BUILDING DIGEST 136

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

DESIGN GUIDELINES FOR GENERAL VENTILATION IN INDUSTRIAL BUILDINGS

Requirements of ventilation in industrial buildings are two fold (1) to remove the contaminants and excess heat liberated during the industrial processes, and (2) to induce air motion for thermal comfort indoors. Inadequate ventilation results in unhealthy and uncomfortable conditions, and adversely affects productivity of industrial workers. Therefore, ventilation requirements should receive desired attention at the design stage itself as subsequent corrective measures prove too expensive.

Ventilation can be divided into two categories, viz. local and general. The local ventilation seeks the specific purpose of trapping the impurities at the source, for exhaust to the outside and thus of preventing their dispersion into the bulk of the indoor air. General ventilation merely consists of exchange of indoor air with outdoor air in a general way. Local ventilation may sometimes be induced with a local air-jet. Whereas general ventilation is an essential requirement of building environment. Local ventilation merely helps of economise on general ventilation requirements. It is carried out either by natural wind and thermal forces or by some mechanical device. The ventilation design should always aim at (i) making the best use of natural forces, (ii) minimising power consumption and (iii) obviating power wastage due to inappropriate operation of ventilating appliances.

The following guidelines have been evolved on the basis of fundamental principles, laboratory investigations and field studies for the design of efficient ventilation systems in factory buildings :

(1) A factory building should have provision for both types of ventilation viz. (i) natural and (ii) mechanical. In other words buildings mainly employing mechanical ventilation (unless of course the industrial process warrants conditioning of supply air) should also have provision for natural ventilation to cope with the exigencies of power shortage or failure. On the other hand, buildings relying mainly on natural ventilation should also be equipped with appropriate types of mechanical gadgets to induce adequate ventilation even under calm outdoor conditions. Total reliance only on one system may result in unsatisfactory conditions indoors.

(2) At an early design stage a decision should be taken whether the main purpose of ventilation is to induce air motion for thermal comfort or to remove the contaminants and the heat liberated during industrial processes. The design should accordingly meet the specific requirements as stated below :

(A) Design for air motion and thermal comfort

(i) To achieve adequate natural air motion indoors, windows should be provided on the walls facing the prevailing wind direction as also on the opposite or adjacent walls.

(ii) The height of window sill should be about 1.1 metres.

(iii) Window height should be about 1.6 metres and width about 2/3rd of wall width. Openings exceeding these dimensions do not contribute significantly to air motion in the working zone indoors.

(iv) Openings around 0.9 metre high should be provided over 2/3rd length of the glazed area in the roof lights.

(v) Building height, although determined by the requirements of industrial processes involved, is generally kept large enough to protect the workers against hot stagnant air below the ceiling as also to dilute the concentration of contaminant inside. However, if high level openings in roof or walls are provided, building height can be reduced to 4 metres without in any way impairing the ventilation performance.

(vi) Ceiling fans with 1500 mm sweep should be provided one each for every 6×6 m² of working area in factories. Ceiling fans are a definite advantage in factories having forced-draft evaporative cooling system.

(vii) The height of the air supply grilles should be about 2.0 metres above the floor level.

(viii) For ease of operation during the running of the forced draft evaporative cooling plant, the controls should be located outside the blast of the blower.

(B) Design for removal of contaminants and heat

(i) Rate of production of contaminants or heat, as the case be, should be determined by actual in situ measurement.

(ii) The maximum allowable concentration (M.A.C.) of the contaminants can be determined from Table 1.

(iii) The required area of ventilation openings for the control of contamiant concentration is determined from nomograph shown in Fig. 1. To use the nomograph the points corresponding to the relevant M.A.C. and the prevailing wind speed at the factory site are joined by a straight line. The intersection of this line with the line representing opening area, gives the required area of opening for a unit rate of contaminant emission. This area multiplied by the rate of contaminant production (M^3/h) yields the required inlet opening area on the windfacing wall, an opening of equal area should also be provided in the roof lights.

