ALASKA CRAFTSMAN HOME PROGRAM

ALASKA
CRAFTSMAN
HOME

Design and Installation Manual for Residential Mechanical Ventilation Systems

Heating Refrigerating and Air Conditioning Institute of Canada

R2000

The Design and Installation Manual for Residential Mechanical Ventilation Systems is published by the Heating, Refrigerating and Air Conditioning Institute of Canada (HRAI). The manual was prepared with a contribution from the Energy Efficiency and Diversity Initiative of Energy, Mines and Resources Canada (EMR).

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INTRODUCTION

1.0 INTRODUCTION AND COURSE OBJECTIVES

Construction details used to reduce energy consumption and moisture damage to the building structure in modern houses greatly reduce natural air leakage. Without mechanical ventilation, normal activities such as laundry, cooking and showers can cause excessive humidity levels resulting in occupant discomfort, condensation on cool walls and windows and bacterial or fungus growth.

There is also a concern with occupant health. Radon, formaldehyde from building materials and furnishings and household chemicals can reach harmful concentrations if ventilation is inadequate.

Furthermore, as building envelopes become tighter, there is increased competition for air among the various systems, equipment, and appliances. A separate outdoor air supply, independent of the general ventilation system, must be provided for all combustion appliances installed in houses.

To address these concerns and issues, Canadian Standards Association (CSA) has developed Standard F326 "Residential Mechanical Ventilation Requirements", which specifies requirements for the installation of mechanical ventilation systems in housing.

The designer and installer of ventilation systems needs to know about mechanical system design and installation guidelines that meet CSA F326. Heating, Refrigeration and Air Conditions Institute of Canada (HRAI) has developed this manual and training program to provide those involved in the design, installation and inspection of mechanical ventilation systems for residences the training and documentation necessary for them to understand the requirements of and comply with the standard.

Course Objectives:

1. To provide residential ventilation systems designers, installers and inspectors with an understanding of CSA F326, Alaska Craftsman Home Program, Inc. (ACHP), and American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) requirements, thus allowing them to design, install and ensure compliance with the requirements.

2. To provide training as part of ACHP's ventilation system installers certification program.

3. The ultimate objective is improved homeowner comfort, health and safety through improved residential ventilation system design and installation.

2

VENTILATION

2.0 GENERAL

Ventilation is the process of supplying or removing air by either natural or mechanical means to or from any space. A separate system, such as a furnace or air conditioner, is generally used for heating and cooling. The purpose of a residential ventilation system is to:

- control odors and air contaminants (indoor air quality control),
- control indoor levels of moisture (humidity control).

2.1 AIR QUALITY CONTROL

A house is said to have poor air quality when the air inside contains a large enough quantity of any substance to adversely affect the comfort, health or safety of the occupants. Odors, chemical pollutants (from furniture, rugs, insulation, cleaning fluids, cosmetics, etc.), radon gas, biological pollutants from people, pets and plants (including molds and mildew), and particulates (such as dust, pollen, and cigarette smoke) are found in the air of every home. If the rate of pollutant generation indoors is high or the ventilation rate is low, indoor pollutant concentrations may be high enough that the comfort or health of the occupants is jeopardized.

There are a number of methods of controlling contaminant levels. These include removing the pollutant source, substitution of polluting products or activities with non polluting ones, sealing, enclosing or encapsulating the source, changes in design, air treatment and ventilation. In all cases some level of ventilation is required to maintain indoor air quality.

Mechanical ventilation systems that provide controlled ventilation throughout the structure are the object of CSA F326, and are the subject of this manual.

2.2 HUMIDITY CONTROL

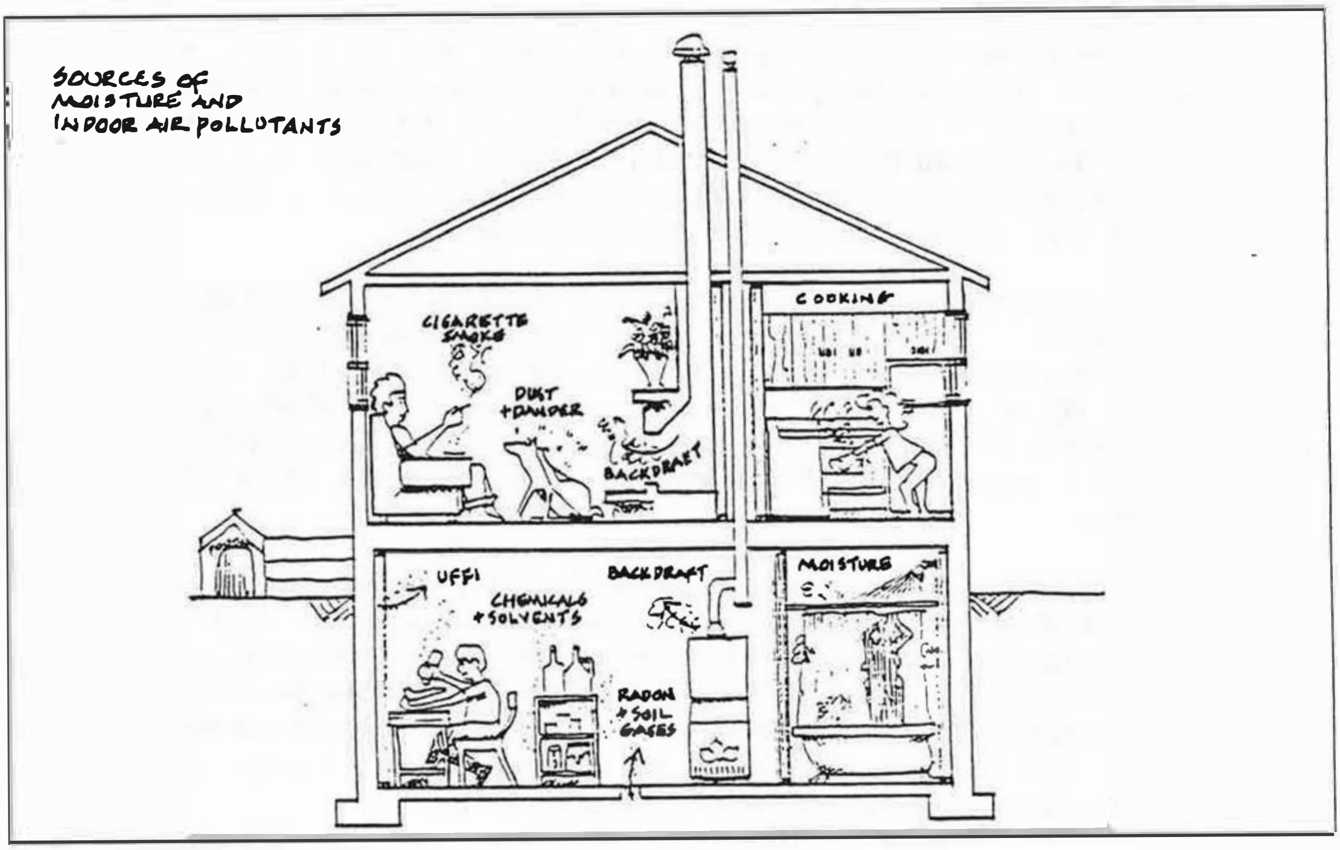
Many existing Alaskan houses are excessively dry during our winters, and humidification is often necessary. However, because of the low rate of natural ventilation in airtight homes, the situation may be reversed and high humidity levels can result. While not always considered a contaminant or pollutant, excessive levels of water vapor in the air can lead to aesthetic, structural and even health problems (because high humidity levels support bacterial and mold growth).

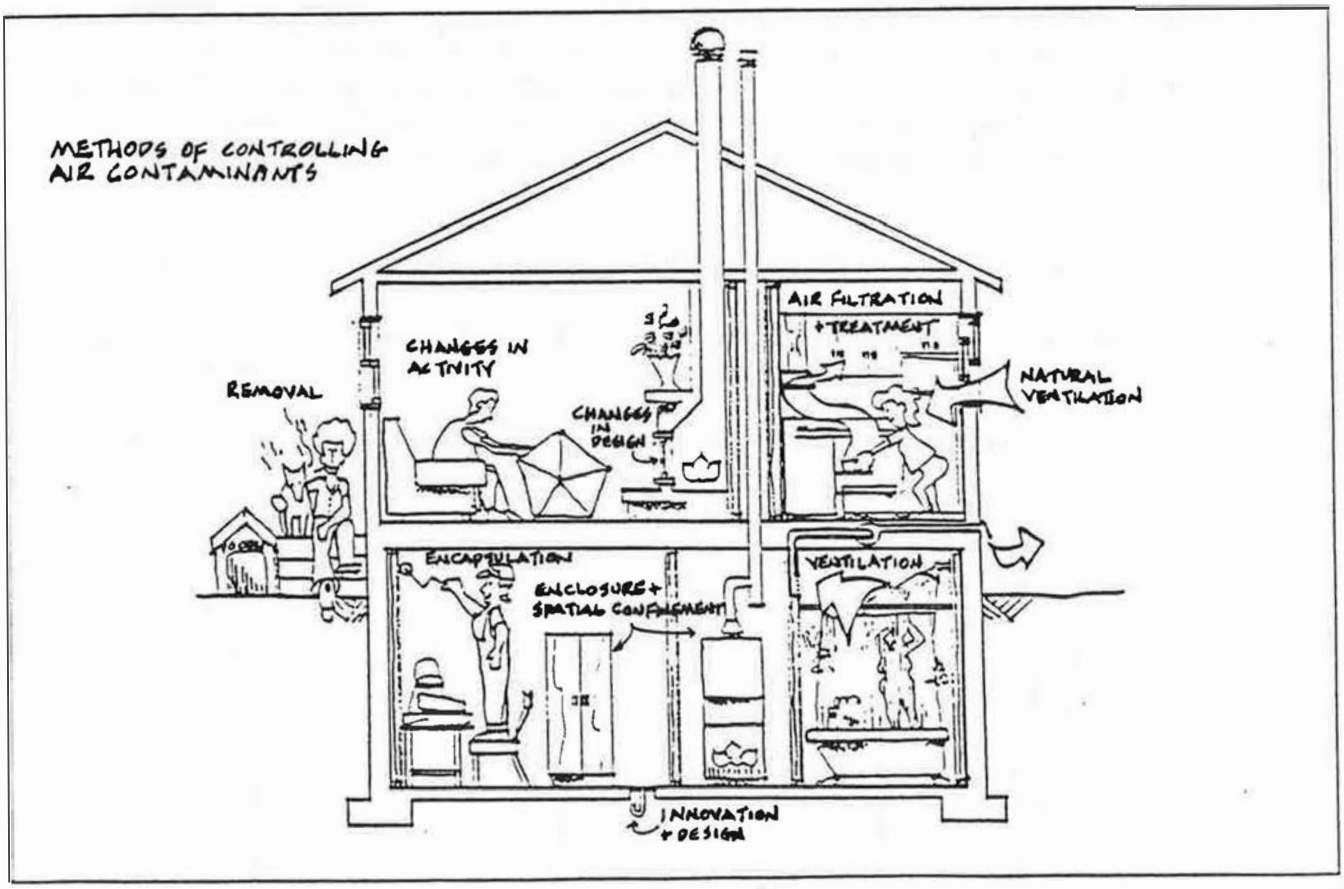
In the winter, it is possible to reduce the humidity level within a building by simply replacing the inside air with outside air (i.e. ventilation). The rate of mechanical ventilation required to control the humidity level in a home will usually be adequate to control contaminants and odors. In some cases, the ventilation system in the house may be so effective in removing water vapor, that humidification may be required.

But why is outside air so dry? In the winter, the relative humidity can approach 100%, yet the air only contains a relatively small amount of water vapor. A closer look at the definition of humidity is needed to understand this.

Absolute Humidity is the measure of the actual amount (weight) of water (in the form of water vapor) contained in a given amount of air, regardless of the temperature of that air.

Relative Humidity (RH) is defined as the amount of water vapor in the air (at a specified temperature) relative to the total amount of water vapor that could be contained in that air at that same temperature. It is usually expressed as a percentage. Warm air can hold more water vapor than cold air. If air is cooled its ability to hold water decreases.


SOURCES OF
MOISTURE AND
INDOOR AIR POLLUTANTS
CIGARETTE SMOKE
DUST + DANDER
BACKDRAFT
COOKING
UFFI
CHEMICALS + SOLVENTS
BACKDRAFT
MOISTURE
RADON + SOIL GASES


METHODS OF CONTROLLING
AIR CONTAMINANTS
REMOVAL
CHANGES IN ACTIVITY
CHANGES IN DESIGN
AIR FILTRATION + TREATMENT
NATURAL VENTILATION
ENCAPSULATION
ENCLOSURE + SPATIAL CONFINEMENT
VENTILATION
INNOVATION + DESIGN

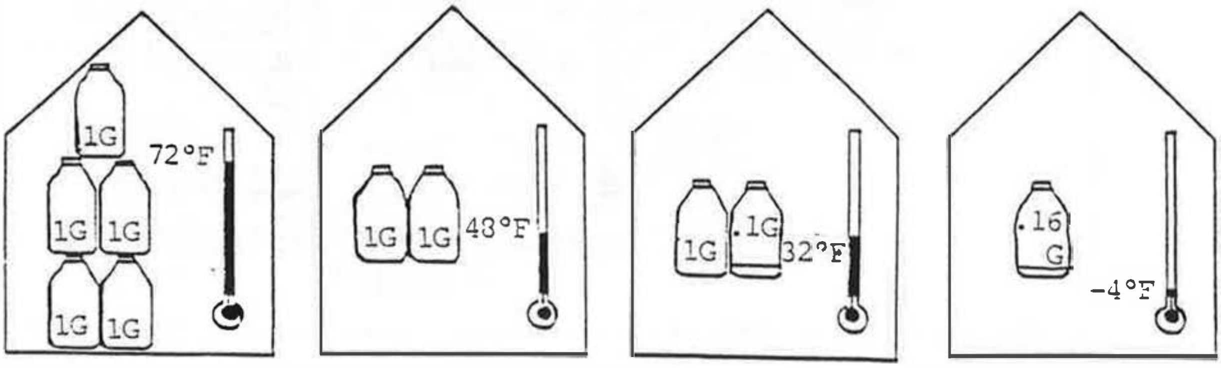
The following example will put this in perspective. The air in a typical 1,300 sf house with full basement can hold up to 5.3 gallons of water at an air temperature of 72°F. If the house air were holding this maximum amount of water, it would have a RH of 100% and an absolute humidity of .039 pound of water per pound of air. If the air in the house had a relative humidity of 40% at 72°F, it would hold 40% of this maximum amount or about 2.1 gallons of water (absolute humidity of 0.0158 pounds of water per pound of air).

If the air in the house were cooled from 72°F and 40% RH, without adding or removing any water from the space, the relative humidity would rise, while absolute humidity remained constant until the air temperature reached 48.2°F. At 48.2° the RH would be 100% and the absolute humidity would still be 0.0158 pound/pound, or 2.1 gallons total water in the house air. The temperature at which the air reaches ***100% RH is known as its saturation temperature or dew point.***

If the air were cooled any more some water would condense out of the air, the RH would remain at 100% and the absolute humidity would fall. At 32° F, the air in the house could hold only 1.1 gallons of water (absolute humidity 0.0083 pound/pound, RH 100%). One gallon would have condensed out of the air. At -4° F, it would contain about .15 gallons of water. If the air were warmed to 72° F from -4°F, and the amount of water in the air were held at .15 gallon, the RH of the air would fall from 100% at -4°F to 3% at 72°F.

In the winter time, house air may cool below its dew point as it passes over cold indoor surfaces (such as windows, around doors, or even cold corners), causing water to condense out on these surfaces. Indoor air leaking into the walls or attic of the house may drop water within the structure as it is cooled below its dew point. To minimize the problems that these may cause, new house construction techniques are designed to:

- avoid very cold surface temperatures (by increasing insulation levels);
- prevent house air from leaking through the building envelope (through airtightness measures and positive pressure imbalance avoidance), and;
- control (reduce) indoor humidity levels (through ventilation).



In the winter, ventilation reduces indoor humidity levels by replacing humid indoor air with dry outdoor air. In the summer, the opposite may occur. On a hot muggy day, outdoor air may have higher absolute humidity than the cooler house air. Introducing outdoor air in this case will increase indoor humidity levels. To effectively reduce indoor humidity levels in the summer, a dehumidifer or air conditioner may be required.

2.3 VENTILATION CODES

Recognizing the need for improved ventilation in housing, the 1985 edition of the National Building Code (NBC) (Subsection 9.33.3 Mechanical Ventilation) specifies mechanical ventilation requirements for all new housing. The Canadian Standards Association (CSA) developed a draft standard, CSA F326 "Residential Mechanical Ventilation Requirements" to provide details on how the building industry could meet the NBC requirements for ventilation. It is anticipated that CSA Standard F326 "Residential Ventilation Requirements" will be adopted by the NBC, and local building code authorities across Canada.

2.4 CSA F326

CSA F326 is made up of three parts. These are:

CSA F326.1	Residential Mechanical Ventilation Requirements;
CSA F326.2	Residential Mechanical Ventilation System Installation Requirements;
CSA F326.3	Residential Ventilation System Compliance Methods.

Scope refers to what is covered or included in a Standard. The following briefly highlights the scope of each part of CSA Standard F326.

CSA F326.1 describes the conditions that ventilation systems must meet. It says that all new housing must have *continuous mechanical ventilation.* It specifies rules for determining the minimum amount of outdoor air that must be supplied to the house, the exhaust system air flow requirements, how and where the air must be distributed and minimum ventilation supply air temperatures. Furthermore, it places restrictions on the maximum imbalance (difference) in ventilation supply and exhaust air flows.

CSA F326.2 covers the installation of residential ventilation systems including workmanship, materials, equipment, insulation requirements for ductwork, system layout and design. It is the "how to" part of the standard.

CSA F326.3 is the compliance part of the standard. It describes how the installer or an inspector is to check an installation or piece of equipment to determine if it meets the requirements of the Standard.

2.5 ITEMS NOT COVERED IN F326

CSA F326 covers mechanical ventilation requirements for all types of housing except apartment-type buildings. These are covered under the National Building Code. CSA F326 is intended only to deal with normal household pollutants and it assumes outdoor air is suitable for ventilation. In cases where exceptional pollutant emission rates are encountered or where outdoor air contaminant levels make it impractical to use outdoor air for ventilation, measures beyond the scope of this standard (e.g. air cleaning, purification, filtration, etc.) are required.

The ventilation air called for in this standard does not provide for the combustion or dilution air requirements for combustion appliances. These must be addressed separately as called for by codes covering combustion appliances (e.g. CAN B139; CAN B149). The standard does, however, recognize the sensitivity of different types of combustion equipment, when specifying indoor to outdoor air pressure difference limits.

Although some ventilation is provided by natural air leakage through the building envelope, it varies greatly throughout the year. It cannot be relied upon to provide the ventilation rates needed to ensure acceptable air quality at all times. All the ventilation called for in the standard must be provided by mechanical means.

2.6 ACHP TECHNICAL REQUIREMENTS

At the date of this publication, the significant difference between the ACHP program requirements and the Canadian CSA F326 requirement is CSA F326 will allow 0.3 air changes per hour. The room count between CSA F326 standard can be compared by looking at Figure D1.2.

* ACHP minimum Air Change per Hour is 0.35.

Air Quality Consideration

The ventilation requirements are intended to ensure acceptable levels of air quality, adequate venting of combustion products, and control of indoor humidity levels for safety and health.

Ventilation

The mechanical ventilation system must have continuous variable-speed control with demonstrated capability of supplying outdoor ventilation air at a continuous rate at a minimum of 0.35 air changes per hour (ach) or 10 cubic ft per minute (cfm) per habitable room. In addition the ventilation equipment must have the capability of supplying 50 cfm ventilation for discontinuous boosts when needed.

The ventilation system must also be able to provide at least 50 cfm additional outdoor air on an intermittent basis and exhaust air at the rate of 100 cfm from kitchens and 50 cfm from bathrooms.

Mechanical ventilation equipment, including air-to-air exchangers, or similar heat recovery ventilators, shall be installed according to this manual, and/or local codes.

- A ventilation test conducted by ACHP certified personnel must verify that the home meets program ventilation requirements.
- **Step 1** - Calculate the *minimum acceptable continuous supply rate of outdoor air for the house*. This is determined on the basis of the installed system having the capacity to provide 10 cfm to each room of the house, and 20 cfm to the basement and utility rooms. Any combined areas, such as the living and dining rooms, are treated as two separate rooms. In the sample exercise, the rooms and the required minimum system capacity are identified as totalling 130 cfm.
- **Step 2** - Calculate the *intermittent supply capability*. The intermittent or peak ventilation flow rate for the house is determined by adding 50 cfm to the minimum continuous ventilation rate. This peak capability will be activated by a humidistat and either manual controls or a timer. The ventilation equipment chosen by the builder must be capable of providing air at this rate. For the sample house, the ventilation equipment must be capable of moving 180 cfm (130+50).

- **Step 3** - Calculate the required dedicated exhaust capability. The distribution of the intermittent, or peak, exhaust capability for the house is determined on the basis that each bathroom must have the capability of exhausting 50 cfm, and the kitchen must have 100 cfm of exhaust capability. In many cases the central ventilation strategy chosen by the builder will have adequate capacity to meet these requirements.

Table 2.2 **VENTILATION SYSTEM CAPACITY**

	Floor/Room	Minimum Continuous Ventilation	Required Exhaust Capacity
	Bedroom	10cfm	
	Bedroom	10 cfm	
	Bedroom	10 cfm	
	Bathroom	10 cfm	50 cfm
	Kitchen	10 cfm	100 cfm
	Living Room	10 cfm	
	Dining Room	10 cfm	
	Family Room	10 cfm	
	Utility Room	20 cfm	
	Bathroom	10 cfm	50 cfm
	Basement	20 cfm	
Step 1	**Total Continuous Ventilation**	130 cfm	
Step 2	**Required Additional Capacity**	add 50 cfm	**Step 3**
	Total System Capacity	180 cfm	200 cfm

2.7 ASHRAE STANDARD 62-1989

Table 2.3[a]
Outdoor Requirements for Ventilation of Residential Facilities
(Private Dwellings, Single, Multiple)

Applications	Outdoor Requirements	Comments
Living areas	0.35 air changes per hour but not less than 15 cfm (7.5 L/s) per person	For calculating the air changes per hour, the volume of the living spaces shall include all areas within the conditioned space. The ventilation is normally satisfied by infiltration and natural ventilation. Dwellings with tight enclosures may require supplement ventilation supply for fuel-burning appliances, including fireplaces and mechanically exhausted appliances. Occupant loading shall be based on the number of bedrooms as follows: first bedroom, two persons; each additional bedroom, one person. Where higher occupant loadings are known, they shall be used.
Kitchens[b]	100 cfm (50 L/s) intermittent or 25 cfm (12 L/s) continuous or openable windows.	Installed mechanically exhaust capacity[c]. Climatic conditions may affect choice of the ventilation system.
Baths, Toilets[b]	50 cfm (25 L/s) intermittent or 20 cfm (10 L/s) continuous or openable windows.	Installed mechanical exhaust capacity[c].
Garages:		
Separate for each dwelling unit	100 cfm (50 L/s) per car	Normally satisfied by infiltration or natural ventilation
Common for several units	1.5 cfm/ft2 (7.5 L/s ft2)	See "Enclosed Parking Garages," Table 2.1

[a] In using this table, the outdoor air is assumed to be acceptable

[b] Climatic conditions may affect choice of ventilation option chosen.

[c] The air exhausted from kitchens, bath, and toilet rooms may utilize air supplied through adjacent living areas to compensate for the air exhausted. The air supplied shall meet the requirements of exhaust systems as described in 5.8 and be of sufficient quantities to meet the requirements of this table.

2.8 "HOUSE AS A SYSTEM"

An underlying concept in this manual and in the standard is the "House as a System", that is the concept that all the components that make up the house are interlinked, and a change to one system may affect the operation of others. For example, operating exhaust only ventilation equipment or appliances can affect the draft of a naturally aspirated furnace, possibly causing it to backdraft which degrades air quality in the house. It may also cause soil or sewer gas to enter the house through the floor drain or basement floor. Taken in isolation, one assumes that turning on the exhaust fan will improve indoor air quality. Looking at all the implications, or considering "the house as a system", turning on an exhaust fan may result in a significant reduction of indoor air quality in the house and possibly even a health or safety hazard. CSA F326 has attempted to develop regulations for ventilation systems which look at the whole picture, (i.e. "the House as a System") so that solutions to one problem do not create other problems.

3

DEFINITIONS

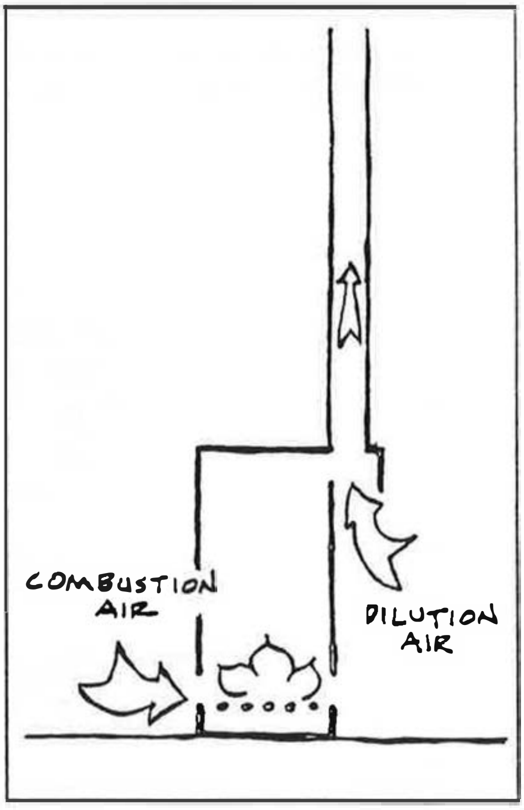
3.0 DEFINITIONS

A number of technical terms are used in this manual and in CSA Standard F326. An effort has been made to ensure that the same meaning has been applied to the terms used in both documents. To help the user clearly understand the text that follows, some frequently used terms are explained in Section 3.1, 3.2 and 3.3 of the manual. As well, definitions given in CSA F326.1 and CSA F326.2 are listed in Section 3.4. In the back of this manual is a glossary with definitions for many other commonly used ventilation system terms.

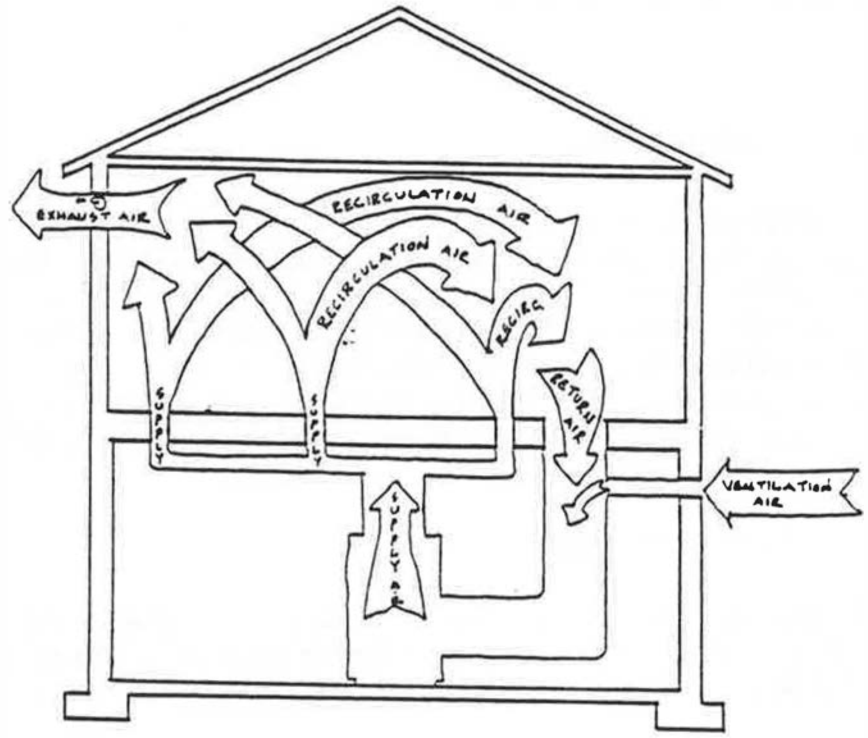
3.1 TYPES OF AIR

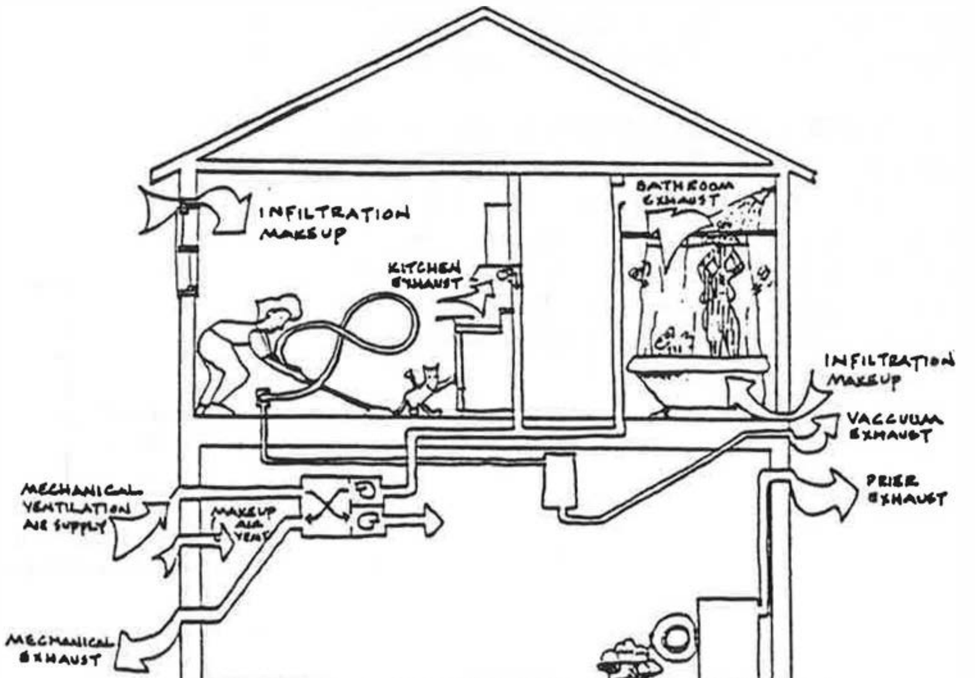
One area of potential confusion is in the use of common words for the types of air in a ventilation system. The following definitions and supporting illustrations describe the meaning of various air stream related terms used in this manual.

