

## UV-C Questions & Answers from UV Resources

**1. What is UV-C?** UV-C is one of many electromagnetic frequencies emanating from the sun. Like other of these waveforms, its properties are unique to its wavelength. To synthesize this frequency, a glass tube is evacuated and refilled with argon at far below atmospheric pressure. Added to this is a small amount of mercury. When the mixture is energized (excited) it creates a glowing plasma of electrons that pass through the mercury vapor. As they strike mercury atoms, a mercury electron is liberated at a frequency representative of mercury's spectral line, which is 253.7nm. The dominant emission (>90%) from these lamps is UV-C energy. The "C" frequency of the electromagnetic UV family has, amongst other things, germicidal effects. This was so important that Westinghouse quickly commercialized the low-pressure mercury vapor "germicidal" lamp in the early 1930's. Its humanitarian value has had worldwide success since.

**2. Is UV-C harmful?** We're exposed to parts of the UV spectrum while outdoors. Generally, excessive UV exposure can produce adverse effects depending on wavelength, type and duration, and UV response differences between individuals. The three basic wavelengths:

- o UV-C - includes the germicidal wavelength of 253.7nm and is used for air and water disinfection. Human overexposure causes temporary skin redness and harsh eye irritation, but no permanent damage, skin cancer, or cataracts.
- o UV-B - is a narrower but more dangerous band of UV. Prolonged exposure has been associated with skin cancer, skin aging, and cataracts (clouding of the lens of the eye).
- o UV-A - is more predominant outdoors than the other two. It helps to tan our skin and is used in medicine to treat certain skin disorders. It is generally a harmless wavelength.

UVA, B and C will damage collagen fibers and accelerate skin aging. Generally, UVA is least harmful; UVB contributes to DNA damage and cancer. It penetrates deeply but does not cause sunburn. Because of no reddening (erythema) it cannot be measured in SPF testing. There's no good clinical measurement of UVB blocking, but it is important that sunscreens block both UVA and B. UVC however, penetrates superficially and has not been associated with long term tissue effects.

**3. How does it affect germs?** Microorganisms are simple organic structures that readily absorb the UV-C wavelength, causing photo-disassociation (destruction). A microbes DNA (deoxyribonucleic acid, is first to be adversely effected due to its weaker molecular bonds. In hundredths of a second it suffers irreparable damage. The subsequent loss of genetic instructions causes cell death and/or the inability to replicate, rendering them harmless. Continuous exposure causes uninterrupted degradation, such as the sun does, only significantly faster.

**4. Does it work?** Yes, scientific and anecdotal references abound for UV-C's efficacy both in literature and in reports of field applications. Of the government reports, NIOSH, OSHA, CDC, GSA, EPA are the most notable. Science in the public forum comes from the University of Cincinnati, Tulsa University, University of Colorado and McGill University (Canada) to name a few. The two labs conducting independent testing and showing very favorable results are ARTI and Battelle. The list of prestigious field studies are too numerous to mention. UVC is used worldwide, more in other countries per capita than in the US. Much of this broader use is for the disinfection of drinking water and treatment of sewage in waste water treatment.

**5. What does UV "C" or UV "GI" mean?** The letters "UV" relates to the magnetic wavelength spectrum known as UltraViolet light. This spectrum is more often broken down into four categories: Vacuum, Short Wave, Middle Wave and Long Wave' or VUV, UVC, UVB & UVA. UVC is the frequency that is the most germicidal and the term UVGI refers to "Ultraviolet Germicidal Irradiation" as used by Federal Agencies such as OSHA, NIOSH, GSA, EPA and the CDC when referring directly to UVC.

**6. Do UV-C lamps produce ozone?** No, but UVC does provide exceptionable conditioning of the air much like the sun does outdoors. UVC fixtures are an air conditioning component that's in addition to other system parts. Those include the filters, coil, heating core, fan, dampers, humidifiers, etc. All are designed to provide a specific function in the job of processing air for occupied spaces.

