UV Air Purification

The Sun: Nature's Outdoor Air Purifier

For years, scientists have known that one of the most effective air purifiers is natural sunlight. Not the light we see when we look out the window, but the invisible "C" band, ultraviolet rays that make up part of the sun's light spectrum. UV-C light inhibits the growth and reproduction of germs: bacteria, viruses, fungi & mold. The sun acts as a natural outdoor air purification system, controlling airborne bacteria with ultraviolet rays.

Indoor Air: High Concentration Of Biological Contaminants

Biological contaminants in indoor air account for over 50% of home allergies, according to the World Health Organization. Asthma and allergy sufferers must endure constant bombardment by molds, dust, and spores. Even worse, inhaling airborne bacteria and viruses can cause sicknesses ranging from allergies to tuberculosis, and are actually the cause of death to an estimated 8.5 million people annually.

The sun's UV rays must directly contact bacteria in order to affect them. This process does not occur indoors. The Environmental Protection Agency reports that indoor air can contain up to 70 times more pollution than outdoor air. The air in a single room can contain hundreds of thousands of infectious bacteria, viruses, fungal spores, and contaminants, which can only be seen with a microscope.

To reduce indoor airborne bacteria, contamination, and particulates, many health and environmental authorities recommend air purification with ultraviolet energy.

Facts About UV

Ultraviolet energy waves, invisible to the human eye, are lethal to the microorganisms found in indoor air. UV's effectiveness is directly related to intensity and exposure time. Also, to destroy microorganisms, UV rays must strike the contaminants directly. UV light penetrates the microorganism and breaks down molecular bonds causing cellular and/or genetic damage. The germs are either killed or sterilized, leaving them unable to reproduce. In either case, live bacterial counts can be significantly reduced and kept under control.

Filter Systems Alone Don't Solve the Problem

The majority of indoor air is conditioned by forced-air heating and cooling (HVAC) systems. Standard fiber air filters are entirely ineffective in trapping germs, as most particles are simply too small, passing right through the porous filter. New, HEPA style filters will only capture air-borne bacteria down to a certain size. These HEPA filters are nominally effective, trapping small airborne contaminates on the filter, creating a breeding ground where germs can continue to grow and multiply.

HVAC systems are a dark and damp breeding ground for mold and bacteria, particularly at the system filter and air conditioning (A/C) coil. The buildup of matter on the A/C coil and filter can significantly reduce the efficiency of the appliance as the airflow is constricted and reduced. This means increased cost to the homeowner on top of the risks of airborne pollutants.

Indoor Air Treatment With UV

UV's effectiveness in killing bacteria is directly related to a microorganism's exposure time. Indoor air in a typical residential forced-air HVAC system will be recirculated over 50 times a day. With a UV generating lamp mounted in the HVAC duct, cumulative exposure can be very effective in controlling indoor bacteria. UV rays will also kill germs that breed in drain pans and A/C coils. Properly positioned, an ultraviolet system can significantly reduce indoor air contamination and prevent the growth of new microorganisms.

The treatment of indoor air with ultraviolet radiation has been successful in health care facilities, food processing plants, schools, laboratories and other applications. It is a safe, silent, and proven method of improving indoor air quality.

Ultraviolet radiation by itself or in combination with a HEPA or other high quality filter, is the most effective way to reduce airborne bacteria and the health risks they represent.

Contaminant Kill Rate

The energy required to kill microorganisms is a product of the UV light's intensity and exposure time. This energy is measured in micro-watt seconds per square centimeter.

Intensity X Exposure Time = microWatt Seconds/cm^2

The chart below illustrates the typical energy necessary to kill many common bacteria, viruses, yeasts & molds.