Combustion Air - air required to provide adequate oxygen for fuel burning appliances in the building. In this manual the term "combustion air" refers to the total air requirements of a fuel burning appliance including both air to support the combustion process and air to provide chimney draft (dilution air).



Exhaust Air - air removed from a space and not reused therein. This includes air from kitchen and bathroom exhaust fans, clothes dryers, vacuum cleaners, etc. which is mechanically expelled to the outdoors. The term "Exhaust" may be prefixed to describe its source (e.g. dryer exhaust, kitchen exhaust, central vac exhaust).


EXHAUST AIR
RECIRCULATION AIR
RECIRCULATION AIR
RECIRC.
SUPPLY
SUPPLY
RETURN AIR
SUPPLY AIR
VENTILATION AIR


INFILTRATION MAKEUP
KITCHEN EXHAUST
BATHROOM EXHAUST
INFILTRATION MAKEUP
VACCUUM EXHAUST
DRIER EXHAUST
MECHANICAL VENTILATION AIR SUPPLY
MAKEUP AIR VENT
MECHANICAL EXHAUST

Make-up Air - outdoor air supplied to replace exhaust air. Make-up air may enter the house by infiltration, through a make-up air duct, through a supply fan, etc. It does not include air entering the house as combustion air or to replace exfiltration air.

Outdoor Air - air from the external atmosphere taken into the dwelling unit with no significant increase in contaminants and not previously circulated through the ventilation system.

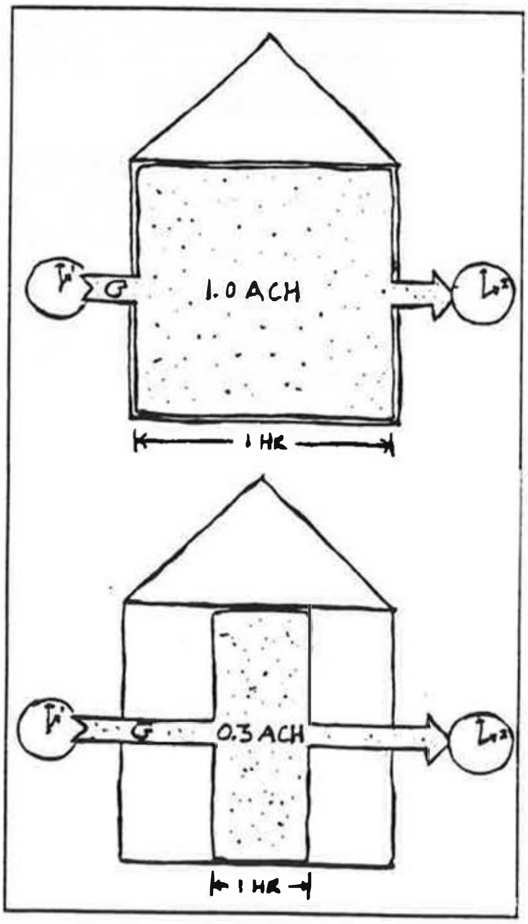
Relief Air - air which is mechanically removed from the house or which exfiltrates from the house to reduce the degree of mechanically induced house pressurization (i.e. it is the opposite of make-up air).

Recirculation Air - air which is removed from a space for conditioning (heating, cooling, cleaning, humidifying, or dehumidifying) and then returned to the space. There is no recirculation air in houses without forced air heating or cooling systems.

Return Air - recirculation air being removed from a space.

Supply Air - recirculation and ventilation air being jointly supplied into a space after being conditioned (heated, cooled, cleaned, humidified, or dehumidified and mixed).

Ventilation Supply Air - outdoor air being intentionally supplied to a habitable space either by mechanical means (e.g. ventilation supply air fans or exhaust fan induced infiltration or make-up air) or natural means (open doors and windows).



3.2 AIR CHANGE RATE

Another term which must be understood is Air Changes per Hour (ACH). 1.0 ACH is that air flow rate which, if maintained for one hour, would move a volume of air equal to the entire conditioned volume of the house, and 0.3 ACH is 30% of the air volume.

3.3 NET, BASE, AND REFERENCE EXHAUST FLOW RATES

When designing residential ventilation systems, the designer must design the systems around the net air flow rate at two operating conditions. The first is the "normal" operating condition, the second is an "extreme" operating condition. These design conditions relate to the amount of air leakage through the building envelope at each operating condition, not to the loads imposed on the ventilation and exhaust equipment (i.e. it relates to "the house as a system").

Net Air Flow Rate - is the difference between the mechanical ventilation supply air flow rate and the mechanical exhaust air flow rate. This difference must be made up by infiltration or exfiltration across the building envelope.

Base Flow Rate Condition - refers to the net air flow rate to or from the house under "normal" operating conditions, i.e. with all continuously operating ventilation and exhaust equipment running (e.g. an HRV on low speed) and all intermittently operating ventilation and exhaust equipment turned off (e.g. clothes dryer, range hood).

Reference Exhaust Flow Rate Condition - refers to the net air flow rates from the house with several intermittent exhaust appliances operating in addition to continuously operating ventilation and exhaust equipment. This is the "extreme" design condition.

These design conditions are discussed in more detail in Section 5 "Ventilation System Design".

3.4 DEFINITIONS FROM CSA STANDARDS F326.1 AND F326.2

Basement- a story or stories of a building located below the first story. First story refers to the uppermost story having its floor level not more than six feet above grade.

Bathroom - any room containing a toilet, urinal, bidet, bathtub, or shower.

Base low rate condition - the design operating mode of the ventilation system when providing the air flow rate necessary to satisfy requirements for the base flow rate of ventilation air as required by Clause 5.1.

Base flow rate of ventilation air - the minimum average rate of ventilation air achieved per day.

Building envelope - the surfaces formed by all components of the building which enclose the conditioned volume.

Certification - the process of confirmation by a nationally recognized certification agency that a product or component meets specified requirements when tested in accordance with a recognized standard.

Conditioned volume - the total interior volume of all stories, including the basement, but excluding any attached or built-in garage or crawl space.

Decorative gas appliance - a self-contained, free standing burning appliance for installation only in a vented fireplace and whose primary function lies in the aesthetic effect of the flame.

Dwelling unit - a suite operated as a housekeeping unit, used or intended to be used as a domicile by one or more persons and containing cooking, eating, living, sleeping and sanitary facilities.

Exhaust air - air removed from a space and not reused therein.

Habitable room - a space or room designed for human occupancy, such as a bedroom, living room, dining room, kitchen, family room, recreation room, or den.

Heat recovery ventilator - a factory-assembled unit which incorporates a means to circulate air for ventilation and provision to transfer heat between two isolated air streams.

Hoods - exterior wall, floor or roof mounted terminals for the outdoor air inlet and the exhaust air outlet.

Makeup air - outdoor air supplied to replace exhaust air.

Occupied zone - the region within an occupied space between planes three inches and six feet above the floor and more than two feet from the walls or fixed air-conditioning equipment.

Outdoor air - air from the external atmosphere taken into the dwelling unit with no significant increase in contaminants and not previously circulated through the ventilation system.

Outdoor winter design temperature - shall be the January 2 1/2% value as given in Table 5 of CAN/CSA-F280-M86, Determining the Required Capacity of Residential Space Heating and Cooling Appliances.

Purchaser - the person or persons having ownership or control (of the dwelling unit) at a date two weeks following the start up of the ventilation system or sooner.

Qualified - acceptable to the regulatory authority.

Recirculated air - air removed from the conditioned space and intended for reuse as supply air.

Reference exhaust flow rate - the sum of the exhaust components as defined in Clause 6.3.

Return air - air removed from a space to be recirculated or exhausted.

Single-family dwelling - a residential dwelling unit, as defined in Subsection 2.1.3(a), Group C of the 1985 National Building Code.

Supply air - air delivered to the conditioned space and used for ventilation, heating, cooling, humidification, or dehumidification.

Utility room - a room containing laundry or maintenance equipment and materials, or used as a workshop.

Vented combustion appliance - a fuel-burning furnace, boiler, heater or fireplace that is connected to a chimney or vent for purposes of exhausting products of combustion outdoors.

Ventilation - the process of supplying and/or removing air by natural or mechanical means to and from any space.

Ventilation air - that portion of supply air which is outdoor air.

Ventilation Components - equipment and materials used in supplying or exhausting air for ventilation purposes, whether or not a part of a ventilation system conforms to CSA Preliminary Standard F326.1.

Ventilation system - all of the components installed for the purpose of providing the controlled ventilation air called for in this Standard.

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VENTILATION & DISTRIBUTION

4.0 VENTILATION AND DISTRIBUTION: TYPES OF SYSTEMS

There are three generic ventilation system types. The three generic ventilation system types are:

1. Mechanical Exhaust only (negative pressure)
2. Mechanical Ventilation Supply only (positive pressure)
3. Mechanical Ventilation Supply and Exhaust

There are three general ventilation air distribution system types. The three distribution system types are:

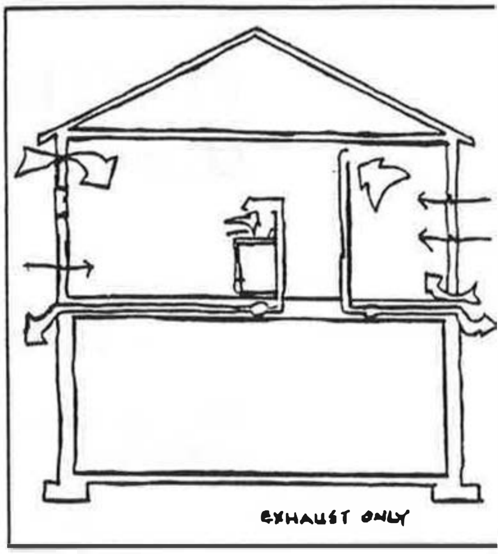
1. Dedicated Distribution Systems
2. Integrated Distribution Systems
3. Through the Wall Distribution Systems

There are two modes of fan operation. The two modes of fan operation are:

1. Intermittent
2. Continuous

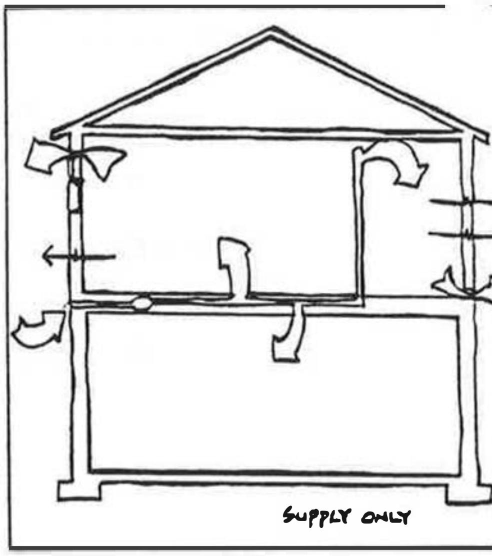
4.1 VENTILATION SYSTEM TYPES

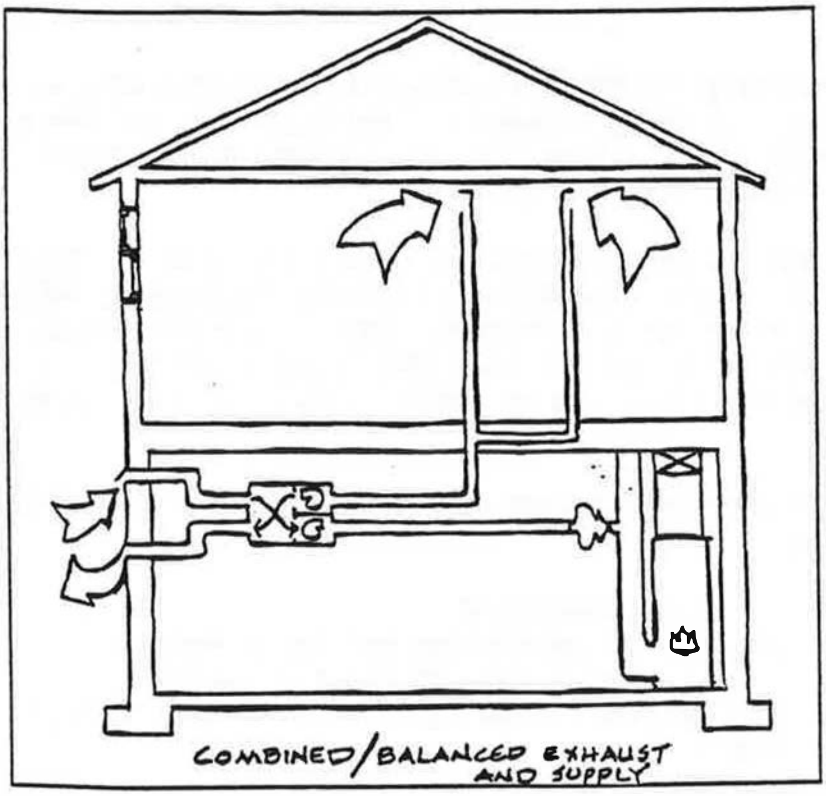
Exhaust-only systems use fans to exhaust air, putting the house under negative pressure. Make-up air comes in through leakage paths in the envelope and through intentional inlet openings. The openings can be regulated to ensure even distribution of the make-up air. Cold drafts may cause occupant discomfort if the system is not well designed.



The negative pressure eliminates the problem of condensation in the walls. However, backdrafting of combustion appliances, such as a woodstove or fireplace, could be a problem. Also, the basement should be sealed to stop soil gases, radon and moisture from being drawn from the soil. Because of these problems, F326 has specific limits on the extent of the negative pressure induced by the ventilation system.

Supply-only ventilation systems use fans to provide ventilation air while an equal amount of house air exits through either deliberate openings or leakage paths in the envelope. This system pressurizes the house, reducing drafts and soil gas (radon) levels, but increasing the problems of condensation in the envelope. In cold weather, positive house pressure can push moist house air into wall cavities and ceilings. Condensation may result, causing moisture related deterioration of the structure. F326 has limitations on the amount by which the ventilation supply air flow may exceed the exhaust air flow. The ventilation supply air must be preheated or distributed in such a way that it mixes with house air before entering occupied spaces. F326 requires mechanical exhaust for spot ventilation, so systems with only ventilation supply fans do not comply with CSA F326.





A combined mechanical ventilation supply and exhaust system uses both ventilation supply and exhaust fans to provide ventilation. The advantage of these systems is they can remove exhaust air from those areas where odors and humidity are generated while supplying conditioned ventilation air as required to the living areas.

A balanced ventilation system is a combined mechanical ventilation supply and exhaust system in which mechanical exhaust air flows are equal to mechanical ventilation air flows (i.e. balanced flows), thus average interior pressures equal to those outdoors are maintained.

Heat recovery ventilators *(HRVs)* are ventilation devices which extract heat from exhaust air being expelled from the house, and use the recovered heat to offset another heating load. Common uses of the recovered heat are preheating the ventilation or recirculation air.

Heat recovery ventilators have two general components. These are the ventilators or fans and the heat recovery elements. Commonly used heat recovery elements include flat plate heat exchangers, heat pipes, heat pumps and rotary exchangers or heat wheels. Most HRVs transfer heat from the outgoing exhaust air stream to the incoming ventilation supply air stream through a heat exchanger.

Other Ventilation Systems with Heat Recovery - CSA F326 defines HRVs as units which:

1. are factory assembled
2. transfer heat between two isolated air streams
3. have a means to circulate air for ventilation
4. have maximum rated capacity of not less than 50 cfm and not more than 400 cfm.

Thus commercially available ventilation systems which use the heat recovered from the exhaust air stream to heat DHW may contain both heat recovery and ventilation elements but not fit within the CSA definition for HRVs.

4.2 DISTRIBUTION SYSTEM TYPES

The three types of ventilation air distribution systems are described below. In all cases, exhaust air is exhausted from odor and moisture producing areas such as kitchens, bathrooms and utility rooms through dedicated exhaust ductwork. The terms dedicated (or independent), integrated (or combined) and through the wall ventilation systems refer specifically to the method of distributing ventilation air throughout the house.

Dedicated, Independent or Separately Ducted Distribution Systems distribute ventilation air using an independent or dedicated set of ductwork. Each habitable room in the house will have its own ventilation air supply outlet or exhaust air inlet. This type of system is commonly used in houses with baseboard or radiant heating systems.

Integrated or Combined Distribution Systems utilize the forced-air heating and/or cooling system to distribute ventilation air throughout the house. The ventilation air supply fan discharges into the forced air recirculation system return duct.

The forced air recirculation fan (which must operate continuously) distributes the ventilation air throughout the house while mixing it with return air.

With this distribution system type, the forced air recirculation fan must run continuously. This ensures that the ventilation air is distributed throughout the house at all times.

Through the Wall Distribution Systems utilize exhaust fans to induce infiltration into the house. There is a requirement for the ventilation air supply to be controlled so as to ensure that the daily average ventilation air flow rate to each room in the house meets the minimum requirements set out in the standard.

4.3 MODES OF FAN OPERATION

Intermittent fan operation refers to a mode of operation by a ventilation or furnace recirculation fan which can be started or stopped by activating occupant controls in the house. Intermittent operation includes fans which run ON/ OFF and high speed operation of two speed fans.

Continuous fan operation refers to fans which operate continuously (24 hours per day) and which cannot be turned off by occupant controls. This includes two speed furnace recirculation fans and ventilation fans which normally operate at a low speed setting but which can be prompted to high speed operation by using occupant controls.

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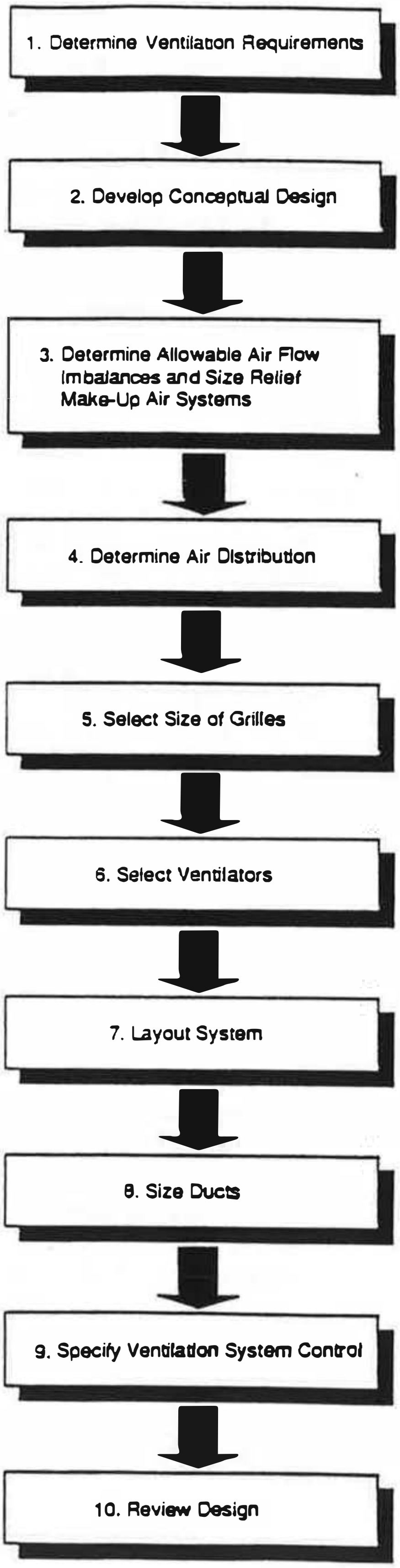
5

VENTILATION SYSTEM DESIGN

5.0 VENTILATION SYSTEM DESIGN



Most successful mechanical system installations, as with many elements of house construction, are those which have been well thought out. A successful installation begins with the design, thus reducing the requirements for the installer to make on the spot decisions. This is not to suggest that problems will not occur on-site which will demand that the installer be able to react quickly and correctly. The basics of successful ventilation system design can be presented easily when the people involved in the design and installation of the system are aware of the house ventilation requirements and understand the basic theory behind air flow in ducts.

A task-by-task design procedure is presented in this chapter. Each task has two sections.

1. **Goal**

   Defines the objective of an end product resulting from completion of the task.

2. **Procedure**

   Explains step by step the hows and whys of achieving the Task Goal. The procedure described in the text is supported with examples.

TASK 1 - DETERMINE VENTILATION REQUIREMENTS

1. Goal

To establish the "design" ventilation rate(s) for the proposed house plan to meet code and occupant requirements.

2. Procedure

Step 1.1
Select Appropriate Ventilation Standard

Normally the designer will design to CSA Standard F326, on which this manual is based. In these cases he need only follow the procedures presented here-in.

If the local authority has more stringent requirements, or if there are exceptional considerations (e.g. poor outdoor air quality, high levels of air contaminant generation inside the house, etc.) the designer should follow the more stringent ventilation system design requirements. For such cases, the designer may wish to refer to ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality,* or some other authority for design guidance.

Step 1.2
Determine the Conditioned Volume of the House

The conditioned volume of the house is required to determine the minimum Base Flow Rates (Step 1.3). Conditioned volume can be estimated using Figure D 1.1 or can be calculated by multiplying the floor area of each conditioned space in the house by its ceiling height. All dimensions must be in the same units (i.e. all meters or all feet, don't mix meters and feet or feet and inches). The volume of a 1200 sf house with full basement should be about 20,000 cu. ft. Do any calculations and record house volume in feet on Worksheet No. 1.

Step 1.3
Determine Minimum Base Flow Rate to Meet CSA F326 Requirements

The minimum base flow rate is the ventilation air supply rate which the ventilation system must provide on a continuous basis. The base flow rate must meet two criteria.

First, it must meet or exceed the sum of the individual room requirements, as calculated using Column 1 of Figure D1.2.

Second, it must equal or exceed 0.3 air changes per hour for the conditioned volume of the house. The air flow that relates to 0.3 ACH for a house can be estimated from Figure D 1.1 or calculated using the following mathematical operations.

Conditioned Volume in cubic feet

$$\frac{\text{(from Step 1.2)}}{200} = \text{flow rate cfm}$$

For a 20,000 cu. ft. house, 0.3 ACH represents an air flow of 100 cfm.

Do all calculations on Worksheet No. 1 and record the greater of the two flow rates as the Minimum Base Flow Rate.

Note: The metric equivalent of the equation is:

Conditioned Volume in cubic meters

$$\frac{\text{(from Step 1.2)}}{12} = \text{flow rate L/s}$$

FIGURE D1.1

FLOOR AREA OF CONDITIONED SPACE* ft^2	m^2	CONDITIONED VOLUME m^3	ESTIMATED AIR FLOW RATES FOR 0.3 ACH L/s	0.3 ACH cfm	1.0 ACH L/s	1.0 ACH cfm
200	18	48	4	9	13	28
400	37	96	8	17	27	57
600	56	145	12	25	40	85
800	74	193	16	34	54	114
1000	93	241	20	42	67	142
1250	116	301	25	53	84	177
1500	139	361	30	64	100	213
1750	162	422	35	74	117	249
2000	185	482	40	85	134	284
2250	209	542	45	95	150	319
2500	232	602	50	106	167	355
2750	255	662	55	117	184	390
3000	278	723	60	127	201	426

* Include basement floor area.

Air flows can be added to estimate volumes or flow rates for areas greater than those shown in the table.

Step 1.4
Determine Minimum Required Exhaust Capability

The exhaust flow requirements are shown in Columns 2 and 3 of Figure D1.2.

Record the required exhaust rates for the kitchen and each bathroom shown on the house plan on Worksheet No. 1. Later in the design process, the designer will decide whether exhaust from each room is to be continuous or intermittent.

FIGURE D1.2

Space Classification	Column 1 Base Flow Rate cfm	Column 2 Intermittent Exhaust	Column 3 Continuous Exhaust
Category A			
Basement	20		
Single Bedrooms	10		
Living room(2)	10		
Dining room (2)	10		
Family room	10		
Recreation room	10		
Other (3)	10		
Category B			
Kitchen (2)	10	100	60
Bathroom	10	50	30
Laundry	10		
Utility room	20		

Notes:

(1) Each area in a basement which is separated by a wall and doorway shall have a minimum ventilation requirement of 10 cfm. This does not include furnace rooms, storage rooms, and closets.

(2) Ventilation requirements for any combination living, dining, and kitchen shall be determined as if they were individual rooms.

(3) Other habitable rooms not listed shall have a minimum ventilation requirement of 10 cfm. This does not include spaces intended solely for access, egress, or storage, such as vestibules, halls, landings and storage rooms.

Step 1.5
Evaluate Special Exhaust Requirements

On occasion, the residential ventilation system designer may wish to install extra exhaust capacity. For example, the homeowner may have a hobby or work room in which noxious materials are used, and for which high rates of exhaust are occasionally needed. The designer will have to compare the costs and benefits of a dedicated point exhaust system (e.g., through-the-wall exhaust and make-up air fans for this room alone) to those of integrating the exhaust for this room into the central ventilation system. The designer may wish to refer to ASHRAE Standard 62-1981 or other industrial ventilation design manuals to determine specific exhaust flow rates and design criteria for such applications.

TASK 2 - DEVELOP CONCEPTUAL DESIGN

1. **Goal**

   To make general decisions regarding system design which will allow the designer to carry out the detailed design tasks.

2. **Procedure**

   Any system design which meets the requirements of CSA F326 and other code requirements is acceptable. Not all possible systems, equipment and design concepts are presented in this manual, and this manual is not intended to limit the designers' alternatives.

   From the outset, the designer must make some basic decisions which affect the system design. These decisions will lead to a conceptual design, that is to say they will define:

- how the system is to operate and be controlled,
- what types of ventilation equipment is going to be used and what areas they are to serve,
- how pressure imbalances will be addressed,
- type (if any) of heat recovery,

- types of distribution systems,

- operating schedules for each system, etc.

The conceptual design forms the basis for the detailed system design. The conceptual design process is usually straightforward and often largely predefined by:

- the house plan,
- type of heating system,
- budget constraints,
- the type of heat recovery to be used (if any),
- builder or purchaser imposed constraints,
- equipment availability,
- technical and code restrictions.

The experienced designer may proceed to the detailed design without consciously developing a conceptual design.

The order of procedure will vary between applications and designers. The procedure is presented here as discrete items but in reality, the designer must think of all the system parts at the same time as he "conceptualizes" the ventilation system design. Fortunately, this is easier said than done. There are no hard and fast rules or rigid steps to be followed. The process is intuitive.

Before he starts, the designer must have answers to some questions about the house and the application. The questions needing to be answered include:

What type of heating system will be used? Ventilation system options and design will be different for a house with a forced air recirculation system than they will be for a house with radiant or baseboard heating systems.

What category of vented combustion appliances (if any) will be installed in the house? Different rules apply to each category of vented combustion appliance (Category I natural draft, Category II induced draft, Category III sealed combustion units). The regulations referring to the lowest category of vented combustion appliances installed in the house apply to the house.

What type of heat recovery equipment - (if any) will be used? The decision whether or not to use heat recovery ventilation may be made for reasons other than straight economics. Equipping a house with some form of exhaust air heat recovery will contribute to its image of being energy efficient. Generally the builder or purchaser will decide whether or not heat recovery equipment is to be installed, and may even dictate the specific equipment to be used.

