Research on:

VENTILATION AND INFILTRATION

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Abstract:
this research is about, providing a comfortable and healthy indoor environment for building occupants is the primary concern of HVAC engineers.

Introduction:

Comfort and indoor air quality (IAQ)depend on many factors, including thermal regulation; control of internal and external sources of pollutants; supply of acceptable air; removal of unacceptable air, occupant activities and preference: proper construction, operation, and maintenance of building system. Proper ventilation and infiltration are only part of achieving acceptable indoor air quality and thermal comfort.

HVAC designers, occupants, and building owners must be aware of and address other factors as well.

Changing ventilation and infiltration rates to solve thermal comfort problems and reduce energy consumption can affect indoor air quality and may be against building code or other regulations, so any changes should be approached with care and be under the direction of a registered professional engineer with expertise in HVAC analysis and design.

Ventilation: is intentional introduction of air from the outdoor into a building; it is further subdivided into natural and mechanical ventilation.

Natural Ventilation: is the flow of air through open windows, doors, grilles, and other planned building envelope penetrations.

Mechanical (or forced) ventilation, show in figure (1), is the intentional movement of air into and out of building using fans, ductwork, intake louvers, and exhaust grills, for example.

Infiltration: is the flow of outdoor air into a building through cracks and other unintentional openings and through the normal use of exterior doors for entrance and egress. Infiltration also known as (air leakage) into a building.

Exfiltration, depicted in (fig. 1) is leakage of indoor air out of a building through similar types of openings. Like natural ventilation, infiltration and exfiltration are driven by natural and /or artificial pressure differences.

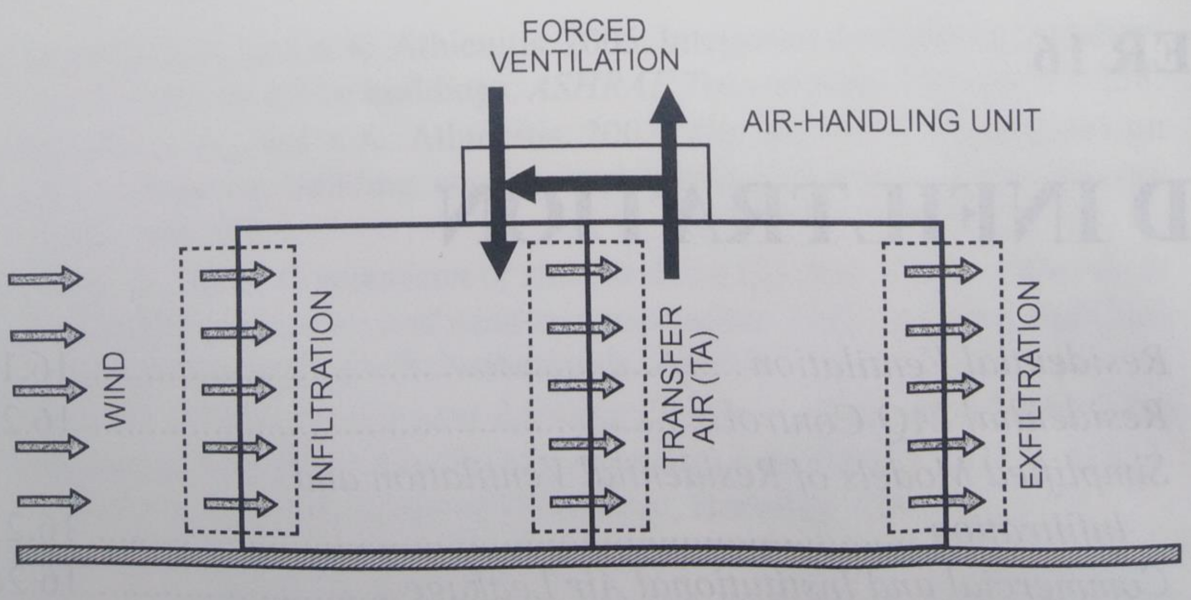

Fig. 1 Two-Space Building with Mechanical Ventilation, Infiltration, and Exfiltration