UV Energy Required for 99% Kill Rate

Bacteria	mW S/cm^2
Bacillus anthracis	8,700
Corynebacterium diptheriae	6,500
Escherichia coli	7,000
Legionella pneumophila (Legionnaires Disease)	3,800
Leptospira interrogans (Infectious Jaundice)	6,000
Salmonella enteritidis	7,600
Salmonella typhosa (Thyphoid Fever)	6,000
Shigella dysenteriae (Dysentery)	4,200
Streptococcus hemolyticus	5,500
Vibrio cholerae (Cholera)	6,500
Virus	**mW S/cm^2**
Bacteriophage (E. Coli)	6,600
Hepatitis virus	8,000
Influenza virus	6,600
Poliovirus	21,000
Rotavirus	21,000
Yeasts	**mW S/cm^2**
Brewer's Yeast	6,600
Baker's Yeast	8,800
Mold	**mW S/cm^2**
Aspergillus flavus	60,000
Mucor racemosus	17,000
Oospora lactis	6,000
Penicillium digitatum	44,000

FIGURE 1

Warning: Never expose eyes or skin to UV-C light. UV lamps must only be operated inside metal ductwork where the light can be contained.

Intensity Of The Light Diminishes Over Distance

UV rays are predominantly emitted perpendicular to the surface of the lamp. In order to determine the intensity of ultraviolet radiation on a surface at different distances from a UV lamp, multiply the intensity of the lamp rating at 1 meter (microWatts per square centimeter) by the intensity factor opposite the distance selected as shown below. This table provides an easy method for quickly calculating ultraviolet intensity.

Unit	Intensity at 1 meter
UV-12	37 mW/cm^2
UV-18	73 mW/cm^2

FIGURE 2

Distance from Lamp (Inches)	Intensity Factor
0	354
1	127
2	69
4	32
6	20
8	14
10	14
15	6
20	4
25	3
30	2
35	1.4
39.37 (1 meter)	1

For example, to determine the ultraviolet intensity produced by one 37 microWatt lamp rating at 1 meter at a distance of 6 inches from the lamp, multiply the rated intensity of the lamp, by the intensity factor given opposite 6 inches, which is 20:

37 X 20 = 740 microWatts/cm^2

Maximizing Exposure To UV

Since UV rays are primarily emitted perpendicular to the surface of the lamp, lamps should be located at right angles to the air flow, so that the rays are emitted parallel to the airflow. This will maximize the exposure time for airborne bacteria as they flow through the HVAC duct system. Placing a lamp on the duct wall parallel to the airflow decreases the area of transmission of the radiation to only the width of the duct. Placing a lamp in a tube restricts the UV radiation to only the air passing through the tube.

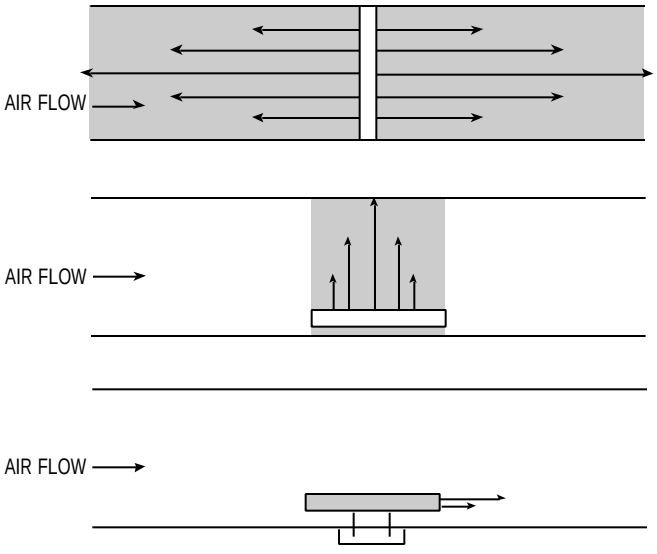

FIGURE 3

Most Effective:

When the lamp is located at right angles to the air flow, airborne bacteria is irradiated for the longest period of time (see shaded area).

Less Effective:

When the lamp is located on the duct wall parallel to the air flow, air is irradiated only while passing the short distance along the lamp (see shaded area).

Least Effective:

When the lamp is located in a pipe or tube, only the air that passes through the tube is irradiated (see shaded area).

Installation Locations

Locating the UV lamp in the supply duct over the A/C coil is the first choice as this is downstream of the air filter, keeping the lamp clean. Also, the lamp will inhibit bacteria growth in condensation formed on the air conditioning coil, a prime breeding ground for bacteria, spores and viruses which can become airborne. Alternatively, install the UV device in the return air duct, preferably downstream of the air filter. Installing a UV device in both the supply (over the A/C coil) and the return is ideal for its cumulative effect.

