Indoor Pollution Control - an Overview

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Introduction

Indoor Air Quality (IAQ) is an important parameter that determines the functioning of a building. Proper IAQ provides comfortable and healthy working conditions to building occupants. In addition, it creates a positive impression on customers and visitors to the building. IAQ directly affects occupant health, comfort and productivity. Serious health impacts resulting from poor IAQ include Legionnaires' disease, lung cancer from radon exposure and carbon monoxide (CO) poisoning. Other health impacts include increased allergy and asthma from exposure to indoor pollutants and sick building syndrome due to elevated indoor pollutant levels. Achieving good IAQ involves proper system design, building pressure control, filtration and treatment of air for pollution control and controlling the temperature and humidity of air to ensure the required comfort levels.

Particulate, Chemical and Biological Pollution Control

Indoor pollutants can be broadly classified as particulate and chemical pollutants. Particulate pollutants are introduced through construction activity and unfiltered outside air intake. Chemical pollutants are usually released by building materials, paints, furnishings and materials brought into the building during its operation.

Pollution control in buildings can be achieved by reducing emissions at source and by filtering and air cleaning. Source control typically includes filtering all outside air taken into the building and using paints and other cleaning products with low Volatile Organic Compound (VOC) content.

Particulate Pollutants and Filtration

Particulate content can be reduced to a large extent by maintaining a positive building pressure to reduce intake of unfiltered outside air to the building. Positive building pressure is typically achieved by balancing the total outdoor air intake with the total exhaust and envelope leakage air rates. However, in a large building, the building pressure is dependent on various factors such as building size and orientation, wind load and building usage. In such cases, proper HVAC system design and control plays a key role in ensuring reduced infiltration.

The fresh air taken into the building needs to be filtered before being supplied to the occupied space.

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Most bacteria found in the atmosphere are in the range of 0.5 to 10 µm and tuberculosis bacillus in the range of 1 to 5 µm. Filters having a Minimum Efficiency Reporting Value (MERV) 8 rating are effective in removing particles with sizes lower than 2.5 µm. Filters with MERV 11 rating and higher are more effective in removing particles smaller than 2.5 µm. In addition to these, High Efficiency Particulate Air (HEPA) filters and Electrostatic Precipitators (ESPs) may also be used to filter particulate contaminants in buildings.

Chemical and Biological Contaminants and Filtration

Chemical pollutants results in several adverse health effect such as respiratory illness, lung irritation and asthma. Ozone, which is a powerful oxidant, can damage books and documents, which can be a concern where these are valuable. Pollutants such as SO_2 with concentrations above 6 ppm can produce mucous membrane irritation. Clinical studies show that even brief exposure of SO_2 – as low as 0.4 ppm – can cause broncho-constriction in asthmatic persons.

Broadly, gas-phase contaminant control can be classified into two categories: pollutant capture and pollutant destruction. Gas-phase air filters such as activated carbon are used widely to capture and remove various pollutants such as ozone, NO_2 and SO_2 from air. Air cleaners using UV light, photo-catalytic oxidation and ozone generators destroy pollutants in the air. However, there is no commercially available air cleaner for CO. Proper location of outdoor air intakes and scheduling of activities and ventilation system are strategies that can reduce the impact of CO on the building occupants.

Indoor Thermal Comfort

Controlling the temperature and humidity of indoor air is important for achieving comfort conditions in a building environment. High indoor humidity can lead to condensation and mold growth, which degrade the building materials as well as affect occupant health. Low humidity is also undesirable as this can lead to drying out of the mucus membrane. In places with high ambient humidity, careful attention needs to be given to designing the HVAC system. The room load and outside air load on the system have different ratios of moisture content and therefore require different cooling set points to achieve the desired comfort temperature and humidity of the supply air.

Air conditioning system loads can be classified broadly as sensible and latent heat loads. These loads can be further classified by their origin. For example, sensible heat load for an AHU serving a commercial office space will be primarily due to the building envelope, people, equipment and lighting. In addition to this, the minimum fresh air also adds to the sensible load component. The latent heat load in this case will be primarily due to the fresh air intake and latent heat load due to people.

