



Contamination control

Infections caught while staying in a hospital prolong the stay of many patients and cause complications in patient care. The reason is clear – the movement of disease-inducing organisms from infected patients to non-infected ones. While this is a serious problem, the origin, nature and route of transmission of infections within hospitals is not yet completely understood. Do the disease carrying organisms travel by air, or on people and things?

One aspect is for sure – that air within the hospital could definitely be a major carrier of infection from one portion of the building to another. **A well-designed airconditioning system, with proper air filtration techniques and processes, and the desired relative air pressure between spaces, therefore becomes a key factor in actively reducing air contamination and spread of infection in a hospital.**

Further, 'isolation rooms' are planned between one zone and another. Such rooms are deliberately maintained at 'negative' air pressures, i.e., the air-flow is 'into' these rooms from all adjacent spaces, and then 'out' of the room, through appropriately designed ducting. These 'isolation rooms' reduce airborne transmission of micro-organisms from one zone to another preventing spread of infection.

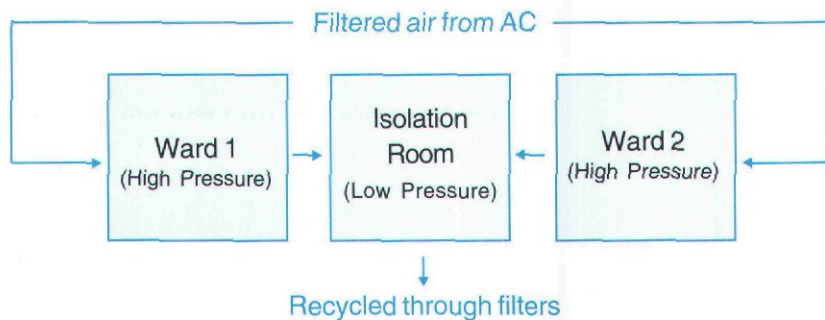


Fig 3. A typical isolation room application



Conversely, a poorly designed airconditioning system can actually increase chances of spread of infection through its ducting and defective air flow patterns.

Some contaminants

To understand how airconditioning can help solve the problem, let us first understand the nature of contaminants in a hospital environment:

Bacteria

Bacteria are transmitted within air or air-and-water mixtures and are typically present in colony-forming units (or clusters) that are larger than one micron in size (a micron measures one millionth of a metre or 1/25,400 of an inch).

Viruses

Airborne viruses that transmit infection are generally less than one micron in size. Examples of such viruses that are virulent within air are *Varicella* (chicken pox / shingles) and *Rubella* (german measles).

Moulds

Moulds are furry growths on the surface of organic matter, caused by fungi, especially in the presence of dampness or decay. Some moulds such as *Aspergillus* can be fatal to advanced leukemia, bone marrow transplant and other immuno-compromised patients (those whose natural immune systems are not functioning).

Table 3.
Typical comparative
sizes of contaminants

	Diameter (microns)
Raindrops	400 - 500
Drizzle	100 - 400
Mist	50 - 100
Fog	1 - 50
Human Hair	30 - 200
Dust	0.1 - 100+
Fumes	0.1 - 1
Smoke	0.001 - 0.3
Pollen	10 - 60
Dust	0.5 - 5
Tobacco smoke	0.03 - 0.3
Oil smoke	0.03 - 1
Lint	10 - 75
Fly ash	0.2 - 200
Fungus spores	1 - 20
Bacteria	0.25 - 30
Viruses	0.0025 - 0.05



Outdoor air

Fresh air that is added into the circulation of an airconditioning system, for purposes of ventilation, may be contaminated by automobile exhaust fumes, dust, dirt or even chemical pollutants, particularly if the outdoor air intakes of the airconditioning system are poorly placed with respect to odour or fume-producing kitchen or toilet exhausts. Such contamination is usually referred to as 'aerosol' contamination.

While efficient air filters on air handling units are capable of removing 99.9% of bacteria present in a hospital area which is airconditioned, viruses, being smaller in size (sub micron), are more difficult to remove by filtration. Attempts to deactivate viruses with ultraviolet light and chemical sprays have not proven reliable or effective enough and hence isolation rooms and anterooms with appropriate ventilation-pressure relationships (which will be explained in detail later) are the primary means used to prevent the spread of airborne viruses in hospitals.

Moulds can be controlled by maintaining low relative humidities and good house-keeping that maintains all surfaces in a clean condition.

Outdoor air for ventilation can be passed through efficient air filters to keep out dust, dirt and automobile exhausts and by judicious locations away from kitchen and toilet exhausts as well as cooling towers.

Let us look at some of these problems and solutions in detail.



Airborne micro-organisms

The air around us also contains a variety of micro-organisms from many sources and bacteria is one of them. A person who sneezes generates thousands of fine droplets of moisture, many of which contain organisms which become airborne. When the water in the droplets evaporates, they become solid particles, most of which can stay airborne indefinitely. Various forms of *legionella* bacteria thrive in ponds and in untreated cooling tower water which can become airborne in sprays from cooling towers or even from the wind stirring up the pond water. They are responsible for respiratory diseases such as Legionnaire's disease.

