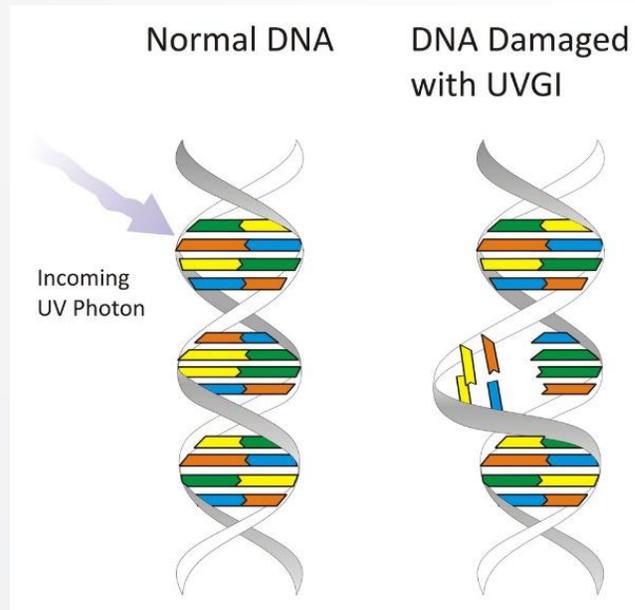


UVGI

Ultra Violet Germicidal Irradiation

UVGI is electromagnetic radiation that can destroy the ability of microorganisms to reproduce by causing photochemical changes in nucleic acids.



"The use of ultraviolet (UV) wavelengths of light in the germicidal range (200-365 nm) for air or surface disinfection is referred to as UVGI. Though the germicidal ability of UV (200-320 nm) has been known for more than 100 years (Kowalski, 2009), conclusive field data are still lacking to demonstrate the effectiveness of UVGI. None of the 10 studies included in this review studied the formation of possible secondary pollutants by UV, e.g., as initiated by ozone chemistry."

Zhang, Yinping, et al. "Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review." *Atmospheric Environment* 45.26 (2011): 4329-4343.

Limitations of UVGI

1. Cannot inactivate spores

Spores, which are larger in size than many bacteria/viruses, are highly resistant to UVGI.

- Novaerus plasma has been independently tested and proven to destroy variety of spores.

2. No effect on dust mites, allergens or VOCs

“No research or studies were found that show UV disinfection is effective in reducing dust mite and mold allergenicity or that UV radiation has the potential to remove gaseous pollutants.”

- EPA Residential Air Cleaners (Second Edition): A Summary of Available Information;

3. Line of Sight Issues

UVC tubes cannot provide direct ‘line of sight’ deactivation all the time as bacteria and viruses pass through the air in ‘clusters’, or stack on top of one another on surfaces. This results in ‘shadowing’ whereby the top-most layer of cells protect the lower layers of cells from the UVC rays.

Limitations of UVGI

4. *Exposure time issues*

UVC irradiation of microbes requires a prolonged exposure time to provide an adequate level of germicidal kill for a device with a safe power output. In the air duct of a modern HVAC system, the 'transit time' through the UVC irradiation source is far too short for it to have a significant effect.

EPA Study on Mould Remediation in US Schools and Commercial Buildings

UVGI cleaners are often installed in air-handling units to limit the growth of vegetative bacteria and moulds on moist surfaces in the HVAC system.

This study reported a 99% reduction in microbial contaminants growing on exposed HVAC surfaces, but a reduction in airborne bacteria of only 25 to 30 %. One reason that the surface disinfection application provides only a slightly noticeable reduction in airborne microbial concentrations may be that microorganisms in the airstream are exposed to the UV light for a shorter time.

Limitations of UVGI

5. Relative Humidity

The effectiveness of UVGI to kill or inactivate microorganisms has been shown to decline when the relative humidity in a room exceeds 60%. Water adsorption onto the virus surface might provide protection against UV-induced DNA or RNA damage. ¹

6. Cost

UVC tubes need to be maintained and replaced regularly for them to remain effective. One portable UV device can cost up to €40,000

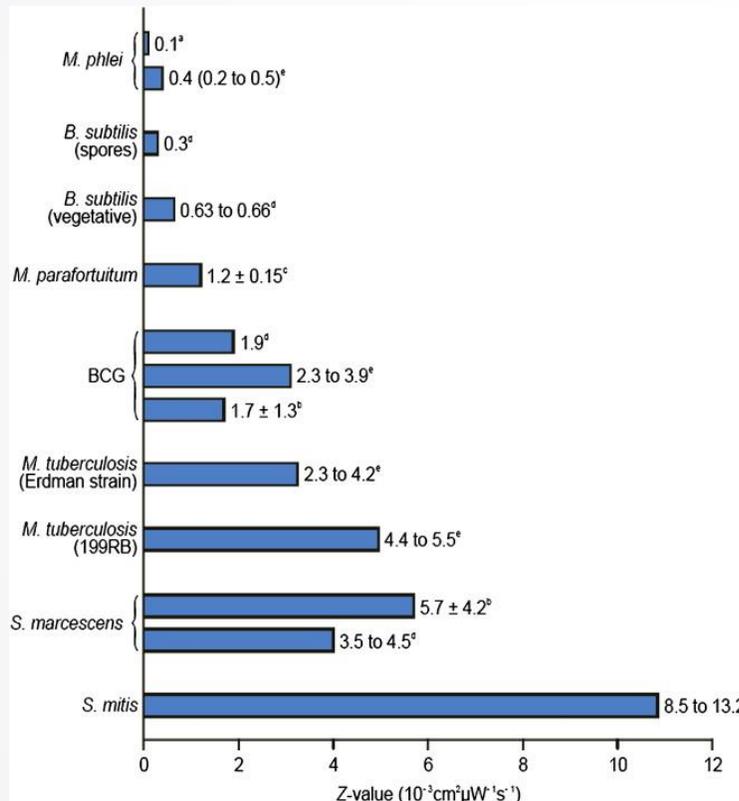
7. Effects on humans

The National Toxicology Program (NTP) classifies UV-C as a probable human carcinogen. Excessive exposure to UV-C radiation can adversely affect the eyes, causing photokeratitis and/or conjunctivitis. Chronic exposure to UV radiation can accelerate the skin aging process and increase the risk of skin cancer.