Air Change Rate:

The air change (or exchange) rate (I) compares air flow to the spaces volume and is; $I=Q/V$

Where Q=volumetric flow rate of air into space (m3/s)

V=interior volume of space (m3)

Also, the number of exchange air in the space volume is;

Q= (Qco / (C1-C0))

Where Qco=average gas leaks inside the room (g/h)

C1=allowed gas limit inside the room (g/l)

C0=allowed gas limit outside the room (g/l)

For example; in meeting room with dimension (4x6x4) m is occupied with (20) persons. each give (23 l/h) of CO_2 gas, if permissible concentration of CO_2 gas is (one L/m3) and concentration of CO_2 gas in outside air is (0.3 L/m3)?

Q=((20x23) / (1-0.3)) = 657.1 m3/h (average ventilation).

Q= (657.1 x 24) = 15770.4 m3/day (ventilation air)

I = 15770.4 / 96 = 164. (change number per day)

The air change rate has units of (1/times) , usually 1/h .When the time unit is (hours)the air change rate is also called (air change per hour ACH) with unit of (1/h) ,Time constants (T) which have units of time (usually in hours or seconds) ,are also used to describe ventilation and infiltration . One time constant is the time required for one air change in a building, zone, or space if ideal displacement flow existed. It is the inverse of the air change rete:

T = 1/I = V/Q

Age of Air: is the length of time (t) that some quantity of outdoor air has been in a building, zone, or space. The youngest air is at the point where outdoor air enters the building by mechanical or natural ventilation, or through infiltration. The oldest air may be at some location in the building or in the exhaust air. When the characteristics of the air distribution system are varied, age of air is inversely correlated with quality of outdoor air delivery. Units are of time, usually in seconds or minutes, so it is not a true efficiency or effectiveness measure.

The age of air concept, however, has gained wide acceptance in Europe.

Necessary amount of ventilation air per person:

At the rest time any person needs between (0.1 – 0.2 liter/s) fresh air, and from this amount just (5%) used in lungs like (O_2).

The out air from lungs contained between (3-4%) of (CO_2) which be around (0.004 liter/s), The suitable level of (CO_2) in any space should be around (5000 ppm) or (0.5%) of total volume in (8 hours).

Table (1) show that the average ventilation for different values in maximum value for different levels of action.

Table (1) average required ventilation to limited CO_2

	Min. necessary ventilation (liter/s) for person		
Action	0.1 % of CO_2	0.25% of CO_2	0.5% of CO_2
At the rest	5.7	1.8	0.85
At simple work	8.6-18.5	2.7-5.9	1.3-2.8
At average work	-	5.9-9.1	2.8-4.2
At hard work	-	9.1-11.8	4.2-5.5
At very hard work	-	11.8-14.5	5.5-6.8

Environmental freshness:

When breathing quietly, human inspire only about (0.16 to 0.20 liters) of air per second. The amount of fresh air needed to sustain life is thus very small indeed, being of the order of (0.2 liters /second per person).

It is highly desirable to keep the amount of fresh air handled by a conditioning plant to a minimum, for economic reasons.

But this minimum is not dictated by the amount of air required for breathing purposes.

Two criteria show the need for larger air quantities sufficient fresh air should be supplied to dilute the carbon dioxide content in the room to below (0.1 %) and to dilute the accumulation of body odors and other smells in the room to a socially acceptable level.

It is generally considered that as little as (5 liters / second per person), is required in spaces such as banking halls and churches, where is no smoking.

On the other hand, as much as (25 liters /second per person) may be needed in areas such as board rooms where a high density of occupation may prevail and where heavy smoking may be likely.

For offices, about (5 to 8 liters / second per person) is desirable, depending on the usage and the degree of smoking.