**7. Does UV-C replace filters?** No, but UVC does provide exceptionable conditioning of the air much like the sun does outdoors. UVC fixtures are an air conditioning component that's in addition to other system parts. Those include the filters, coil, heating core, fan, dampers, humidifiers, etc. All are designed to provide a specific function in the job of processing air for occupied spaces.

**8. Do air filters remove microorganisms?** Yes, in varying degrees depending on their rated efficiency. Note that for an anticipated infectious disease application, the type, efficiency and location of a filter should be of major concern. For microorganisms, the filters goal is to provide a reduction in the total number of viable microbes per "unit volume of air" downstream of it. Fortunately, some filters can also be utilized with UV-C in an approach referred to as "catch and kill". With the proper filter, UVC can kill and/or degrade what the filter has caught. Thus, for a given microbe and its products, the filters effect can be an integral part of the resulting concentration in a space. It should also be note that viruses can be as small as 0.02 microns so the target organism needs to be known so as to provide a predictable result. Additionally, a filter system can't abate microbial growth on surfaces, in drain pans, or in plenum's and ductwork, UV-C is the tool of choice here.

**9. How do you size UV-C applications?** For IAQ, improved heat transfer, reduced maintenance and odor, an approach used for well over ten years is to put the lamp row centerlines on 30 - 45" centerlines. Most highly regarded manufacturers have software that can size these types of installations, and more. Only consult one of these reputable manufacturers when sizing infectious disease agent applications.

**10. Is UV-C hard to install?** Not at all. Simple installation instructions are provided along with layout drawings populated with all the necessary dimensional specifics. Product designs are emerging that allow installation of UV-C in AHU's in under an hour in many cases! This also includes fan-coil, unitary

and rooftop units, the hardest systems to keep clean. Consult a reputable factory and then involve them in any infectious disease application.

**11. Where is it installed?** UV Resources' fixtures are designed specifically for installation in HVACR systems, and applications. In existing equipment, microbial infestations are common. Anywhere moisture intermittently or continuously forms. Simple testing bears this and its eventual remediation out. Best results are obtained when the UV-C is located close to the offending surface. Fixturing is generally installed from 6" to up to 50" away from the surface to be irradiated. This way the application is sure to degrade and eliminate surface and waterborne contamination.

**12. Do you clean surfaces first?** Results are obviously more dramatic when you don't but it really gets down to time. UVC will degrade organic material on, and often within a surface in a time frame unique to the type and amount being removed. But usually within 180 days or less. Once the contaminants are known, UV Resources might help you make that decision. Generally, cleaning first is done to hasten the cleanup process. Where the contamination is unknown, it is wise to irradiate the contaminants for at least 30 days and fully gowning before disrupting them.

**13. How do you know it's working?** There are several ways to demonstrate, sample or measure the many things taking place. One is to use a contact plate containing malt agar. Before UV-C is installed, the surface is lightly touched with the plate. Then it's allowed to incubate for roughly 96 hours. After UV-C is installed, the procedure is performed again in the same place. What often are seen are a 98%+ reduction in organism growth? The drain pan and its water can be similarly sampled using a different growth medium for bacteria. Some of the other ways are:

- o A visible reduction of mold will be seen in a very short period of time.
- o Coil pressure drop has been shown to drop over 10% in <30 days (depending on surface cleanliness and water activity), of course there is usually an associated rise in system airflow and capacity.
- o Drain pans and drain pan water become significantly cleaner.
- o All line-of-site surfaces, i.e. insulation, etc. will start to look much cleaner.
- o Most of the associated odors from irradiated contamination disappear.
- o Many IAQ complaints have been documented as reduced.

**14. Should UV-C products be UL Listed?** Yes. For complete safety, UVGI fixtures must have be tested and Listed as UL/C-UL under Category Code ABQK (Accessories, Air Duct Mounted), UL Standards: 153, 1598 & 1995 respectively.