Viruses or virus particles are also airborne microorganisms of the one-cell type termed as "microbes". Moulds or fungi are also in the same category.

Aersol contamination

Airborne contaminants other than organisms may be either an aerosol or a gas. An aerosol is a suspension of solid or liquid particles in the air. The size of an aerosol is usually measured in microns. A micron is one millionth of a metre or 1/25,400 inch.

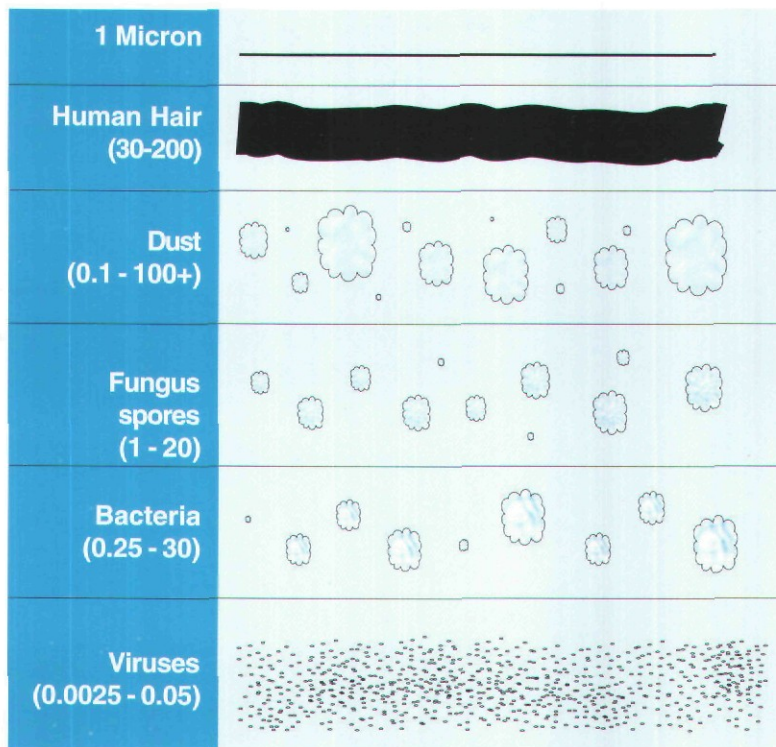


Fig. 4. Comparison of sizes of contaminants.

Dusts are solid aerosols generated from the reduction of larger solid materials. A marble cutter creates dust while slicing through a marble slab with an electric saw. Larger dust particles settle rapidly while smaller dust particles tend to stay suspended in the air or settle very slowly. Another solid aerosol is a fume such as from arc welding, formed by the condensation of vapors of solid materials. Fogs and mists are liquid aerosols. Smokes are solid or liquid aerosols formed by the incomplete combustion of organic substances such as from an automobile exhaust.



The solution – air filtration

While hospitals provide important services in helping cure the sick, they are, by their very nature, places where cross-contamination is likely to occur unless strict environmental control measures are in place. Airborne contamination must therefore be controlled and air filtration is one method commonly used by engineers designing airconditioning systems.

Air filtration supplies the means to obtain the level of particulate cleanliness required to:

- Protect the general well-being of the occupants of a hospital
- Removing airborne bacteria from operating room air to help prevent post operative infection
- Protecting the décor of occupied spaces by removing the staining portion of airborne dust

Filtration is achieved by introducing filters of the desired fineness in the path of the return air to remove impurities from the air. While general comfort airconditioning applications require filters that can remove particles of 20 microns and above, cleaner areas require a second level of filtering using finer filters that remove particles down to 5 microns in size. And spaces like operating theatres require a third stage of filtration as well, using filters known as HEPA filters that can filter particles down to 0.3 micron in size. Since filtration of bacteria is vital in hospitals, 3-stage filtration is mandatory in operating theatres.



Since no minimum standards for air filtration have as yet been established in India by the health authorities, HVAC design engineers tend to follow the standards laid down by ASHRAE.

Table 4. Filter Efficiencies for Central Ventilation and Airconditioning Systems in General Hospitals

Minimum Number of Filter Beds	Area Designation	Filter Efficiencies, %		
		No. 1 ^a	No.2 ^a	No.3 ^b
3	Orthopaedic operating room	25	90	99.97 ^c
	Bone marrow transplant operating room			
	Organ transplant operating room			
2	General procedure operating rooms	25	90	
	Delivery rooms			
	Nurseries			
	Intensive care units			
	Patient care rooms			
	Treatment rooms			
	Diagnostic and related areas			
1	Laboratories	80		
	Sterile storage			
1	Food preparation areas	25		
	Laundries			
	Administrative areas			
	Bulk storage			
	Soiled holding areas			

^a Based on ASHRAE Standard 52.1.

^b Based on DOP test.

^c HEPA filters at air outlets.



Note the three different levels of filtration in these guidelines. There are many more variables for the use of filtered air in different areas that must be considered, and these include:

- air movement relationships to adjacent areas
- minimum changes of outside air per hour
- minimum total air changes per hour
- recirculation by means of room units
- the need for all air to be exhausted directly outdoors.

Effective air filtration is therefore an essential component of hospital airconditioning design.