

more efficient) HVAC components and improved indoor environmental quality.

- **Filtration and air-cleaning** affect only the air that passes through the filtration and air-cleaning device, whether it is outdoor air, recirculated air, or a mixture of the two. Building envelopes in residential and commercial buildings are, in general, quite leaky, and significant quantities of air can infiltrate the building envelope with minimal filtration. Field studies have shown that, unless specific measures are taken to reduce infiltration, as much air may enter a building through infiltration as through the mechanical ventilation system. Therefore, building managers should not expect filtration alone to protect a building from outdoor releases, particularly for systems in which no make-up air or inadequate over-pressure is present. Instead, filtration in combination with other steps, such as building pressurization and tightening the building envelope, should be considered to increase the likelihood that the air entering the building actually passes through the filtration and air-cleaning systems.

Ultraviolet Germicidal Irradiation (UVGI). UVGI has long been used in laboratories and health care facilities. Ultraviolet radiation in the range of 2,250-3,020 Angstroms is lethal to microorganisms. All viruses and almost all bacteria (excluding spores) are vulnerable to moderate levels of UVGI exposure. Spores, which are larger and more resistant to UVGI than most bacteria, can be effectively removed through high efficiency air filtration. For these reasons, today most UVGI systems are installed in conjunction with high efficiency filtration systems in many health care facilities.

Ultraviolet (UV) lamps resemble ordinary fluorescent lamps (see Figure 5-10), but are specially designed to emit germicidal UV and include a glass envelope to filter out harmful, ozone forming radiation. The lamps are available in a variety of sizes and shapes and must be mounted in special housings and located so that people are not exposed to direct irradiation. Newer more advanced compact UV tubes provide higher output in the UV-C bandwidth



Figure 5-10
UVGI array used for air disinfection with reflective surfaces

SOURCE: LUMALIER INCORPORATED

(253.7 nanometer wavelength) and increased reliability. UVGI safety measures, such as duct access interlocks that turn off the lamps when the duct housing is opened, should be used.

Manufacturers offer UVGI systems suitable for in-duct or large plenum installations. Retrofitting UVGI systems can also be relatively simple if sufficient space is available. There are UV lamps that can be mounted externally in ductwork and pressure losses across such lamps are often negligible. When installing a UVGI system, attention must be paid to maintaining design air velocity and temperature of the UV lamps. Cooling the plasma inside a UV lamp can significantly affect its UV output. Polished aluminum reflective panels can also be used to increase the intensity of a UVGI field in an enclosed duct or chamber. The design velocity for a typical UVGI unit is similar to that of particulate filters (about 400 feet per minute). It is very important to properly design and install UVGI systems in order to obtain the desired effects. **Improper systems may provide a false sense of protection. For a discussion of the factors that should be considered when designing and sizing a UVGI system, additional information can be found in W. J. Kowalski, *Immune Building Systems Technology* (McGraw Hill, 2003).**

A design utilizing a combination of filtration and UVGI can be very effective against biological agents. Smaller microbes, which are difficult to filter out, tend to be more susceptible to UVGI; while larger microbes, such as spores, which are more resistant to UVGI, tend to be easier to filter out.

5.4.2 Applying External Filtration

Applying external filtration to a building requires modifications to the building's HVAC system and electrical system, and it also usually requires minor architectural changes to reduce air leakage from the selected protective envelope. These changes are necessary to ensure that, when the protective system is in operation, all outside air enters the building through the filters. The air exchange that normally occurs due to wind, chimney effect, and operation of fans must be reduced to zero. This is