**15. What warranty should I expect?** Fixtures should be warranted for 3 years and the lamps for 1 year.

16. What are the limits of temperature, humidity and velocity? Not all UV-C products meet UL specifications, including drip-proof construction and proper electronics function at 1-77°C parameters as found in HVAC equipment. Essentially, UV Resources products have no HVAC limits. Additional parameters met are 99% RH and 1000 fpm respectively, but contact the factory when other operational challenges are anticipated.

**17. How are used lamps disposed off?** Currently, most users would dispose of them as they would any glass trash, such as their fluorescent lamps! Large fluorescent lamp users follow EPA and state guidelines, and UV-C lamps would then fall into those same guidelines. If you have a fluorescent lamp disposal program in place, UV-C lamps would simply fall into that same program.

**18. Should UV-C lamps be cycled with the fan?** When all things are considered, the best case can be made for running them continuously. Also, when lamp and power supply performance, and their life are considered, they run better and longer when running continuously. So wherever possible, run them continuously.

**19. When do you change lamps?** For infectious disease applications, change-out should be performed using an output measurement device such as a radiometer, while following factory specifications and/or recommendations. For IAQ or mold control, large installs might benefit from a radiometer to preclude premature change-outs. Changing lamps when their output decreases by 20% is common, this usually occurs in about 12-15 months. So for installs with no radiometer, re-lamp at least annually and replace burn-out as soon as possible.

**20. Do lamps need cleaning?** UV Resources lamps will usually degrade common organic debris that might accumulate on the tube surface; therefore, periodic cleaning is usually not required.

**21. How are lamps cleaned when necessary?** Cleaning could be necessary if a lamp has been exposed to any form of hard water, high levels of damp organic debris or any form of oil (i.e. body oil). Vinegar can be used for mineral deposits, Windex for damp organic debris and pure alcohol and a lint free cloth for oil. Commonly available cleaners should work fine if they don't leave any residue behind.

**22. What if microbes are attached to dust particles?** In HVAC systems, microbes of concern are either located on a surface or are airborne. UVC will usually degrade simple organic materials like dust particles on a surface to unhide the target microbe and destroy it. Airborne microbes are unhidden in at least two ways. Much of the dust is removed by the filter system before the microbe enters the UV-C cavity. And/or, dust particles are tumbling or will tumble in an airstream allowing for near 360° global exposure, leading to UV-C energy absorption of a sufficient amount. In infectious disease specific installs, air filters greater than 85% ASHRAE Dust Spot efficiency should be used, so not only will there be minimal dust, many microbes will not pass through either.

**23. What is inactivation?** For mold and bacteria, doses of UVC energy may not cause immediate cell death but the microbe could be "inactivated". What's meant by this is that while some biological activity may still exist, cell replication is impossible; the microbe is no longer viable. Simply, the subject microbe cannot multiply, rendering it harmless! What's more, small doses of UV-C over time have been shown to

hasten cell death. As viral particles are not a life form, we depend solely on inactivation to rid ourselves of their impending harm.

**24. If I can't see UVC energy, what do I see?** Around 90% of the energy generated by a UV-C lamp is in fact UVC energy. The remainder is visible light (blue hue) and a small amount of infrared (heat). Given the brightness from UV-C lamps, that 3-4% of visible light gives one an idea of the amount of UVC energy a lamp produces.

**25. If I see blue the lamp's working?** Not necessarily, the blue color comes from an inert gas within the lamp that doesn't produce UVC. The lamp can be lit (blue) yet not produce much, if any UV-C energy. This would be a poor indicator.

**26. Will UVC kill dust mites?** There's no evidence that a UV-C dose suitable for a given microbe kill will have any effect dust mites at all. Very high UVC energy or long term exposure to UV-C should disrupt some of the mite's biological functions, which may lead to death. However, there's also no evidence anywhere that dust mites live in A/C ductwork.