The designer must know what type of heat recovery system is to be used (e.g. air-to-air, exhaust-only with DHW preheat).

Generally, designing for heat recovery will involve using a central exhaust system operating continuously. If the recovered heat is used to preheat the ventilation air, one can assume that the ventilation supply and exhaust air streams will be balanced, at least for the base flow rate condition.

Armed with this information, the designer can then make decisions about the following.

Ventilation Supply to and Exhaust from Each Room

In Task 1, the minimum required air flow rates were established. CSA F326 requires that the average air flow rate to each room meet the requirements specified for that room. Thus, each room must have at least one of the following:

- a ventilation air supply
- a recirculation air supply
- a recirculation air return
- an exhaust outlet

The ventilation system must be designed to ensure the minimum flow rate requirements are met. (Rooms with only an exhaust or return may receive their ventilation air from other rooms in the house.) If a room is equipped with only a ventilation air supply or with only an exhaust and/or return, there must be an open path for air to flow into or out of the room at all times (e.g. undercut doors).

The designer may choose to design for higher air flow rates. A decision to do so may be prompted by a pressure imbalance at the Base Flow Rate Condition which violates the allowable house pressure increase. Another reason for calling for higher than minimum air flows may be to balance air flows for an HRV system.

Pressure Regime

The three types of pressure regimes are:

- negative house pressure (i.e. mechanical exhaust from the house exceeds ventilation air supply to the house)
- positive pressure (i.e. ventilation supply to the house exceeds mechanical exhaust)
- balanced pressure (i.e. mechanical exhaust equals ventilation air supply).

Many system designs will result in the house operating at one of the pressure regimes some of the time and another pressure regime at other times. If the system is designed to maintain balanced air flows at all times, the undesirable aspects of excessively negative or excessively positive pressures are avoided (you wouldn't have to do Task 3!) and the problems of providing for relief air or make-up air vents is avoided. Balancing the base flow rate condition is straightforward, but methods for balancing air flows for other exhaust appliances (e.g. clothes dryers, range top grilles) is more complex and costly.

Air Flow Rate to be Met by Each Ventilation Fan

The designer needs to decide which air flows or rooms are going to be handled by each ventilator. This step will establish how many different ventilators will be used and their required capacities. The designer should also consider whether (or which) exhaust fans will be operated simultaneously with (which) ventilation supply fans, and which air flows (if any) will pass through an HRV.

Type of Exhaust System

Point or Local Exhaust refers to fans which are installed to exhaust a single location or point in the house (e.g. a range hood). Point or local exhausts usually run on an intermittent or demand basis. They generally run unbalanced.

Central Exhaust refers to a fan which draws exhaust air from more than one point in the house via a duct system. Often central exhausts are operated on a continuous basis at a low flow rate with the capability of being switched to high speed to solve temporary humidity or odor problems.

It is possible (and in many cases probable) for a house to have more than one exhaust air system and/or ventilation supply air system, and both point and central exhaust systems.

Intermittent or Continuous Operation

CSA F326 requires that ventilation air be continuously supplied to all habitable rooms in the house. Although mechanical exhaust from kitchens and bathrooms is mandatory, it may be continuous or intermittent. The following points should be kept in mind as you decide whether fan operation is to be continuous or intermittent.

- The required flow rate for intermittent exhaust systems is higher than that required for continuous exhaust systems.
- Point exhaust systems (e.g. range hoods and wall fans) are usually operated on an intermittent basis.
- Heat recovery ventilator operation will most likely be continuous.
- Continuously operating fans must operate quietly, otherwise the house occupant will disable them.
- Many houses will have some continuous exhaust air flows through a central system and intermittent point exhausts serving other areas.

Ventilation Air Distribution Methods

CSA F326 requires that ventilation air be continuously supplied to all habitable rooms in the house. Ventilation air may be introduced to the space in the following general ways:

- through dedicated ductwork which ducts ventilation air directly to each room. This is required in houses without a forced air recirculation system;
- through the house's forced air recirculation system. This can be achieved by having a ventilation supply fan deliver ventilation air into the furnace return or by having a fresh air make-up duct connected to the furnace return;
- through infiltration which occurs when mechanical exhaust air flows exceed mechanical ventilation supply air flows. If infiltration is used, the house must have a method of ensuring that the average daily outdoor air

leakage into each room meets the minimum requirements. (There is a system developed in Europe with outside air ducts equipped with automatic flow control dampers into each room. Although these may revolutionize the residential ventilation industry, at this point in time they are not suitable for cold climate applications and cannot closely regulate air flows.)

Method of Dealing with Pressure Increases or Decreases

If ventilation and exhaust air flow imbalances (either at the base flow rate condition or the reference exhaust flow rate condition) will cause greater positive or negative pressure differences across the building envelope than allowed, the system designer must evaluate alternative methods of limiting the pressure differences. Possible strategies include:

1. Change fuel burning appliances to a higher category to allow a greater negative pressure imbalance.
2. Installing relief air or make-up air vents. Sizing of these is discussed in Task 3. The designer must be aware of the size of vent required for various air flow imbalances.
3. Modify ventilation supply and exhaust air flow rates as required to ensure compliance at both base flow rate condition and reference exhaust flow rate condition. For example, air flows could be selected that caused the house to operate under positive pressures at the base flow rate condition while the net air flows at the reference exhaust flow rate condition would result in negative house pressures, both within the acceptable limits.
4. Install additional exhaust and/or ventilation supply fans which operate so as to reduce design condition air flow imbalances.
5. Select system controls which avoid/prevent imbalance.
6. Design for balanced flow.

Control Strategy/Integration with Other Systems

At the conceptual stage, the designer needs to decide how the various components that make up the ventilation system are going to operate, what is going to prompt a system to turn on or turn off and what equipment operates with other equipment. This is the control strategy. The designer must have a clear picture in his mind how all the pieces of the ventilation and exhaust systems are going to interact. He must be confident that the system he is conceptualizing will meet all the requirements of the ventilation standard to which he is designing.

Location of Heating and Ventilating Equipment

Depending on the house design and builder or purchaser directives, the heating and ventilating equipment may be located in a basement, in a main floor mechanical room or closet, in a garage, crawl space or attic. The location selected for this equipment may limit the type of equipment or systems that can be used for the application.

TASK 3 - DETERMINE ALLOWABLE AIR FLOW IMBALANCES AND SIZE RELIEF OR MAKE-UP AIR SYSTEMS

1. Goal

To ensure that unbalanced mechanically induced airflows into or out of the house will not create health, safety or envelope moisture problems. This is done by limiting the maximum permissible differences between mechanical ventilation supply and mechanical exhaust air flows for the house or by selecting and sizing relief air or make-up air systems as required to meet CSA F326.

2. Procedure

The purpose of this task is to avoid air flow imbalances which cause pressure differences across the building envelope that can generate the health, safety or structural problems discussed in 4.1 "Ventilation System Types" (i.e. soil gas and radon, backdrafting, moisture in walls and attics).

The procedure outlined below recognizes that:

- air flow imbalances across the building envelope result in a pressure difference across the envelope. This pressure imbalance drives air leakage from the high pressure side of the envelope to the low pressure side to balance the airflows,
- as the air flow imbalance across the building envelope increases, the pressure differential across the building envelope increases,
- as the surface area of the building envelope increases, the leakage area increases, thus the envelope's ability to handle air flow imbalances increases,

- a negative pressure difference across the building envelope (i.e. lower pressure in the house than outside the house or house depressurization) may cause combustion appliances to backdraft,
- the threshold pressure difference at which a combustion appliance will backdraft is a function of the design of that appliance and its flue,
- the appliance installed in the house which is the easiest to backdraft determines the depressurization safety limit for the house,
- modern houses are very airtight and contain more and stronger exhaust appliances than houses built in the past, so, in general, the risk of backdrafting is greater in new houses than in older houses.

FIGURE D3.1

Pressure Decrease Limits

Class of Fuel Burning Appliance	Base Flow Rate Conditions				Reference Exhaust Flow Rate Conditions			
	Pressure Decrease Limit		Leakage Factor		Pressure Decrease Limit		Leakage Factor	
	Pa	in. W.G.	L/s m²	(cfm/ft²)	Pa	in. W.G.	L/s m²	(cfm/ft²)
Category 1 (i.e. natural draft type)	5	(0.02)	0.04	(0.008)	5	(0.02)	0.04	(0.008)
Category 2 (i.e. induced draft type)	10*	(0.04)	0.07	(0.014)	10*	(0.04)	0.07	(0.014)
Category 3 (i.e. sealed unit or non fuel burning appliances)	10*	(0.04)	0.07	(0.014)	20*	(0.08)	0.12	(0.024)

* The lesser of:
- the pressure value in the figure above, and
- the value for which the appliance has been certified by an accredited certification agency.

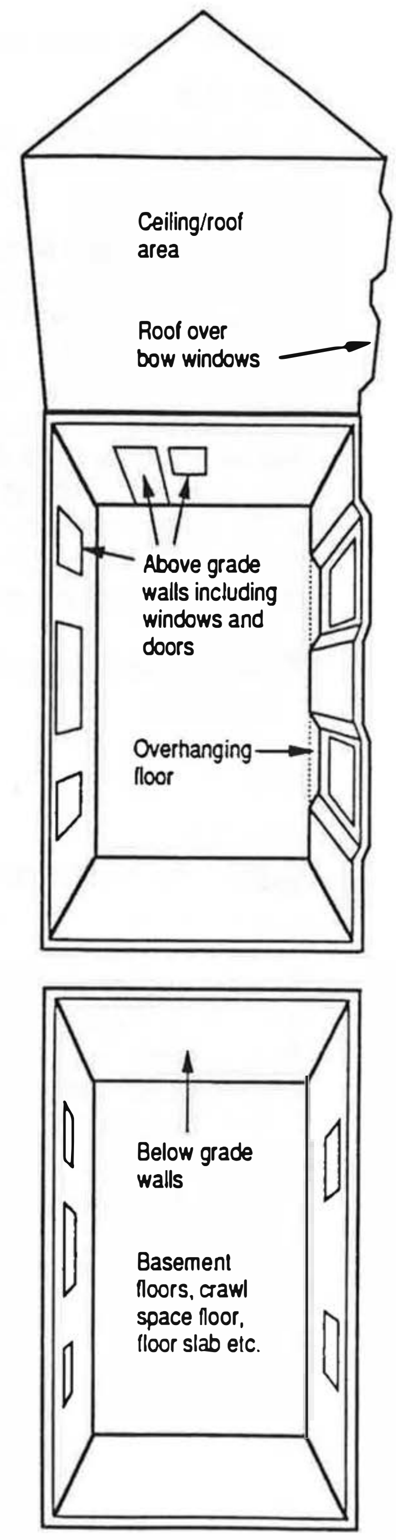
The method presented here is a simplified procedure which will generally result in more stringent design requirements than called for in F326. Appendix IV contains a procedure for a method which precisely meets F326. In order to apply this more precise method the house must be finished and a blower door test be done. The results of the blower door test are used to determine the allowable airflow imbalances.

In Steps 3.1 and 3.2 information regarding the building envelope surface area and Category of combustion appliances are determined. In Steps 3.3 through 3.5 the 'allowable' air flow imbalances at each of the three design conditions for the house are determined. In Steps 3.6 through 3.7 the actual airflow imbalances at these design conditions are determined for the house in question. Finally, in Step 3.8 makeup and relief air systems are selected and sized, if required.

Step 3.1
Calculate Building Envelope Area

The surface area of the building envelope is required to complete Task 3. Building envelope refers to those surfaces which separate the conditioned or heated space inside a building from unconditioned spaces and the outdoors. The envelope includes below grade portions of basement walls and floor slabs. Envelope area is found by adding the interior surface areas of all exterior walls (including doors and windows), floors and ceilings. The surface area of a 30 x 40 foot house with full basement should be about 4700 sq. ft. Perform all calculations and record envelope areas on Worksheet No. 3.

To change square feet into square meters, divide square feet by 10.78.



Building Envelope Components

Step 3.2
Determine Governing Combustion Appliance Category

In order to avoid combustion appliance backdrafting, depressurization of the house caused by mechanical exhaust is limited. The degree of depressurization allowed depends on the type (if any) of combustion appliances installed (or planned for) in the house. Figure D3.1 categorizes houses based on the category of combustion appliances installed in the house, specifies the maximum negative pressure to which a house containing that category of combustion appliance may be subjected and notes the Leakage Factor (i.e. allowable air flow per unit building envelope area) at each of two design conditions. The applicable Category for a house corresponds to the lowest category of combustion appliance installed or planned for the house. Fireplaces are Category 1 appliances unless specifically labelled otherwise.

Record Category numbers and Leakage Factors in Step 3.2 on Worksheet 3.

Step 3.3
Determine Allowable Net Supply Flow Rate

The Allowable Net Supply Flow Rate is the amount by which mechanical supply air flow to the house may exceed mechanical exhaust from the house. The air flow quantity is limited to prevent interstitial moisture problems caused by excessive quantities of house air from being blown into the building envelope. The Allowable Net Supply Flow Rate is determined by the following calculation:

0.07 x Envelope Area in m2 = Allowable Net Supply Flow Rate in L/s

0.014 x Envelope Area in ft2 = Allowable Net Supply Flow Rate in cfm

Step 3.4
Determine Allowable Net Exhaust at the Base Flow Rate Condition

To calculate the Allowable Net Exhaust air flow at the Base Flow Rate Condition, multiply the Base Flow Rate Condition Leakage Factor recorded in Step 3.2 by the envelope area calculated in Step 3.1. Record this data is Step 3.4 in Worksheet 3.

Step 3.5
Determine Allowable Net Exhaust at the Reference Exhaust Flow Rate Condition

To calculate the Allowable Net Exhaust air flow at the Reference Exhaust Flow Rate Condition, multiply the Reference Exhaust Flow Rate Condition Leakage Factor recorded in Step 3.2 by the envelope area calculated in Step 3.1. Record this data in Step 3.5 in Worksheet 3.

Step 3.6
Determine the Net Air Flow Rate at the Base Flow Rate Condition for the Design Condition

Figure D3.2 graphically illustrates the Base Flow Rate Condition. At this design condition, all continuously operating supply and exhaust equipment is operating.

To calculate the Net Air Flow Rate add all the exhaust air flows from the house at this condition and from that total subtract all the supply air flows to the house. Record this number in Step 3.6. If the sum of the mechanical exhausts from the house under this condition exceeds the sum of the mechanical supplies to the house (i.e. there is a net exhaust air flow rate from the house) mark a plus sign (+) in front of this number. If the sum of the exhausts is less than the sum of the supplies (i.e. supplies exceed exhausts) mark a minus sign (-) in front of this number.

Step 3.7
Determine the Net Air Flow Rate at the Reference Exhaust Flow Rate Condition for the Design Condition

The Reference Exhaust Flow Rate Condition is an extreme design condition used to ensure that depressurization, (which occurs when high volume exhaust appliances installed in the house are operated), will not result in a risk to occupant health and safety. The Net Air Flow at the Reference Exhaust Flow Rate Condition, illustrated graphically in Figure D3.3, is the sum of the following three components:

a) the net exhaust flow rate of the clothes dryer or 160 cfm if one is not installed or the actual flow rate is not known;
b) the net exhaust flow rate of the two additional installed mechanical exhaust flow devices providing the largest net flow for the exhaust, whether or not they are intended for ventilation purposes (e.g. a central vac is not intended for ventilation purposes);
c) the Net Air Flow Rate at the Base Flow Rate Condition for the Design Condition determined in Step 3.6. If the sign recorded in Step 3.6 is positive (+), this amount is added to a and b above, if it is minus (-), this amount is subtracted from the sum of a and b above.

The term net in each case above means the amount by which the exhaust flow rate exceeds the mechanical ventilation supply flow rate.

An exhaust device with a make up air device (e.g. a range hood with an interlocked make up air fan) may have a net exhaust flow rate of zero. Common "additional installed mechanical exhaust devices" referred to in b) might include an externally vented range hood, a bathroom fan or a central vac. Figure D3.4 contains typical flow rates for exhaust appliances.

Calculate the Net Exhaust at the Reference Exhaust Flow Rate and record it in Step 3.7 of Worksheet 3.

FIGURE D3.2
Net Air Flow at Base Flow Rate Condition

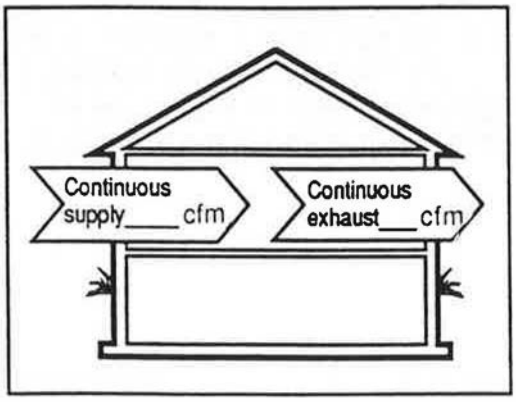


FIGURE D3.3

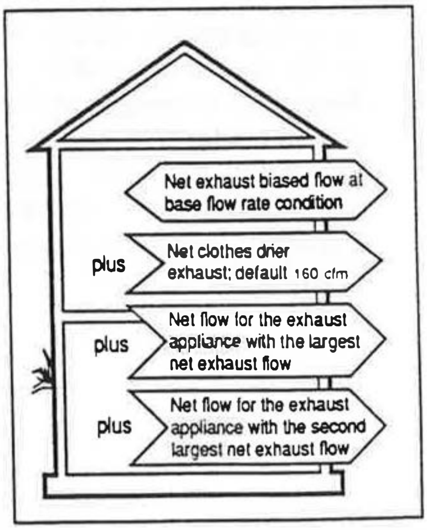


FIGURE D3.4
Airflows of Various Air Exhaust Devices

Exhaust Devices	Range of Airflows	
	L/s	(cfm)
Bathroom Fans	20 - 50	(40 - 100)
Standard Range Fan	50 -100	(100-200)
Grill-Top Range Fan	60 - 500	(120 -1000)
Clothes Dryer	40 - 75	(85-160)
Central Vacuums (exterior exhaust)	45 - 65	(90 - 130)

Step 3.8
Select and Size Relief and Make-up Air System

When the net air flow rates to or from the house at either the Base Flow Rate or the Reference Exhaust Flow Rate Design Conditions calculated in Steps 3.6 and 3.7 above exceed the corresponding Allowable Net Flow Rates calculated in Steps 3.3 to 3.5, measures must be taken to control the building envelope pressure increase or decrease.

The designer has a number of options available to him to resolve an air flow imbalance problem in the house. These include:

- selecting smaller exhaust equipment,
- increasing the Supply Bias Net Flow Rate to reduce the Net Air Flow at the Reference Exhaust Flow Rate Condition,
- installing relief or makeup air fans on selected equipment in the house or interlock fans so that competing fans cannot operate simultaneously or complimentary fans will work together,
- providing make-up or relief air vents,
- selecting fuel burning appliances from a higher category.

To determine if a relief air system is required, compare the Net Air Flow Rate at the Base Flow Rate Condition to the Allowable Net Supply Air Flow Rate. If the Net Air Flow Rate into the house at the Base Flow Rate Condition exceeds the Allowable, a relief air system sized to handle the difference between the two air flows is needed. If this is to take the form of a relief air vent, refer to the 10 Pa column of Figure D3.5 to determine the diameter of vent needed.

A make-up air system is needed if the Net Air Flow Rate out of the house at the Base Flow Rate Condition (from Step 3.6) exceeds the Allowable Net Exhaust at the Base Flow Rate Condition (from Step 3.4) or if the Net Air Flow Rate at the Reference Exhaust Flow Rate Condition for the Design Condition (Step 3.7) exceeds the Allowable Net Exhaust at the Reference Exhaust Flow Rate Condition (Step 3.5).

To size a make-up air system, find the difference between the design condition net exhaust air flow and the allowable net exhaust airflow and size the system to meet that airflow difference. If a make-up air vent is to be used, size it to meet this air flow difference. Using Figure D3.5 look up the vent size needed to handle the airflow difference in the column with the allowable pressure decrease limit for that condition (from Step 3.2).

If both relief and make-up air are required and if they are to be provided by a passive duct or vent, a single vent of the largest size can be used. Note that very large make-up air vents may be required with Category I fuel burning appliances (5 Pa pressure decrease limit).

FIGURE D3.5

Maximum Air Flow Met by Relief and Make-up Air Vents

Vent Diameter		ELA cm²	Allowable House Pressure Increase or Decrease					
			5 Pa (0.02 in. W.G.)		10 Pa (0.04 in. W.G.) Air Flow Met by Vent		20 Pa (0.08 in. W.G.)	
inches	mm		L/s	(cfm)	L/s	(cfm)	L/s	(cfm)
3	75	44	4	(8)	5	(10)	10	(20)
4	100	78	7	(15)	12	(25)	16	(35)
5	125	123	14	(30)	20	(42)	30	(65)
6	150	177	19	(40)	35	(75)	50	(105)
7	175	240	33	(70)	50	(105)	75	(160)
8	200	314	47	(100)	70	(150)	100	(210)
9	225	398	66	(140)	100	(210)	135	(290)
10	250	491	85	(180)	140	(290)	180	(380)
12	300	707	140	(300)	200	(420)	290	(620)
14	350	962	200	(420)	290	(620)	450	(950)
16	400	1257	290	(620)	430	(900)	660	(1400)

TASK 4 - DETERMINE AIR DISTRIBUTION

1. Goal

To locate the ventilation air outlets and exhaust air inlets on the house floor plan and to proportion the air flows to and from them.

2. Procedure

The function of the ventilation system is to remove stale inside air from the house and replace it with outdoor air. Ventilation effectiveness is a measure of how well the system removes indoor air contaminants from the house and distributes ventilation air to each room. Ventilation efficiency is related to the amount of air that must be supplied to or exhausted from the space to achieve a given level of effectiveness. A system may be effective but inefficient (i.e. it keeps the air fresh but moves large quantities of air to do so) or efficient but not very effective (removes a small amount of air which is highly contaminated, but is undersized). A well designed system will be both efficient and effective.

The location of the ventilation air supply, return and exhaust air grilles around the house and the quantity of ventilation supply air to or exhaust air from each grille will determine the ventilation system efficiency and effectiveness. Properly locating ventilation supply and exhaust grilles and proportioning of the air flows around the house will ensure good distribution of ventilation air around the house, efficient removal (exhausting) of moisture and air contaminants and high occupant comfort levels (i.e. no cold spots or drafts).

Step 4.1
Determine if the Ventilation Air Supply is to be Integrated with a Forced-Air Heating or Cooling System

In houses with central forced-air heating, the ventilation air supply can be integrated into the house distribution system.

Integrating the ventilation function with a forced-air system will reduce the cost of the ductwork for distributing ventilation air throughout the house. The ventilation air can be discharged into the cold air return duct of the furnace. The furnace recirculation fan will then distribute the ventilation air throughout the house after mixing it with return air.

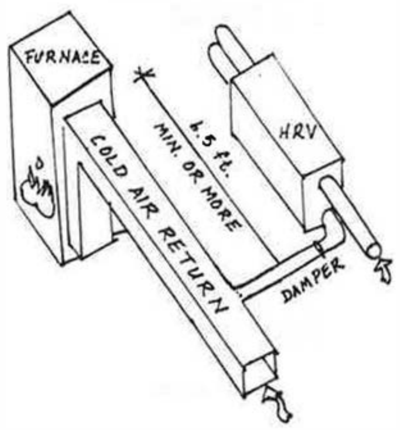
For integrated HRV systems, indirect connection of the ventilation supply air duct to the furnace return air duct is required unless specified and endorsed by the HRV manufacturer.

For an indirect connection, the ventilation air supply duct must have an opening to the house within 12 inches of the inlet into the return air duct. This ventilation air inlet into the return air duct must be at least 6.5 feet away from any oil or gas furnace. The forced-air heating system must be installed with a continuously operating recirculation fan.

Step 4.2
Determine Ventilation Supply Air Design Temperature

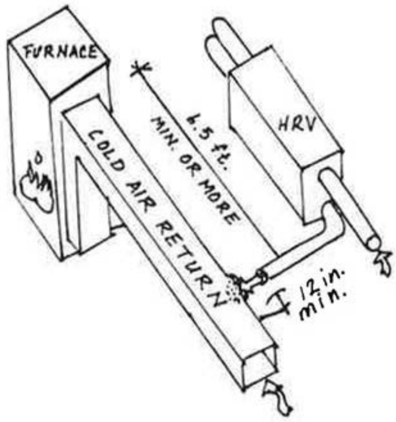
The ventilation air design temperature is the temperature at which the ventilation air is supplied to the house at the 2.5% winter design temperature in the climate in question. The factors which will affect the ventilation air temperature are:

- the outdoor air temperature:
- the effectiveness of the HRV (if one is used);
- the mixing ratios of ventilation air to furnace recirculation air (in integrated systems); and,
- the set point temperature for any duct heaters on the ventilation air supply.



DIRECT CONNECTION

If outdoor air is brought into the house without being tempered, the outdoor design temperature will be the ventilation air design temperature. If ventilation air is introduced to the space through an HRV, the ventilation air design temperature is the temperature of ventilation air as it leaves the HRV (at the outdoor design temperature). The temperature of air leaving an HRV is estimated by using the 2.5 % winter design temperature from Appendix I and Figure D4.1.



INDIRECT CONNECTION

If the ventilation air is mixed with furnace return air, estimating the ventilation air design temperature will require you to calculate the ratio of flow from each air stream at the design condition as follows:

$$VF = \frac{\text{VENTILATION AIR FLOW}}{\text{TOTAL AIR FLOW}} \times 100$$

where

VF	=	percent of total air flow which is ventilation air.
VENTILATION AIR FLOW	=	is the maximum ventilation air flow rate (i.e. includes all air entering the mixed air stream through make-up air fans and vents as well as from HRV or ventilation fans). Use the air flow rate for the ventilation supply air fan operating at high speed.
TOTAL AIR FLOW	=	is the total air flow in the mixed air stream. In a forced air system use the furnace supply air flow with the furnace fan operating at low speed.

To determine the mixed air temperature use the 2.5 % winter design temperature or the temperature of air leaving the HRV as the cold air stream temperature and Figure D4.2.

Record the appropriate Design Ventilation Supply Air Temperature on Worksheet No. 4.

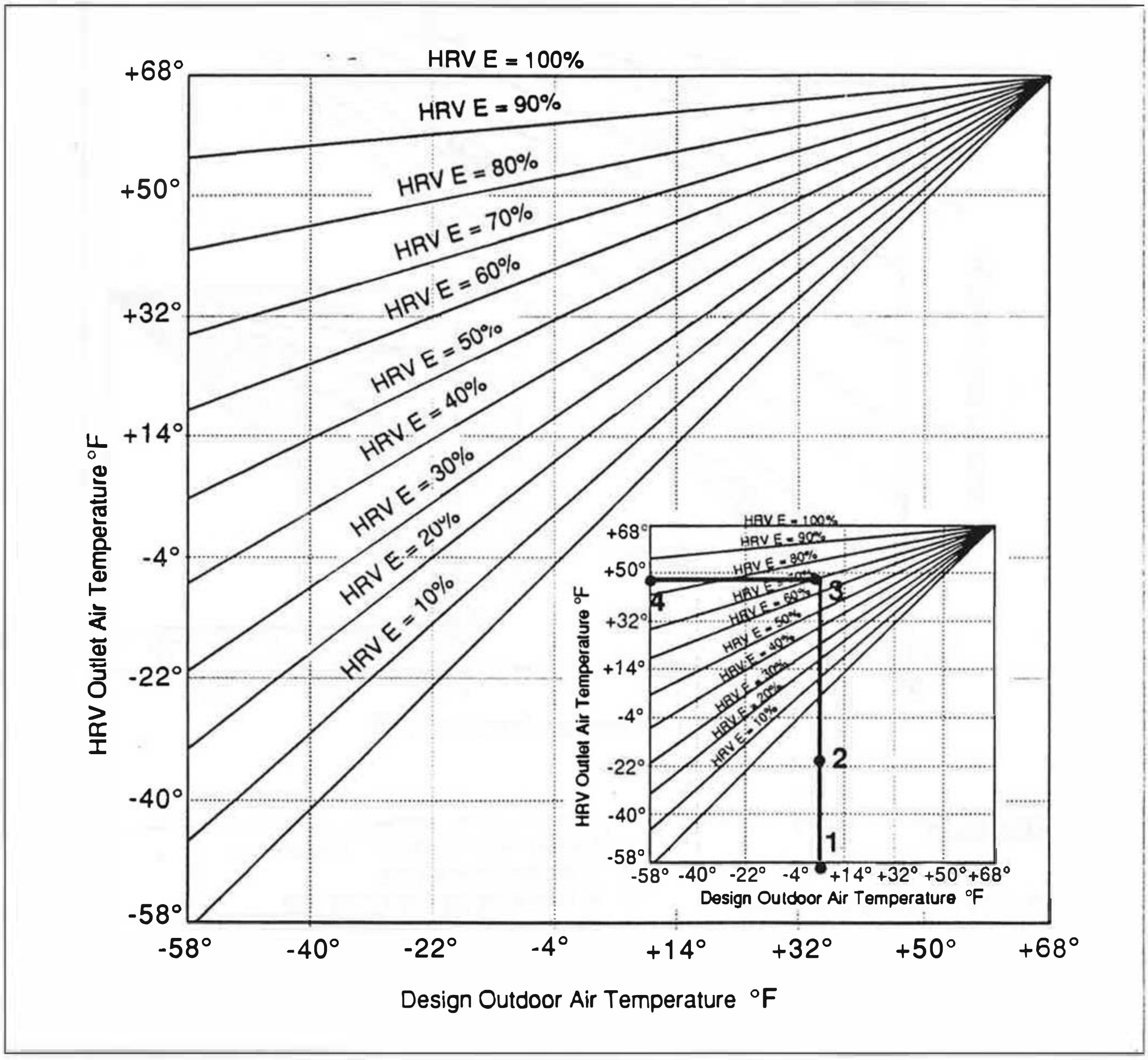


FIGURE D4.1

HRV Outlet Air Temperature Graph

HRV E = Apparent sensible effectiveness for lowest temperature test, from HRV spec. sheet.

