AIR CONDITIONING AND REFRIGERATION
Journal
The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

Issue : January-March 2001

Indoor Air Quality (IAQ)
Issues at stake

By Deepak Pahwa

President Bry-Air (Asia) Pvt. Ltd.,

New Delhi

Pahwa is a 1969 graduate in Electrical Engineering from Banaras Hindu University. He heads an industrial group in small-medium enterprises with exports to South-East Asia and USA, and is a member of both ISHRAE and ASHRAE. Also serves as a member of ASHRAE TC 3.5: Dessicant & Sorption

Why should we focus on "Indoor Air Quality", when we should be more concerned about the "Outdoor Air Pollution", which is the single most vexing problem being faced today by city planners, environmentalists and health professionals?

Indoor Air
is more polluted
than
outdoor air
Myth or Reality?

Depending on which building you work in and in which area of the city you live in "indoor air can be upto 10 times more polluted than outdoor air". Strange, as this may sound, the fact remains that the air we breathe, working or living, 85% of the time in conditioned spaces may be more injurious to health than outdoor air.

The world focus is now shifting from the **environment** to the **invironment**. Just as in the 70s, the concerns were "Energy Conservation", in the 80s it was "Global Warming

and Ozone Depletion", the focus in the 90s and in this millennium will remain "Health Hazards" and "Indoor Air Quality".

Over the last 15 years, our knowledge of environmental risk to public health due to poor air quality has increased dramatically. Science advisory boards have consistently ranked indoor air pollution among the top five environmental risks to public health. Poor indoor air quality leads to an increased incidence of health related symptoms, which in turn can lead to an increase in absenteeism and loss of productivity.

What is Indoor Air Quality?

Indoor Air Quality refers to the nature of conditioned air that circulates throughout the space/area where we work and live, that is, the air we breathe during most of our lives. IAQ, refers not only to comfort, which is affected by temperature, humidity and odors, but, also to harmful biological contaminants and chemicals present in the conditioned space.

Most people control the environment in their homes to a degree, which is comfortable and healthy for them. They will open windows if the room feels stuffy and unaired; they will use exhaust fans in the kitchen and toilets to clear smoke and odors; they will not use freshly painted rooms until the smell has gone away. Although, by such practices they can avoid immediate adverse effects, they may not have enough awareness of the long-term effects, of the paint removing chemicals used during refurbishing, which may increase the risk of heart or liver disease, or the long term effect of exposure to insecticides being commonly used.

What is Indoor Air Quality ?

`Indoor Air Quality'

is defined as the nature of the

conditioned air, that circulates throughout

space / area where we work and live,

i.e. the air we breathe

during most part of our lives.

What is Indoor Air Quality?

Some Questions ?

How does it effect our health?

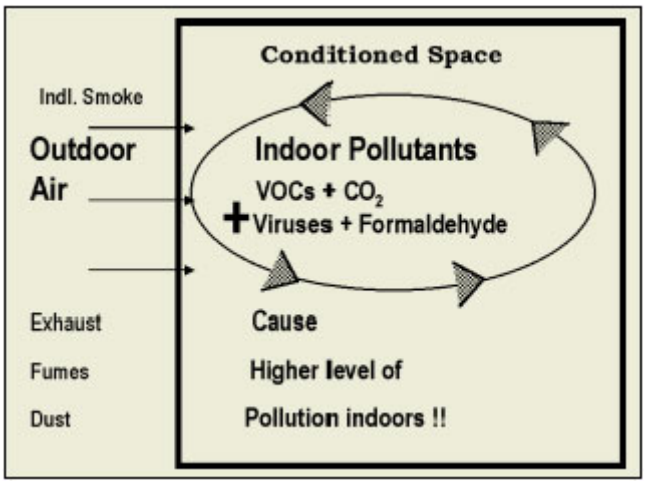
How can we improve indoor air quality?

What technologies fulfil this need

with effective use of energy.

Some Answers . . . . . .

What is easy to accomplish by an automatic behavior at home is much more difficult to accomplish when applied to buildings inhabited by people of widely varying sensitivities and sensibilities. In many modern large commercial structures, for example, occupants have virtually no control over the environment, they cannot open windows, they cannot turn on exhaust fans and cannot leave the room if a colleague has severe cold and cough. They have no control over the atmosphere in a cinema hall, which smells stuffy and unaired, when they walk in; restaurants or banquet halls, which smell stale and damp or boardrooms with heavy smoke filled air.



