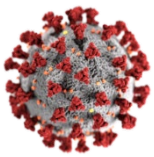


To All Bioclimatic Customers,

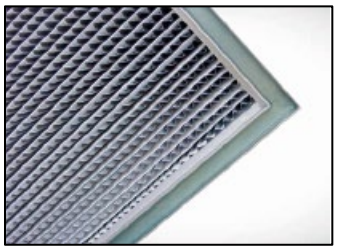
This might be helpful in answering questions that may be posed to you during this time of uncertainty. You will almost certainly be asked by your customers about what to do to purify the air as COVID-19 concerns arise.

The corona virus is a highly contagious pathogen (fits the highest Risk Group 4, a pathogen that can cause serious human disease, can be readily transmitted, directly or indirectly, and usually without effective treatment and preventive measures). What can we do to substantially reduce the virus in an occupied space? This memo offers some guidance for the design of HVAC systems when considering solutions that target airborne COVID-19, and what Bioclimatic can provide.

First, beware! There are a number of product suppliers suddenly offering simple, low cost solutions. This virus is not to be toyed with. Whereas some of these products may offer some degree of efficacy they do not provide much value if there is only some minor, unproven reduction. Skimp on your sunscreen and you'll get burned.

Capture. To physically remove the virus from the breathing zone a HEPA filter needs to be employed. HEPAs are rated for their efficiency based on a 0.3 micron particle size. For example, 99.97% rating indicates that 99.97 percent of 0.3 micron particles are captured. For best HEPA performance the 99.99% filter that utilizes a better seal to prevent bypass is the way to go.

The mechanisms for how a HEPA filter removes very small particles is somewhat complex, not just a matter of being a tight sieve. When airborne the virus is usually attached to larger bio-aerosol particles so 99.99% HEPAs are the practical and effective choice. The capture of viruses that are on the order of 0.1 micron in size still occurs at over 99% (COVID-19 has been observed at 0.07 to 0.09 microns).



TriDim Tri-Pure gel seal HEPA

Deactivate. UVGI (ultraviolet germicidal irradiation, or C-band UV) is very well known and widely used to deactivate pathogens of all types. The wavelength of this light corresponds very closely to where molecular bonds are broken down; it destroys the DNA to prevent replication.

To be most effective there are a few metrics to keep in mind.

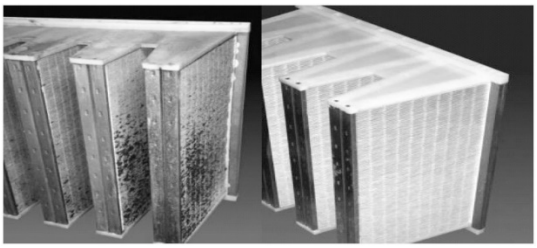
- The higher the intensity of the UV light the better. This implies high output lamps. It also suggests that the surrounding surfaces should be as reflective as reasonably possible. Certain surfaces like aluminum can allow more UV-C energy to reflect and "stay in play" versus being absorbed by the surface. The closer the lamps are to the pathogen the better. All are important system considerations.
- For intensity, rule of thumb for airborne viruses is placing high output lamps at 12" centers or approximately 30 watts/ft^2 with lamps arranged perpendicular to the airflow. Understanding this has not been tested for the corona virus, this should provide about 98% deactivation for air at 55^o F and at 500 fpm in the *moving* airstream.
- The longer the duration of direct exposure the better. Slower air velocity or long straight runs of duct are obviously helpful. Warmer air also improves the effectiveness.

UVR RLM Extreme HO lamps

So how do we put this together for an effective and practical solution? Bioclimatic can provide a number of good, better, best solutions. Consider a "best" solution, the combination of the strengths of *both* HEPA filtration and UV deactivation. Capture and kill. We can offer this in our ceiling unit (2' x 4', recirc only, 500 CFM), in a full SAH unit sized (for the airflow and physical size required), or in kit form for retrofits or duct installations. UV lamps are installed immediately upstream of the HEPA filter resulting in extremely high removal *and* deactivation. Air is clean, servicing is safer, with added benefit that filters won't degrade due to the presence of viable microorganisms.

Growth shown on non-irradiated filter (left) and microbe-free irradiated filter (right).

(Kowalski and Bahnfleth, 2000)



Need an extra measure of protection? Add a second bank of lamps downstream of the HEPA to attack any viable virus that breaks through the filter (recall the HEPA is not 100% effective). Or if budget or space is limited, you can scale back to use just UV without the HEPA. [Our bipolar

ionization and PCO products will also provide some deactivation of pathogens but not as capable on a single pass as capture/kill, good but ***not*** best as a COVID-19 solution.]

Important: For extreme applications the above solutions alone may not be appropriate. BIBO (bag in, bag out; required for severe bio-hazard filters to protect the service tech and for proper filter disposal) or multiple stages of UV may be indicated. Bioclimatic makes no claim of producing sterilizers and does not produce medical devices; we produce air purification systems that can only act on the virus that is drawn into our systems.

Design and use considerations:

- Consider the air change rate to be sure the potentially contaminated air is adequately circulated and drawn into the air purification system. Suggest a minimum of 12 ACH through our system (CDC recommendation for isolation precaution).
- When using UV any exposed material must be UV tolerant. Cotton, some synthetics, foam, rubber, or plastics can be weakened or destroyed if unprotected.
- UV is harmful to skin and eyes and must be utilized with proper safeties and interlocks.
- UV lamps must be replaced about once a year with continuous use. Not an option as the lamp output will degrade rapidly and the effectiveness will be lost.
- HEPAs when being replaced should be handled with care. If there is any doubt as to hazardous exposure then the appropriate PPE steps must be implemented for this service (again, for the severe applications we recommend BIBO filter housings).

Last note, reminder that Bioclimatic does not mass produce equipment, nothing right off the shelf. We are getting busy so lead times will reflect the demand for these solutions. Please contact Bioclimatic with questions or RFQs.

Maybe we can all help stem this ugly pandemic in some small way.

Ceiling Unit – MC880

USAH System

Vertical Indoor SAH

Wash your hands frequently for at least two minutes, and practice social distancing!

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