Also, the use of (liters/second per $m^2$of floor) area is satisfactory for offices where the typical densities of occupation are well established, varying from (6 m^2/person to 12 m^2/person), with (10 m^2 /person) as an average.

(Table 2) Following values for fresh air supply rates are satisfactory:

Application	Liters /second per person	Liters/second per m2
Private dwellings	8-12	-
Board rooms	18-25	-
Cocktail bars	12-18	-
Department stores	5-8	-
Factories	-	0.8
Garages	-	8.0
Operating theaters	-	16
Hospital wards	8-12	-
General offices	5-8	1.3 to 2
Private offices	8-12	1.3 to 2
Restaurants	12-18	-
theaters	5-8	-

Lavatories, especially those without external openable windows, are a special case (as often are some others of those mentioned above).
The recommendation is that they be provided with extract ventilation by mechanical means to give (15 air changes an hour), or (80 liters / second) lavatory pan, or (16 liters / second per m2), whichever is the greater.
The supply of fresh air may also be necessary, or even mandatory, by mechanical means.

Unwanted Heat:

Sensible heat for seating worker be around (0.1 kw) (Table 3) .If assume that average air change is (16 liters/second),then this sensible heat affect to increase heat inside the room by:
(0.1x1000)/ (16x1.205x1.205x1.012) =5.1k
In case the heat lost in the room zero.

Table (3)

Action	Sensible heat (w) for people		
	Sensible heat	Latent heat	Total
Seating worker	100	70	140

Average air changes:

In variable unknown, building, zone, or space for ventilation should depend on the random base, can use (table 4) like guide; but volume of zone with long of necessary time can affect to the average of supply amount air.

For example, consideration air for hall became very much like a storage of air. Using to reduce supply amount in short time for space.

(Table 4) ventilation depend on average change air

Type of space	Changing time	Clearance ventilation W/m3/k.
Meeting room	3-6	1.0-2.0
Bed room	1-2	0.33-0.66
Machine room-boiler room	10-15	3.33-5.0
Class room	3-4	1.0-1.33
Corridors	2-3	0.67-1.0
entrance hall	3-4	1.0-1.33
Factory. Open type	1-4	0.33-1.33
Factory. With very crowded room	6-8	2.0-2.67
Casting factory with gas exist unit	8-10	2.67-3.33
Casting factory without gas exist unit	10-20	3.33-6.67
Operating room in hospital	20	6.67
Treatment room in hospital	10	3.33
Ground kitchen	20-30	6.67-10.0
Underground kitchen	40-80	13.33-26.67
Bakery	10-15	3.33-5.0
Clothes washing and coloring hall	10-20	3.33-6.67
Library	3-4	1.0-1.33
Living room	1-2	0.33-0.67
Ground offices	2-6	0.67-2.0
Underground offices	10-20	3.33-6.67
Restaurant and bars	10-15	3.33-5.0
Rolling factory	8-10	2.67-3.33
Storage	1-2	0.33-0.67
Workshop with unhealthy smoking	20-30	6.67-10.0

Classification according to efficiency:

In a board way it is possible to distinguish between filters according to the efficiencies they show on the methylene-blue basis, special types of filters being excluded.

On this basis we can say the following:

Automatic roll	10-20%
Viscous	5-15%
Dry fabric (cotton-wool pads obliquely arranged)	25%
Dry fabric (cotton-wool wadding in V-arrangement)	35%
Dry fabric (cotton-wool wadding plus fine glass wool)	75%
Electrical	50-90%
Brush type	10-20%
Absolute	65-99.9%
Cleanable cells	10%

Efficiencies are related to the velocity of airflow through the filtering medium, and the manufacturers recommendation should not be exceeded.

It is often possible, particularly in absolute filters, to improve efficiency by using a larger filter having a reduced velocity of airflow.

Pressure drops are also related to efficiencies, expect in electrical filters which achieve a high efficiency without the need for a large pressure drop.