Poor IAQ results in

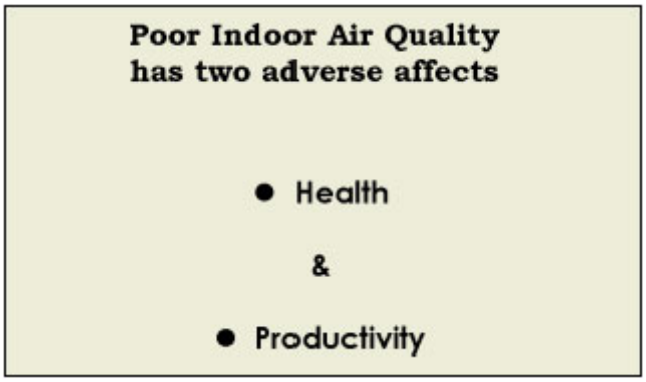
- eye, nose and throat irritation
- headache
- fatigue
- reduced concentration
- irritability
- dry skin and nose bleeds . . . . .

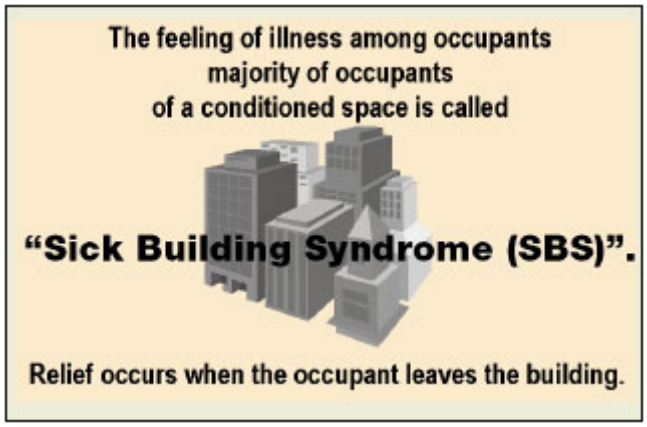
The old adage, "you can please some people some of the time but not all people all the time" holds true in the HVAC industry. Artificial environments are geared to the norm and not to the individual.

In a conditioned space, since free passage of air is limited, with little or inadequate fresh air ventilation, it produces an indoor air environment with relatively high levels of contaminants, bacteria, fungi and dust. The indoor air will certainly have all of the pollutants of the outdoor or surrounding air and those, that are generated within the building by people and their activities like smoking, hair sprays, cleaning products, paints and pesticides spray residues, carpeting, copy machines and air-conditioning coolants. As a result, indoor air may contain a concentration of some components which are greater than the outdoor ambient air. The composite effect of multiple pollutants can seriously impact human respiratory systems leading to various short term and long term illness.

The origins of poor IAQ lie in the emphasis on energy conservation in the 1970s, which resulted in tighter buildings with recirculated air for building ventilation and minimum amounts of fresh air being brought into commercial buildings. Ventilation for comfort began to compete with ventilation for health. This minimized the amount of air to be heated or cooled and hence conserved on energy. This resulted in a situation described as the 'Sick Building Syndrome' (SBS), a term which was used to describe the presence of

acute non specific symptoms in the majority of people, caused by working in buildings with an adverse indoor environment. It was a cluster of complex irritative symptoms like irritation of the eyes, blocked nose and throat, headaches, dizziness, lethargy, fatigue irritation, wheezing, sinus, congestion, dry skin, skin rash, sensory discomfort from odors and nausea. These sysmptoms are usually short term and experienced immediately after exposure; and may disappear when you leave the building.



