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VENTILATION OF BUILDINGS FOR HUMAN OCCUPANCY

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VENTILATION OF BUILDINGS FOR HUMAN OCCUPANCY

October 1984

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VENTILATION OF BUILDINGS FOR HUMAN OCCUPANCY

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VENTILATION OF BUILDINGS FOR HUMAN OCCUPANCY

1.0 INTRODUCTION

1.1 Purpose

This publication is a technical support document to DRM 10-7/51, Building Design. It is intended for use primarily by building services design engineers and technologists, field engineering and service staff, and consultants in establishing ventilation requirements for departmental buildings.

1.2 Scope

This guideline describes current design theory for ventilating systems for departmental buildings. There is particular emphasis on:

a. ventilation air quantities for human and process occupancies;

b. odour control and decontamination of room air; and

c. energy savings related to ventilation air requirements.

1.3 Definitions

The reader should use the following definitions in applying this guideline:

Ventilation: the simultaneous process of supplying outside air to, and removing used air from a space (by mechanical or natural means) to maintain an acceptable air quality level for the specific occupancy use.

Ventilation Air: that portion of supply air which comes from outside (outdoors) plus any recirculation air that has been treated to maintain the desired air quality within the designated space.

2.0 BUILDING VENTILATION REQUIREMENTS

2.1 General Remarks

Ventilation for air quality control is required in all closed buildings and structures.

The quality and quantity of ventilation air depends on whether the requirement is for:

a. human occupancy,

b. process occupancy, or

c. building structural stability and material preservation.

The various interrelated codes and standards governing the provision of ventilation for departmental buildings are given in Appendix A.

2.2 Requirements for Human Occupancy

Fresh outdoor air contains approximately 21% oxygen (O2) and 0.03% carbon dioxide (CO2) by volume, the remainder being mainly nitrogen. Significant variations in these proportions can render it unfit for human use.

For human occupancy of closed buildings, a minimum concentration of 16% O2 and a maximum concentration of 0.5% CO2 are commonly accepted standards for prolonged exposure.

Air requirements for humans vary according to activity. When seated, a person inhales approximately 540 L of air per hour. The exhaled air contains about 16% O2 and 4.0% CO2. Thus, if only 540 L of fresh air is provided, per hour per person in a closed space, the O2 and CO2 concentration eventually approaches these levels. Individuals would experience a temporary loss of vitality and ability. If, however, 10 times this amount of fresh air is provided (5 400 L/h or 1.5 L/s), the ultimate levels become 20.5% O2 and 0.4% CO2--well within the acceptable minimum standards.

O2 consumption and CO2 production increase with the human activity. For example, people standing require 2.25 L/s of fresh air. The minimum fresh outside air supply recommended for human occupancy in departmental buildings is 2.5 L/s per person. Actual requirements shall be established according to the codes and standards in Appendix A and/or as recommended herein.

The recommended air volumes for specific types of human occupancies in buildings are given in the ASHRAE Handbook of Fundamentals, and in the current "ASHRAE Standard #62".

The reader is cautioned that these requirements do not include ventilation for processes taking place in the building. Requirements for these operations and design methods for dual purpose occupancy (human and process) are given in 2.4 and 2.5.

2.3 Odours and Contaminants (Dilution and/or Removal)

The intensity of an odour is the attribute which is most reliably measured, and serves as the basis for emission standards for ambient odours.

The most common way to reduce odour intensity is by dilution, using ventilation air.

Ventilation air requirements for this purpose are built into the minimum recommended ventilation air rates for the various occupancies given in the current "ASHRAE Standard #62". Required ventilation for odour control does not increase as the room air space allowed per occupant decreases, and no additional ventilation allowances are necessary.

The ASHRAE Handbook of Fundamentals permits a reduction in ventilation rates when special recirculated air filtering and odour removal equipment is employed. For most departmental applications, this equipment, with its resultant higher capital, maintenance, and operating costs, is not normally required. If used on specific applications the minimum ventilation air rates should not be reduced.

For notes on removing odour and contaminants from process applications involving combustion, chemical, and other industrial processes, see "ASHRAE Standard No. 62". Before proceeding, however the designer should consult all federal, provincial, and local codes and standards governing these processes.