1. Start at Design Air Temperature.
2. Draw line vertically up.
3. At HRV E go straight across.
4. Read HRV supply air outlet temperature.

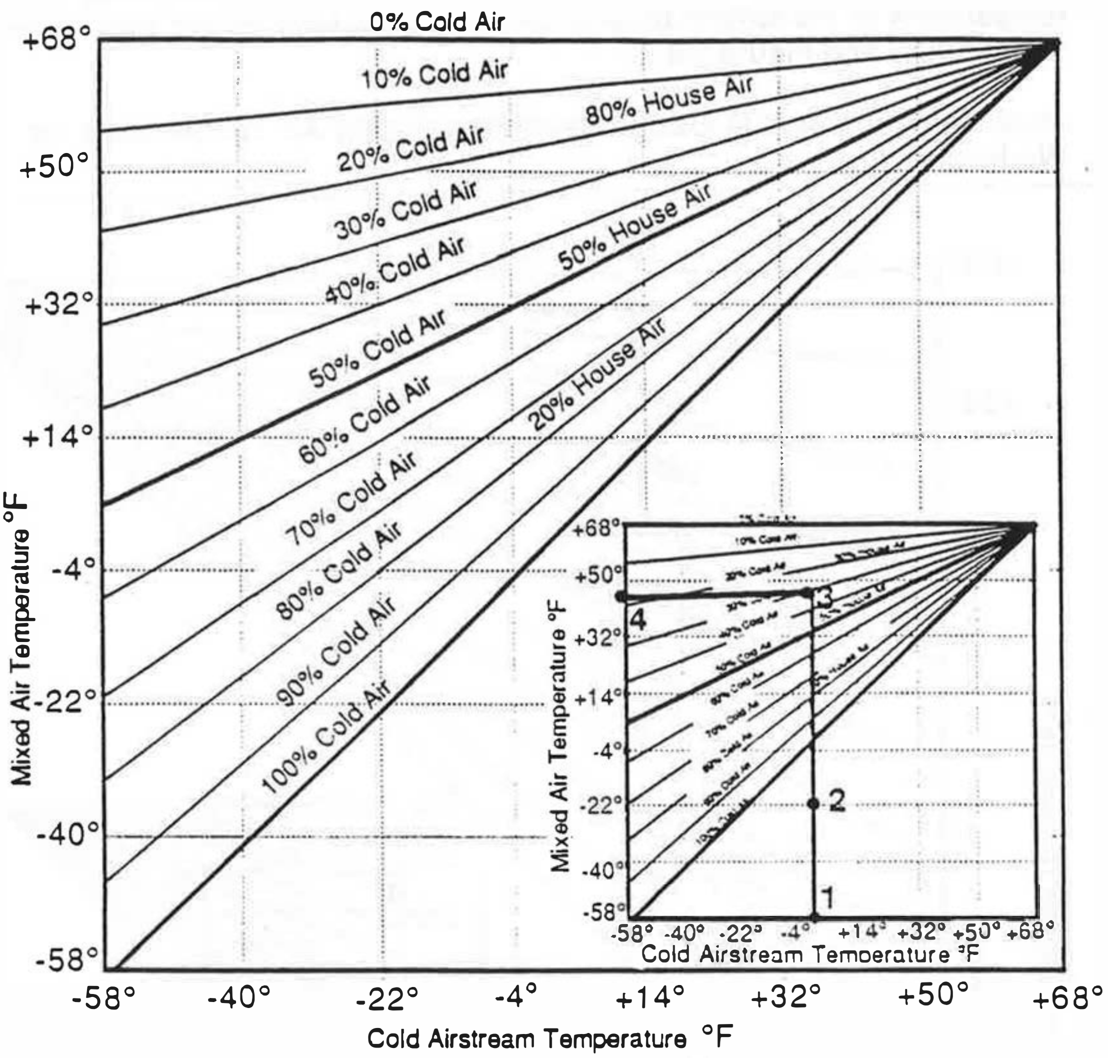


FIGURE D4.2

Mixed Air Temperature Graph

1. Start at Cold Airstream Temperature.
2. Draw line vertically up.
3. At % cold air go straight across.
4. Read mixed air temperature.

Step 4.3
Determine if Ventilation Air Preheating is Required

If the air temperature entering a furnace can fall below 54° F, the air must be preheated or tempered to a higher temperature before it enters the furnace. Size electric preheaters (in watts) using Figure D4.3 or by the following calculation.

.333 x air flow cfm x temperature rise needed °F = preheater size in watts

(1.2 x Air Flow (L/s) x Temperature Rise Needed (°C) =
Preheater Size in Watts)

(Note, for mixed air systems, use the mixed air stream air flow and required temperature rise.)

Infiltration air is assumed to be effectively warmed as it is introduced into a space, and so preheating is not required (fortunately).

FIGURE D4.3
Preheater Size in Watts

Air Flow		Required Temperature Rise					
L/s	cfm	5°C 9°F	1 0°C 1 8°F	20°C 36°F	30°C 54°F	40°C 72°F	50°C 90°F
25	50	150	300	600	900	1200	1 500
50	100	300	600	1200	1 800	2400	3000
75	150	450	900	1800	2700	3600	4500
100	200	600	1200	2400	3600	4800	6000
125	250	750	1500	3000	4500	6000	7500
150	300	900	1800	3600	5400	7200	9000

1 kW = 1000 watts

For air flows greater than those given in Table D4.3, air flows and heater sizes may be added. Table D4.3 can be used primarily as a reference to check the reasonableness of calculated preheater capacity.

Step 4.4
Determine if High-Wall Ceiling Supply Grilles are Recommended

The designer needs to be cautious about how the ventilation air is supplied to the house as it could be well below room temperature. Cooler air can be pre-heated using duct heaters and/or mixed with house air in locations where occupant comfort won't be adversely affected.

If the ventilation supply air design temperature falls below 65°F, it is recommended that it be introduced through high-wall or ceiling outlets which discharge the air horizontally. Both result in improved air mixing at the ceiling before the air drops down into the room. High-wall and ceiling outlets have the disadvantage of requiring additional ductwork which can result in more duct fittings and increased installation costs.

An alternative is to use some form of supplementary heat to raise the ventilation supply air design temperature. Some possible methods are heating the ventilation air with an electric duct heater or hot water coil, installing an HRV (or one with a higher effectiveness) and increasing the portion of return air in the supply air stream.

Step *4.5*
Locate the Supply Air Grilles or Diffusers

For a dedicated ventilation air supply system, the preferred method of supplying ventilation air is through high-wall or ceiling outlets which discharge the air horizontally. In fact, this approach is also recommended for forced air heating systems that are integrated with the ventilation system. When the cooler ventilation air is discharged in this manner, it tends to be warmed as it drops into the occupied areas of the room.

High-wall registers should be located within 6 to 12 inches from the ceiling and should incorporate louvers that project the air slightly upwards and across the ceiling. A long and narrow grille will allow for a better spread across the ceiling. The designer may use air distribution systems that minimize air velocity to reduce drafts in thermally sensitive areas.

Step *4.6*
Proportion the Ventilation Air to Each Outlet
(Dedicated Systems Only)

The ventilation air delivered to a room should reflect the typical number of occupants and the activity level expected in that room. For example, areas of the home used for entertainment or where occupants may smoke should receive a greater portion of the ventilation air than a child's bedroom. In any case, the minimum requirements from Figure D 1.2 must be maintained in each room. Category B rooms may be supplied from other rooms, provided they have continuous exhaust of at least 10 cfm.

Step 4.7
Check Supply Air Flow to Each Room
(Integrated System Only)

Where the ventilation system is integrated with a forced air heating system, the designer has two general alternatives in ensuring proper distribution of the ventilation air. In the first alternative, the supply air to each Category A room in the house is proportioned so as to ensure that the minimum ventilation air flow rates are met.

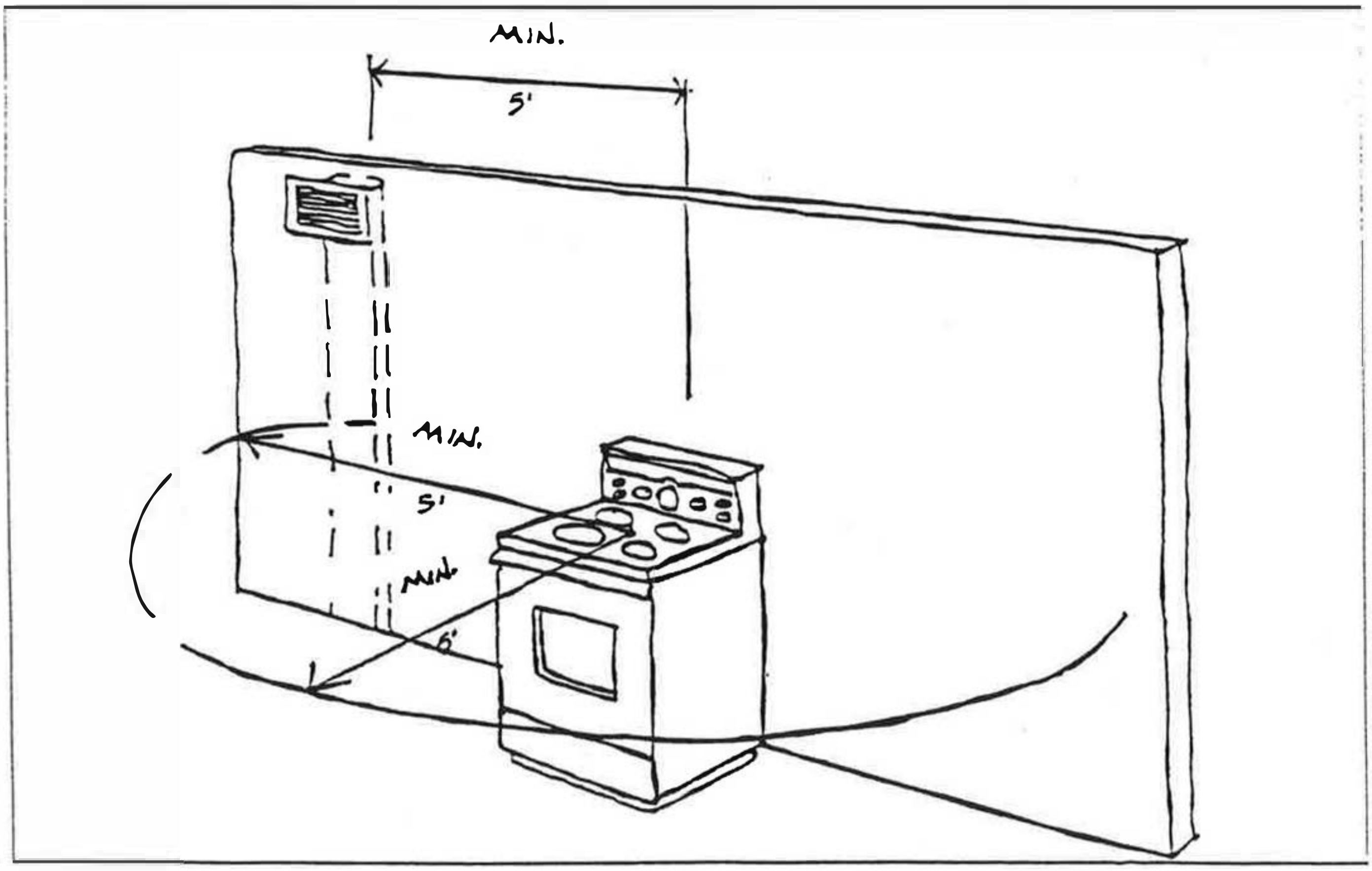
The second alternative acknowledges that cooling or heating loads will most often determine how supply air flows are proportioned around the house. For systems in which the portion of supply air to some rooms is less than that required to ensure the ventilation supply air rates set out in Table D1.2, the forced air system must supply or return at least 40 cfm of air through each Category A room and have an air flow rate of at least 1.0 ACH. If the supply to a room is less than 40 cfm, the combined return and exhaust air flows from that room must be increased to 40 cfm or another method supplying fresh air to that space must be utilized.

Category B rooms must have a minimum continuous supply or removal of 10 cfm. Check room to room air flow requirements and furnace recirculation capacity. Adjust supply and return air flow rates as required to meet the standard and note details on working drawings.

Step 4.8
Locate Exhaust Air Grilles

Exhaust inlets are required in the kitchen and each of the bathrooms. It is also advisable to exhaust from the laundry, as this is a high humidity area.

Exhaust grilles should not be located near ventilation supply air grilles or "short circuiting" may occur. For best air movement, avoid locating supply and exhaust grilles in the same room. Exhaust grilles should be located high on the walls or in the ceiling. Kitchen exhaust may be provided with a range hood or a wall (or ceiling) mounted exhaust grille. A kitchen exhaust grille must be located at least five feet from the center of the range (measured in a horizontal direction). Kitchen exhaust grilles must be equipped with grease filters. Exhaust grilles in the laundry room must be equipped with integral lint filters. Filters must be easily serviceable.



Step 4.9
Proportion Exhaust Air from Each Grille

CSA F326 specifies minimum exhaust flow rates of 100 cfm from the kitchen and 50 cfm from each bathroom if intermittent exhaust operation is used and 60 cfm from kitchen and 30 cfm from bathrooms if continuous exhaust operation is used. The designer has a variety of options available to meet these requirements, and he may choose to use some continuous and some intermittent exhaust air flows.

TASK 5 - SELECTION AND SIZING OF GRILLES

1. Goal

To select and size ventilation supply and exhaust air grilles for the ventilation system.

2. Procedure

Step 5.1
Size the Ventilation Supply Grilles

If the ventilation system for a house is integrated with the furnace recirculation air, supply air grilles will be selected to meet the requirements of the heating system air flows. When selecting grilles for dedicated ventilation systems, it is important to consider factors such as the velocity of air discharging from the grille and the resulting "throw". As air velocity through the grille is increased, pressure drop across the grille increases. As grille size increases, air velocity through the grille is decreased and air mixing (related to discharge velocity and throw) decreases. Discharge velocities between 500 and 800 fpm are typically chosen as the best compromise between pressure drop, noise level, air mixing, and grille size for commercial system type grilles and slot diffusers in residential applications. Commercial type grilles and registers can be adjusted to direct supply air into the room so as to promote good mixing and thus maximize both effectiveness and efficiency of the ventilation system.

Figures D5. 1 and D5.2 illustrate some of the formats for grille data for commercial type grilles and diffusers.

Trying to select "quality" supply air grilles or registers for high-wall or ceiling locations may prove to be a frustrating experience for the designer of dedicated ventilation systems because air flow rates are so low. The designer may be further frustrated in attempts to acquire reliable pressure drop or equivalent length data for a particular grille design. However, "hi-tech" grilles for low-volume ventilation systems are beginning to appear in the market. The availability of such components will undoubtedly improve as popularity of residential ventilation systems grows.

FIGURE D5.1

Typical Formats for Commercial Grille Data

Jet Velocity fpm		400	600	800	1000	1200
Size Area	Total Pressure	009	020	036	057	083
1 1/2"	Flow CFM/Ft	16	23	31	39	47
039	Side Wall Throw Ft	2.4.6	4.7.10	6.10.14	8.13.18	9.14.20
2"	Flow CFM/Ft	22	34	45	56	67
056	Side Wall Throw Ft	3.5.7	5.8.12	7.11.16	9.14.20	11.17.23
2 1/2"	Flow CFM/Ft	30	45	60	75	90
075	Side Wall Throw Ft	4.6.8	6.9.13	8.12.17	11.16.21	13.19.25
3"	Flow CFM/Ft	37	56	74	93	117
093	Side Wall Throw Ft	4.6.9	7.10.14	10.13.18	12.17.22	15.20.26

FIGURE D5.2

Grille Size (in x in)	Area Factors (Free Area)	Neck Area (ft^2)	Outlet Velocity	400	600	800	1000	1200
			Velocity Pressure	.002	.004	.007	.010	.015
			Total Pressure	.010	.025	.039	.065	.100
9 x 6	.16	.375	CFM	64	92	128	160	192
			Throw	2-3-6	4-5-10	6-7-13	8-11-14	10-14-23
12 x 6	.21	.500	CFM	84	126	168	210	252
			Throw	4-5-9	6-7-14	8-10-18	10-15-24	12-17-27
18 x 6	.32	.750	CFM	128	192	256	320	384
			Throw	4-6-11	7-10-20	10-14-23	13-18-30	15-20-34

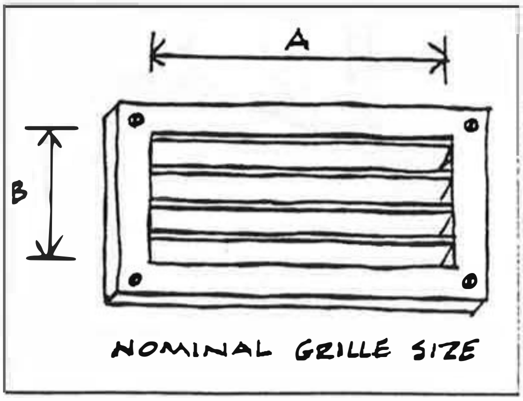
Throw Data is based on Terminal Velocities of 150 fpm, 100 fpm and 50 fpm respectively.

Usually, the designer will be selecting pressed steel or plastic grilles, without the benefit of detailed performance data. For these types of grilles, discharge velocities should be kept below 500 fpm. Sizing this type of grille involves selecting a grille with a free area large enough to avoid discharge velocities above 500 fpm. Figure D5.3 illustrates the relationship between grille size, free area and maximum air flows for common grille sizes.

Record grille size and type on the ventilation system drawings and Worksheet 5.

FIGURE D5.3
Pressed Steel Grille and Plastic Data

Nominal Grille Size (Inches)	Free Area (sq. in.)	Maximum Air Flow L/s	cfm
8 x 6	24	39	83
10 x 4	20	33	69
10 x 6	30	49	104
12 x 6	40	65	137
14 x 6	46	76	160
14 x 8	62	101	214
15 x 10	83	136	289
24 x 6	80	131	278
24 x 8	105	172	365



Step 5.2
Size the Exhaust Grilles

Size exhaust air grilles based on a maximum velocity of 2.5 m/s (500 fpm) through the "free area", of the grille using Figure D5.3. Record grille sizes on the ventilation system drawings and Worksheet 5.

Step 5.3
Determine Door Undercut Requirements

If a room does not have both a supply and an exhaust or return air grille, (i.e. ventilation supply and the return or exhaust are in different rooms), the air flow pathway must always be open. Air flow through doors can be ensured by installing a grille in the door (sized using Figure D5.3) or by undercutting the door. Figure D5.4 has door undercut requirements for various air flows. The door undercut must be above the finished floor level (including carpet, underlay and carpet edgers) when the door is closed. Record door undercut requirements on the drawings and Worksheet 5.

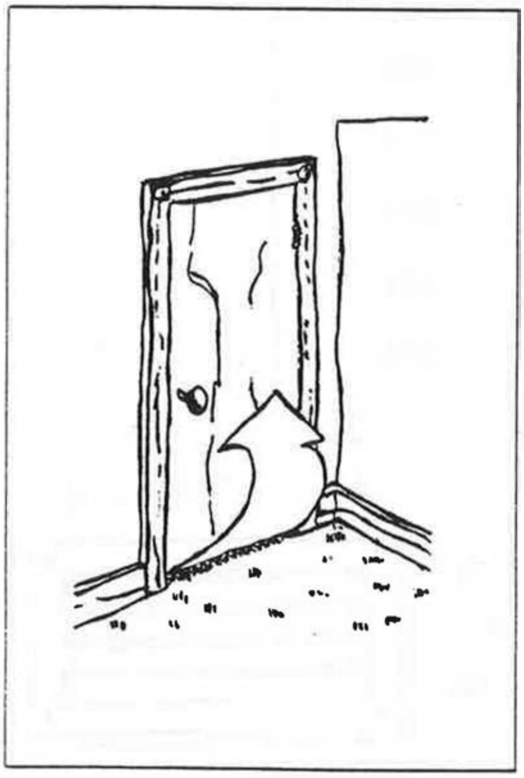


FIGURE D5.4

Door Undercut Data

Maximum Air Flow		Minimum Undercut	
L/s	cfm	mm	inches
15	30	13	1/2
30	60	20	3/4
45	90	25	1
60	120	32	1 1/4

TASK 6 - SELECT VENTILATION EQUIPMENT

1. Goal

To select ventilators that will satisfy the ventilation and exhaust requirements for the house plan.

2. Procedure

Step 6.1
Make "First-Cut" Ventilation Equipment Selections

Select ventilation equipment with the capacity to meet the design air flow rates designated for the ventilation systems. Often the designer will be designing the ventilation systems around specific equipment. In this case, he must confirm that the preselected equipment has CSA certification and that it will do the job. Normally, the ventilation equipment will consist of one or more of the following equipment types:

1. Fresh air intake into a furnace return.
2. Fans (intake, exhaust, range hoods, etc.).
3. HRVs.

In order to select ventilation equipment, the designer requires performance data for the ventilation equipment (i.e. air flow/pressure drop data and noise level ratings). All ventilation system equipment used must be CSA approved for the intended use. HVI or CSA certification of performance data for fans and ventilators ensures the designer or installer that the equipment has been tested to a standard. The air flows quoted for certified fans can confidently be used in system design. If ESPs are not given, assume the certified test data is for an ESP of 0.1" (25 Pa).

The performance of the rangehoods and exhaust fans typically installed in new housing is often defined by a single air flow rate. Unless otherwise stated in product literature, it can be assumed that the air flow rate quoted is for an External Static Pressure (ESP) of 0.1 " (25 Pa) at the fan box outlet with the fan operating at its highest speed. Performance data for some ventilation equipment will be presented in a graphical or a tabular form. Figures D6.4 and D6.5 illustrate some common formats for ventilation equipment performance data.

HRV SPECIFICATION SHEET

Testing Agency: ______________________
Date Tested: ______________________
Manufacturer: ______________________
Address: ______________________
____
Telephone: ______________________

Model: Blowhard B
Serial Number: B 123456
Options Installed: ______________________
____
____
Electrical Requirements: ________ Volts ________ Amps

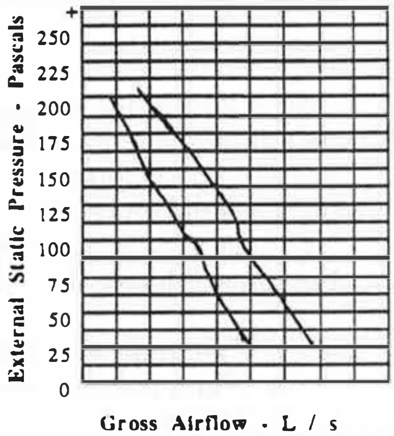
VENTILATION PERFORMANCE

Maximum Continuous Rated Airflows:
_____ L / s @ _____ C
_____ L / s @ _____ C

Airflow Range for Multispeed Units:
High Speed: 114 L/s Low Speed: 40 L/s

Lowest Temperature Unit Tested To: -25 C
Low Temperature Ventilation Reduction During -25 C Test: 8%
Maximum Unbalanced Airflow During -25 C Test: 29 L/s
Exhaust Air Transfer Ratio: .03

External Static Pressure		Net Supply Air Flow		Gross Air Flow			
				Supply		Exhaust	
Pa	in. W.G.	L/s	cfm	L/s	cfm	L/s	cfm
25	.1	113	240	117	248	100	212
50	.2	108	228	112	237	93	198
75	.3	100	213	104	220	89	188
100	.4	94	200	98	207	82	175
150	.6	84	178	86	183	69	147
200	.8	64	135	66	140	56	118



ENERGY PERFORMANCE

		Supply Temperature		Net Airflow		Supply / Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
		oC	oF	L/s	cfm					
HEATING	i	0		40		1		84	102	
	ii	0		60		1		82	94	
	iii	0		80		1		81	90	
	iv	0		100		1		82***		
	v	-25		60		.96		61	75	
	vi	-25		70				59***		
COOLING	vii	35		72		.99		28**		
	viii	35		51		.99		26*		

*Description of Defrost;

Comments from Test Agency:

** Indicates Total Recovery Efficiency, not Sensible Recovery Efficiency.
+ 250 Pascals = 1" of Water: 0.47 L/s = 1 cfm.
*** Calculated for R2000 Home Program Rating Purposes.

ORTECH Reference Report:

Testing was performed in general accordance with CAN/CSA - C439 - 88, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators and was conducted in accordance with normal professional standards. Neither the ORTECH International nor their employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission. Specification Sheet format revised September, 1988.

For systems incorporating HRVs, the HRV Design Specification Sheets are an excellent source of design information for performance, cross leakage, and heat recovery efficiency. HRV Design Specification Sheets are available from equipment suppliers for all HRVs approved for use under CSA F326. Figure D6.1 shows an example of an HRV Design Specification Sheet. For design purposes, refer to the "Net Supply Air Flow" column on the HRV Design Specification Sheet to determine whether the HRV can meet the required ventilation rates. HRVs must be equipped with an automatic, self defrosting means, if air flow restrictions due to icing in the unit may occur. Appendix II contains a guide on how to read and use the data sheets.

Test data may refer to noise levels. Noise levels may be measured in dB (decibels), dBA (absolute decibels) or sones. dB and dBA are measurements of the energy in the sound. When comparing fans rated in dB or dBA, use the following guide:

a 3 dB change is just noticeable
a 5 dB change is clearly noticeable
a 10 dB change sounds twice (or half) as loud.

The higher the rating, the louder the fan.

Residential ventilation equipment noise levels are more often rated in sones. Sones are an indication of the noise level as heard by the ear. The relationship between sones and what the ear perceives is linear. One sone is equivalent to a quiet running refrigerator. If the sone rating doubles, so does the apparent noise level of the equipment. A very quiet fan will have a sone rating under 2.0. Noisy fans have sone ratings above 6.0.

In addition to the sound rating of a fan, the fan's location in the house (relative to quiet areas), the installation or mounting method used, the fan's frequency of operation and the background noise levels in the house (e.g. street noise, other equipment) will affect the occupants' perception of whether the fan is quiet or noisy.

Step 6.2
Size Fresh Air Intake to Furnace Return

One of the simplest and least costly methods of supplying ventilation air to a house with a forced air system is with a fresh air intake connected into the recirculation air return duct. The negative pressure on the upstream (i.e. return) side of the recirculation air fan is utilized to draw outdoor air into the recirculation air duct, thus eliminating the need for an additional fan in the system. The recirculating fan must run continuously to ensure that ventilation is maintained.

If a two speed forced air recirculation fan is used, the system must be designed so that the base ventilation rate requirements are met when the fan runs at low speed (and when return duct suction is at its lowest) and the air flow imbalance limits are not exceeded when the recirculation fan operates at high speed.

