The AIR is changing. Are you?
Index

- What is Indoor Air Quality
- Indoor Air Pollutants
- Effects of Poor IAQ – SBS & BRI
- IAQ Enhancers
- Method of Ventilation – Energy Recovery Devices
- Total Energy Recovery Wheel
- OutDoor Pollution
- Using Fresh Air to achieve IAQ in polluted Cities
Target to design an efficient building and increase the value

- Reducing energy use:
  - Rationalizing the orientation of building;
  - Improving facade and window design;
  - Improving the performance of HVAC-systems;
  - Adding renewable energy production.

- Improving Indoor Environment Quality:
  - Thermal comfort;
  - Indoor air quality (IAQ);
  - Lighting environment;
  - Acoustic environment;
  - Visual environment.
What is IAQ?

IAQ Stand for ‘Indoor Air Quality’

Indoor Air Quality (IAQ) refers to the Nature of the conditioned (Heat/Cool) air that circulates throughout space/area where we work and live i.e. the air we breathe during most of our lives.
refers not only to comfort which is affected by:

- Temperature
- Humidity
- Odour

but also to

- Harmful chemicals and
- Biological contaminants present in the conditioned space
A Common **MYTH**

Air pollution occurs only Outdoors.
or
In Industrial Environment.

**TRUTH!!**

Air inside Conditioned Space can be substantially more polluted than outdoor air.
ANOTHER FACT
HUMAN BEING SPEND 80 to 90% TIME INDOOR

Research clearly indicates that we spend 90 % of our time indoors and the growing scientific evidence that the air indoor is almost 10 to 100 times more polluted than outside, the risk to health is much greater indoors than outdoors
INDOOR AIR POLLUTANTS

- Formaldehyde
- Radon
- Asbestos
- VOC from solvents, paints, varnishes, carpets etc.
- Biological organisms like bacteria, viruses, fungus
- Odours and dust &
- Environmental tobacco smoke (ETS)
- All outdoor pollutants - sulphur, nitrogen dioxide, carbon monoxide, high pollen counts, pesticides, chemicals etc.
Primary Sources of Indoor Air Pollution

- Outdoor air
- Building and Construction Materials and Furnishings
- Building Occupants and Activities
- Inadequate Building Design and Maintenance

Diagram showing various sources of indoor air pollution:
- Ozone
- VOCs
- Particulates
- Bioaerosols
- Perchloroethylene and other VOCs
- VOCs
- Bioaerosols
- VOCs
- VOCs
- Particulates
- Ozone

Specific pollutants include:
- Carbon monoxide
- Benzene
- Formaldehyde
- Pesticides
- Bioaerosols
- Perfume
- Body odours
- Poly aromatic hydrocarbons
- Carbon monoxide
- Benzene
- VOCs
- Formaldehyde
POOR IAQ - HEALTH CONSEQUENCES
CATEGORIZED AS “SBS” & “BRI”

SBS - SICK BUILDING SYNDROME
- No specific illness or identifiable cause of discomfort
- Cluster of complex irritating symptoms incl.
  - Headache, nausea, fatigue
  - Dizziness, lethargy
  - Respiratory problems
  - Coughing, wheezing
  - Eye, nose & throat irritation
  - Dry skin, skin rashes
  - Sensory discomforts

BRI - BUILDING RELATED ILLNESS
- A more serious condition
- Symptoms of diagnosable illness are identifiable
- Cause of illness directly attributable to environmental agents in air
- Diseases include:
  - Legionnaire’s disease
  - Sensitivity pneumonitis
Indoor Air Contaminants Are Difficult And Expensive To Detect And Measure

ASHRAE Recognizes CO₂ Levels As The Reliable Surrogate Index To Monitor Indoor Air Quality

High Concentrations of CO₂ indicate high pollutant levels which Cause Drowsiness and Discomfort and an Inability to Think, Reason, and Retain Information and Respond.

ASHRAE- 62- 2001 Stipulates that the Indoor CO₂ Levels shall not exceed 1000 ppm.
Monitor CO2 levels with……..

**CO₂ Sensor**

- Self Calibrating and CO₂ concentration is adjustable from 0 to 10,000 ppm
- Microprocessor Controlled
- Low voltage wiring
- Easy to read display
- Handheld, light weight and Compact.
- Highly accurate measurements
- Easy front panel programming
- Selectable CO₂ Setpoint
- System Return Air Duct Mounting option
Methods to Enhance IAQ
. . . . to reduce Indoor Air Pollution

- Control source of pollution
- Remove pollutants from air
  - Increasing ventilation/dilution
  - Air cleaning
Seal particle board, plywood etc., which emit formaldehyde, with varnish to reduce emission.