2.4 Requirements for Process Occupancy

"Process occupancy" refers to all activities requiring ventilation which are not dealt with in section 2.2 for human life support. Included are operations involving the release of products of combustion, vapourizing chemicals, gases, and solid particles.

Ventilation for these processes should, in most cases, be provided independently of requirements for human occupancy. Exceptions are buildings or areas where human occupancy is infrequent and of short duration (such as supervision in a water treatment or sewage plant), or where the process is continuous during all human occupancies. In such cases one system may suffice for both "process" and "human" occupancy if local regulations permit.

Self-contained processes (such as enclosed paint spray booths or rooms and some specialized machines and manufacturing equipment having directly connected ventilation supply and exhaust air), operate independently from the building environment. However, most commonly used processes take their supply air from the adjacent building environment. It is therefore important that the matching process ventilation air supply be introduced as close to the point of use as possible.

System design parameters for all process occupancy ventilation applications shall not be less than those detailed in the current ASHRAE "Systems" and "Application" handbooks. The manufacturer's design requirements are to be followed for the particular process concerned whenever they are available. Some specific applications are dealt with in TSD-51-28, Space Conditioning Systems for Special Building Types. Appendix B shows the various methods of providing ventilation systems for both human and process occupancies in departmental buildings.

2.5 Design Procedure for Ventilation Systems

The following example illustrates the design procedure, which will:

- ensure compliance with codes and regulations,
- provide the required ventilation for all human and process activities, and
- conserve energy under all normal building use occupancy conditions.

Example

A three-bedroom house designed for 6 occupants and having a living space net volume of 450 m3 is built to the tight building requirements of "the measures" (Appendix A). It is to be heated with a forced warm air oil-fired system having a fuel consumption rate (at winter design conditions) of 2 L of fuel oil per hour. All ventilation air is to be provided by mechanical means. What air quantities are required?

Solution

(a) Appendix 1 states that section 9.33.4 of the National Building Code requires that the ventilation system be capable of providing up to one air change per hour, resulting in an air flow rate of 125 L/s.

(b) System arrangement will be as per "Mode 3" Appendix B, with one process occupancy (the oil burner in the furnace). HOEA will be required as per note 3.

(c) Air requirements are as follows:

Human Occupancy

Supply Air - constant supply of 2.5 L/s/person for 6 people - (as per ASHRAE minimum standards) = 15 L/s

Exhaust Air - constant exhaust to match supply - (little or no exfiltration through building due to tight construction) = 15 L/s

- intermittent exhausts
  Kitchen 10 L/s
  Washroom 10 L/s
  (as per ASHRAE minimum standard) = 20 L/s

Process Occupancy

Supply Air to Oil Furnace

- Combustion supply air for 2 L of oil/h = 8 L/s

(d) The total ventilation air supply required under full load conditions for human and process occupancy is 43 L/s. This is less than one third of the capability requirements of the supply air system set by code regulations in (a) above.

From the above example, it can be seen that if the ventilation air supply for human occupancy in a tightly built residence is connected to the warm air heating system's return air plenum, the amount of air being supplied relates closely to the sum of the mechanical exhaust systems in use at any given time. The system is therefore self-regulating and very energy conservative. If the HOEA fan is provided with a multi-speed control and is increased in capacity, greater flexibility will be had during intermittent occupancy which exceeds design conditions. Similarly, during periods of less than design occupancy, reduced ventilation rates can be obtained by adjusting the HOEA fan speed resulting in energy savings. (See 2.8 for ventilation energy savings in larger buildings).

As in other process occupancies, the 8 L/s of combustion supply air must be introduced to the burner in a manner that will ensure immediate shutdown of the process if the air supply is interrupted in any way.

In the above example, the process ventilation air can be introduced with the human occupancy ventilation air or separately, as long as this operational safety criterion is met.

2.6 Ventilation for Moisture Control

Moisture produced by humans in a building where no process occupancy exists will in most cases be adequately handled by the human occupancy ventilation system designed according to the example in 2.5. Exceptions may include:

(a) new or renovated buildings with high initial material moisture content;

(b) buildings equipped with non-air-circulating heating systems; and

(c) buildings with inherent construction defects such as excessive exfiltration, inadequate insulation, etc., which may promote condensation within and on walls, roofs, floors and windows.

