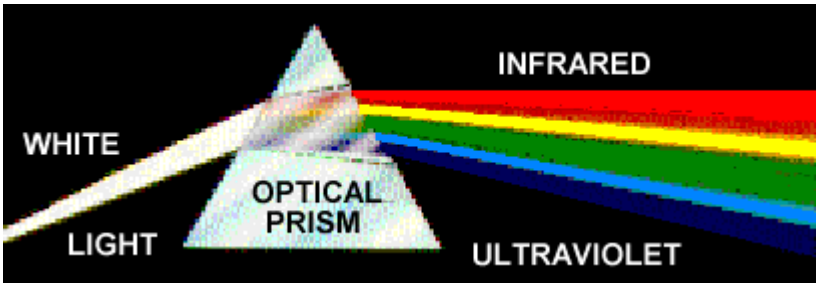
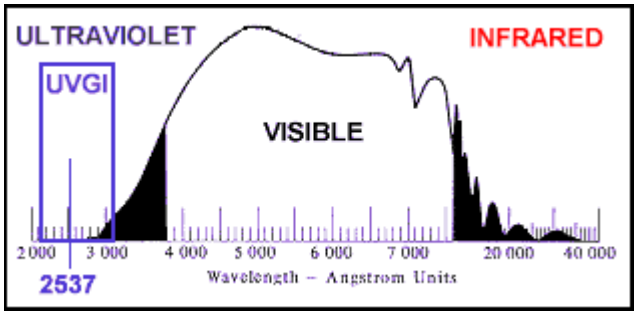
Ultraviolet Germicidal Irradiation



The use of ultraviolet germicidal irradiation (UVGI) for the sterilization of microorganisms has been studied since the 1930s. Microbes are uniquely vulnerable to the effects of light at wavelengths at or near 2537 Angstroms due to the resonance of this wavelength with molecular structures. Looking at it another way, a quanta of energy of ultraviolet light possesses just the right amount of energy to break organic molecular bonds. This bond breakage translates into cellular or genetic damage for microorganisms. The same damage occurs to humans, but is limited to the skin and eyes.



The ultraviolet component of sunlight is the main reason microbes die in the outdoor air. The die-off rate in the outdoors varies from one pathogen to another, but can be anywhere from a few seconds to a few minutes for a 90-99% killing of viruses or contagious bacteria. Spores, and some environmental bacteria, tend to be resistant and can survive much longer exposures. UVGI systems typically use much more concentrated levels of ultraviolet energy than are found in sunlight.
Some properly designed, and well-maintained, UVGI installations have proven highly effective, as in certain hospitals, and some studies performed in schools. CDC guidelines recommend the use of UVGI only with the simultaneous use of HEPA filters and high rates of purge airflow. The germicidal effects can also be species-dependent.
Laboratory tests have achieved extremely high rates of mortality under idealized conditions. In actual applications, many factors can alter the effectiveness of UVGI, including the following :

- Exposure time (the air velocity must allow for a sufficient dose).

- Room air mixing (for non-powered applications like ceiling units).
- Power levels.
- The presence of moisture or particulates provides protection for microbes.
- Dust settling on light bulbs can reduce exposures, maintenance is necessary.

One especially effective application of UVGI is the control of microbial growth in air handling unit cooling coil and filter assemblies. The constant exposure has been found to be very effective at controlling fungal growth, either because the spores are inactivated, or perhaps because mycelial growth cannot be sustained under continuous exposure. Certain types of UVGI designs seem to provide a much higher rate of disinfections than standard models operating at nearly identical spectrums, the difference being the result of improvements in the electrical power controls and regulation of internal plasma temperature, resulting in the generation of a more constant energy density at a distance from the light source.

Viruses are especially susceptible to UVGI, more so than bacteria, but are also very difficult to filter. Some studies have shown that viruses are more sensitive to ultraviolet radiation at wavelengths somewhat above the normal UVGI broad-band wavelength of 2537 A (Rauth 1965; Setlow 1961). A combination of filtration for bacteria and spores, with UVGI for viruses may be an optimum combination if all components are sized appropriately.

UVGI Theory & Rate Constants for Airborne Pathogens

UVGI inactivates pathogens according to the standard decay equation

S = exp(-kIt)

In this equation S represents the fraction of the original population that survives exposure at time t, and I represent the UVGI intensity. The rate constant k has been determined experimentally for a number of bacteria, viruses and spores, at different power levels. See Mathematical Modeling of Ultraviolet Germicidal Irradiation for Air Disinfections by Kowalski et al 2000 for a summary of most of the known rate constants for the indicated pathogens.

Source:

PennState Architectural Engineering

Airborne Pathogen Control Technologies

Current

- Isolation Systems
- Air Filtration
- Ultraviolet Irradiation
- Outdoor Air Purging
- Electrostatic Precipitation
- Negative Air Ionization
- Vegetation

http://www.engr.psu.edu/ae/iec/abe/control.asp