Maintain humidity levels between 30 to 40% to retard growth of mold, mildew, fungus etc.

Use cleaning agents, solvents, paints carefully.

Although, source control is the most effective way of dealing with Indoor Air Quality (IAQ) problem, it is often impractical, expensive and sometimes impossible.
The Solution to Pollution is Dilution
i.e.
“More Fresh Air ... Indoors”
Ventilation

*The preferred solution for Indoor Air Quality problems*

Ventilation is the movement of air and its contained pollutants to outdoors and flow of fresh air indoors.

- The flow of fresh air dilutes the concentration of pollutant indoors.
- It is ideal way of keeping indoor air clean.

However, simple mechanical ventilation increases the fresh air load on conditioning systems resulting in increase in tonnage . . . more energy cost.
"A minor 1 % (5 min/day) increase in office work can off-set the annual cost of ventilating the building."

"The full costs of installation and running the building can be off-set by productivity gains of just under 10%.”

"A reduction of indoor air temperatures by 1 °C can roughly increase the performance of office work by 1% (valid above 22 °C).

"Doubling the outdoor air supply rate can reduce sick leave prevalence by 10 %, and increase office work by 1,5%.”

Fresh Air Calculation as per ASHRAE 62.1 – 2010

Fresh Air = 5 cfm/person + 0.06 cfm/ft$^2$

Suppose the office area is 10000 sq ft and there are 100 persons sitting in that area, so fresh air becomes:

F/A = 100X5 + 0.06X10000 = 1100 cfm

i.e 11 CFM / person
Ventilation Rates

IAQ generally refers to the quality of the conducted air in an indoor environment. Other terms related to IAQ include Indoor Environmental Quality (IEQ) and "Sick Building Syndrome".

<table>
<thead>
<tr>
<th>Application</th>
<th>Ventilation Rate/person</th>
<th>Application</th>
<th>Ventilation Rate/person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office space</td>
<td>20 cfm</td>
<td>Auditorium</td>
<td>15 cfm</td>
</tr>
<tr>
<td>Smoking</td>
<td>60 cfm</td>
<td>Conference Rooms</td>
<td>20 cfm</td>
</tr>
<tr>
<td>Lounge</td>
<td>20 cfm</td>
<td>Classrooms</td>
<td>15 cfm</td>
</tr>
<tr>
<td>Restaurants</td>
<td>25 cfm</td>
<td>Hospital Rooms</td>
<td>25 cfm</td>
</tr>
<tr>
<td>Beauty Salon</td>
<td>30 cfm</td>
<td>Laboratory</td>
<td>20 cfm</td>
</tr>
<tr>
<td>Bars/Cocktail</td>
<td>30 cfm</td>
<td>Operating Rooms</td>
<td>30 cfm</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>20 cfm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### IAQ (Ventilation) Standards

- **ASHRAE 62.1 and EN 15251** specifies the ventilation rate for office buildings.

#### Minimum ventilation for occupants in l/s/person (cfm/person)

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASHRAE 62.1</td>
</tr>
<tr>
<td></td>
<td>Category I</td>
</tr>
<tr>
<td>Minimum ventilation for occupants</td>
<td>2.5 (5.3)</td>
</tr>
</tbody>
</table>

#### Additional ventilation for building in l/s/m² (cfm/ft²)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 (0.06)</td>
<td>0.5 (0.1)</td>
<td>1 (0.2)</td>
<td>2 (0.4)</td>
<td>0.35 (0.07)</td>
<td>0.7 (0.14)</td>
<td>1.4 (0.28)</td>
<td>0.3 (0.06)</td>
<td>0.4 (0.08)</td>
<td>0.8 (0.16)</td>
</tr>
</tbody>
</table>

**A** – Very Low Pollution  **B** – Low Pollution  **C** – Not Low Pollution

- **ASHRAE**: \[(2.5 + 0.3 \times 7) / 7 = 0.7 \text{ l/s,m}^2 (0.13)\]
- **LEED (ASHRAE+30%)**: \[0.7 \text{ l/s,m}^2 \times 1.3 = 0.9 \text{ l/s,m}^2 (0.17)\]
- **EN Category II, low polluting**: \[(7 + 0.7 \times 7) / 7 = 1.7 \text{ l/s,m}^2 (0.32)\]
Thermal Comfort Standard (ASHRAE 55 – adaptive comfort)
The Designer’s Dilemma