In these situations, short-term relief (to prevent further damage to the structure) may be had with a temporary process ventilation system. The long-term solution is, of course, to correct the defects that caused the problem.

For moisture-producing processes such as manufacturing, and commercial laundries and kitchens, a process ventilation system should be designed to suit the moisture removal requirements. For additional information, refer to TSD-51-31 Humidification in Buildings.

2.7 "Free Cooling" Using Ventilation Air

"Free Cooling" with outside ventilation air at ambient temperatures using the building's air handling equipment, which is designed for energy efficient ventilation, is usually impractical.

The small Δt in summer (temperature differential between outside air and building environment air) requires outside air volumes many times those necessary for human occupancy ventilation to achieve effective cooling of the human environment. During other seasons of the year where a large Δt exists, building heat gain exceeds building heat loss, and the regular human occupancy ventilation system may then be capable of meeting all or most of the environmental cooling requirements, using free cooling ventilation air. If use of "free cooling" is shown to be practical for a major portion of the summer cooling load, then a separate free cooling ventilation system could be designed for summer use only.

The departmental design requirements for ventilation in schools and special building types are detailed in DRM 10-7/54, School Design, and TSD-51-28, Space Conditioning Systems for Special Building Types.

2.8 Energy Conservation Controls and Advisory Systems

The outdoor intake air load needed for human occupancy uses from 20% to 40% of the total heating or cooling energy for a building. There will be maximum energy savings when the air is supplied in the required quantities for the building occupancy and use conditions at a given time, as stated in 2.2, 2.4 and 2.5. Responsive, trouble-free control systems are required to accurately control air flow rates. For small buildings with low outside air requirements, the control system can be simple. Large buildings with large volume outside air intake requirements might benefit from the use of a "variable volume type" outside air system. One such system employs modulating air dampers which respond to increased CO2 levels in the building's return air system.

A variety of control systems are available to suit the size and operating criteria of the project. The designer shall ensure that whichever system is used is cost effective in terms of energy savings.

Instructional material describing the operation(s) of the system(s) must be developed and detailed by the designer to suit the equipment being installed as well as the specific requirements of the building's occupants, who will be operating the system(s). Operational techniques, instructional brochures, warning signs etc., must be simple, clear and concise. Mounted signs should be of lamacoid plastic with large letters.

The implementation of tight building construction required by the Measures for Energy Conservation in New Buildings, (See Appendix A) makes it mandatory for life safety that all ventilation systems be provided with visual and audible warning devices to alert the building occupants to equipment failures.

Appendix A

DIRECTIVES AND CODES GOVERNING VENTILATION REQUIREMENTS AND SYSTEMS FOR DEPARTMENTAL BUILDINGS

1. DEPARTMENTAL GUIDELINE DRM 10-7/5 ENERGY CONSERVATION

2. "THE MEASURES" (ALSO KNOWN AS "MEASURES FOR ENERGY CONSERVATION IN NEW BUILDINGS" ISSUED BY THE ASSOCIATE COMMITTEE ON THE NATIONAL RESEARCH COUNCIL OF CANADA OTTAWA.)

3. FOR RESIDENTIAL OCCUPANCY - NATURAL VENTILATION MEANS NON-MECHANICAL NBC SECTION 9.33 SUBSECTION 9.33.3

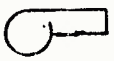
4. FOR RESIDENTIAL OCCUPANCY - MECHANICAL VENTILATION MEANS MOTORIZED FANS NBC SECTION 9.33, SUBSECTION 9.33.4 FOR SYSTEM FAN CAPACITIES UP TO 1890 L/s - VENTILATION SYSTEM MUST BE CAPABLE OF PROVIDING UP TO ONE AIR CHANGE/h

5. FOR OTHER THAN RESIDENTIAL OCCUPANCY - MECHANICAL VENTILATION MEANS (MOTORIZED FANS) NBC SECTION 9.33, SUBSECTIONS 9.33.1.3 AND 9.33.1.4 - GOOD ENGINEERING PRACTICE SHALL BE APPLIED IN THE DESIGN SUCH AS THE PROCEDURES OF THE ASHRAE GUIDE, DATA AND HANDBOOKS