(iv) The maximum allowable temperature rise above the outdoor temperature can be read from Table 2.

Table 1
Maximum Allowable Concentration

Sl. No.	Substance	Permissible concentration (ppm) (parts permillion parts of air)
1.	Acetaldehyde	200
2.	Acetone	1000
3.	Ammonia	100
4.	Benzene	35
5.	1,3—Butadiene	1000
6.	n—Butanol	100
7.	2—Butanone	250
8.	Chloroform	100
9.	Carbon monoxide	100
10.	Carbon dioxide	5000
11.	Chlorine	1
12.	Cyclohexene	400
13.	Ethyl accetate	400
14.	Ethyl alcohol	1000
15.	Ethyl amine	25
16.	Ethyl Benzene	200
17.	Ethyl Bromide	200
18.	Ethyl Chloride	1000
19.	Ethyl ether	400
20.	Ethyl Formate	100
21.	Hydrogen Sulphide	20
22.	Hexane	500
23.	Isopropyl Alcohol	400
24.	Isopropyl ether	500
25.	Methyl Alcohol	200
26.	Methyl Chloride	100
27.	Methyl Chloroform	500
28.	Nitrogen di oxide	5
29.	Octane	500
30.	Pentane	1000
31.	Propyl Acetate	200
32.	Sulphur Dioxide	10
33.	Toluene	200
34.	Trichloro ethylen	200
35.	Xylene	200

