A dry media filter is at the lowest efficiency rating when it is 'clean'. The increase in efficiency corresponds to a decrease in open area as the media collects fibers and particles. In dust critical environments the user typically can't wait for the increased efficiency. As a result of this type issue, ASHRAE 52.2 defined the minimum efficiency reporting value (MERV) to describe filter performance.

- Throw-Away Fiberglass Media MERV 1 -MERV 4
- Pleated Media Air Filters 30% ASHRAE MERV 10 -MERV 11
- Pleated Media Air Filters 65% ASHRAE MERV 13 * (*65% ASHRAE is about 20% effective on less than 1 micron particles)
- Pleated Media Air Filters 95% ASHRAE MERV 14
- HEPA air filters are not MERV rated as they exceed the ASHRAE test protocol 52.2 used in determining the MERV ratings. In fact, HEPA air filters are the ONLY mechanical air filters that are tested and certified to meet a specific efficiency at a specific particle size. All HEPA air filters must meet a minimum efficiency of 99.97% at 0.3 microns.



UNIT ACCESS SAFETY

Door safety switches will be provided on all doors in unit to de-energize the UV lights when an access door is opened. In addition, safety labels will be located on all doors that have a door safety switch. If the segment does not have a door, a label will be added to the segments panel. To safely access the a unit where UV lighting has been installed, use the UV Control Panel to turn off the UV lights.

UV CONTROL PANEL

A control panel will be provided with every UV light option. The control panel will be type NEMA 1 for indoor and type NEMA 3R for outdoor units. The Control panel will be mounted in close proximity to the UV lamp option. The purpose of the control panel is to provide a means of disconnecting the UV lighting circuit(s) before opening an access door. Should an access door be opened before disconnecting the UV circuit(s), the door safety switches will turn off the UV lights automatically. The control panel would then be used to reset the UV light circuit(s) when the technician's tasks have been accomplished.

DESIGN PARAMETERS*

For complete safety, JCI fixtures have been independent tested, listed and labeled as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively, no exceptions.

Segment

The segment containing the UV lamp system should be easily accessible for regular cleaning and easy maintenance.

1. Electric power should always be turned off when performing any service maintenance, replacing or cleaning the UV lamp
2. Each UVC system should have the option of a view port to facilitate the viewing of the lamp assembly without the possibility of over-exposure to UV-C.
3. UVC can be the cause of temporary skin redness and eye irritation. People should never look at the UV light.

Installation

Fixtures are mounted to disinfect the intended surface(s) as well as all of the available line of sight air-stream by proper placement and incident angle reflection. Fixture placement is consistent with the third party irradiation and intensity calculations.

1. Fixtures are constructed of stainless steel with UVC proof metal bases
2. Fixtures are equipped with UL approved fixture-to-fixture mechanical and electrical connections that facilitate proper installation and coupling to A/C power from one end.
3. Each fixture is equipped with an electrical interlock, which will not allow the fixture to energize unless it's properly installed to its factory supplied track.

All access panels and doors to the UVC assembly and/or within view of the fixtures include mechanical interlock switches to assure that the UVC assembly will be de-energized when any of these accesses are opened.

Operation

Air handling unit fans should remain on 100% of the time to ensure the air in the building is ideally mixed. Research is very quick to show that indoor air contamination drops very quickly after the UV is turned on, and that the continued improvement depends on the susceptibility of the organisms to UV exposure.

1. UV-C units should be left on continuously as turning them on and off ages the bulbs and power supplies.
2. Kill rates vary depending on whether the spores are influenced by the airflow rate and the duration of exposure to UV-C.
3. Lamp configurations are applied for disinfection based on tunnel size, CFM, and relative humidity of the system.
4. UV-C can be applied to the most demanding situations.

The efficiency of a UV-C light depends on the total input power, on the exposure time and on the specific microorganism present in the indoor air.

1. Isolated changes in humidity have a measurable but very small effect on lamp irradiance.
2. Lamps and fixtures are configured in sufficient quantity and in such a manner so as to provide an equal distribution of UVC energy
3. Each lamp contains no more than 5.5 milligrams of mercury consistent with current environmental practices while producing the specified output at 500 fpm in temperatures of 55-135°F.
4. Useful lamp life shall be 9000 hours with no more than a 20% output loss at the end of one year of continuous use.
5. Radiometers are optional and available to detect and measure the intensity of the radiant thermal energy. Radiometers should be included on any critical installation. They will be installed so not to obstruct the ability to sense the direct rays of the UV-C light.

***NOTE: These design parameters establish the minimum safety requirements for the control of UV-C lamps. See also "Guidelines on the last page of this document.**

UV-C GUIDELINES

Application guidelines that will help to create a safe UV-C system.

- **DO** - Always disconnect power to lamps before entering a UV-C equipped unit.
- **DO** - Disconnect all power before installing or changing fixtures and tubes.
- **DO** - Wipe lamp(s) down with alcohol and a lint free cloth prior to operation.
- **DO** - Operate a UV system continuously whenever possible.
- **DO** – Install provided “Warning” labels on all accesses to the UV-C lamps installed.
- **NOTE:** If a slight odor occurs when UV-C is first used, wait 24-48 hours before taking action as many coil based organic materials will boil off some VOC during that time frame.

- **DON'T** - Enter a UV-C install without first disconnecting all power.
- **DON'T** - Look at any UV-C lamp without approved eye and face protection.
- **DON'T** - Touch tubes (quartz) with bare hands or they must be wiped down with alcohol and a lint free cloth.
- **DON'T** - Expose untested wiring or other organic materials to direct UV-C light. If necessary, wrap the untested material with aluminum and/or aluminum duct board tape.
- **DON'T** - Operate a UV-C system with missing or failed tubes.
- **DON'T** - Cycle UV-C lights with fans that cycle more than twice a day; instead operate continuously.
- **DON'T** - Expose fixtures or lamps to excessive amounts of water.