Appendix B

SYSTEMS ARRANGEMENTS FOR VENTILATION OF DEPARTMENTAL BUILDINGS

LEGEND

 = Mechanical vent fan

HOSA = Human occupancy with outside supply air (conditioned as required)

POSA = Process air with outside supply air (conditioned as required)

HOEA = Human occupany with air exhausted to outside

POEA = Process air with air exhausted to outside

KEA = Kitchen(s) with air exhausted to outside

WEA = Washroom(s) with aire exhausted to outside

L/s = Litres of air per second

NOTES

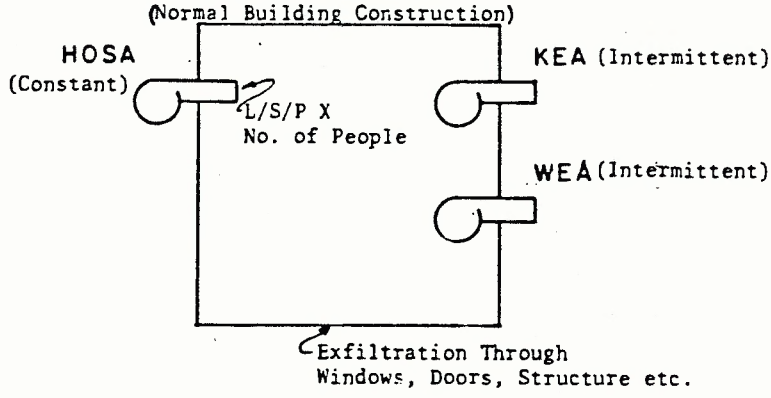
1. Do not recirculate air from individual process rooms or areas to central or zone air circulating systems. All supply air must be exhausted to outdoors.

2. For tight building construction as per "the measures", provide constant human occupancy exhaust air as shown in Mode 2.

3. Each process ventilation application installed in a human occupancy environment shall have its own separate supply and exhaust system coupled for operation together, whether in the constant or intermittent operating mode.

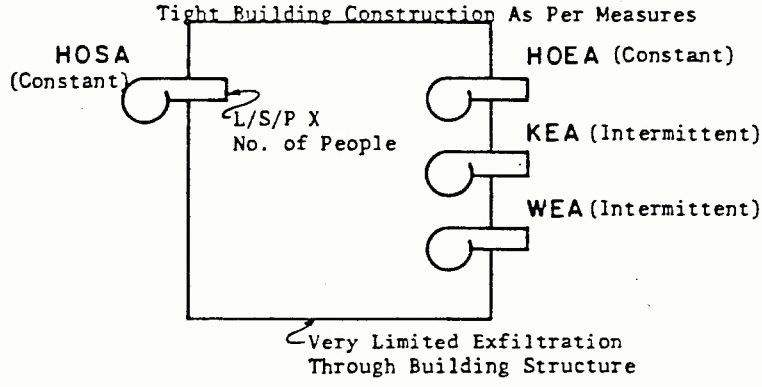
MODE 1

HUMAN OCCUPANCY ONLY
RESIDENTIAL APPLICATION
(Normal Building Construction)



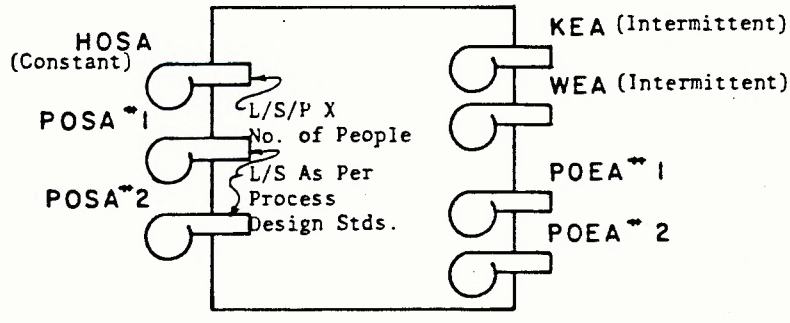
MODE 2

HUMAN OCCUPANCY ONLY
RESIDENTIAL APPLICATION
Tight Building Construction As Per Measures



MODE 3

HUMAN OCCUPANCY
RESIDENTIAL + ONE OR MORE PROCESS



SEE NOTES 1, 2 & 3