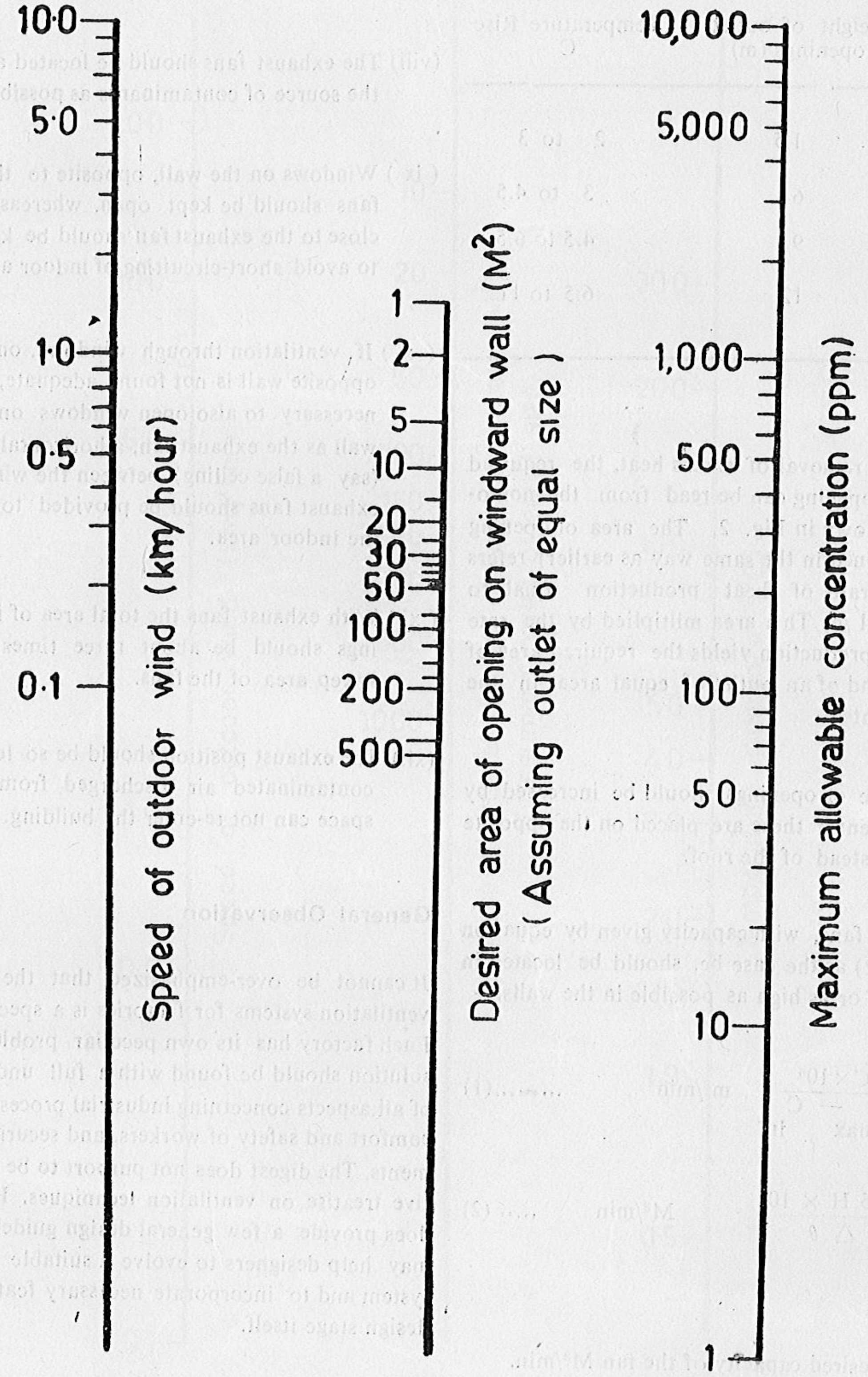

Fig. 1. Nomograph for determination of area of ventilation openings for rate of contamination liberation 1 Metre^3/hour

Table 2

Allowable Temperature Rise Values

Sl. No.	Height of outlet openings (m)	Temperature Rise °C
1	1.5	2 to 3
2	6	3 to 4.5
3	9	4.5 to 6.5
4	12	6.5 to 11

(v) For the removal of excess heat, the required area of opening can be read from the nomograph shown in Fig. 2. The area of opening (determined in the same way as earlier) refers to the rate of heat production equal to 10^6 KCal /h. This area miltiplied by the rate of heat production yields the required area of inlet and of an outlet of equal area in the roof lights.

(vi) The size of openings should be increased by 10 per cent if these are placed on the opposite walls instead of the roof.

(vii) Exhaust fans, with capacity given by equation (1) or (2) as the case be, should be located in the roof or as high as possible in the walls:—

$$Q = \frac{C \times 10^6}{C_{max} - C_{in}} \text{ m}^3/\text{min} \quad \ldots\ldots(1)$$

$$Q = \frac{3.5\ H \times 10^6}{\Delta\ \theta} \text{ M}^3/\text{min} \quad \ldots\ldots(2)$$

Where

Q = Desired capacity of the fan M^3/min.

C = Rate of contaminant produced M^3/min.

C_{max} = MAC of contaminant in ppm

C_{in} = Concentration of contaminant in the incoming outdoor air ppm.

H = Rate of heat liberation, K Cal/min.

$\Delta\theta$ = Difference in the temperatures of outgoing and incoming air (°C).

(viii) The exhaust fans should be located as close to the source of contaminants as possible.

(ix) Windows on the wall, opposite to the exhaust fans should be kept open, whereas windows close to the exhaust fan should be kept closed to avoid short-circuiting of indoor air.

(x) If ventilation through windows, only on the opposite wall is not found adequate, and it is necessary to also open windows on the same wall as the exhaust fan, a horizontal partition (say a false ceiling) between the windows and exhaust fans should be provided to cover half the indoor area.

(xi) With exhaust fans the total area of inlet openings should be about three times the total sweep area of the fans.

(xii) The exhaust position should be so located that contaminated air discharged from the work space can not re-enter the building.

General Observation

It cannot be over-emphasized that the design of ventilation systems for factories is a specialised job. Each factory has its own peculiar problems and a solution should be found with a full understanding of all aspects concerning industrial processes, health, comfort and safety of workers, and security requirements. The digest does not purport to be an exhaustive treatise on ventilation techniques. However, it does provide a few general design guidelines which may help designers to evolve a suitable ventilation system and to incorporate necessary features at the design stage itself.