FIGURE D6.3

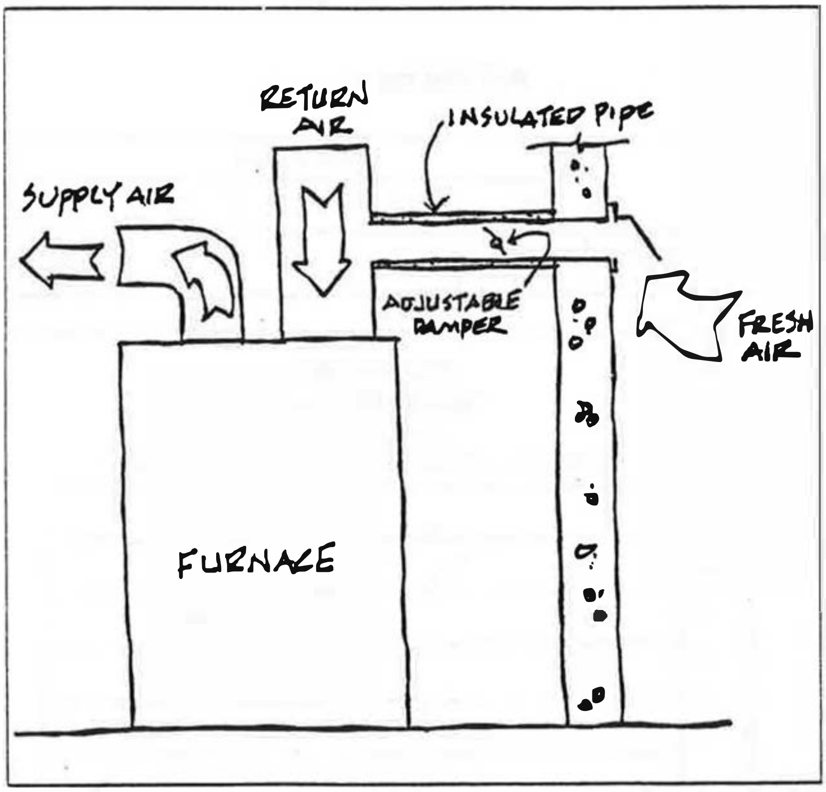
Sizing Data for Fresh Air Intake

Fresh Air Intake Duct Diameter		Design Static Pressure in Furnace Return Air Duct			
		more than 0.05" 12 Pa		more than 0.10" 25 Pa	
mm	inches	L/s	cfm	L/s	cfm
100	4	20	40	30	60
125	5	35	70	55	110
150	6	60	120	90	190
175	7	90	175	130	270
200	8	120	250		

If duct is longer than 15' or has more than one fitting (other than intake hood, balancing damper and duct heater) increase diameter one inch.

Because the suction on the return side of recirculation fans is usually low (0.05 to 0.10 inches Wg or 12 - 25 Pa) it is important for the fresh air intake to be short and straight. In most cases, it will be made of insulated flex duct. Figure 6.3, the sizing chart for fresh air intakes is based on a fresh air intake less than 15 feet long with not more than one fitting (other than the intake hood, balancing damper and duct heater—if required).

Record the diameter of the fresh air intake on Worksheet 6A and on working drawings.



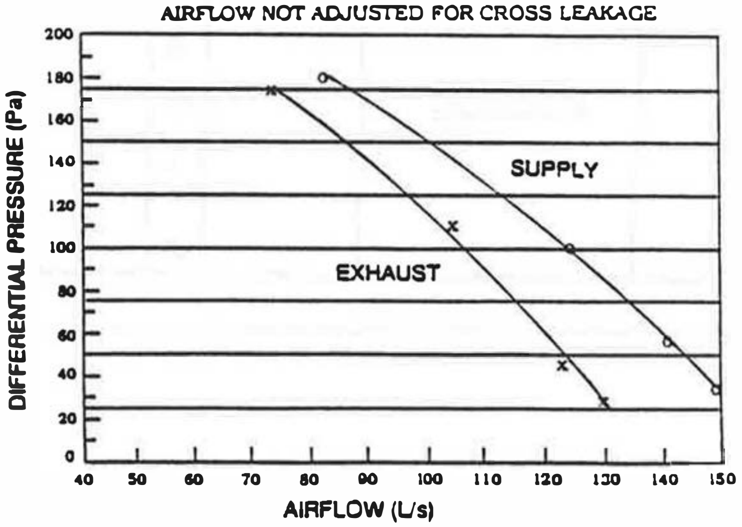
Step 6.3
(Non HRV Systems) Establish the External Static Pressures (ESP) for Ventilator Fans

External static pressure (ESP) is the air pressure rise between the inlet and outlet ports of the ventilator. The ESP represents the force (air pressure) which is available to push or pull air through the system ductwork after the internal resistances of the fan casings, heat exchange core and possibly filters are overcome. The ESP of an installed ventilator is the pressure drop in the ventilation system ductwork. Referring to the fan performance data in Figure D6.4 or D6.5, it can be seen that, for a given ventilator, air flow decreases as ESP increases.

FIGURE D6.4

	ESP in. WG				
	0.1	0.2	0.3	0.4	0.5
Air Flow cfm	150	140	120	80	30

FIGURE D6.5
Typical Fan Curve
AIRFLOW TEST
AIRFLOW NOT ADJUSTED FOR CROSS LEAKAGE



For a given fan, increasing ductwork restrictions will increase the ESP and decrease air flow rates. Typical operating ESPs for residential ventilation systems range from as low as 0.03 in w.g. (7.5 Pa) for through the wall exhaust systems to 0.6 in. w.g. (150 Pa) for long fully ducted central systems.

The designer must have information about the ventilator's air flow performance from either the manufacturer's literature or from independent fan test lab results in order to do the system design. With combined supply/exhaust ventilator units (e.g. HRVs), performance information should be available for both the exhaust and ventilation supply fans. It is important that the performance data for the ventilator be for the complete unit rather than merely for the fan itself.

The duct design flow rate for a standard ventilation fan is the peak air flow rate which is to be handled by that fan. The ventilator's ESP at the duct design flow rate is used to determine duct sizes for the air distribution system. Record the ESP at the design flow rate for each ventilation fan in the house (except for HRV fans).

Circumstances may dictate that the designer lay out and size the ductwork before final ventilator selection has been made, or before ESP data has been obtained from the manufacturer. In this case, it is suggested that the designer assume the external static pressure for both the supply and exhaust fans is 0.10 inches for through the wall systems, 0.25 in. WG in small central systems and 0.45 inches in large central systems.

Record fan data on Worksheet 6B.

Step 6.4
(HRVs only)
Determine Low Temperature Adjustment Factor (LTAF)

Many HRVs cannot maintain constant air flow rates during cold weather because of frosting in the heat exchange core and because of the operation of the HRV defrost cycle. Therefore air flow rates must be increased during cold weather to ensure that, on average, the minimum continuous ventilation requirement is maintained.

The Low Temperature Ventilation Reduction Factor reported on the HRV Design Specification Sheets is the percentage reduction in air flow rates when the HRV is tested to CSA Standard C439-M, "Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators."

Using Figure D6.6, the Temperature Zone Map, determine the temperature zone for the design location. Using this temperature zone and the Low Temperature Reduction during the lowest temperature test from the HRV spec sheet, use Figure D6.7 to find the Low Temperature Adjustment Factor.

Example:

From HRV Design Specification sheet the
Low Temperature Ventilation Reduction During
Lowest Temperature Test = 19%

Location: Dauphin, Manitoba - Temperature Zone 4

Low Temp Adjustment Factor (LTAF) = 1.2

FIGURE D6.6 TEMPERATURE ZONES

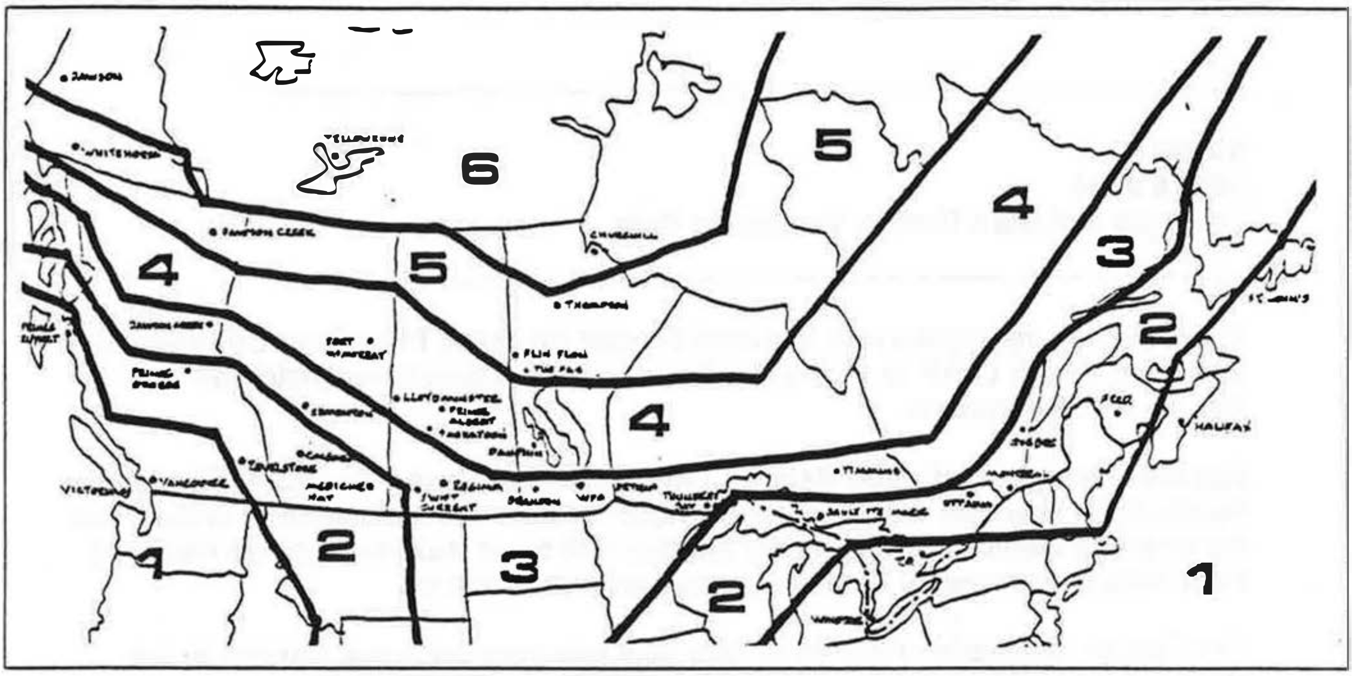


FIGURE D6.7

Low Temperature Adjustment Factors (LTAF)

Low Temperature Ventilation Reduction	Temperature Zone					
	1	2	3	4	5	6
10 %	NCR	NCR	NCR	1.1	1.1	1.1
15 %	NCR	NCR	1.1	1.1	1.1	1.2
20 %	NCR	1.1	1.1	1.2	1.2	1.3
25 %	NCR	1.1	1.1	1.2	1.3	1.4
30 %	NCR	1.1	1.2	1.3	1.4	1.5
35 %	NCR	1.1	1.2	1.3	1.5	1.6
40 %	NCR	1.1	1.2	1.4	1.6	1.8
45 %	NCR	1.1	1.3	1.4	1.7	2.0
50 %	NCR	1.1	1.3	1.5	1.8	2.1

NCR - No Correction Required

Step 6.5
(HRVs only)
Calculate Adjusted Design Ventilation Rate

The minimum ventilation rate required to meet the Base Flow Rate Condition is multiplied by the LTAF to determine the minimum required ventilation air flow rate for an HRV system.

Adjusted Design Ventilation Rate = LTAF x Minimum Base Flow Rate. This is the minimum air flow rate that must be provided by the HRV ventilators to ensure that the average ventilation rate in cold weather will be at least as large as the Base Flow Rate requirements. Enter this value on Worksheet 6C.

The Design Ventilation Rate must also take into account cross leakage in the HRV. Cross leakage occurs when air being exhausted from the house leaks into the supply air stream (or vice versa). The Net Supply Air Flow given on the HRV spec sheet has already been adjusted for cross leakage. This is the amount of ventilation air being supplied at a given E.S.P. The total amount of air being moved through the ductwork is represented by the Gross Air Flow column.

To summarize:

1. When determining HRV supply fan ESP, use the Adjusted Design Ventilation Rate as calculated above, and the Net Supply Air Flow from the HRV spec sheet.

2. When determining the air flow in the ductwork use the corresponding Gross Air Flow for the supply fan from the HRV spec sheet.

Step 6.6 - (HRVs only)
Determine Duct Design Air Flows

Air-to-air HRV systems must be designed for balanced air flows.

The duct sizing is performed based on the maximum or peak air flows that will flow through the system. The designer may wish to use higher air flow rates than the minimum required for the house. For example, if the minimum required exhaust capability exceeds the ventilation air supply design flow rate for the house, it may be necessary to increase the ventilation air supply design flow rate above this minimum to maintain balance in the ventilation system.

An alternative to increasing the supply duct design flow rate of a central ventilation system may be to decrease the exhaust flow rate to a level which matches the minimum adjusted design supply rate (thus to maintain a balance in the central system) and to meet the total minimum exhaust flow requirement by installing intermittent, point exhausts (e.g. a kitchen range hood). If this is done make sure that the air flow imbalance limitations of Task 3 are not violated.

The duct design air flow rate for a balanced HRV system is the greater of:

a) the design ventilation air flow rate adjusted for LTAF and cross leakage, as calculated in Step 6.5 and;

b) the total exhaust flow to be met by the HRV.

Step 6.7
Establish the ESP for the HRV Fans

Using the design air flows determined in Step 6.5 refer to the HRV Design Specification Sheet to establish the ESP for each fan. Record these data on Worksheet 6C.

Step 6.8
Modify Room to Room Air Flows

If the ventilation air supply flow rate has been increased above those rates used in Task 4 and Task 5 it will be necessary to check the calculations in those steps including ventilation supply air temperatures, preheater sizing, grille sizing and air flows to or from rooms.

TASK 7 - LAYOUT SYSTEM

1. **Goal**
   To locate the ventilation equipment and all the ventilation system duct-work, including fittings, on the house floor plan.

2. **Procedure**

Step 7.1
Choose Locations for Ventilation Equipment

The ventilation equipment should be centrally located in relation to the house ventilation ductwork in order to minimize excessively long duct runs and to reduce the need for considerable numbers of fittings, elbows, etc. Allow easy access for servicing and maintenance. Avoid locating the ventilators under bedrooms or other quiet areas in the house to minimize the impact of any fan noise or vibration. The design effort is immediately negated if the system is switched off by the occupant due to unacceptable noise levels.

Cold air ducts in heated spaces and warm air ducts in unheated spaces must be insulated. This is commonly done with pre-insulated flex duct. Figure D7. 1 contains the minimum required insulation levels for insulated ducts. The designer should locate ventilators and HRVs as close as possible to the exhaust air outlet and ventilation air supply hoods so as to minimize duct insulation requirements. HRVs should be located in close proximity to a drain and an electrical outlet.

FIGURE D7.1
Required Insulation Levels for Ventilation Air Ducts

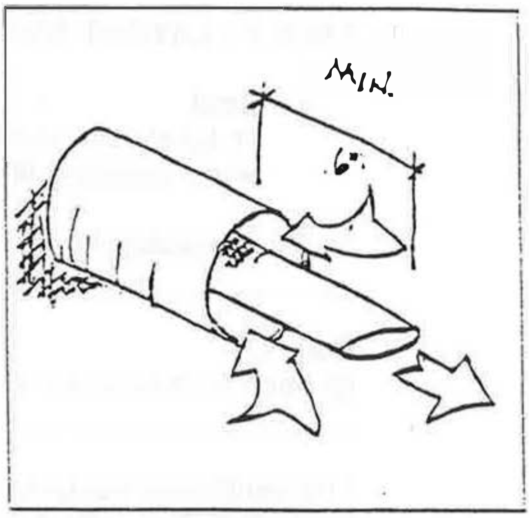
SITUATION	(R)
Cold Air Ducts in Heated Spaces	(4)
Exhaust Air Ducts in Unheated Spaces	(3)
Supply and Return Air Ducts in Unheated Spaces	
Outdoor Temperature (°F)	
19 to 12	(3)
10 to 1	(5)
0 to -11	(7)
-13 to -20	(8)
-22 to - 29	(10)
-31 or colder	(12)

Step 7.2
Locate Ventilation Air Intakes and Exhaust Outlets

If separate exterior ventilation supply and exhaust hoods are installed, they should be located at least six feet apart to prevent contamination of the ventilation supply air by exhaust.

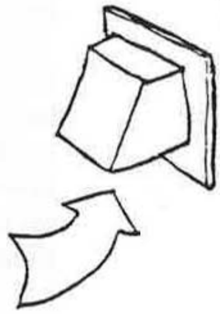
If concentric intake and exhaust tubes are utilized, the exhaust nozzel must be located inside the intake duct and extend at least six inches beyond the rim of the air intake. The exhaust nozzel should be sized for outlet velocities of 1000 fpm or more.

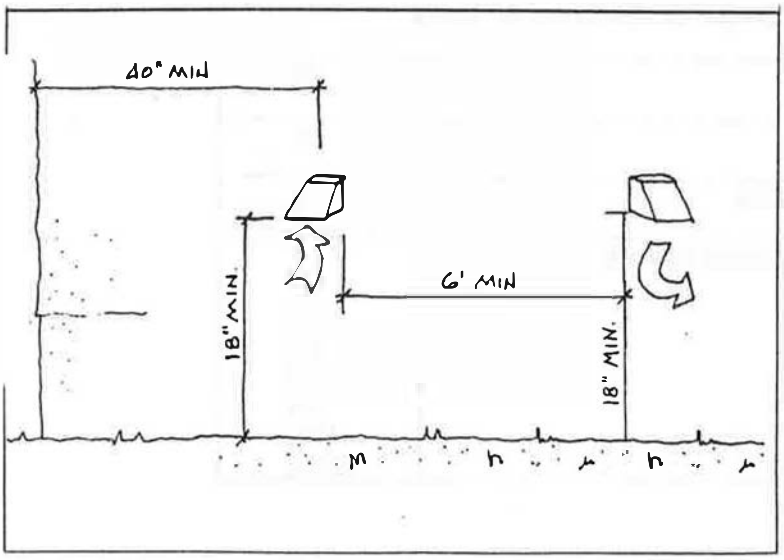
Ventilation air intakes should not be located near drive-ways, parking lots, exhaust hoods for dryers, high-efficiency furnace flues, gas meters and oil fill pipes. Ventilation air intake hoods must be located at least 18 inches above grade (and other nearby horizontal surfaces) and the exhaust hood must be located at least eight inches above grade.

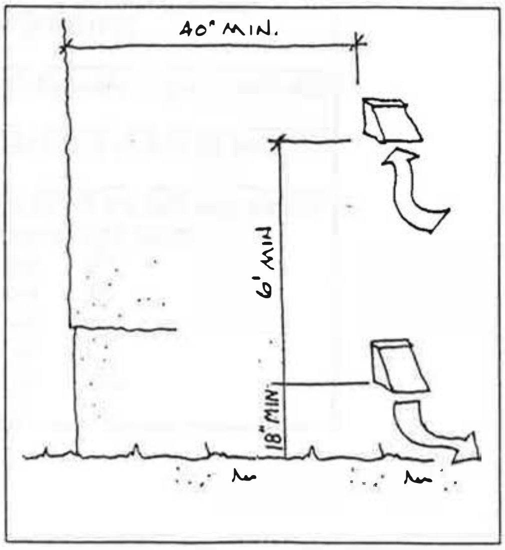


AREAS TO AVOID WHEN LOCATING FRESH AIR SUPPLY INLET

Gas Meters
Driveways
Garages
Dryer Vents
Exhaust Air Vent
Gas Furance Vent
Oil Fill Pipe
Garage Containers
Corners
Snow Build-up
Attics
Crawlspaces





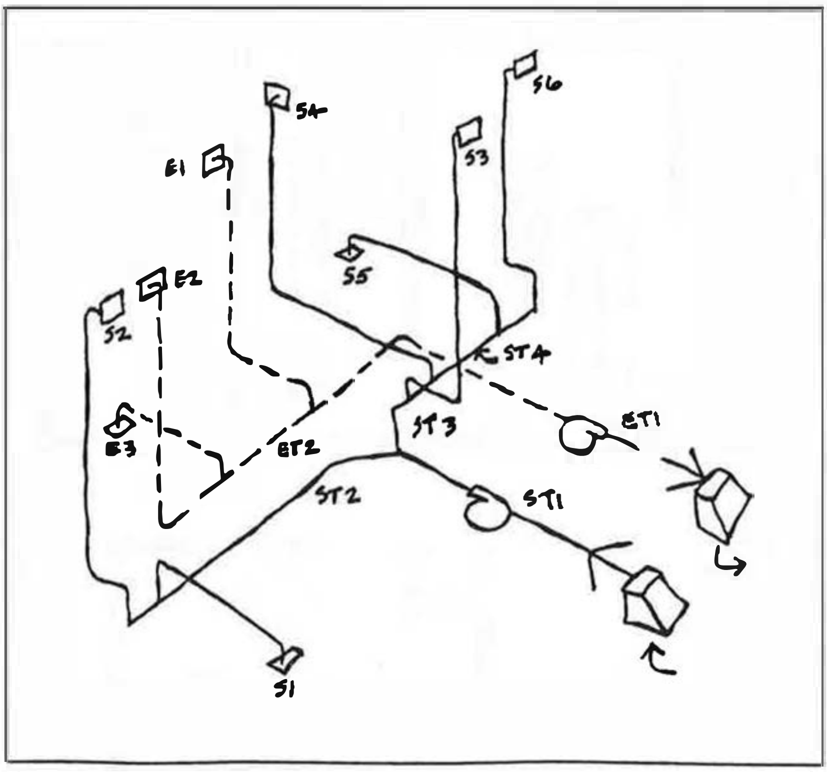


In cold climates the exhaust should not discharge over a walkway, as moisture condensing out of the exhaust air stream may cause icing on the walk.

Note: In the bottom two figures the 40" Minimum (1 m) dimension is from the hood to the corner of the house.

Step 7.3
Lay Out Ductwork

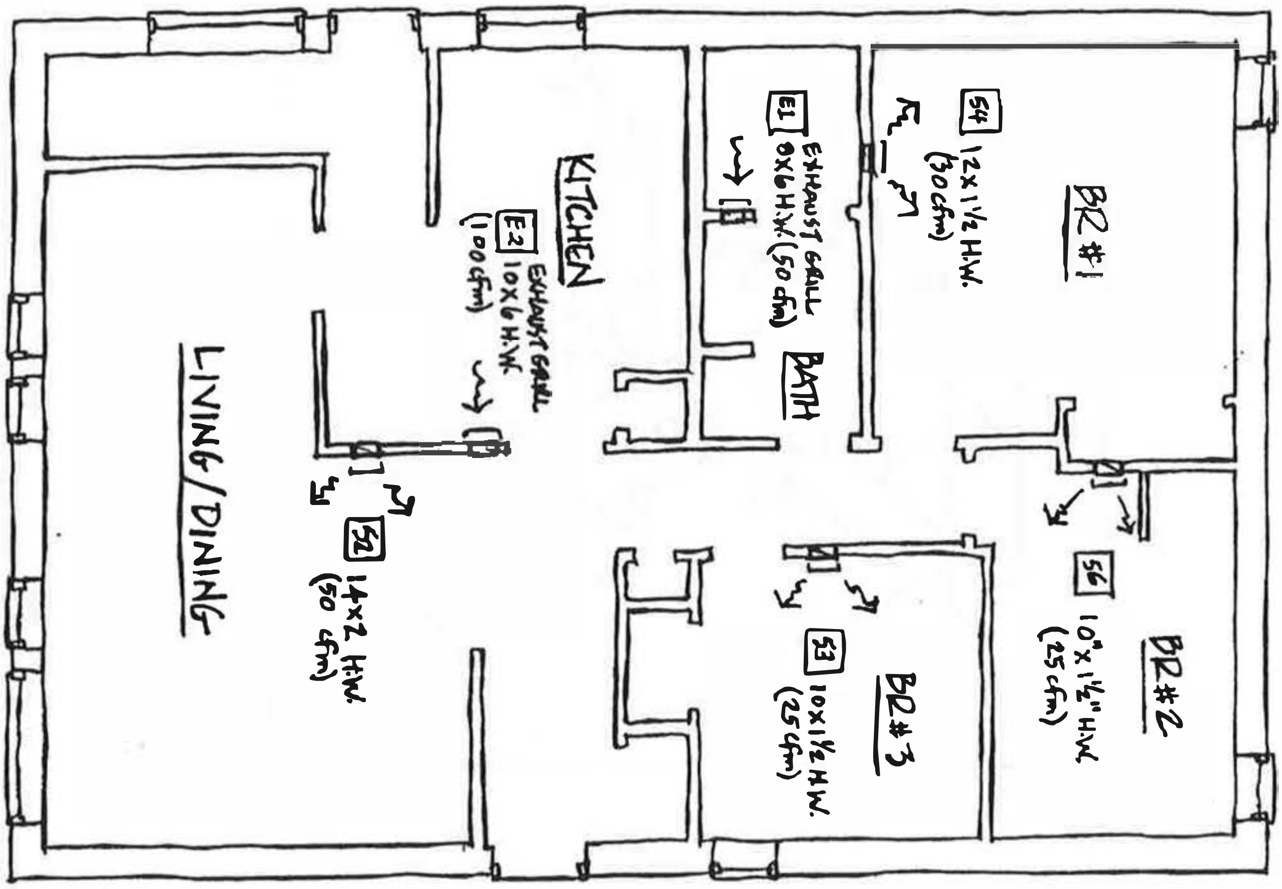
Lay out all branch ducts and trunk ducts to scale on the house plan. Indicate all risers, elbows and fittings. Where a plan view of the ductwork will not clearly show the fittings used, draw a sectional or perspective view. All branch ducts must be equipped with balancing dampers. These should be located as near to the ventilator as is practical. As well, a method of adjusting total air flow is required for all continuously operating ventilators.

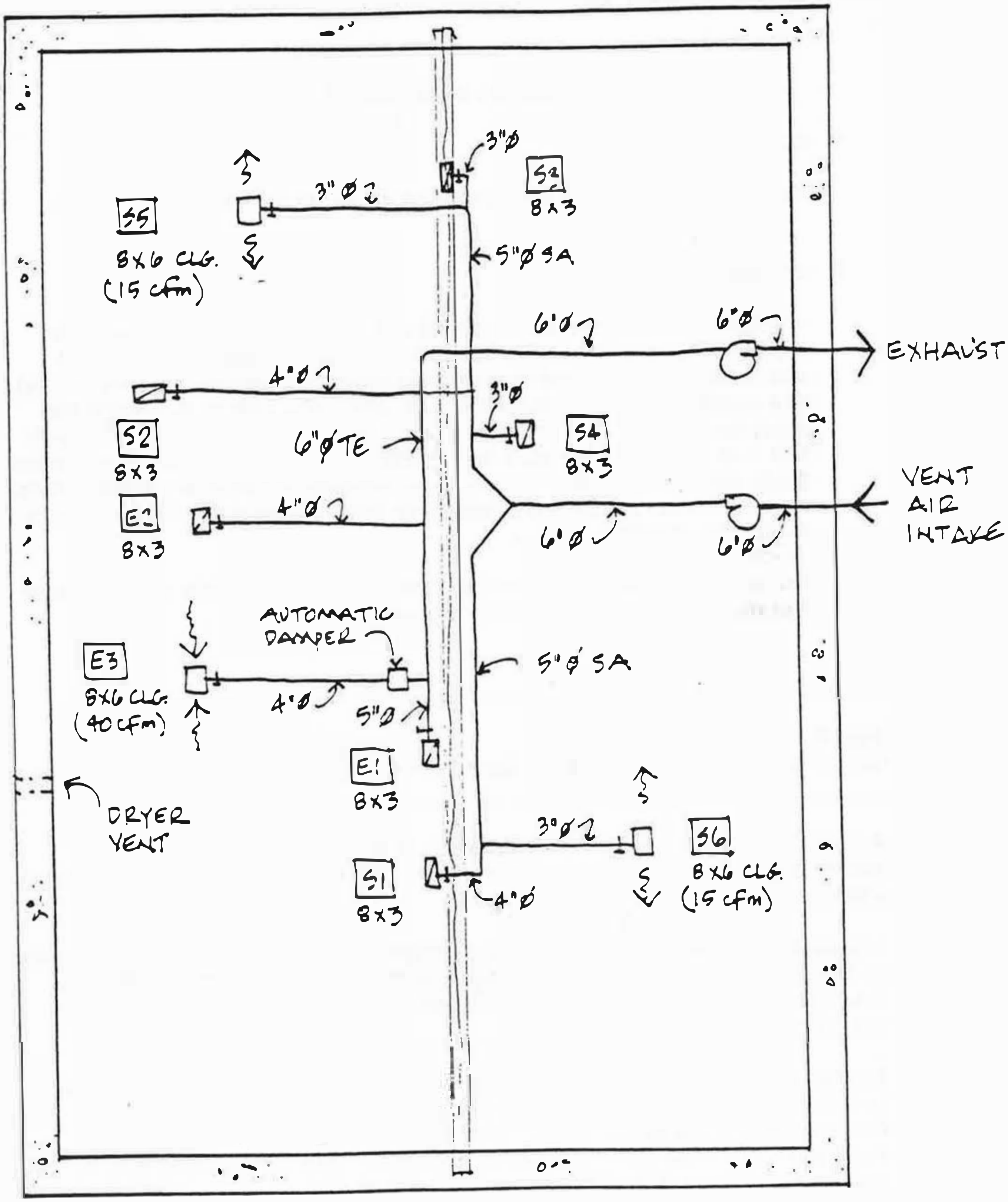


Air flow capacity of a ventilator is influenced by two things - duct size and equivalent duct length. The design of the ventilation system should reflect the designer's efforts to minimize the length of ductwork and the number of fittings in the system. Not only will this approach maximize air flows or minimize pressure losses within the distribution system but it will also reduce system installation costs. Ducts should be smooth, straight and short. Although flexible ducts have some advantages in terms of ease of installation, the air pressure drop in them is high, typically double the pressure drops of sheet metal ducts. They should only be used where absolutely necessary.