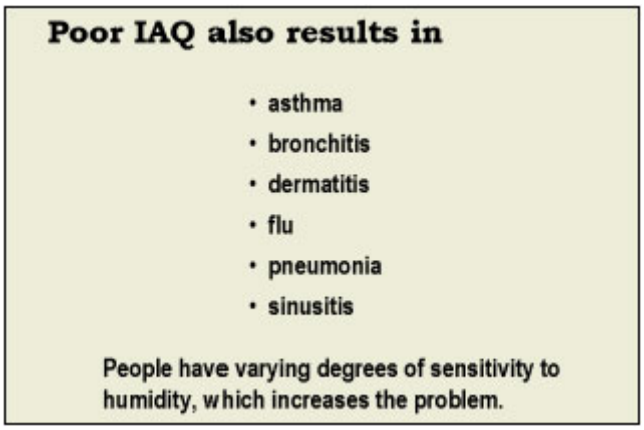


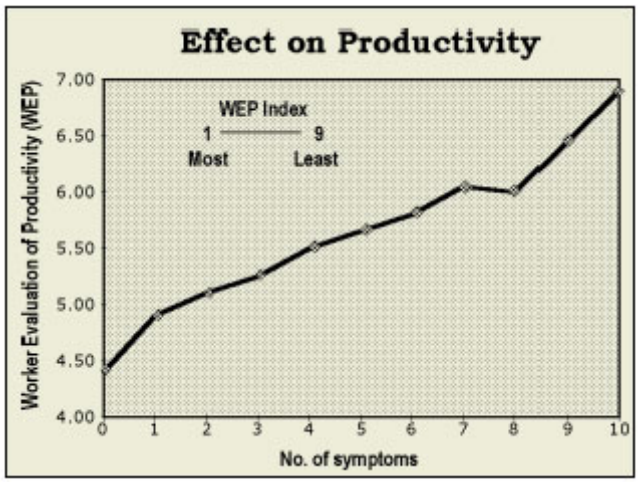
SBS is suspected when a substantial portion of the people spending extended time in a building report or experience acute on site discomfort.

The building related illnesses (BRI) are attributed directly to specific airborne building contaminants, like the outbreak of legionnaire's disease after a convention and sensitivity pneumontis with prolonged exposure to the indoor environment of the building.

The economic consequences of the SBS and BRI are decreased producvity, absenteeism and the legal implications if worker IAQ complaints are left unresolved.

While there is no proof that maximum comfort leads to maximum productivity, there is ample evidence that an improved environment decreases worker complaints and absenteeism thus directly enhancing productivity.





How does one know if the air inside your building is dangerous to your health?

Often it is difficult to determine which pollutant or pollutants are the source of a person's ill health or even if indoor air pollution is the problem. Many indoor air pollutants cannot be detected by our senses and the symptoms they produce can be vague and sometimes similar making it hard to attribute them to a specific cause.

Although it is extremely expensive and difficult to detect or measure indoor air contaminants, **CO_2 or carbon dioxide has been recognized by ASHRAE** (The American Society for Heating, Refrigerating and Airconditioning Engineers) as **the surrogate ventilation index** or the only measurable variable. Carbon dioxide levels in an airconditioned room is a good indicator of occupancy and ventilation rate within a space. CO_2 by itself is not considered an indoor air contaminant and humans are the major source of CO_2. However, if, CO_2 levels in a room are higher than 1000 ppm, then it is an indication that not enough outdoor air is coming in to dilute the CO_2 level. Measurement of CO_2 is easy and instruments are available to measure it within the enclosed space.

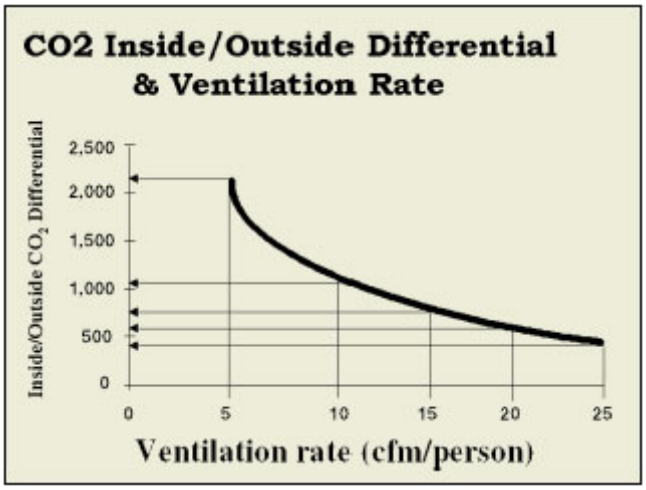
How do we measure IAQ ?