An Air Handling Unit (AHU) with only a cooling coil can control a single variable at a time. In traditional AHUs, this coil is controlled to maintain either the return air temperature or a fixed supply air temperature with variable air flow rate to match the load. Controlling additional parameters such as Air Changes per Hour (ACH) and humidity will introduce additional components such as constant volume boxes and electrical heaters, which will cause the system to operate inefficiently.

Sensible Heat Ratio (SHR) is the ratio of the sensible heat load to the total heat load of a system. Room SHR is typically in the range of 0.8 to 0.9. Average outside air SHR is typically in the range of 0.5 to 0.6. Supply air temperature required to achieve the zone comfort level is different for the return air and the outside air. This mismatch in the sensible and latent heat load is the primary reason due to which single equipment such as an AHU cannot maintain the zone design temperature and humidity in an energy efficient manner.

Minimum Fresh Air Standards

Industry standards for fresh air intake are governed either by CO_2 levels in the zone or a positive pressure in critical and hazardous operations. *ASHRAE Standard 62.1* is the most widely used standard for minimum ventilation requirements in non-residential facilities. The standard specifies minimum fresh air and ventilation requirements for various facilities. Table 6-1 from *Standard 62.1* gives the minimum ventilation requirements for different environments (see *Table 1*).

Table 1: Minimum fresh air requirement for various spaces as per ASHRAE 62.1-2007

Occupancy category	People outdoor air rate	Area outdoor air rate	Default values	
			Occupant density	Combined outdoor air rate
	cfm/ person	cfm/ft²	per 1000 ft²	cfm/person
Office space	5	0.06	5	17
Reception	5	0.06	30	7
Main lobby	5	0.06	10	11
Warehouse	-	0.06	-	-
Restaurant/ cafe	7.5	0.18	100	9
Hotel room	5	0.06	10	11
Pharmacy (prep)	5	0.18	10	23

This above table provides the minimum fresh air that needs to be introduced into the space. This air quantity cannot be reduced due to various IAQ concerns as discussed earlier. In places where fresh air is not taken through an AHU, untreated fresh air infiltrates into the space through openings and cracks. This untreated fresh air increases the zone air humidity, thereby affecting indoor air quality. Owing to the high outdoor air humidity rates in India, the fresh air load forms a significant portion of the total cooling load.

Traditional system design has relied on using a single AHU to control the zone humidity, temperature, IAQ and pressure. Trying to control all these parameters with single equipment makes the equipment run in an inefficient manner. A Dedicated Outdoor Air System (DOAS) aids in taking care of humidity and pressurization requirements. This segregation of control enables

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accurate control of all parameters at all times in the most energy efficient manner.

IAQ Control Using Dedicated Outdoor Air System

Dedicated Outdoor Air Systems have been around for quite some time; however they have not been used widely. A DOAS typically consists of a fan blower, an air filtration unit and a cooling coil (DX or chilled water). DOAS controls the supply dew point temperature to ensure accurate humidity control. This treated fresh air can either be supplied to the zone directly or to the recirculation AHU.

The conditioned fresh air provided by a DOAS to the space has much lower water content than the room air. When this dry air is mixed with the room air, the resulting air mixture will have a humidity level much lower than the room air humidity. This leaves the AHU to take care of the sensible load alone. In systems using terminal devices such as Fan Coil Units (FCUs) and Variable Refrigerant Flow (VRF) units, condensation is also eliminated, doing away with the need to provide condensate drain lines for these units. Reduced condensation and moisture in the zone and the local HVAC component reduces areas and potential for microbial growth.

A DOAS can also be used to provide Demand Controlled Ventilation (DCV) based on room CO_2 levels. Due to the flow modulation capabilities of the DOAS system, the overall energy consumed by the air conditioning system is reduced as less fresh air needs to be treated during partial occupancy hours. A DOAS also reduces or eliminates the reheat requirements in the system by conditioning only part of its total air flow rate. This improves the overall energy efficiency of the cooling system with less over-cooling required to maintain the zone humidity requirements.

Conclusion

The large variety of pollutants in the environment and the enhanced awareness of their harmful impact on human health, along with the increasing focus on energy efficiency, have led to the introduction and acceptance of a number of solutions that complement the traditional filters. Each of these solutions has its own advantages and limitations in different areas of application. ❖