Viscous filters

Essentially, these filters have a large dust-holding capacity but a low efficiency, and this defines their sphere of application; for example, they are more suitable for use in industrial areas where a high degree of atmospheric pollution prevails. Their drawback in usually expense, particularly in automatic versions.

The principle of the viscous filter is that if the mixture of dust and air is forced to follow a tortuous path in negotiating a passage through the filtering medium, inertial separating of the more massive dust from the lighter air will occur. (fig. 2) illustrates the cell and automatic types.

Dry filters:

Cotton-wool, glass-fiber fabric, asbestos-woven fabric, pleated paper of various types, foamed polyurethane, cellular polythene and other materials are used for the construction of dry filters.

As with viscous filters, there are cell-type and automatic roll-type filters available.
The construction of these, in board outline, is very similar to that of viscous filters. No oil is used, of course, and the way in which efficiency is improved is by increasing the surface area of the fabric offered to the airstream for filtration purposes. In cell-type this is achieved by using pads of material placed obliquely across the airstream (fig. 3). An alternative to this, which can be made to yield very high efficiencies, is to use a system pf pleating.
This is best achieved with paper as a material, although asbestos is also used and gives high efficiencies (fig. 4) shows an arrangement of pleating.
When a very large amount of material is used in a filter, the efficiency becomes very high and the filter is turned an “absolute “filter. No filter is truly absolute but almost any desired efficiency could be achieved if sufficient filtering fabric were used; this would be associated with a high pressure drop, but one way of achieving a high efficiency without the penalty of wasted energy is to use a very large filter, that is, one with a very low face velocity. Naturally, the capital cost is increased.
Automatic dry-fabric filter consists of an upper roll of clean fabric wound downwards across the airstream. The dirtied material is then re-wound into a roll at the bottom of the unit. (fig. 5) shows this arrangement.

Electric filters:

An electric filter is illustrated in (fig. 6) The principle of operation is that when air is passed between a pair of oppositely charged conductors it becomes ionized if the voltage difference between the conductors is sufficiently large. Both negative ions and positive ions are formed, the latter being in the larger quantity. By contact with the dust particles mixed with the airstream, the charge of the ions is shared with the dust. In this way, about (80%) of the dust particles passing through the ionizing field are given a positive charge and the other (20%) a negative charge. The ionizing voltage used varies somewhat, and to achieve a given efficiency of ionization smaller air velocities can be used with smaller voltage. However, typical ionizing voltages are from (7800 to 13000).

Wet filters:

Washers and scrubbers of various sorts are used extensively throughout industry, largely for the absorption of soluble gases. They are not very commonly used for cleansing the air of solid dust particles. The effectiveness of a washer in removing a dust depends on the “wettability” of the dust by water. This is a function of the surface tension of the water when it is in contact with the solid involved. Different forces of surface tension are the rule for different materials.

Centrifugal collectors:

If air is made to travel in a circular path, centrifugal force acts both on the molecules of the air and on the associated dust particles. The dust particles being the heavier, the force on them is the greater and so they are forced to the outer boundary of the curved airstream.

This is the principle of the cyclone, illustrated in (fig. 7). This method of dust removal is not in use in air-conditioning systems. Its application is confined to industrial exhaust installations where the dust mixed with the airstream is relatively massive, such as wood shavings and sawdust.

Adsorption filters:

The process of absorption, which is chemical process, is to be distinguished from that of adsorption, which is purely physical process.

Just as there is an attraction between a liquid and a solid at a surface, so there is also an attraction between a gas and a solid at a surface.

An explanation of the mechanism of this cohesive force is beyond the scope of this text but the consequences of it are briefly discussed in the following.