- Indoor air contaminants are difficult and expensive to detect and measure.
- Integrate odor.
- CO_2 levels recognized by ASHRAE as the surrogate ventilation index (only measurable variable)
- CO_2 levels in an air-conditioned room is a good indicator of occupancy and ventilation rate within a space.

ASHRAE Standard

- CO_2 itself is not a contaminant but elevated CO_2 concentration occurs at the same time when other pollutant levels build-up.
- ASHRAE 62-1989 stipulates that indoor CO_2 level should not exceed 1,000 ppm.

The measurement of CO_2 levels in a building gives us an idea about the ventilation rates in a building. This is important, as the cause of SBS over the years has been attributed to the building's HVAC systems and inadequate ventilation systems. Some specialists have even likened the HVAC system of a building to the heart, lungs and pathways in a human body. A building ventilation system acts like the lung in conveyng or reducing contaminants. The pathways convey the pollutants from one area to another.

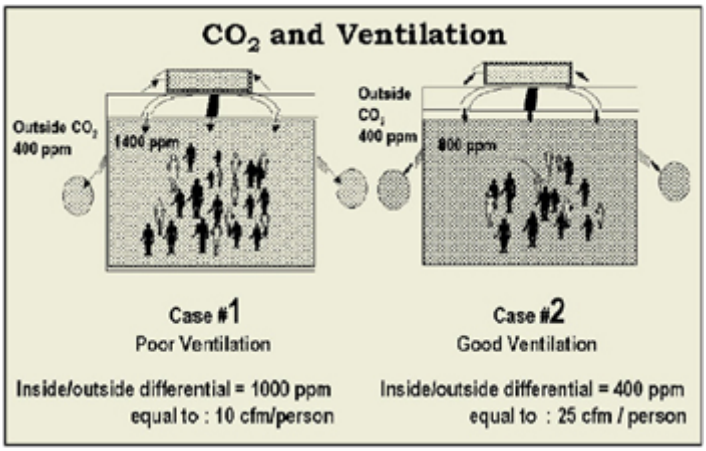


Ventilation systems –

- can bring in pollutants from outside,
- they can be the source of pollutants inside
- they can cause pollutants to flow from one location in a building to another or

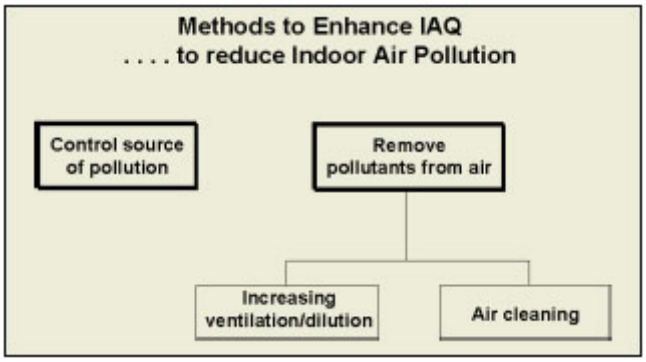
- they can fail to dilute or remove pollutants from a building or a portion of it. When all these factors add up, the single biggest cause of IAQ emerges as – improperly designed, installed, operated or maintained ventilation systems.

Some of the most commonly brought in air pollutants are smog, elevated mold spores or pollen due to seasonal growth, vehicle exhausts, legionella and other bacteria from adjacent cooling towers, bacteria or algae from standing water or decaying vegetation.



The most common pollutants generated within a ventilation system are mold spores and bacteria from water in condensate pans, fiberglass from insulation and general dust and debris from the system, which has not been cleaned or properly filtered.

Improper pressure relationships can direct pollutants where they don't belong. For example bathrooms have exhaust fans to remove odors and bacteria. If there is a supply vent in the bathroom thats more powerful than the exhaust then air will flow from the bathroom to adjacent areas.



Tightly constructed buildings, as most modern commerical buildings are, dependant on fresh air supplied by the ventilation system to dilute contaminants normally generated and present within a building. When the fresh air supplied is insufficient, they can build up to a point where they become a health hazard for the occupants.