- Fresh air ventilation runs contrary to the guidelines being followed by HVAC professionals. Higher fresh air ventilation needs translate into higher outdoor air changes per changes, which leads to more air-conditioning loads necessitating installation of higher capacity plants. This leads to higher initial cost and higher energy bills.
- The right humidity levels have to be maintained despite the increased ventilation rates and also to avoid expensive and inefficient solution like re-heat.
- New standards and increased awareness of the effect of IAQ on health necessitates the engineers and building designers conceptualize and provide cost effective solution to indoor air quality requirements.
Balancing Ventilation rates for IAQ & HVAC system energy consumption

Europe : Heating Centric Products & Design
North America : Cooling Centric Products & Design
Asia & Brazil : Moisture Centric Products & Design
( HOT & HUMID CLIMATES )
Outside Air load - Mumbai Ventilation Load index Mumbai (for 1000cfm)
Solution for Hot & Humid Climates

Air to Air Heat Exchangers units which recover total energy from exhaust air & use this energy to pre-cool & dry the fresh air into the buildings.
Total Energy Recovery Wheels
Universal Rules of Total Energy Wheels

1. Heating/Cooling Energy (e.g. 80%) Is Always Returned To Where It Came From

   ![Diagram of Heating/Cooling Energy]

   - Heat In
   - Heat Out
   - Cooling Energy In
   - Cooling Energy Out

2. Moisture and Dry Air (e.g. 80%) Is Always Returned To Where It Came From

   ![Diagram of Moisture and Dry Air]

   - Moisture In
   - Moisture Out
   - Dry Air In
   - Dry Air Out
Design your Air with

Energy Recovery Ventilators (ERVs) for Fresh & Healthier ‘In’vironment

SOLUTION TO POLLUTION IS DILUTION
Redesign or Maintain Your IAQ (Indoor Air Quality) with

Maintaining IAQ in

BPOs / Call Centers / Office Buildings
Conference / Meeting Rooms
Hospitals / Healthcare facilities
Schools / Institutions
Supermarkets / Retail Stores
Restaurants / Bars / Discotheques
Gymnasiums / Recreation Centres
Movie Theatres / Auditoriums

. . . And all other air-conditioned spaces!
Delhi in the News!
Outdoor Air Pollution 101

- Particulate Contamination
- Gaseous Contamination

- Solids (Particulates) – 0.003 to 100 microns
  - Dust
  - Smoke

- Liquids (& Vapours) – 1 to 9 microns
  - Vapours
  - Aerosols

- Gases – 0.0003 to 0.007 microns
  - Sulphur Oxides (Sox)
  - Nitrogen Oxides (NOx)
  - Formaldehyde (HCHO)
  - Chlorine (Cl2)
  - Hydrogen Sulphide (H2S) … etc.
Particulates vs. Gaseous Contaminants

Limit of ULPA filters

Particle Size, Microns

0.0001 0.001 0.01 0.1 1 10 100

BACTERIA

VIRUSES

PLANT SPORES

INSECTICIDE DUST

FERTILIZER

COAL DUST

TOBACCO SMOKE

COOKING SMOKE/GREASE

HOUSEHOLD DUST

PET DANDER

HUMAN HAIR

GAS
What is Particulate Contamination (PM 2.5)

- **Human hair**: 50-70 microns in diameter
- **PM2.5**: Combustion particles, organic compounds, metals, etc. <2.5 microns in diameter
- **PM10**: Dust, pollen, mould, etc. <10 microns in diameter

Fine beach sand: 90 microns in diameter

Source: US EPA
Sources of Particulate Contamination

- Vehicles (Predominantly Diesel)
- Thermal Power Plants
- Open Fire Cooking (Chullahs)
- Stubble Burning
- Burning of Wastes
- Industrial Process Emissions
Sources of Gaseous Contamination