**27. Do I need UVC if I use anti-microbial treated filters?** Some of the microbes that are caught in anti-microbially treated filters do die away. But there's many more years of evidence and independent tests that show microbes caught by untreated filters, also die away! An exception in both cases is mold, on damp filters, which is characterized by identifiable odor? However, none of this precludes the years of evidence that simply, microbial counts are always lower downstream of any filter when compared to upstream. Nor do filters in any way address the growth of microorganisms on other surfaces, and in drain pans; all of which leads to the eventual buildup of organic materials. In this latter, and more important issue, UV-C is the only non-chemical form of continuous source control.

**28. Can UVC save energy?** Yes, in literally thousands of controlled tests, organic materials build-up on coils was removed with UV-C to provide two eventual results: 1. the pressure drop across a coil declines to increase air flow. 2. the leaving air wet-bulb temperature differential increases. Energy savings are therefore through increased heat absorption (transfer), reduced air horsepower (or increased air volume) and/or reduced run time, including at a condenser. These reductions and increases always manifest themselves in some form of energy saving work.

**29. Do bio-films affect coil performance?** Published papers document surface heat exchange efficiency loses of up to 30% from the build-up of organic material? Also, the large amount of coil cleaning compounds and "replacement coil" manufacturers tend to attest to the prevalence of the problem. Honeywell's Brian Krafthefer is best published in this area.

**30. What if I can't see mold on a coil, etc.?** Even a slight visual occurrence of mold would require millions of these microorganisms per square inch, and most of that is usually mold laden nutrient; which has always been thought to be simple dirt. Also, greater amounts of this material can be within the coil, rather than on its visible surface. In fact some of the more notable IAQ problems have occurred in so-called dry climates, where visible dirt or microbial activity was not apparent.

**31. Can UVC be installed in packaged rooftops or outdoor units?** NEMA style fixtures using single ended lamps have been designed specifically for rooftops and other outdoor systems and are surprisingly affordable and easy to install.

**32. Can UVC be installed in small units?** Yes, unit ventilators, heat pumps and fan coil units, etc. are all critical candidates for UVC as they are often the dirtiest, most inefficient and IAQ problematic systems in existence. Pricing has recently dropped.

**33. Can UV-C kill 100% of all airborne microorganisms?** Usually not, though more important are the very large number reductions from the use of UV-C. The CDC is a good example of how UV-C is the most perfect and sometimes the only choice to get the job done. Just as important, UV-C leaves nothing behind like other methods!

**34. Is UVC expensive?** Not any longer as they are less than \$0.04 per CFM. As such, the costs for lost heat exchange efficiency; air horsepower, surface cleaning and drain pan tablets already exceed that cost. Yet, exclude are routine labor, downtime, complaint service and most important, absenteeism and litigation. The costs of lost work, play and companionship; or even duct cleaning, and system change-out are not even factored in. Replacement lamps are far less yet.

**35. How does a homeowner know when to change lamps?** There are no accurate or affordable ways at this time so the industry standard for re-lamping has been one year. The best month is April to have the freshest lamp during the summer months.

**36. Why did we hear much about Bioaerosols?** Because it's a major component of poor IAQ. The scientific researcher who popularized the word "bioaerosol" is Dr. Harriet Burge. Her position was and is that bioaerosols account for a larger portion of the IAQ issue than has been thought. The fact that she was right then and now is one of the reasons for UV-C's popularity.

**37. Are bioaerosols a bigger problem now?** No question, and for many reasons. Within an HVAC system we find more microbial activity today than in years gone by. Some reasons concern our operational and maintenance procedures. For example, time clock operation (A/C system shut down - to conserve energy) exacerbates microbial growth. During these 8 - 12 hour, and weekend shut-downs, higher surface and liquid temperatures are achieved. These warmer but still damp coils and drain pans are perfect microbial forums. Adding to this are that these areas aren't cleaned as often as they once were (food). Note that when they are, chlorinated compounds have been outlawed so their modern replacements are mostly inert ingredients; or mold food! One can visualize the increasing problem.

**38. Can UV Resources products be used at 50Hz A/C?** Yes, all of our voltage options can as their operation is totally independent of line frequency.