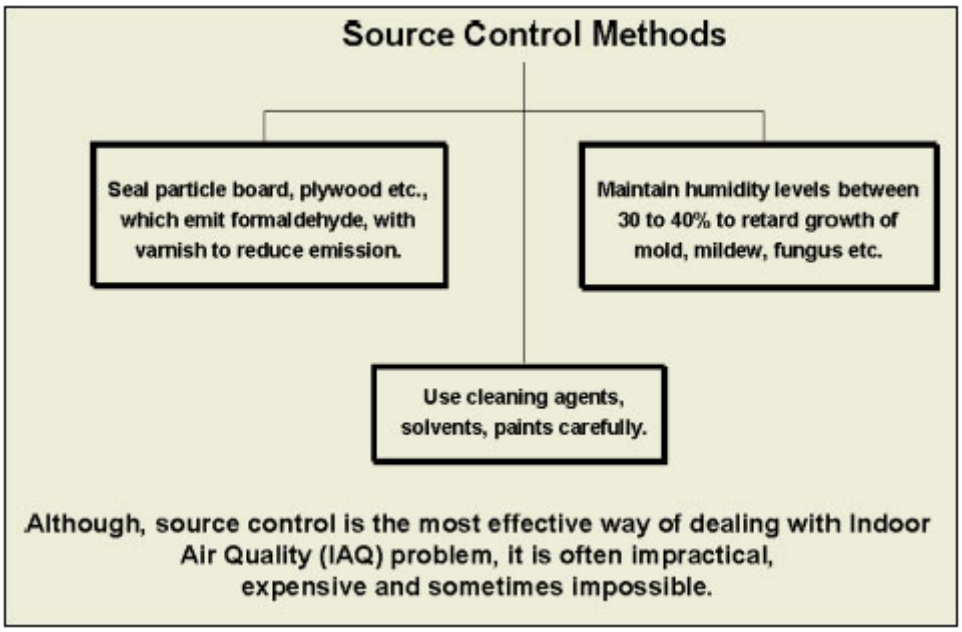
So far its only bad news, the good news is that indoor air quality can be improved. Once we have identified that a combination and cocktail of outdoor and indoor pollutants

pose a threat to health, general well being and productivity, what measures can be taken to improve the indoor air quality?

The two main approaches are Source Control and Removal of Contaminants.

1. In the Source Control, if the source is identifiable and removed then this is the best method. Some of the methods would be:

1. Banning smoking or providing a separated ventilated space for smokers.
2. Using and storing paints, solvents, pesticides, adhesives in closed containers in well ventilated areas.
3. Using these pollutant sources in periods of low or no occupancy.
4. Allowing time for new building materials to gas off before occupancy.
5. Fixing any water leaks.
6. Replacing water stained ceiling tiles or carpets and drying.
7. Control of humidity to safe level so that mold, fungus and algae formation are prevented.
8. Regular maintenance of HVAC systems including duct cleaning.
9. Providing efficient filtration in the HVAC system for keeping outdoor pollutants out.
10. Exhaust air from rest rooms, copy rooms and printing facilities directly to the outside.



2. For Removal of Contaminants ... one of the methods is to use Air Cleaners, Ionizers and Electronic Precipitators. Though these can rid indoor air of some microscopic particles such as dust and combustion products, they do not purify the air and at best can be used in addiion to Source Control and adequate ventilation. Increasing the ventilation rate and air distribution rate is a good and cost effective way of reducing indoor pollutant level. At the minimum, HVAC systems should be designed to meet ventilation standards in local building codes. Advanced designs of new buildings feature mechanical systems that bring outdoor air into the building. Some of these designs include energy efficient heat recovery ventilators.

Increased awareness of the importance of IAQ has resulted in "alternative" technologies being offered for achieving IAQ. Filtration and Ozone Generators have resultantly been highlighted.

However, as **EPA** (United States Environmental Protection Agency: www.epa.gov/iaq/pubs/ozonegen.html) and Health Canada reports, (About Health Canada: www.hc-sc.gc.ca/ english/archives/releases/99_19e.htm), Ozone generators do more harm than good as they can cause damage to lungs.

Do we have any ventilation standards to follow?

If you trace the history of ventilation standards, we see that the rationales for ventilation began with a concern for health and about a century ago began to gravitate toward a concern for comfort, with particular regard to odor and sensory irritation. Based upon the knowledge available then, for years afterwards, ventilation rates necessary to achieve comfort seemed readily to surpass those necessary to maintain health. Reasearch on health and IAQ performed over the last two decades has justified a return to a concern for health.