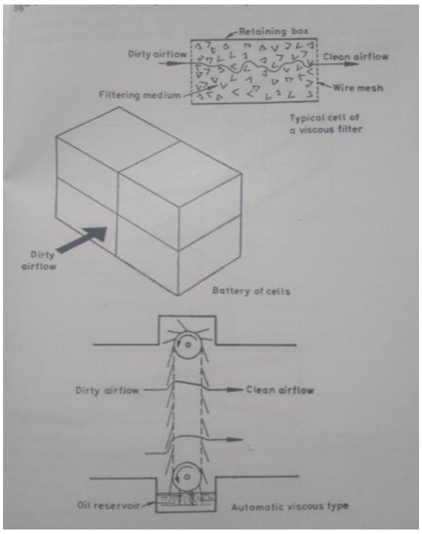

Fig. 2 Viscous filters

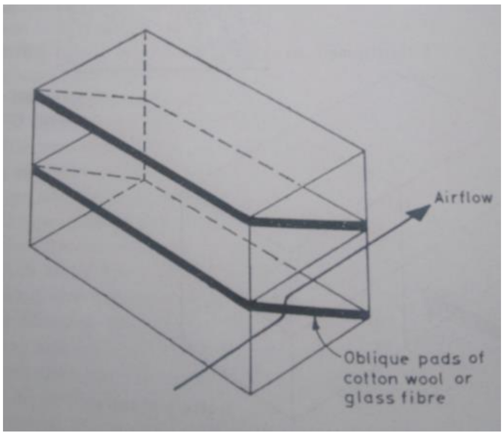

fig. 3 Dry filters:

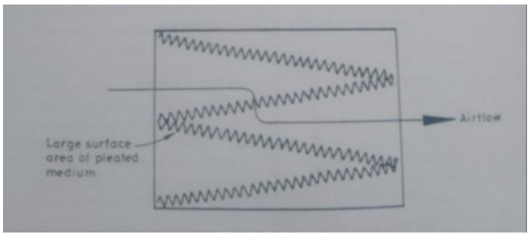

fig. 4 Dry filters:

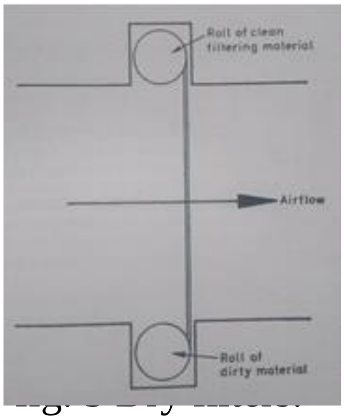

fig. 5 Dry filters:

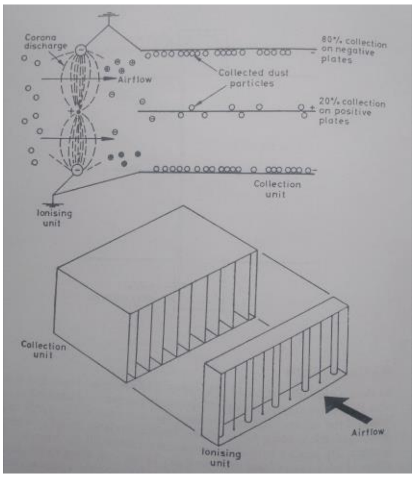

fig. 6 Electric filters

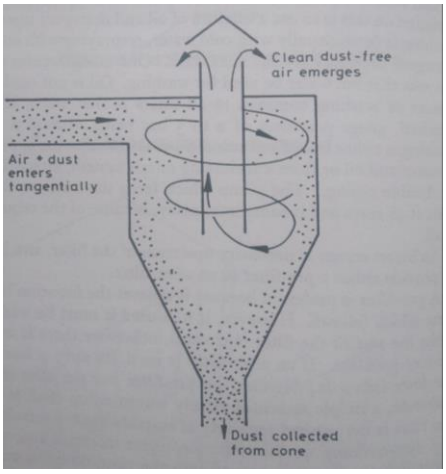

fig. 7 Centrifugal collectors

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