• Vehicles

• Open Sewage System

• Industrial Processes
## Acceptable Levels

<table>
<thead>
<tr>
<th>Substance</th>
<th>Limit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter (PM2.5) 24 h mean</td>
<td>&lt; 25 µg/m³</td>
<td>WHO Air Quality Guideline</td>
</tr>
<tr>
<td>Particulate matter (PM10) 24 h mean:</td>
<td>&lt; 50 µg/m³</td>
<td>WHO Air Quality Guideline</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>&lt; 1000 ppm</td>
<td>ASHRAE 62.1-2013</td>
</tr>
<tr>
<td>Sulphur dioxide (SO₂) 24 h mean</td>
<td>&lt; 20 µg/m³</td>
<td>WHO Air Quality Guideline</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂) 1 h mean</td>
<td>&lt; 200 µg/m³</td>
<td>WHO Air Quality Guideline</td>
</tr>
<tr>
<td>Ozone (O₃) 8 h mean</td>
<td>&lt; 100 µg/m³</td>
<td>WHO Air Quality Guideline</td>
</tr>
<tr>
<td>Carbon monoxide (CO) 8 h mean</td>
<td>&lt; 75 ppm</td>
<td>ASHRAE 62.1-2013</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>&lt; 0.1 mg/m³</td>
<td>ASHRAE 62.1-2013</td>
</tr>
</tbody>
</table>
Health Effects of Higher Pollution Levels

Particulate Contamination

- Increasing respiratory symptoms, e.g. irritation of the airways, coughing, or difficulty in breathing;
- Decreasing lung function;
- Aggravation of asthma;
- Development of chronic bronchitis;
- Adverse effects on the cardiovascular system; and
- Premature death of people with heart or lung diseases.
Health Effects of Higher Pollution Levels

Gaseous Contamination

SOx:
- Irritates the throat and lungs;
- If there are fine dust particles in the air, it can damage a person's respiratory system; and
- If combined with other substances in the air, it produces a haze that reduces visibility.

NOx:
- Increased incidence of respiratory illness,
- Increased airway resistance (due to inflammation),
- Damage to lung tissue,
- Chronic obstructive pulmonary disease or COPD (narrowing of the airways),
- Emphysema (as part of COPD),
- Pulmonary edema (accumulation of excessive fluid in the lungs),
- Infant and cardiovascular death.
Points to ponder

- Reducing Outdoor Air Pollution is not necessarily in our control – dependent on multiple factors / agencies

- Indoor Air Pollution is what we can control and it is the Indoors where we spend most of the times – Residences / Offices / Schools / Malls / Hotels
Designer’s Dilemma

- World Wide fresh outdoor air is brought in to improve Indoor Air Quality as per established ventilation rates.
- The guidance on these ventilation rates is practised based on ASHRAE / European Standard (EN 15251) / Local Codes.
- These ventilation rates guidelines have evolved over the last few decades and have been decided after years of research, implementation and feedback.
- In cities like Delhi and Beijing the dilemma is that the Outdoor Air Quality itself is bad.

**Hence, the Outdoor Air has to be properly cleaned before being introduced in the occupied spaces to achieve the following:**

- Dilute the Indoor Contaminants built up and exhaust the same
- Maintain the building under positive pressurization to prevent any infiltration
- Remove the Particulate and Gaseous Contaminants
Particulate Filtration

Typically Particulate Filtration Stages can be classified as:

- **Primary Filtration** (G1 – G4 as per EN – 779 or MERV 1 – 8 as per ASHRAE 52.2)
- **Secondary Filtration** (M5 – M6 & F7 – F9 or MERV 9 – 15)
- Another class of filtration is HEPA (High Efficiency Particulate Air Filters) and ULPA (Ultra Low Penetration Air Filters) which are generally used in Clean Rooms / Hospitals and Manufacturing Areas.
Particulate Filtration

EU 2 Washable
EU 3-4 Washable
EU 3-5 Washable
EU 3 Bag Filter
EU 5-9 Bag Filters
EU 5-8 Box Filter
HEPA/ULPA Filter
Gas Phase Filtration

The process of removing harmful gases is done by adsorbing these gases on an adsorbent and neutralizing / oxidising them by treating with a suitable chemical.

- The process is specific and depends on the chemical nature of both the media and gas.
- The process is instantaneous and irreversible.
- Changes harmful gases to harmless solids.
- The Phenomena is called Chemisorption
Gas Phase Filters

Odor Filters

Gas Phase Filters
Stand Alone Room Air Purifier
Central Ducted Air Purification System

Fresh Air

+ve Pressure
FEW IAQ UNITS
AIR PURIFICATION SYSTEM – LEADING INTERNATIONAL SCHOOL
AIR PURIFICATION SYSTEM – LEADING INTERNATIONAL SCHOOL
CHEMICAL FILTER UNIT
THANK YOU