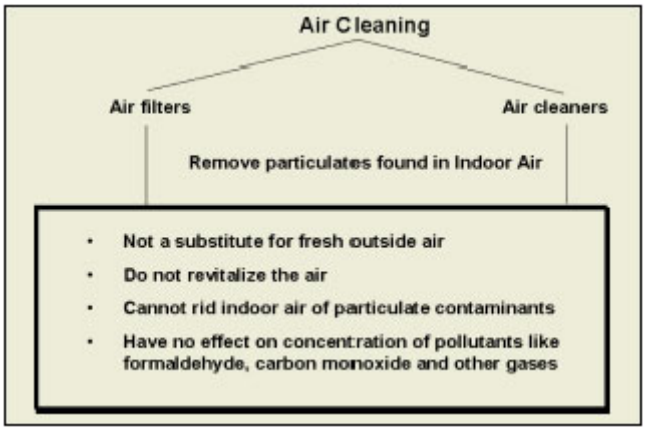
ASHRAE – The American Society for Heating, Refrigerating and Air Conditioning Engineers has exercised jurisdiction over Indoor air quality over the years. ASHRAE's standard carries significant weight because its existing standard has become the most widely used and cited document for IAQ in the world.

Initially the ASHRAE standard 62-1973 recommended levels of ventilation were intended to suffice "for the preservation of the occupant's health, safety and well being".

In ASHRAE 62-1981 it changed to specify indoor air quality and minimum ventilation rates which “will be acceptable to human occupants and will not impair health”.

ASHRAE 62-1989 and 90, the next revision stated the purpose as “to specify minimum ventilation and indoor air quality that will minimize the potential for adverse health

effects."



Standard 62-1989 recommends fresh air intake of 20 cfm per person.

There is an ongoing debate about the new standard, which is eight years into its making, to incorporate chemical, physical and biological contamination as well as moisture and temperature that can affect human health and perceived air quality. Another main aspect is that it will be written in a code compliant language. It will address factors, which go beyond design and will address construcion, startup, operation and maintenance. Ventilation rates now include a building component as well as an occupant component recognizing that office machines, copiers etc. also are a source of contaminants in space.

Regulations and Guidelines

Regulatory Body	Country	Standard	Ventilation	CO_2 (not exceeding)
OSHA	US	29 cfr 1910.1033 (Proposed)		800ppm
ASHRAE	US	62-1989	15 cfm/person 20 cfm/person 7 people/1000ft2 for office	1000 ppm
Codes for new homes/construction				
NBCC	Canada		0.5 AC/HR	1000 ppm
	Sweden		0.5 AC/HR	1000 ppm
	France		0.5 AC/HR	1000 ppm
	Japan		15 cfm/person	1000 ppm

On August, 15, 1998, ASHRAE proposed a new industry standard for ventilation. Known as "Ventilation for Acceptable Indoor Air Quality", the proposed new standard would impose:

1. New and renovated buildings to be designed with strict adherence to complex heating and air conditioning system design procedures.

2. Failure to perform routine maintenance operations, like changing air filters, becomes a building code violation.
3. Businesses are required to retain all inspection and service records for the life of heating and air conditioning systems.
4. Every business must designate a "responsible party" to manage indoor air quality–a person, department or contractor who must be trained in indoor air quality principles and regulations.
5. Acceptable indoor air quality cannot be achieved in the presence of environmental tobacco smoke, regardless of the ventilation and filtration systems installed (a major problem for restaurants and bars).