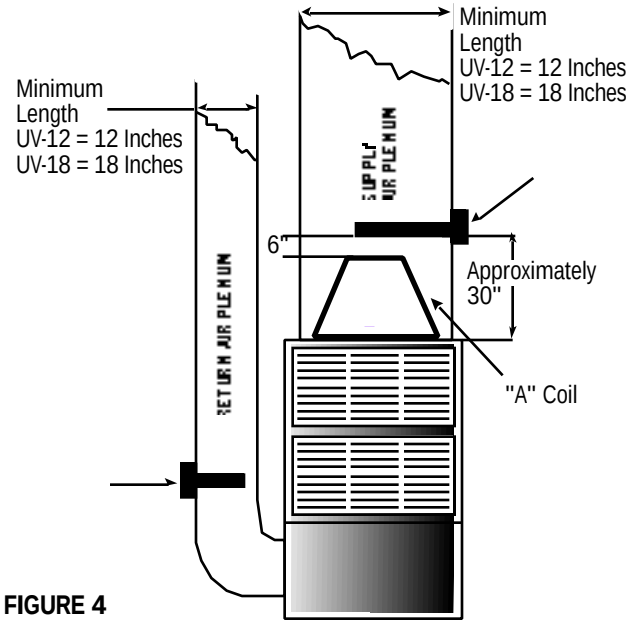

FIGURE 4

Calculations for How Many Lamps & Which Size

Practical factors are:
1) the square footage of the home/office.
2) the size of the duct.

Square Footage	UV-12 (for Ducts less than 18" wide)	UV-18 (for Ducts 18" wide or more)
1000	1	1
1500	2	1
2000	2	1
2500	3	2
3000	3	2
3500	4	3
4000	4	3

FIGURE 5

Note: Spacing between lamps should be at least four inches.

Output Life

It is important that lamps be replaced when the ultraviolet output falls below minimum requirements for protection. Even though a lamp may appear to be operating satisfactorily because it still maintains the blue visible glow, the ultraviolet output may be significantly reduced.

To maintain maximum benefits, UV lamps should be replaced annually.

Cleaning

Lamps should be wiped with a clean cloth dampened with alcohol or ammonia and water in order to eliminate oil, dirt, and fingerprints for maximum ultraviolet output. Conditions of the application will dictate how often lamps need to be wiped, however, it is recommended to clean the lamps every 6 months.

Impact of Dust on Output

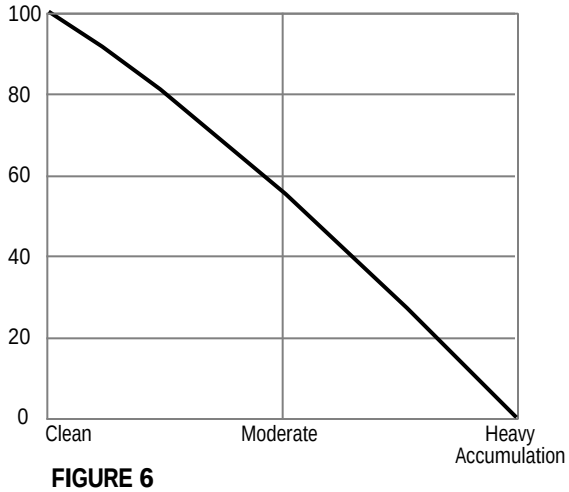

FIGURE 6

Lamps should be located downstream of the filter to maintain lamp cleanliness and efficiency.

Summary

With tighter home construction, indoor air quality has declined dramatically. Indoor air is laden with invisible bacteria, viruses, toxins and molds. Filtering systems offer little or no solution because these airborne contaminants are so small they pass through the filter or simply collect on the filter medium, creating a breeding ground. Recirculated air contains millions of disease and allergy-causing microorganisms which not only live in the air, but are multiplying with each cycle through the system.

Ultraviolet radiation (UV-C) replicates the natural outdoor purification system of the sun by destroying the allergy and disease-causing microbes living and multiplying in indoor air. Ultraviolet radiation is a safe, cost-effective method of purifying indoor air. By itself, or in
combination with a HEPA or like-quality filter, it is the most effective way to reduce airborne bacteria and the health risks they represent. The result is a clean, safe, healthy home environment.