Step 7.4
Label Trunk and Branch Ducts

Identify all ventilation air outlets (e.g. VI, V2, V3) and all exhaust inlets (e.g., El, E2, E3) as well as all trunk duct sections (e.g., VT-A, ET-A) on the plan. This identification will be used to identify specific duct runs in Task 8 "Size Ducts".





3"Ø
S3
8x3
S5
8x6 CLG.
(15 cfm)
3" Ø
5"Ø SA
6"Ø
6"Ø
EXHAUST
4"Ø
3"Ø
S2
8x3
6"Ø TE
S4
8x3
VENT
AIR
INTAKE
E2
8x3
4"Ø
6"Ø
6"Ø
AUTOMATIC
DAMPER
E3
8x6 CLG.
(40 cfm)
5"Ø SA
4"Ø
5"Ø
E1
8x3
DRYER
VENT
3"Ø
S6
8x6 CLG.
(15 cfm)
S1
8x3
4"Ø

TASK 8 - SIZE DUCTS

1. Goal

To determine the minimum size for each duct in the ventilation system.

2. Procedure

There are a number of detailed methods to size ductwork for ventilation systems. However, the time required to use these detailed methods is extensive (typically a half day for an experienced user on a typical house). The simplified method presented here allows the user to size ductwork using fan ESP, air flow in the duct and a count of the number of fittings in that duct run. In some cases the simplified method may result in oversized ducts, but the benefits in terms of time savings and ease of understanding and application (which will mean fewer errors) justifies its use for most residential applications.

For very large residential and for commercial systems, it is recommended that detailed design methods be applied.

Step 8.1
Determine Air Flow through Each Duct Section

A trunk duct is a duct run which supplies to, or exhausts from, two or more branch ducts. Branch ducts are ducts which carry air flow between a trunk duct and a single grille.

The design air flow rate in each trunk duct section is found by adding the design air flow rates of all the branch ducts serviced by that section of the trunk duct. Record duct flow rates on Worksheet 8 and on the duct layout drawing beside the appropriate duct.

It is possible to reduce a trunk duct run into shorter sections, one between each branch line takeoff, and thus reduce the size of a trunk duct along its length. However, this is not always done as it complicates both the design and the installation, and trunk duct runs are usually quite short. Remember, adding reducers will increase the fitting count for the duct run.

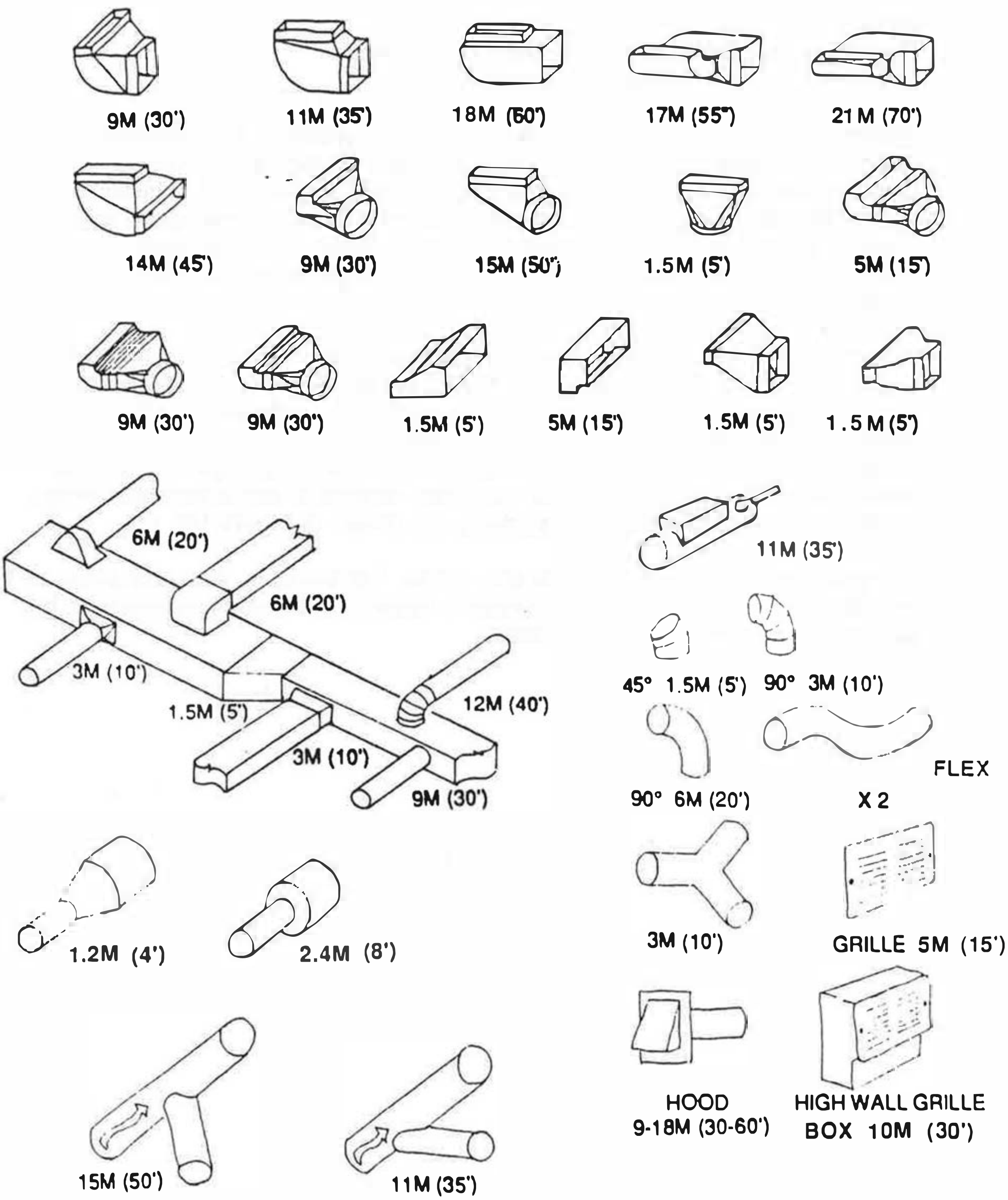
Step 8.2
Determine Number of Fittings in Each Duct Run

Starting at the grille and working through to the outside hood, count fittings for each branch duct run. The fitting count for a branch duct will include all fittings from the outside hood to the grille or diffuser at the top end of that branch (i.e. every fitting that air going through that grille must pass). Worksheet 8 should be used to record the number of fittings in each duct run. For trunk ducts, use the fitting-count for the branch duct with the most fittings served by that trunk duct section.

As air is forced through ductwork, the External Static Pressure of the ventilator is spent overcoming the resistances imposed by the ductwork and fittings. Each size and type of fitting imposes its own resistance to air flows. To simplify the analysis of different ducts and fittings, the pressure losses of fittings, grilles, and hoods are equated to the equivalent length of a smooth straight duct (of the same diameter as the fitting). The equivalent lengths of some common fittings applied to residential ventilation systems are shown in Figure D8. 1 .

It is very important not to overlook any fittings. For example, inlet and exhaust hoods, grilles and stackheads are easy to forget in the design calculations but do result in system pressures losses.

DUCT FITTINGS AND EQUIVALENT LENGTHS



Step 8.3
Size Ducts

Determine the minimum duct diameter for each section of ductwork in the system. Using Figure D8.2 or D8.3, follow down the column with the appropriate ESP range for the ventilator selected and across the row with the air flow that equals or just exceeds the design condition air flow rate for the duct being sized. The intersection of this column and row identifies the basic duct diameter required. Record this number on Worksheet 8.

FIGURE D8.2
Rules of Thumb for Bath and Kitchen Fans*

AIR FLOW cfm	L/s	MIN DUCT DIA up to fix fittings Up to six fittings	
up to 25	up to 12	3 inches	75 mm
to 50	to 25	4	100
to 90	to 45	5	125
to 125	to 60	6	150
to 175	to 80	7	175
to 250	to 120	8	200
to 300	to 140	9	225

If fitting count is 7 to 15, use next size larger duct.

If fitting count is greater than 15, use two sizes larger duct.

Fitting count is the number of fittings downstream of the fan outlet, including the exhaust hood at outside wall plus extra counts as outlined below.

For each 3 m (9.8 feet) or part thereof of smooth ductwork, add one to fitting count.

If flex duct is used increase flex duct one size and count each bend or elbow in the flex as one count fitting, OR use flex duct size noted in the table and add one count to fitting count for each 1.5 m (4.9 feet) or part thereof of flex duct and count each bend or elbow in flex duct as two fittings.

*Fan air flow to be rated at 0.1inch wg (25 pa).

Adjust the duct diameter for the fitting and/or flex duct count as required by the conditions listed at the bottom of the chart. Enter the adjusted duct diameter on Worksheet 8 and on the working drawings. Repeat this process for each duct section. The designer or installer may choose not to downsize the ducts in a particular run and thus need not do the sizing procedure for ducts carrying lesser air flows which have lesser fitting counts.

When in doubt, go up one duct size. Oversizing helps ensure the system can meet design air flow rates.

FIGURE D8.3

Rules of Thumb for Duct Sizing for Central Exhaust and Supply Fans

DESIGN AIR FLOW cfm	L/s	FAN ESP Pa more than 25 / in W.G more than 0.1	65 / 0.25	100 / 0.40	150 / 0.60
		Min. Duct Diameter, in.			
10	5	3	3	2 *	2*
20	10	4	3	3	3
30	15	4	4	3	3
40	20	5	4	4	4
50	25	5	4	4	4
60	30	6	5	4	4
80	40	6	5	5	5
100	50	7	6	5	5
125	60	7	6	6	5
150	70	8	7	6	6
175	85	8	7	6	6
200	95	9	7	6	6
225	105	9	8	7	6
250	120	9	8	7	7
300	140	10	8	7	7
400	190	12	9	8	8
500	235	12	10	9	9

If the fitting count for a duct is more than eight, increase duct size larger than called for in Table.

If the fitting count for a duct is more than sixteen, increase duct two sizes larger than called for in Table.

Fitting count is all the fittings that air to or from the room must pass through to flow between the outdoors and the room it serves, plus flex duct counts as outlined below.

If flex duct is used increase flex duct one size and count each bend or elbow in flex duct as one fitting, OR use flex duct size as noted in Table and add one to fining count for each 3 m (9.8 feet) or part thereof of flex duct and count each bend or elbow in flex duct as two fittings.

*for sizing purposes only, do NOT install ductwork under 3 inches.

Step 8.4 (optional)
Convert to Equivalent Rectangular Duct Size

If you wish to use rectangular ductwork (e.g. for a rectangular stack to a high-wall grille), it must have at least the same air flow capacity as the round duct it replaces. Use Figure D8.4 to convert the round duct to the equivalent rectangular duct.

FIGURE D8.4

Circular / Rectangular Duct Equivalents

Standard Stack or Riser Size	Circular Duct Diameter (inches)	Minimum Rectangular Duct Dimension (inches)
10 x 3.25	4	2.5 x 6 3 x 4.5 3.25 x 4.5 3.5 x 4
10 x 3.25	5	2.5 x 10 3 x 7.5 3.25 x 7 3.5 x 6 4 x 5.5
12 x 3.25	6	3 x 11 3.5 x 9 4 x 8 5 x 6 5.5 x 5.5
14 x 3.25	7	3.25 x 14 3.5 x 13 4 x 11 5 x 9 5.5 x 7.5 6 x 7
	8	3.5 x 18 4 x 15 5 x 11 5.5 x 10 6 x 9 7 x 8
	9	5 x 14.5 5.5 x 13 6 x 12 7 x 10 8 x 9
	10	6 x 15 7 x 13 8 x 11 9 x 10

TASK 9 - SPECIFY VENTILATION SYSTEM CONTROLS

1. Goal

To design a control System which operates the ventilation system so that it meets the ventilation code and the purchaser's requirements.

2. Procedure

Step 9.1
Develop Operating Strategy

Thus far the designer has developed a conceptual system design and has determined the various air flow requirements and the air distribution within the house, selected fans and/or an HRV, and identified what type of relief or make-up air systems to install (if any are needed). At this stage in the design process, many aspects of control strategy will be fixed by previous design decisions. Now, the designer should review the system design and the ventilation system requirements and specify how the system is to operate (i.e. the operating strategy) and how it is to be controlled to operate in this fashion (i.e. the control strategy).

Continuous operation of the ventilation system is required with control of higher speed operation by one or more of the following recommended:

- dehumidistat(s)
- interval or crank timer(s)
- manually operated switch(es)

Operating and control strategies must be identified for each piece of equipment in the supply, exhaust, make-up and relief air systems. In reality, design decisions are not made separately for each component, but are made while considering all the pieces at once (i.e. the house as a system).

The control strategy selected will largely define the controls required for any ventilation system. The controls may function at line voltage or on a low voltage circuit. Low voltage control wiring can be done by the sheet metal mechanic or installer using doorbell wire. The following briefly highlights some design considerations for the various systems that need to be controlled.

Ventilation Air Supply Systems

The "basic" ventilation air supply system must continuously provide ventilation air throughout the occupied space. Operating strategies which can achieve this are:

- continually operating combined ventilation supply and exhaust systems (with dedicated duct systems or integrated with forced-air systems);
- continuously operating exhaust air systems (supply by infiltration);
- continuously operating supply only fans (with dedicated duct systems or integrated with a forced air system);
- outdoor air intake to the forced air system return (requires continuous operation of the recirculation fan).

Exhaust Air Systems

The "basic" exhaust system must be sized to expel specific volumes of air from bathrooms and kitchens. The exhaust air system may operate intermittently or continuously. If fans are designed for continuous operation, they must be wired without ON/OFF switches and they must be suitable for continuous, quiet operation. Many designs will incorporate both continuous and intermittent exhaust fans.

Make-up and Relief Air Systems

If make-up and/or relief air systems are required, they must function so as to avoid pressure and air flow imbalances in the house which exceed the allowable maximums determined in Task 3. Make-up air fans must be approved to CSA 22.2 #113 and certified for use under moist conditions and at low temperatures.

Make-up air fans can be simultaneously switched with the exhaust devices they are installed to counterbalance. Relief air fans may be controlled to turn off when exhaust devices are switched on. Make-up and relief air vents may be damper equipped or may be permanently open. Ideally, damper mechanisms would be operated by a barometric pressure controller. The problem is, 5 Pa is equivalent to 6 1/2 mph wind, 10 Pa = 9 mph wind, 20 Pa = 13 mph wind.

Where do you put a sensor so it isn't confused by the wind conditions?

Practically, large vents would be equipped with automatic dampers, wired to open (or close) whenever exhaust devices were operated. Make-up and relief air systems must be positively controlled (i.e. they must operate so as to avoid imbalances without requiring deliberate human intervention).

Air Preheat Systems

Preheating or tempering ventilation and make-up air can be achieved in a number of ways including:

- using HRVs,
- mixing cold ventilation air with house air,
- heating ventilation air with electric duct heaters, and
- combinations of the above.

There are two ventilation air temperatures to keep track of during the design, the minimum 54°F temperature required for air entering a furnace and 63°F , the temperature below which high-wall supply grilles are required.

Of the above air preheating or tempering systems, the only one which requires control is the duct heater option. The two types of controls available for duct heaters are ON/OFF controls and modulating controls. ON/OFF controls turn the heater on and off based on the air temperature upstream of the heater. For a given air flow rate, the duct heater will increase the air temperature by a fixed amount. This will usually result in heating the air stream more than required.

Modulating controls sense the air temperature after it has passed through the heater, and adjusts the heater output so the air stream is heated to the set point temperature. Modulating controls eliminate the overheating condition which can occur with ON/OFF controls, but are more expensive.

The designer should write down in detail how he wants the ventilation system to function. This description is the system operating strategy.

Step 9.2
Design the System Controls

If ventilation equipment is wired for low voltage controls, wiring instructions and drawings will be included in the installation manual. The designer may have to design a control system specific to a particular installation. He should determine what controls are to be installed and where they are to be located. The following guidelines should be considered when selecting and locating the controls:

- Do not locate controls behind doors or in other awkward places.
- Position wall switches at the same height as the light switches in the house, usually 50 to 54 inches above the floor.
- Do not mix control functions. For example, don't install a dehumidistat where a high-low switch is needed. Although the dehumidistat can be used as a high-low switch, this will confuse the occupants.

Frequently, a given control function can be achieved by more than one approach. Here, simplicity is the objective. Some commonly used control components include:

Dehumidlstat - This is a humidistat which closes a set of contacts (i.e., switches "on") when humidity rises above the set point and opens the contacts (i.e., switches "off') when humidity falls below the set point. At least one dehumidistat should be centrally located on each floor (except in an unfinished basement) of the house. Each should be wired into the ventilation equipment fan control circuit, initiating high-speed operation when the relative humidity in the house rises above the set point.

Installing a dehumidistat in the exhaust air duct is not recommended, as this does not allow the occupants to easily reset the control to meet the changing needs of the house. This will unnecessarily increase heating and cooling loads.

ON/OFF Switches - The common light switch is used as an occupant control to initiate high-speed fan operation. These are commonly located in the kitchen and washrooms.

Crank Timer Switches - This occupant-operated control serves the same purpose as the simple toggle switch (i.e., initiates high-speed ventilator operation), except that the crank timer ensures that the ventilation fans will not operate indefinitely on high speed because someone forgot to turn the switch off. Laundry room exhaust fans are a good application for crank timers. Crank timers are available for different set times, ranging from 15 minutes to several hours.

Double Pole Double Throw (DPDT) Toggle Switch - This control is essentially two toggle switches operated by a common thumb switch. These are used when two separate electrical circuits need to be operated simultaneously to satisfy the operating strategy.

For example, in a washroom, a DPDT Can be used to switch a central exhaust fan to high speed and turn on the light. Wiring the light and fan into one circuit would mean the bathroom light would come on whenever the fan was switched to high speed. Therefore the fan and the light must be in separate electrical circuits. DPDT switches conveniently accommodate this requirement.

Electrical code prohibits wiring line voltage and low voltage circuits in the same junction boxes. Therefore, DPDT switches cannot be used for mixed line voltage/low voltage applications.

Relays - Relays are electro-magnetic devices which allow a power supply in one circuit to operate electrical contactors in one or more other circuits. Each circuit can operate at a different voltage and may have normally open or normally closed contactors. Relays are more costly to install than DPDT switches and make an audible clunk when switched.

Occupant controls which switch the ventilation system fans from low speed (or OFF) to high speed operation must be wired so that any single switch can shift the ventilation system fans ON or to high speed regardless of the position of the other switches. This is generally done by parallel wiring. A side benefit of parallel wiring is that it is not necessary to connect all control switches directly to the ventilation system fans. It is possible to connect several control switches in parallel to a single set of Wires.

Step 9.3
Draw Controls onto System Plans

Complete the ventilation system drawings by marking on the location of all controls, and indicating to which electrical circuits the controls are connected.

TASK 10 - REVIEW DESIGN

1. Goal

To check that the design calculations are correct, that the system can be built as designed and that the design will meet the system requirements.

2. Procedure

Step 10.1
Review Design

Using the checklist in Figure D10. 1, review all calculations and procedures, making sure calculations are correct and that no steps have been overlooked.

Confirm that space is available in the house for all duct runs and sizes. Revise duct sizes to accommodate any changes that must be made. Remember, if 8x3 rectangular stacks to a high-wall grille are to be used, it will be necessary to frame the interior partitions using 2x4's rather than 2x3's.

In addition, it may be necessary to incorporate a mechanical wall for the riser ducts to the second floor of a large two-story house. This may be done by framing a 2x6 partition wall or by putting a pipe chase in a closet.

FIGURE D10.1: CHECKLIST

The ventilation system must not be used to provide combustion air for any vented combustion appliance. Fireplaces, furnaces and gas stoves require separate combustion-air supplies, designed specifically for the appliance they serve.

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6

VENTILATION SYSTEM INSTALLATION

6.0 CODES AND STANDARDS

This section describes the installation of a ventilation system in detail. Although some of the information has been covered in previous sections, its importance makes it worth reviewing again.

Each ventilator should come with its own installation manual. If it did not, call the manufacturer or supplier and request one. In addition to conforming to the equipment manufacturer's installation requirements, there are a number of codes and standards which establish minimum material and performance requirements for ventilators and their installation. Appendix III lists some of these relevant to the ventilation system installer.

The installation must comply with all local building, electrical and mechanical codes.

You may find that various installation instructions or codes may not agree with each other. The prime purpose of the ventilation system is the long-term health and safety of the occupants of the house, followed by occupant comfort and system performance. For this reason, the installation must conform to the most stringent recommendations.

6.1 DESIGN AND LAYOUT REVIEW

The first step when installing a ventilation system is to review the working drawings and system layout. If the system was designed by you, this will be a straight forward task. If the plans were drawn by others, you should familiarize yourself with the ventilation equipment installation instructions and relate them to the design at hand. The working drawing should show the location of the ventilation equipment, ductwork and other system components and specify their size, type, etc. On-site changes that have been made to the floor plan, the mechanical room or basement area may require you to modify the system layout. Major deviations from the plan, particularly from the duct layout, may invalidate the duct sizing done by the designer. The impact of any changes in ductwork layout must be assessed with respect to the ability of the ventilation equipment to meet required air flows.

Depending on the extent of the changes, it may be necessary to increase the duct diameter or select different ventilation equipment. The installer must satisfy himself that the required airflows will be provided by the system. This can be done by counting fittings on any trunk and branch ducts that have been modified to determine if upsizing is required or if downsizing is possible.

If the ventilation system has not been designed to meet CSA F326 and there are vented combustion appliances in the house, the installer must do a backdrafting test on the house once the installation and building envelope are complete. (See Reference 13 in Appendix III for details on how to do backdrafting tests.) If backdrafting is detected, the installer must either undertake corrective measures (and check their effectiveness with another backdrafting test) or provide the homeowner with a written notice describing the backdrafting problem (Form B).

6.2 LOCATION

The ventilation equipment should be located so that the ducts leading to and from it are reasonably short and straight. Although it is possible to "elbow" a way around most obstructions, it is desirable to locate the ventilation equipment so that changes in air flow direction are minimized. As you "elbow", remember that extra fittings may require larger duct sizing.

The location of continuously operating ventilation fans should be selected to minimize noise. Because of their airtight construction, new houses are much quieter than older houses, and so fan noise is more noticeable. The homeowner may be more sensitive to fan noise if the heating system is not forced air. With a forced air system, the sound of the ventilation equipment fans is offset by the sound of the furnace fan. Noise may be reduced by incorporating sound attenuation devices (i.e. duct silencers) in the ductwork. Installing noisy ventilation equipment is a sure way to get called back after the new homeowner has moved in (see Design Step 6.1 for a discussion on fan noise levels). Fans and HRVs located adjacent to bedrooms or living rooms will get turned off if the noise bothers the house occupants. When this happens, the purpose of the ventilation system is defeated.

All ventilation equipment must be located to allow easy access for servicing.

HRVs and all condensate lines must be installed in a space where the temperature is maintained above the freezing point.

6.3 FANS AND HRVS

Ventilation fans and HRVs must meet minimum standards to meet the installation requirements of CSA F326.2. Specifically, fans and HRVs must be CSA approved for the type of installation being considered. All ventilators must be clearly labelled regarding elements which require caution or need to be identified for cleaning or maintenance.

HRVs must:

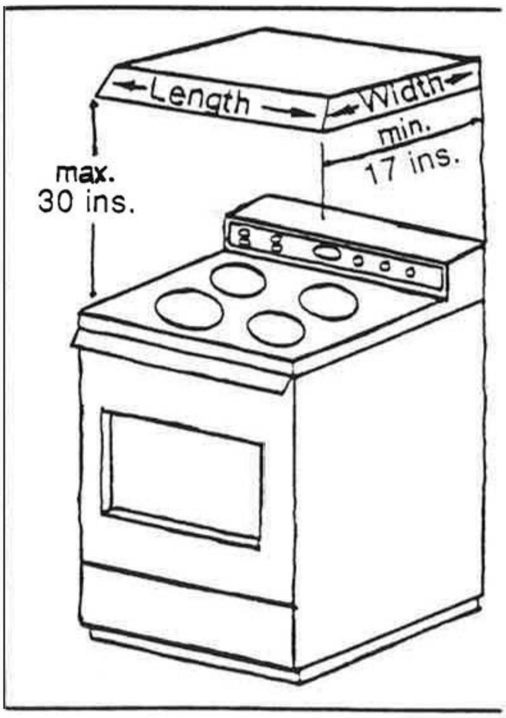
- be selected based on the results of tests carried out in accordance with CSA Standard C439, Standard Methods of Test for Rating the Performance of Heat-Recovery Ventilators.
- have certification provided that states the heat recovery ventilator will perform in accordance with the manufacturers' published data when tests in accordance with CSA Standard C439.
- be equipped with automatic, self-defrost if air flow restriction due to icing may occur.
- have available an installation kit including vibration isolation means for both the equipment and duct connections. The kits shall be included on the parts list provided with the HRV information package.
- not be installed with an imbalance of air flow of more than 10% during normal operation, including defrost, unless otherwise specified by design.
- have clear and understandable installation and operating instructions and warranty (in writing).
- not be connected in parallel with other fans or HRVs into a common air duct system unless specifically approved by the manufacturer.
- not be directly ducted to or from any appliances (e.g. dryer, range hood, central vac, combustion appliance).

Wall and ceiling fans must:

- be certified for electrical safety to CSA 22.2 #113.
- have removable or hinged interior grilles which permit access for fan and motor repair, maintenance and replacement.
- be supplied with comprehensive instructions and performance data in for the purpose of describing ventilator performance, installation requirements, maintenance and repair procedures, parts list and supplier names and homeowner operating instructions.

Range hoods must:

- be certified for electrical safety to CSA 22.2 #113.
- exhaust directly to the outside and not be connected to other exhaust fans or ducts (or HRVs).
- have noncombustible, corrosion-resistant material ductwork to the outdoors.
- be at least as long as the range and at least 17 inches wide (front to back). The bottom run of the range hood must not be more than 30 inches above the range top.
- have a minimum capacity of 3.5 cfm per inch of range hood length for range hoods mounted against the wall, and 4 cfm per inch of range hood length for range hoods not located against walls.
- be equipped with a grease filter at the intake end.



Continuously operating fans must:

- be certified by the manufacturer for continuous operation in the environment in which they will be installed.
- operate quietly when properly installed.

6.4 MOUNTING

Mounting hardware varies with each ventilator. In many cases fans and HRVs are suspended from the joists near the ceiling of the basement or mechanical room. If you must drill holes in the joists, drill near the mid-point of the joist so the joist is not structurally weakened.

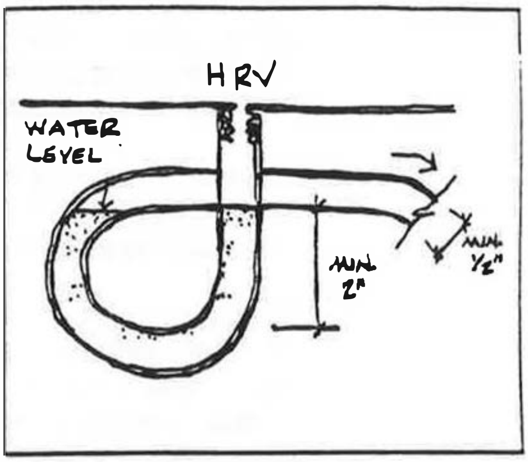
Properly mounting ventilation equipment will reduce noise generated by ventilation equipment. Carefully follow the manufacturer's instructions and use all hardware specified for noise and vibration control.

The ventilators should be positioned at a height that accommodates the incoming ducts without major changes in duct direction. The entire support mechanisms and the ventilators should be checked for rough edges that might catch or tear clothing or injure persons moving in the area. Remember, ventilation equipment is often located in poorly-lit rooms at a child's eye level.

Although it is usually desirable to position ventilators near the ceiling, they should not directly touch the ceiling, ceiling joists, walls or any rigid part of the house. This precaution will prevent vibration noise from being transmitted directly to the house structure.