ASHRAE Standard 62 R
Minimum Outdoor Air Requirements for Ventilation

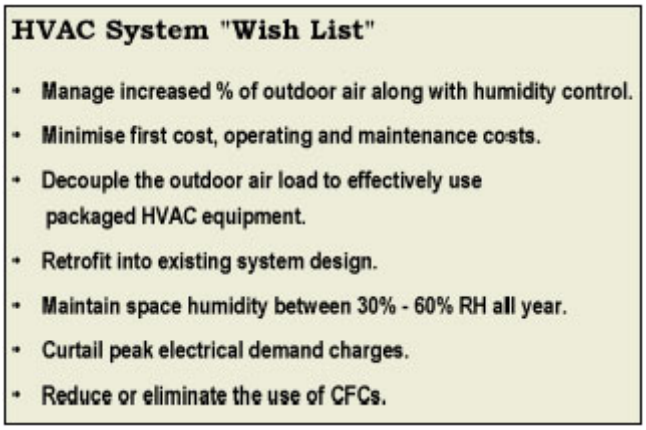
	Prescriptive Requirements	
	People R_p cfm/person	Building R_B cfm/ft2
Office Space	6.0	0.07
Restaurants	6.0	0.17
Bars / Cocktail	6.0	0.17
Hotel Rooms	5.0	0.17
Disco / dance floors	15.0	0.07
Auditoriums	5.0	0.07
Conference Rooms	5.0	0.07
Class Rooms	6.0	0.11
Hospital Room	-	0.27
Operating Room	8.0	0.36
Supermarkets	7.0	0.06
Health Club	24.0	0.07

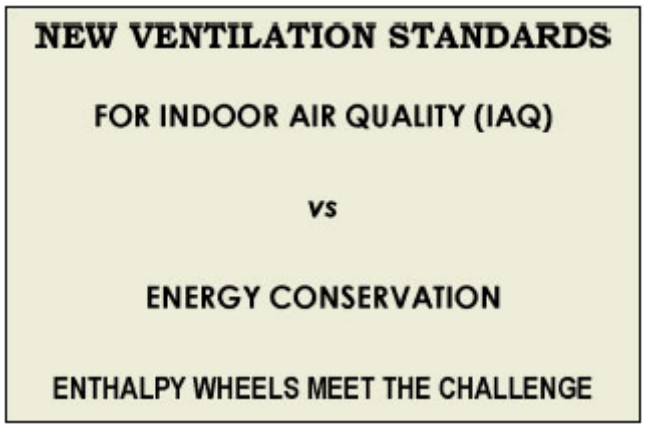
R_p meets the requirement for people sufficient to satisfy occupants of the space R_B are for spaces

Non adherence to building codes and ventilation standards in advanced nations, particularly in U.S.A., have caused the number of litigations regarding IAQ problems to increase dramatically in recent times. A study regarding why so many building get into lititgation revealed the following as answers.

- Ignoring signs and symptoms
- Continuous degradation
- Addressing short-term concerns
- Looking for the inexpensive fix
- Failure to involve key users

- Failure to communicate
- Failure to manage a crisis.





Who can be sued for SBS?

Architects, contractors, HVAC contractors, building owners and managers, manufacturers, distributors of products, leasing agents, and real estage agents.

Education and communication are important parts of any air quality management programme. When everyone associated with the building designers, architects, contractors, owners, managers and occupants fully understand the issues and communicate with each other they can work more effectively together to prevent and solve problems.

Architects when designing and building new homes and building can incorporate ideas as well the choice of materials that ensure that IAQ issues of ventilation, humidity control and source control of pollutants are kept in mind. Some of them can be:

- Use radon resistant construction techniques
- Choose building materials and furnishings that will keep indoor air pollutant to a minimum
- Provide proper drainage and seal foundations in new construction

- Install mechanical ventilation systems
- Ensure that combustion appliances are properly vented.

It is also important that architects provide adequate space, while designing a building, for ventilation and ventilation equipment so that airconditioning consultants can incorporate the same.

Most buildings are not designed to accommodate equipment which can improve ventilation.

Thus, engineers, and designers, today, constantly face the challenge to conceptualise, design and specify a cost-effective solution for conditioning large volumes of fresh air. An ideal 'airconditioning' equipment should sanitise, cool, heat, humidify/dehumidify, evenly distribute air through the area and all, cost effectively. That is the challenge, the designer faces today.

Innovative designs of the building and efficient design of the HVAC system with incorporation of energy recovery systems can reduce energy bills and reduce first costs as well.

In conclusion I would like to stress only on one point, that as designers, builders, architects, planners, HVAC engineers and above all concerned citizens, while we are building a new and resurgent India, let us not ignore these important issues that have emerged due to previous mistakes or we'll be paying a much more costly penalty–that is the health of our future generations–our children. Let us spread this message and consciousness among the people so that they can act now. Knowledge about the potential danger is half the battle won!!!