Illustrated Example

It is required to find out the area of ventilation openings for a 6 metre high factory building. The rate of heat production is 1.5×10^6K. Cal/h and the

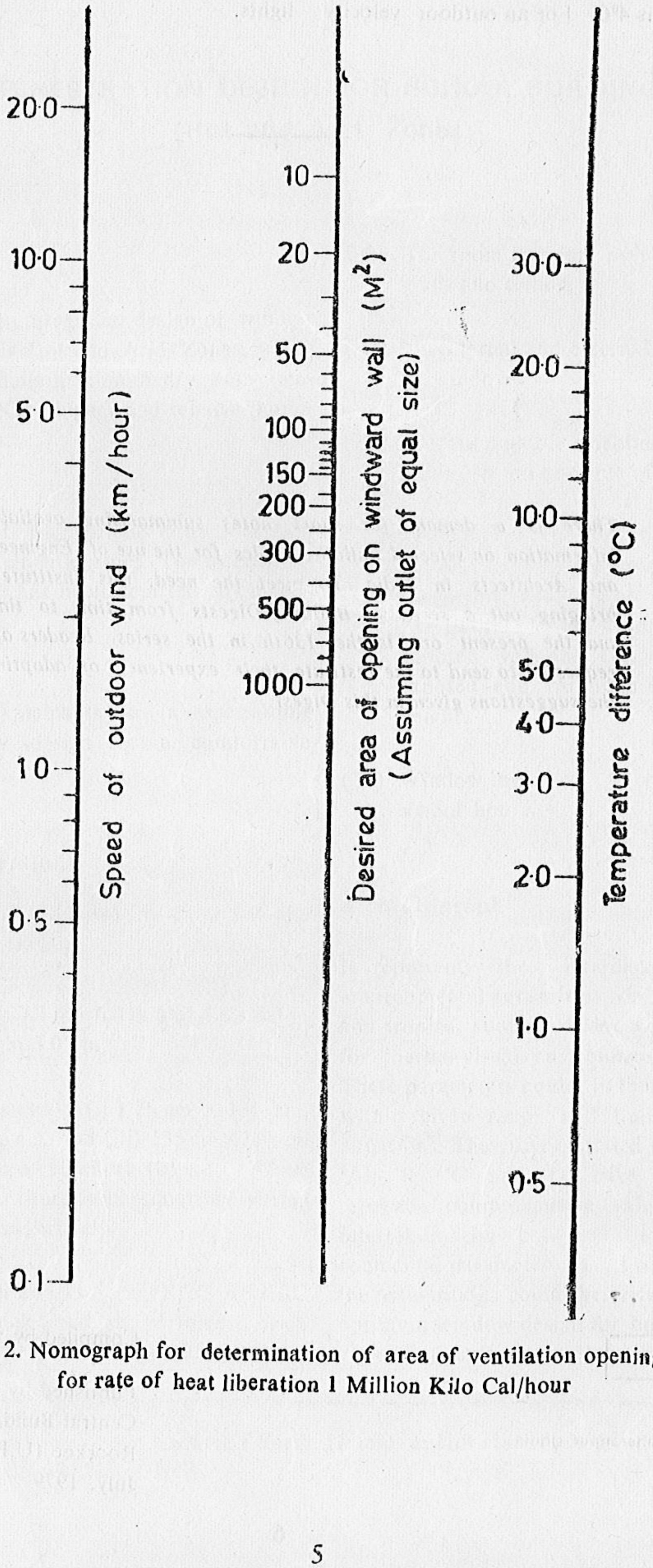

Fig. 2. Nomograph for determination of area of ventilation openings for rate of heat liberation 1 Million Kilo Cal/hour

prevailing outdoor wind speed at the site of the factory is 15 km/h.

Solution

The allowable temperature rise for 6 m height, as seen from Table 2 is 4°C. For an outdoor velocity of 15 km/h. the inlet opening as read from the nomograph (Fig. 2) is about 120 m². Therefore, an opening of 120×1.5 i.e. 180 m² should be provided on the winward wall. An opening of equal area should also be provided in the roof lights.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 136th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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