¹ Riley RL, Kaufman JE. Effect of relative humidity on the inactivation of airborne *Serratia marcescens* by ultraviolet radiation. *Appl Microbiol.* 1972;23:1113–20.

Limitations of UVGI

8. The magnitude of the effect is species-dependent.



A recent Taiwanese study found that the effectiveness of UVGI depends strongly on the type of virus nucleic acid, and that viruses with dsRNA or dsDNA are significantly less susceptible to UV inactivation.

Tseng C-C, Li C-S. Inactivation of virus-containing aerosols by ultraviolet germicidal irradiation. *Aerosol Sci Technol* 2005;39: 1136-42

Fig 1. Relative sensitivity of selected airborne microorganism to UVGI. The higher the z value, the greater the microorganism's sensitivity to UVGI.

Farhad Memarzadeh et. Al. Applications of ultraviolet germicidal irradiation disinfection in health care facilities: Effective adjunct, but not stand-alone technology. *Am J Infect Control* 2010;38:S13-24.)

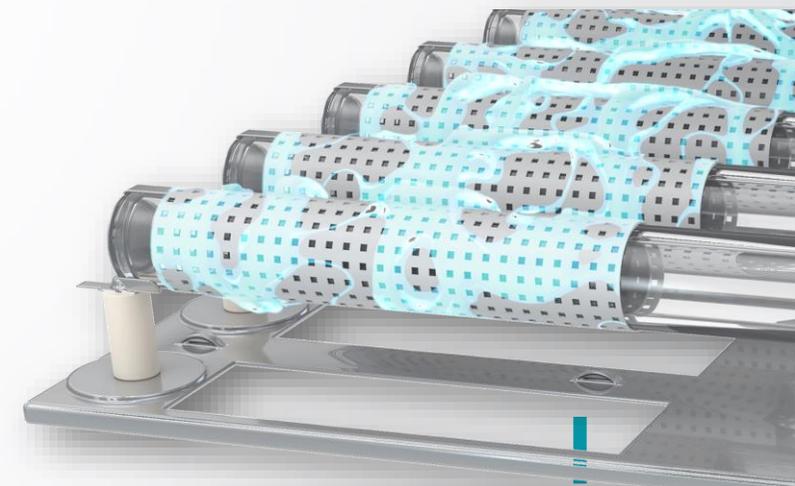
Limitations of UVGI

Significant parameters that determine performance of UVGI systems include:

- **Relative humidity** - effectiveness decreases as humidity increases.
- **Lamp output** – intensity of output will diminish with age, dust particles settling on bulbs.
- **Ventilation** – Too little air results in insufficient air mixing. Greater rates of ventilation, however, may decrease the length of time the air is irradiated, thus decreasing the killing of bacteria.
- **Temperature** - output of UVGI lamps diminishes as the temperature fluctuates.
- **Lamp aspect ratio**
- **Lamp location**
- **Reflectivity**

How NanoStrike[®] Wins Over UVGI technology

- Ability to inactivate all viruses
- Ability to destroy bacteria and fungal spores, preventing colonization
- Ability to burst pathogens avoiding any probability of self-healing
- Ability to avoid AMR
- No line of sight (shadowing) effect
- Ability to be used as a stand-alone solution
- Longevity of out of the box performance
- Lower total cost of ownership (TCO) with low power consumption, no cleaning, no replacement of bulbs, no admin costs for managing cleaning, maintenance & re-ordering
- Continuous 24x7 operation
- No light disruption at night
- IEC 60601 medical equipment certification (Protect 800 | 900)
- No destruction of device from inside out
- No harmful by-products
- No emissions
- No cleaning of bulbs
- Safe around people



Hospital Air Cleaning Technology Comparison

1 = Not Effective 5 = Very Effective

	 NOVAERUS	Photocatalytic Oxidation	UVGI Cleaner	Sanitization Misting	HEPA Filtration	Ozone	Laminar Air Flow	Carbon Filtration
Harmful byproducts	NO	YES ¹	YES ²	YES	NO	YES ³	NO	NO
Prevents filter colonization	5	3	4	1	1	1	1	1
24/7 bacteria load reduction	5	3	3	1	5	1	1	5
24/7 viral load reduction	5	3	4	1	1	1	1	1
24/7 fungal and bacterial spores reduction	5	3	4	1	5	1	1	5
24/7 odour & VOC neutralization ⁴	5	3	1	1	1	1	1	5
Operating costs for maintenance	LOW	HIGH	HIGH	HIGH	MEDIUM	HIGH	LOW	MEDIUM
Removal of ultra/fine particulates ⁴	5	1	1	1	5	1	1	3

1. PCO can produce formaldehyde. 2. At high levels, UV can create noxious gases and is mutagenic.
3. High levels of ozone is unsafe to humans. 4. Defend 1050 only.