If noise transmission is of particular concern in an installation, ventilation equipment may be mounted on a floor stand. Although mounting the ventilation equipment on a stand will reduce the usable floor space in the basement, the transmission of noise to the living area of the house will be reduced. If there is no basement, the ventilation equipment can be floor mounted on the main floor of the house.

6.5 DRAIN



In most HRVs, moisture will condense in the exhaust side of the heat exchange core during cold weather operation and may condense in the supply air side during hot weather operation. These units will be equipped with a drain connection at the bottom of the HRV casing. The drain pipe must incorporate a water trap that is at least two inches deep. It should be hand filled with water before it is connected to the HRV. The drain must be at least 1/2" in diameter and be graded so that the water will flow out of and away from the HRV. The drain usually goes to a floor drain or some other drain such as a laundry tub or sink. If the HRV location makes a gravity drain impractical, a condensate sump and pump must be installed to pump any condensation to a drain.

6.6 ELECTRICAL

Most residential fans and HRVs are connected to a 120 volt circuit. Wiring should be done in accordance with the manufacturer's instructions and the Electrical Code. A separate circuit breaker is not required for the HRV. The electrician should be given the manufacturer's wiring instruction and a description of the control strategy for all wiring and controls he is to connect.

The ventilation system may require supplementary heat for the ventilation air supply. Unless they are specified or supplied by the manufacturer, the installing contractor is responsible for ensuring the suitability of the heater for the application and for providing electrical interlocks with the fan.

Electric ventilation air supply duct heaters must be tested and approved to CSA 22.2 #113 (October 31, 1988) and approved for heating low temperature air in a potentially moist environment. Sheet metal or approved ducting shall be used a minimum of 5 feet downstream and 1 foot upstream from electric duct heating units. The air flow through the fan must match duct heater specifications. The duct heater must be easily accessible for repair or replacement.

6.7 CONTROLS

The control strategy selected for ventilation system operation will largely define the controls required for the system. Controls may function at line voltage or on a low voltage circuit. Class II (18 gauge) wire can be used for low voltage control systems. It is both cheaper and easier to work with than the wire needed for line voltage applications.

If the ventilators are wired for low voltage controls (many HRVs have low voltage controls), wiring instructions and drawings will be included in the installation manual provided by the manufacturer. The designer may also have designed a control system specific to a particular installation. The installer should determine what controls are to be installed and where they are to be located. The following guidelines should be considered when selecting and locating the controls.

- Bathroom on/off or high-low switches or interval timers should be located next to the light switches.

- The switch(es) in the kitchen should be convenient to the stove and other working areas.

- Dehumidistats should be centrally located, away from supply air grilles. They should be wall mounted in a central location and have an operating range from 20% to 80% relative humidity as well as an "OFF' position. The humidity level is set at the discretion of the occupants, normally around 30 to 50% in the winter and OFF in the summer.

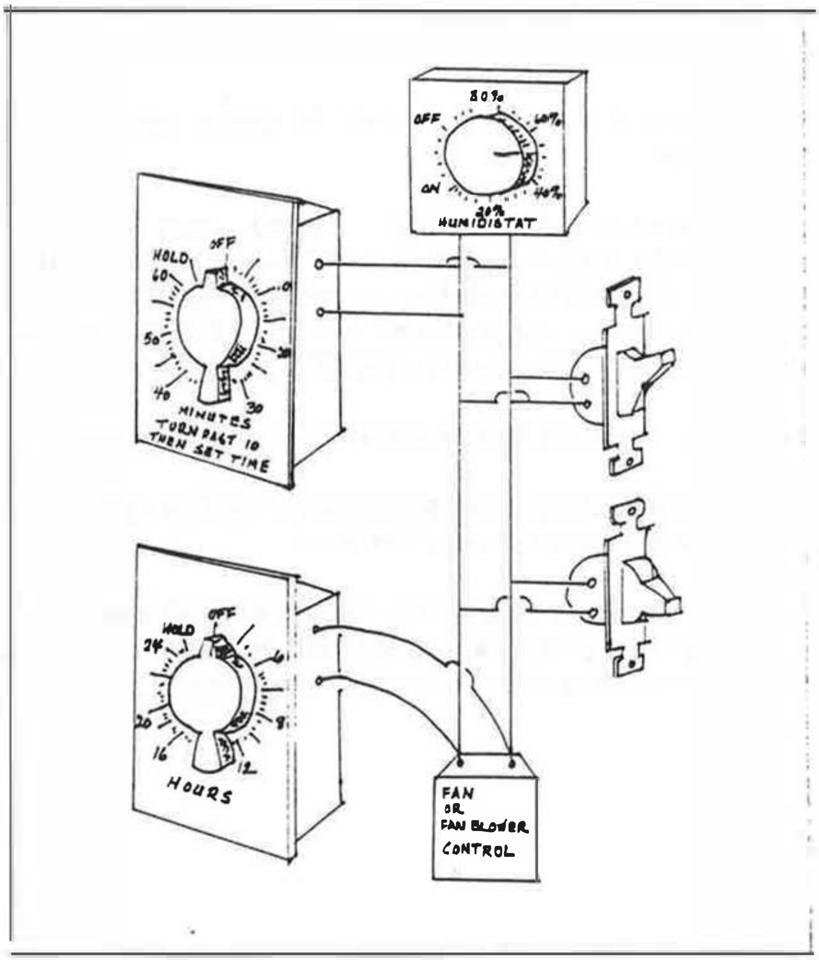
- Do not locate controls behind doors or in other awkward places.

- Position wall switches at the same height as the light switches in the house, usually 50 to 54 inches above the floor.

- Do not mix control functions. For example, don't install a humidity controller where a high-low switch is needed. Although the humidistat can be used as high-low switch, this will confuse the homeowner.

It will be much easier to run the wiring for the controls before drywall is put up. Wiring must be run where it will not be damaged by other trades. Avoid exterior walls where wires will penetrate the house air/vapor barrier. The wire should be pulled snug and straight and fastened using plastic coated tacks or staples. Run wiring parallel to the building lines. Keep it neat. The wire should-be fastened to the stud within four inches of the switch box. Leave a foot of wire for the final connection to the control switch.

Occupant controls turn ventilators ON and OFF or from low speed to high speed operation. They must be wired so that any single switch can shift the fan(s) ON or to high speed operation regardless of the position of the other switches. This is generally done by parallel wiring. A side benefit of parallel wiring is that it is not necessary to connect all control switches directly to the ventilator. It is possible to connect several control switches in parallel using a single set of wires.



6.8 DUCT INSTALLATION

If the ventilation system was designed properly, the location and size of all ducts and flow dampers will be shown on the drawing. If this information has not been provided, the installer will be responsible for duct layout and sizing, as discussed in Section 5 "Ventilation System Design".
Installers should also check the ventilator manufacturer's installation manual for requirements or recommendations specific to the fans or HRVs being installed.

Duct Materials

The NBC requires that all supply air ducts be constructed of non-combustible materials.

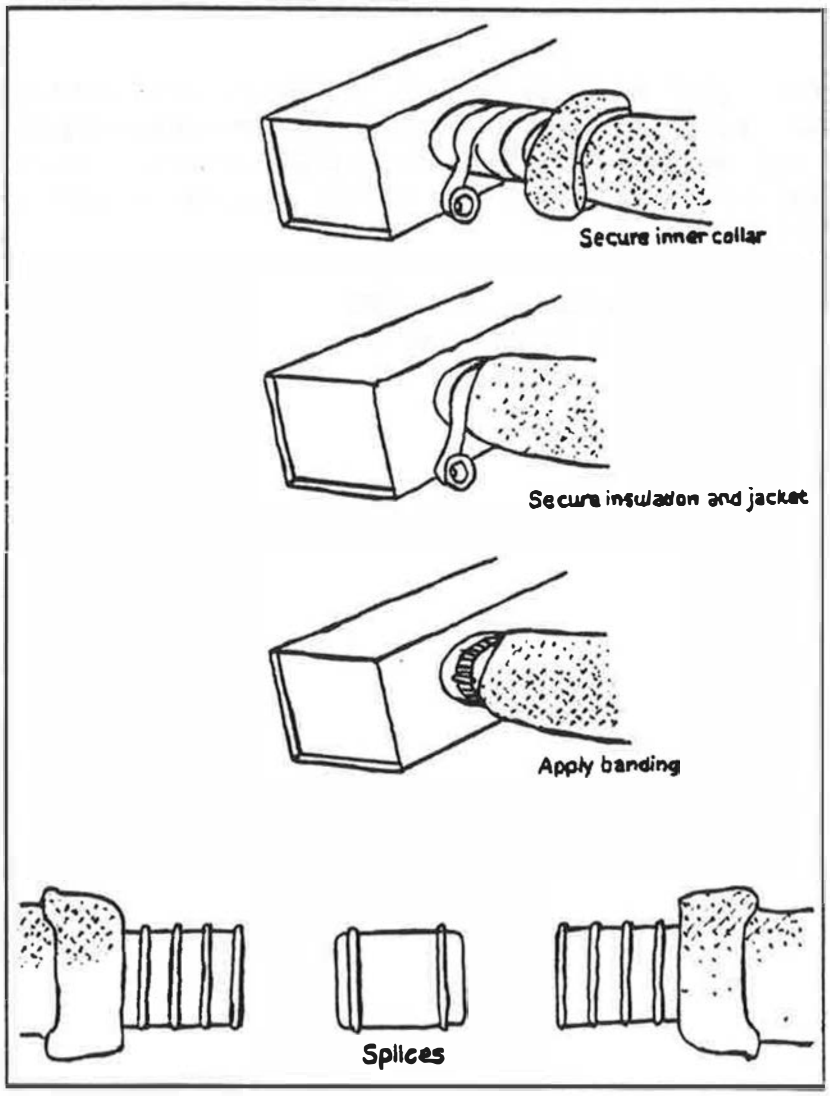
Unfinished wall cavities can be used as exhaust air ducts, although the cavity should be well sealed to avoid air losses. If kitchen exhaust ducts use the wall cavity, the wall cavity must be clad in sheet metal. It must have a grease filter at the air intake. Exhaust ductwork from kitchens must be non combustible, corrosion resistant material.

Bathroom exhaust ducts can be of combustible materials but should be sealed and lined with a finish impervious to water.

Flex Duct

Ducts should be smooth, straight and short. Although flexible ducts have some advantages in terms of ease of installation, the air pressure drop in them is high. Flexible ducts typically have pressure drops double those of sheet metal ducts. Flex ducts must be one inch larger in diameter than sheet metal ducts in most applications. Flex ducts should only be used where necessary. All flexible ducts must meet the requirements of ULC Std 181 for Class 1 Ducts.

Connections must meet ULC Class O or Class 2 air duct connectors as specified in ULC 110 Standard for Air Ducts.



Noise Control

Ductwork must be connected to HRVs using flexible duct, a canvas connection, or some other method of isolating ventilator vibration from the ductwork. Flexible ducting eases the task of connecting the ductwork to the ventilator and reduces the transmission of noise and vibration to the ductwork. Follow all the manufacturer's mounting and installation instructions for HRVs and fans.

Ventilation equipment manufacturers or suppliers have duct silencer sections available which reduce duct-born noise. These can be placed on the house side of the fan (i.e. inlet of an exhaust fan or outlet of a supply fan) to reduce "air" and motor noise from the fan.

Duct Sealing

All ductwork joints and seams must be sealed or taped to ensure ventilation air is supplied to and exhaust air is removed from the appropriate space. If cloth duct tape is used, it should be double thickness over joints and seams. Duct sealants should be rated for 20 year life. Duct sealer (e.g. Duro Dyne, nex-a-Duct, 3 M or United) is the preferred method of duct sealing. A secondary benefit of sealed ductwork is a reduction in ventilation system related noise levels.

Duct Fittings

A change in duct direction creates a resistance to air flow. The greater or the more abrupt the change in direction, the greater the pressure drop. A mitered 90 degree elbow has a pressure drop ten times that of a long smooth 90 degree bend.

Try to minimize the number of elbows and fittings. Use the shallowest elbow angle that can accommodate the required direction change (e.g. two 45's may be as good as two 90's for an elevation change but have only half the pressure drop). This will help ensure that the system can provide air flows as designed.

6.9 VENTILATION AIR SUPPLY DUCTWORK

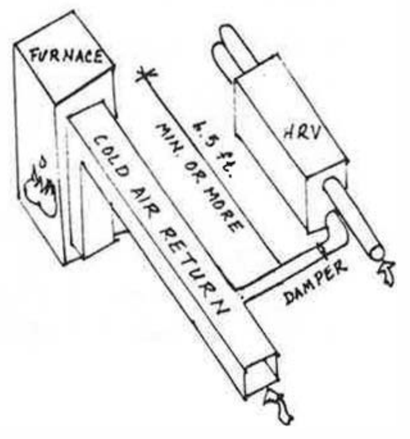
Forced Warm Air Heating

In houses with forced warm air heating systems, the furnace fan and ducts are commonly used to distribute ventilation air throughout the house. If this is the case the furnace's circulating fan must operate continuously, even in the warm periods.

Ventilation air can be fed to the furnace return via an outside air supply duct which operates on the suction of the furnace return, it may be mechanically supplied as is the case with an integrated HRV or it may occur by infiltration induced by a continuously operating exhaust fan.

The distribution of ventilation air in integrated forced air systems requires that the supply air flow be proportioned to the rooms so as to ensure the minimum ventilation air flows are met or that the recirculation fan has a flow rate of at least 1.0 ACH at all times. By using a two speed furnace fan which operates continuously at low speed and kicks onto high when the furnace turns on, energy use can be reduced along with ambient noise levels.

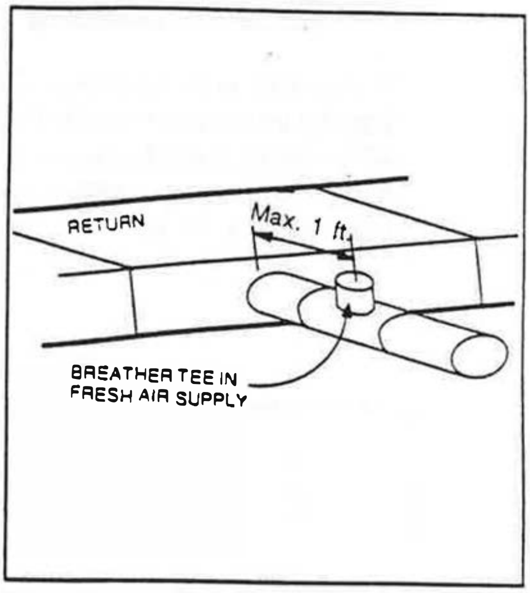
If a fresh air intake to the recirculation air return is used, it must be sized to ensure the required ventilation rate is maintained with the recirculation fan operating at its lowest speed and that the air flow imbalance limits are not exceeded when the recirculation fan operates at its highest speed. The intake duct must be insulated and equipped with a balancing damper. It must be as short as practical and have a minimum number of fittings in it. Sizing of fresh air intake ducts is discussed in Design Step 6.2.



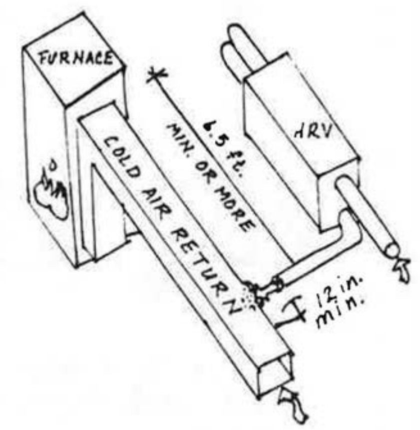
DIRECT CONNECTION

Direct connection of an HRV to a recirculation air return duct can only be done if it is recommended by the HRV manufacturer and approved by the local regulatory authorities. If a direct connection is used, a single speed, continuously operating recirculation fan is mandatory. This is to prevent the pressure fluctuations in the return air duct (caused by changing recirculation fan speeds) from affecting the ventilation air supply flow through the HRV, thus causing HRV air flow imbalances.

Indirect connection of the HRV ventilation air supply to the recirculation return is required if a two speed recirculation fan is used in an integrated system. The indirect connection approach requires that the ventilation air be supplied to the recirculation air return duct through a "breathing tee" or return air grille in the heating system ductwork. A "breathing tee" is a ventilation air supply duct with an open tee located within one foot of the return air duct. It allows the HRV to function without ventilation supply air flow rates being affected by the recirculation fan speed fan.



With the return air grille approach, HRV ventilation supply air is "dumped" near a grille in the return air duct just upstream of the recirculation fan. The HRV ventilation air supply duct outlet should point at the grille and end one foot or closer to the return air grille to ensure that the ventilation air will be drawn into the return air duct. It is important not to oversize the return air grille as this will reduce the furnace's ability to draw air through the ductwork from other areas of the house, nor to undersize it as this will affect its ability to draw the ventilation air into the return duct. The free area of the return air grille should be equal to or slightly larger than the cross sectional area of the ventilation air supply duct. A balancing damper should be entry into the return air grille. This allows the installer to balance the HRV ventilation supply air flow with the amount of air being drawn through the pick-up grille into the return air duct.

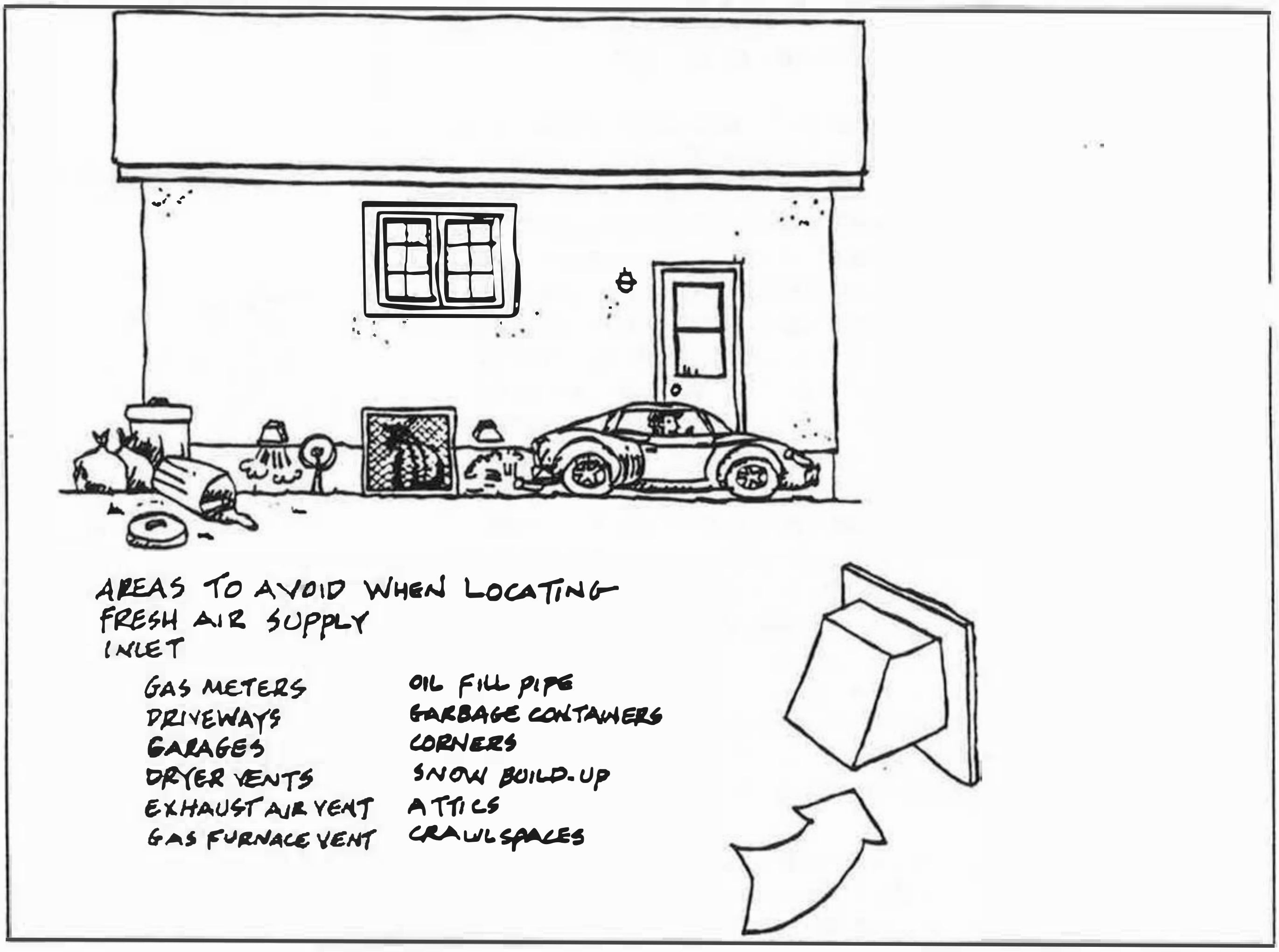


INDIRECT CONNECTION

Building codes prohibit locating return air grilles in an enclosed furnace room with combustion heating appliances. If combustion appliances are used, and the furnace is to be enclosed in a room, locate the ventilation air supply pick-up grille outside any logical future furnace-room wall locations and a minimum distance of six feet from the vented combustion appliance.

Non Forced-Air Heating

In houses with baseboard or radiant heat, the normal practice is to continuously supply ventilation air to the living areas such as the living rooms and bedrooms with dedicated ductwork or by infiltration through the building envelope (exhaust only systems), and to exhaust stale air from the kitchen, bathrooms and laundry area.



6.10 EXHAUST AIR DUCTWORK

Direct connection of range hoods, clothes dryers or any other appliance to an HRV is not permitted. If there is an exhaust inlet (the alternative is a range hood) it should be located on the wall near the ceiling or in the ceiling. In either case it must not be closer than five feet any direction horizontally from the center of the range.

It is recommended that clothes dryers be vented directly outdoors. If clothes dryers are vented into the house, the laundry room should have an exhaust air pick up. Exhaust air grilles in laundry rooms must be equipped with a lint filter. Gas dryers must always be vented directly outdoors.

6.11 INTAKE AND EXHAUST AIR HOODS

Outdoor air intake and exhaust air openings must be protected from weather using a louver, weather cowl, gooseneck or other weather resistant design.

The intake and the exhaust duct hoods must be sized to accommodate the ducts to which they are connected. The outdoor air intake hoods must be labelled as such. The vapor barrier on ductwork through the house walls shall be sealed at all joints and seams with the house air/vapor barrier. See 6.12 "Duct Insulation" for an illustration of how to do this.

Intake Hood

Intake hoods should be located so as to minimize containment of ventilation air. The following points should be observed when selecting and locating the intake hood:

- intake hoods should be located upstream of prevailing winds from the exhaust outlets,
- intake should be located away from driveways, garbage containers and places where hazardous or toxic gases could be present,
- intake must not be located in a garage, attic or crawl space,
- intake should be located at least six feet away from dryer vents, exhaust air vents, the exhaust outlet from a medium or high efficiency furnace,
- intake must be located at least 40 inches from a gas meter, oil fill pipe or garbage containers,

- intake must be located at least 18 inches above grade or other nearby horizontal surface and above the expected depth of snow accumulation so that it won't suck in debris and snow. If the opening is protected from snow accumulation, this clearance may be reduced to 10 inches. The higher the intake can be located, the better,

- the intake must be located at least 40 inches away from the corner of the building, where wind turbulence may affect system balance or blow up excessive amounts of dust and debris.

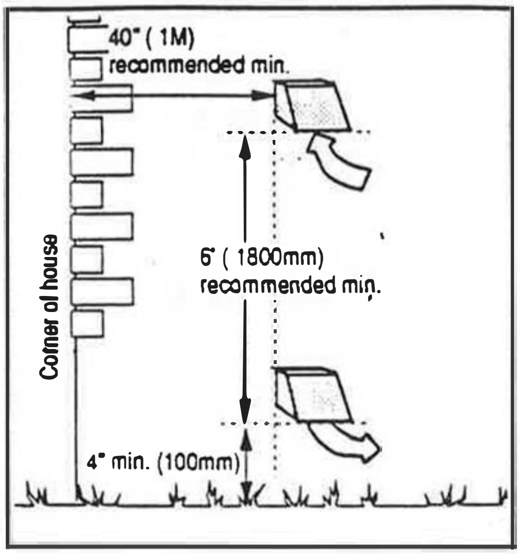
Exhaust Hood

The purpose of the hood is to minimize the effect of wind outlet is not as critical as the ventilation air intake. The following points are important:

- the location should be at least six feet from the ventilation air intake so that the exhaust air cannot circulate back into the intake (an exception is where an exhaust nozzle is used with a concentric ventilation air intake),

- the bottom of the outlet opening shall be at least four inches above finished grade or any nearer permanent horizontal surface,

- outlet must be located at least forty inches away from the corner of the building to avoid areas of high turbulence,

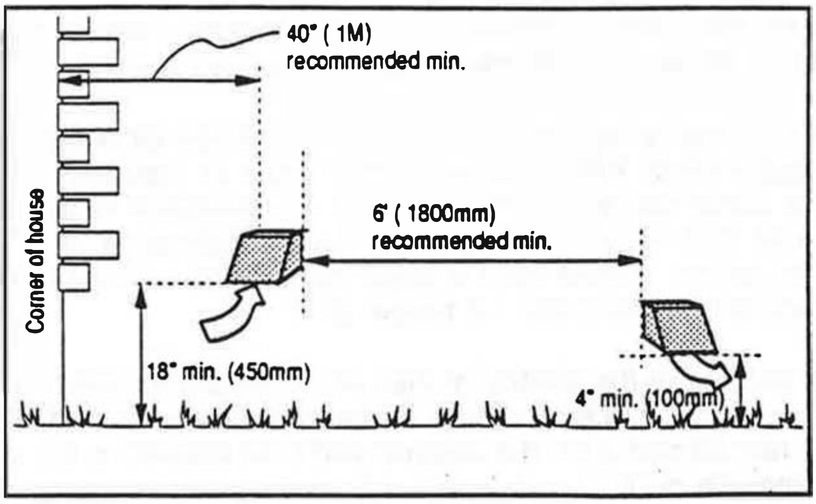


- don't locate the outlet above a gas meter, electric meter or near a walkway where fog or ice could create a hazard,

- don't exhaust house air into a garage, workshop or other unheated space,

- outlet should be equipped with a hood and bird-screen (minimum mesh 1/4 inch). Insect screen should not be used because of its tendency to frost up in cold weather,

- backdraft dampers are not required, but if they are used they must be functional.



6.12 DUCT INSULATION

Ductwork which carries cold air through heated spaces or house air through unheated spaces must be insulated and have vapor barriers. CSA F326 addresses three types of situations requiring insulated ductwork.

First, cold air ducts in heated spaces (e.g. ventilation air supply ducts and the exhaust duct from an HRV to the outdoors) must be insulated to (R3) and have a continuous vapor barrier on the outside of the insulation to prevent moisture in the house air from entering the insulation and condensing on the duct surface or in the insulation. It must have a vapor barrier and be insulated wherever the duct surface temperature can fall below 57°F.

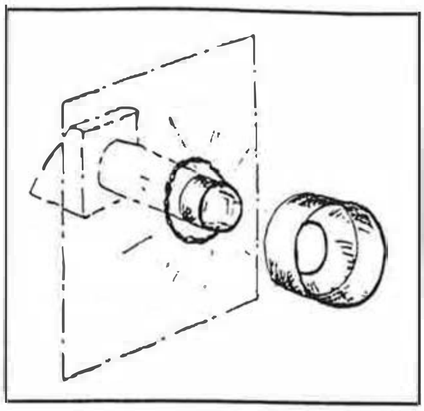
Condensation out of the airstream may occur inside ductwork which carries house air through unheated spaces, if the airstream is cooled below its dew-point. The requirements for the second and third situations are intended to prevent this from happening.

The second situation addresses exhaust air ducts passing through unheated spaces (e.g. an attic). Here, the minimum insulation value is (R3).

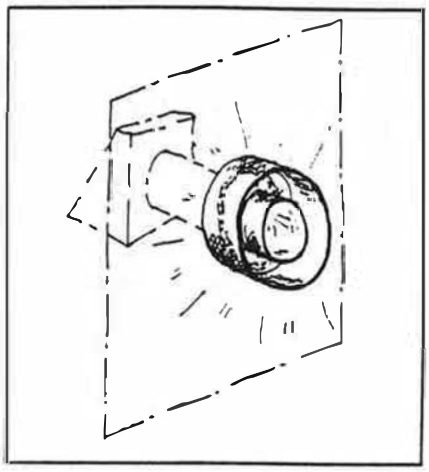
Third, ducts carrying warm air through unheated spaces for distribution to the house must be insulated to the levels called for in Figure 6.1.

FIGURE 6.1
Required Insulation Levels for Ventilation Air Ducts

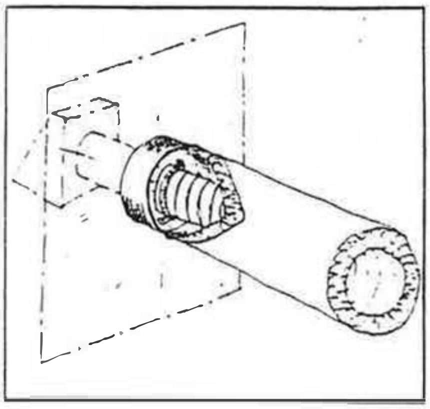
SITUATION	(R)
Cold Air Ducts in Heated Spaces	(4)
Exhaust Air Ducts in Unheated Spaces	(3)
Supply and Return Air Ducts in Unheated Spaces	
Outdoor Temperature (°F)	
19 to 12	(3)
10 to 1	(5)
0 to -11	(7)
-13 to -20	(8)
-22 to -29	(10)
-31 or colder	(12)



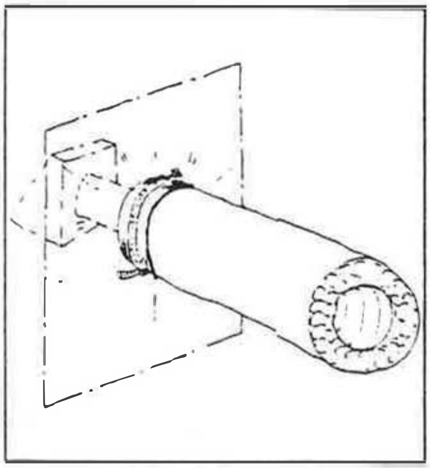
Insulated "flex-duct" may be used provided the duct run is not too long. Care must be taken not to damage the vapor barrier on the duct insulation. Experience has shown that even a small tear in the vapor barrier can lead to the accumulation of significant quantities of condensation in the duct or insulation. The vapor barrier must be sealed at both ends of the duct. Repair all holes and tears with tape.



In addition to being insulated and having an interior air vapor barrier, it is important that warm air ducts in unheated spaces be graded so that any condensation will run out of the duct. The duct must be properly sealed so that the condensation does not run into the duct insulation or pool in the attic or crawlspace. The seal on the outer vapor barrier is not required, as condensation will not form on the outside of these ducts. Where the duct is insulated on its outside surface, the duct can be considered to provide the vapor barrier, provided it has been adequately sealed.



Seal duct vapor barriers to house vapor barrier at all penetrations. This is not as easy as is depicted in textbook illustrations. It requires special materials (poly, acoustical sealant, utility knife), patience and sometimes more physical room than is available (e.g. between the floor joists and above a frame wall in the basement). It is recommended that connections to insulated ducts be done using double collars like those commonly used for the cold side ductwork on HRVs. These greatly simplify the connection and vapor barrier sealing procedure.



Don't forget, you must seal the duct vapor barrier over the insulation at all cut ends, and all rips or cuts in the vapor barrier must be taped or sealed using appropriate materials.

6.13 DAMPERS

Balancing dampers must be provided in all continuously operating ventilation systems to permit balancing total air flows.

Balancing dampers are required in all branch lines of central systems.

Balancing dampers must be easily adjustable and have a method of locking the damper at the set position. If ductwork is not accessible (e.g. trunk ducts which branch off inside finished walls) it may be necessary to locate flow balancing dampers in the stack head behind the room grille.

Fire dampers are required where ductwork passes through fire walls (1985 NBC 9.10.13.15).

Balancing dampers on HRVs are usually located in the warm side ductwork. This is done to avoid having the damper in the insulated/vapor barriered ductwork. All balancing dampers must be located where they are easily accessible. A single damper must not be used to balance air flows to more than one branch line.

Backdraft dampers are not required on exhaust ductwork. If used, they must have tight sealing blades and be suitable for extended use in harsh climates. Dampers have been reported to become stuck open (or closed) in the field, and may not operate effectively.

NEVER INSTALL BACKDRAFT DAMPER TYPE EXTERIOR HOODS ON VENTILATION SUPPLY, MAKEUP OR COMBUSTION AIR INLETS.

6.14 FILTERS

The ventilation air supply must have either an insect screen or a filter. The filter can be located in the inlet hood, in the ductwork or as an integral part of the ventilator case as is done in most HRVs. If in line filters are located in the ductwork, make sure they are sized for the application (the face area of the filter should be at least double the cross sectional area of the duct it is in) and make sure the filter housing is well sealed against air leaks. Filters must be easily accessible for cleaning or replacement, without requiring special tools.

Filters should be labelled including instructions regarding cleaning or replacement frequency and procedures.

Range hoods and exhaust grilles in kitchens must be equipped with grease filters. Exhaust grilles in laundry rooms must have lint filters. Once again, these must be easily accessible for cleaning or replacement.

6.15 GRILLES AND DIFFUSERS

Properly locating ventilation supply and exhaust grilles and proportioning of the air flows around the house will ensure good distribution of ventilation air around the house, efficient removal (exhausting) of moisture and air contaminants and high occupant comfort levels (i.e. no cold spots or drafts).

If the ventilation supply air design temperature falls below 65°F, it must be introduced through high-wall or ceiling outlets which discharge the air horizontally. Both result in improved air mixing at the ceiling before the air drops down into the room. High-wall and ceiling outlets have the disadvantage of requiring additional ductwork which can result in more duct fittings and increased installation costs.

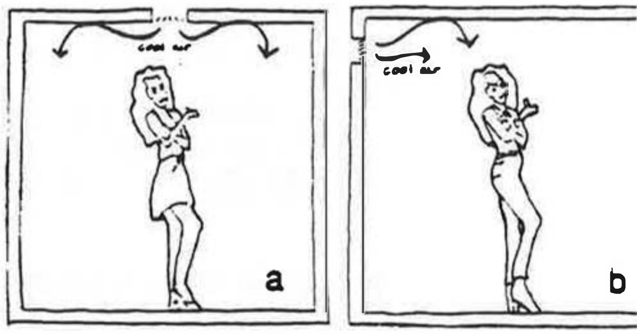
High-wall registers should be located within 6 to 12 inches from the ceiling and should incorporate louvers that project the air slightly upwards and across the ceiling. A long and narrow grille will allow for a better spread across the ceiling. The designer may use air distribution systems that minimize air velocity to reduce drafts in thermally sensitive areas.

Exhaust inlets are required in the kitchen and each of the bathrooms. It is also advisable to exhaust from the laundry, as this is a high humidity area.

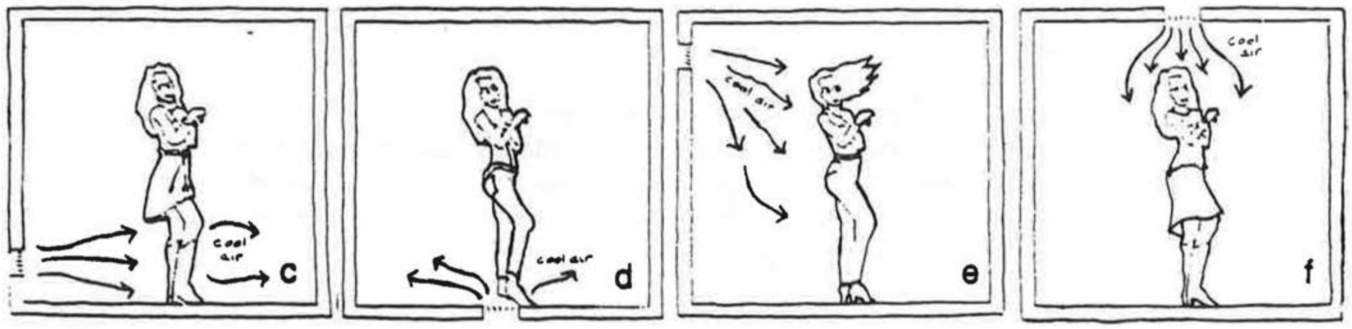
Exhaust grilles should not be located near ventilation supply air grilles or "short circuiting" may occur. For best air movement, avoid locating supply and exhaust grilles in the same room. Exhaust grilles should be located high on the walls or in the ceiling. An exhaust grille in a kitchen must be located at least five feet from the center of the range (measured in a horizontal direction). Kitchen exhaust grilles must be equipped with grease filters. Exhaust grilles in the laundry room must be equipped with integral lint filters. Filters must be easily serviceable.

Size exhaust air grilles based on a maximum velocity of 500 fpm through the "free area", of the grille using Figure 6.2. Record grille sizes on the ventilation system drawings.

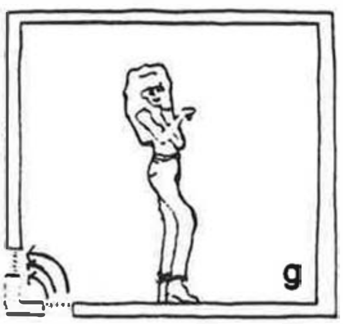
If a room does not have both a supply and an exhaust or return air grille, (i.e. ventilation supply and the return or exhaust are in different rooms), an air flow pathway into (or out) must always be open. Air flow through doors can be ensured by installing a grille in the door (sized using Figure 6.2) or by undercutting the door. Figure 6.3 has door undercut requirements for various air flows. The door undercut must-be above the finished floor level (including carpet, underlay and carpet edgers) when the door is closed. Record door undercut requirements on the drawings.



a, b: Good grille locations



c, d, e, f: Grille locations and air flow patterns may cause discomfort



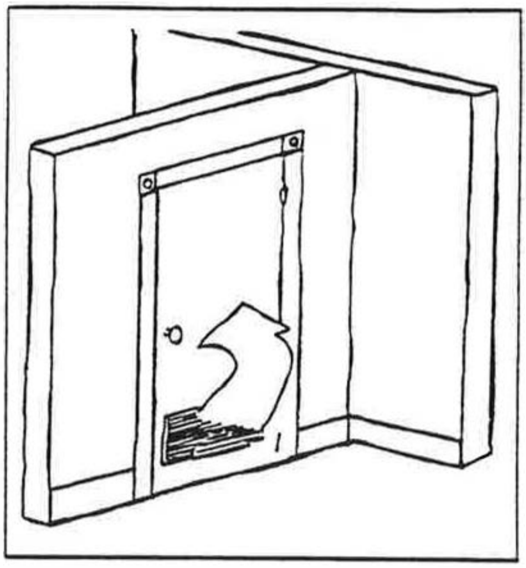
g: Inefficient and ineffective ventilation due to short circuiting from supply to return

FIGURE 6.2
Pressed Steel Grille and Plastic Data

Nominal Grille Size (Inches)	Free Area (Sq. in.)	Maximum Air Flow cfm
8 x 6	24	83
10 x 4	20	69
10 x 6	30	104
12 x 6	40	137
14 x 6	46	160
14 x 8	62	214
15 x 10	83	289
24 x 6	80	278
24 x 8	105	365

FIGURE 6.3
Door Undercut Data

Maximum Air Flow cfm	Minimum Undercut inches
30	1/2
60	314
90	1
120	1 1/4



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7

SYSTEM COMMISSIONING

7.0 PRE START-UP INSPECTION

Once the installation is complete, the installer should do a visual inspection of all components in the ventilation system. He should specifically check the following items:

1. Ventilator Mounting

- All equipment should be mounted securely.
- Supports should be properly fastened to the joists
- Vibration isolators should be in place, if they were specified by the manufacturer.
- Excess material should be trimmed and smoothed from mounting brackets and hardware.

2. Ducts

- The ducts should be properly supported.
- The flexible duct should be firmly attached to its connectors.
- All duct joints should be taped.
- Cold air ducts in heated spaces and warm ducts in cold spaces should be insulated.
- Any joints or tears in the vapor barriers on the insulated ducts should be patched and sealed.
- Ducts must be sealed to the house vapor barrier wherever they pass through it.

- Flex ductwork, if it is used, should be supported so that it does not sag. All splices and terminations in the flexible ductwork should be done according to the suppliers recommendations.
- Make sure the flex duct liner has been properly stretched, so that it provides the smoothest air flow surface possible.
- Check that the ducts are connected to the appropriate HRV outlets. More than one installation has had ducts connected to the wrong ports.

3. Outside Duct Termination

- Check that the ducts are sealed to the vapor barrier at the outside wall.
- Are the locations of the inlet and outlet safe?
- Outside duct terminations must have birdscreens and hoods.
- Hoods must be sized to match the ductwork they serve (minimum 100 mm or 4" diameter).
- Outdoor air intakes must be labeled as air intakes.

4. Grilles and Diffusers

- Are all dampers open?
- Are all ducts connected to the grilles or diffusers?
- If the ventilation air supply is indirectly connected to a forced warm air system, the ventilation air supply outlet or breather tee must be within one foot of the return air pick up.
- The grilles and diffusers should be large enough not to inhibit air flow or cause wind noise or whistling.

5. Wiring and Controls

- Check to see that both line power and low voltage controls are properly wired. Line voltage wiring has mistakenly been connected into low voltage circuits in several installations.

- All electrical connections must be enclosed.
- Occupant controls should be installed in the living areas.

6. **Drains**

- Are the drains equipped with traps?
- Are drain lines properly graded?
- Are traps filled with water?
- The HRV drain hose must lead to a drain.

7. **Filters**

- Ensure that filters are clean after house construction is completed. Install new filters if required.

8. **Instruction Manual**

- Refer to the instruction manual and check that all manufacturer's instructions have been met.
- Check the plan and make sure all required ductwork is in place.
- Check that all components are labelled as required (hoods, filters, cautions, etc.).

7.1 START-UP

Once the visual inspection has been completed and any deficiencies corrected, the installer may start up the ventilation system and check out its operation. Each of the occupant controls should be checked separately. It may not be possible to test out all operation modes of a ventilator (e.g. an HRV defrost cycle). During the initial start up, follow the manufacturer's instructions. Typically, these will include the following steps for each separate system.

- Set all occupant switches to the "off" position. To set a dehumidistat to the "off" position, turn it to "high" or 100%.

- Turn on the power at the breaker box, then turn the ventilator being tested on to high speed operation. Listen for any unusual noises that might indicate fan damage or malfunction.

- With the fan(s) running on high, feel the air flow at the outside exhaust and/or ventilation air supply hoods with your hand. There should be a brisk breeze at both. If there is not, check the position of dampers and fan operation.

- Check the ventilators and ducts for vibration and air leaks. Make whatever adjustments are necessary to the mounting system to minimize excessive noise. Tape any air leaks from the ducts.

- Turn the control switches to the normal operating position. The system being tested should now function at its normal or "base flow rate" condition. If not, check the occupant controls to see if any are in the "on" or "high" position. Once the system is functioning at the "base flow rate" condition, check the operation of each of the occupant controls. Dehumidistats are checked out by lowering the humidity setting below the house humidity. Adjusting the dehumidistat to the minimum setting should shift the fans to "ON" or high speed operation. Check the function of controls when they are switched on at the same time.

- If a ventilator operates low speed/high speed, listen to make sure the fan motor(s) don't stall or surge when operating at low speed.

- If the manufacturer's instructions describe a method of checking the HRVs' defrost cycle or duct heater controls, check their operation. Otherwise, the installer will have to wait until winter to find out if these controls function properly (e.g. customer complaint). If possible, it is best to check it during installation and start-up.

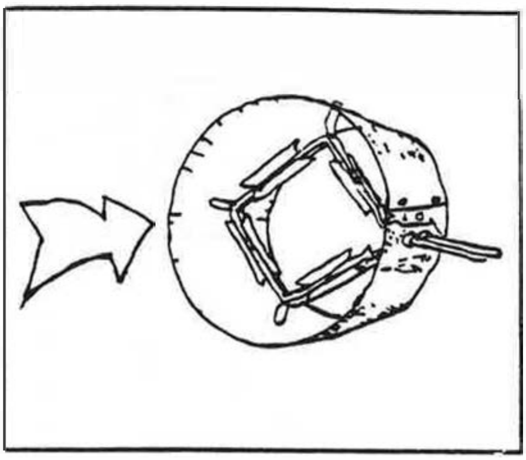
- Relief Air/Make-up Air systems should be checked to make sure they function as designed. Check the function of these systems by operating each of the controls or house systems which should activate or deactivate the Relief Air or Make-up Air systems.

- Identify and correct any control problems.

Once the system start-up is completed, it is time to measure and balance the supply and exhaust air flows.

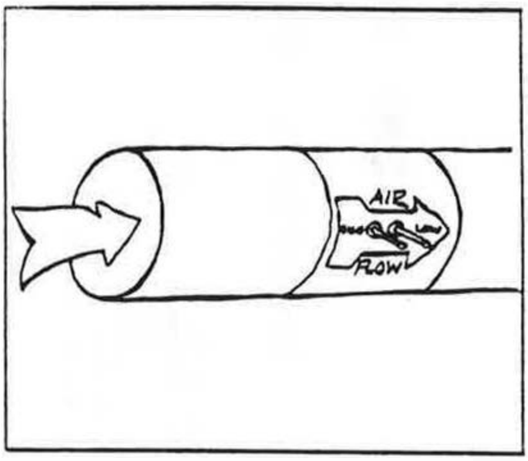
7.2 AIR FLOW MEASUREMENT AND BALANCING

To ensure that the design air flow requirements have been met, the installer must measure the ventilation air supply and exhaust flows to and from the house at each of the "design conditions". The results of these measurements must be recorded on the Certification Form, discussed in Section 7.4.



Air Flow Measuring Equipment

Instruments which can be used to measure air flows in ducts include hot wire anemometers which measure air velocity and pressure sensing probes connected to a manometer or magnehelic gauge which measures velocity pressures or the "wind force" of the air in the duct. If you have access and know how to use air balance equipment like that used to balance HVAC systems in commercial buildings - proceed accordingly.



Several HRV manufacturers market airflow grid devices designed to mount directly in the ductwork. These air flow grids are connected to an inclined manometer or a magnehelic gauge which senses air pressures in the duct. A chart provided with the air flow grid converts the measured air pressure to an air flow rate. Using these devises is simple and straight forward but the air flow grid must be located in a section of duct away from the turbulence caused by fans, fittings, and dampers. Figure 7.1 illustrates where the grids may be located.

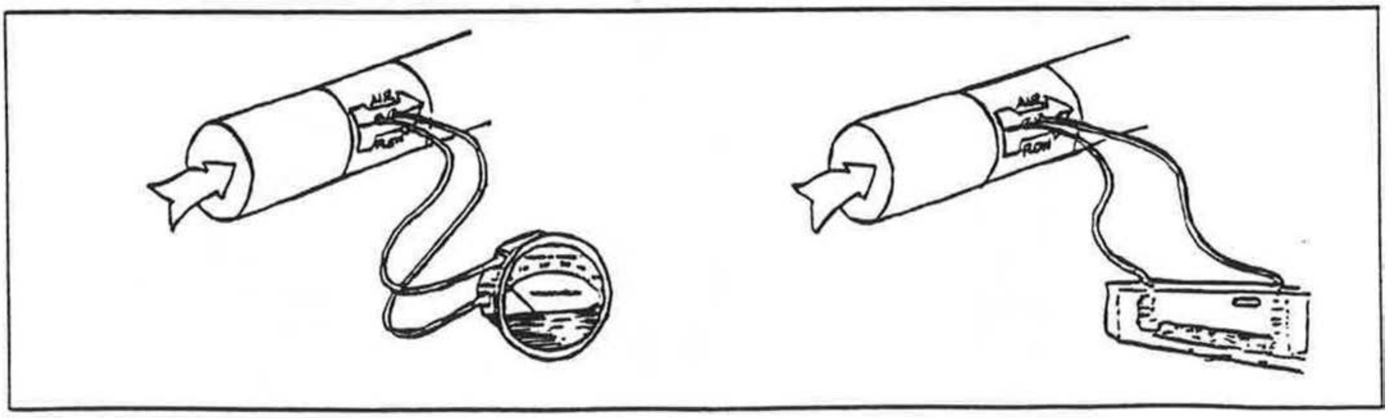
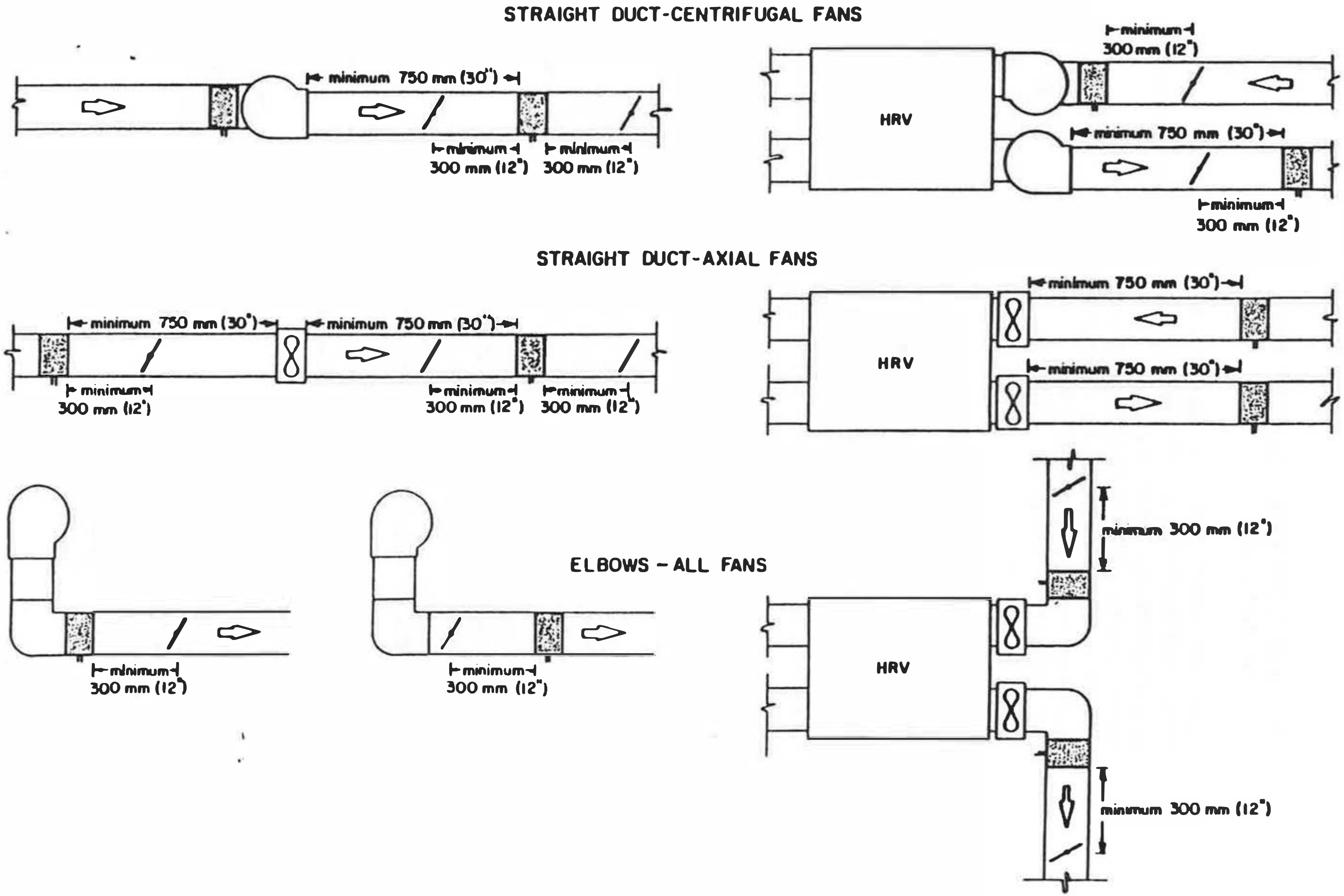


FIGURE 7.1


STRAIGHT DUCT-CENTRIFUGAL FANS
minimum 750 mm (30")
minimum 300 mm (12")
minimum 300 mm (12")
HRV
minimum 300 mm (12")
minimum 750 mm (30")
minimum 300 mm (12")
STRAIGHT DUCT-AXIAL FANS
minimum 750 mm (30")
minimum 750 mm (30")
minimum 300 mm (12")
minimum 300 mm (12")
minimum 300 mm (12")
HRV
minimum 750 mm (30")
minimum 750 mm (30")
ELBOWS - ALL FANS
minimum 300 mm (12")
minimum 300 mm (12")
HRV
minimum 300 mm (12")
minimum 300 mm (12")

Room-to-Room Balance

Balancing the air flows to and from the various rooms in the house need not involve measuring the air flows. However, it is necessary to confirm air flow at supply and exhaust grilles. This can be done by feeling the breeze at each grille or using a thread or a piece of tissue paper hanging on a wire. Balancing is done by closing off dampers in high flow ducts, thus encouraging increased air flow in the other ducts.

Prepare the House

Before the ventilation air supply and exhaust flow rates can be measured and balanced, the air/vapor barrier in the house must be completed. Fireplace dampers must be shut and doors and windows tightly closed. The clothes dryer must be off if it is vented directly outside and the furnace and hot water tank should be turned off if they are not electric units. In short, the building envelope must be sealed in its normal "closed up" condition. The ventilation system must be complete and all filters and register dampers set to their operating positions.

Measuring the Airflows

When measuring air flows, the house is closed up to the normal winter mode as described above. The ventilators are turned off and the main balancing dampers are moved to the fully open position. The airflow grid, or other air flow measuring probe, is then inserted into the warm side ducts. It is best to begin with the side that has the longest equivalent duct length (i.e., highest pressure drop, thus the lowest air flow rate. This will often be the exhaust air side of an HRV). With the air flow grid or probe inserted and all ductwork in place, the ventilator is started. Magnehelic gauge or incline manometers are the recommended instruments for measuring air pressure. They must be properly levelled, to ensure accurate readings. If you use a magnehelic gauge for pressure measurement, lightly tap the gauge before taking your reading.

Using the chart that converts pressure readings to air flows, record the actual air flows measured in cfm. Compare these to the design air flow rates.

If the measured flow of air in either the supply and exhaust duct does not meet the flow specified by the design, remedial steps are required. First, confirm that fans are operating (and at the correct speed). Then check that all dampers are in the open position and that inlets, filters or heat exchanger cores are not blocked or damaged. Check ductwork for leakage.

Refer to the ventilation equipment manufacturer's trouble shooting guide. If this is not successful, the designer or equipment supplier should be consulted. Ductwork modifications, booster fans or an alternate ventilator or HRV may be required.

Balance the System

If both ventilation air supply and exhaust flow rates meet or exceed the design requirements, but violate design requirements (i.e. air flow imbalances exceed the allowable maximums or HRV systems are more than 10% out of balance), the system must be balanced. To balance, the excessive air flows are reduced by adjusting the balance damper in the duct with the excessive flow until the air flow falls within the design limitations.

We have already discussed what to do if one or both of the air flows are lower than the design flow rate. If both air flows in a balanced system exceed the design air flow rate, you may reduce the flows by partially closing the dampers in both the supply and exhaust air streams. For continuous, one speed ventilation systems this should be done, while it is not necessary for the high speed setting of "HIGH/LOW" speed systems.

Once the flows are balanced, lock the damper in position. For two speed systems, follow the manufacturer's instructions to set the "low" speed fan setting. Adjust the "Low Speed" setting so it matches the "base flow rate" design conditions. Record the final gauge readings. Turn off the ventilators, remove your instruments and reconnect the ductwork.

While HRV air flows are required to be balanced within 10% of each other, you will find that by using the above procedure, it should be possible to achieve a near balanced condition.

7.3 CERTIFICATION

CSA Standard F326.2 requires that the installer certify completion of the installation and correct airflow measurement and balancing adjustments by completing CSA F326 Form A, "Ventilation Installation Certification Form".

The installer shall certify that a complete set of manuals with clear instructions for system operation and routine maintenance has been provided for the householder. The installer shall sign the Form and provide copies to the purchaser, the equipment supplier and to the regulatory authority (i.e. building inspector).

GLOSSARY

Ambient Air
Generally, the air surrounding an object.

Air Barrier
A material carefully installed within a building envelope assembly to minimize the uncontrolled passage of air into and out of a dwelling.

Air Change Per Hour (ACH)
A unit that denotes the number of times a house exchanges its entire volume of air with outside air in an hour.

Air Conditioning, Summer
Comfort air conditioning used primarily when outside temperature and humidity are above those to be maintained in the conditioned space.

Air Conditioning, Winter
Heating, humidification, air distribution, and air cleaning, where outside temperature is below inside room temperature.

Air Flow
The volume of air being moved, expressed in litres per second (L/s) or cubic feet per minute (cfm).

Air Flow Distribution
The distribution of air within the conditioned space.

Air Leakage
The uncontrolled flow of air through a component of the building envelope, or the building envelope itself, when a pressure difference is applied across the component. Infiltration refers to inward flowing air leakage and exfiltration refers to outward flowing air leakage.

Air Permeability
The property of a building component to let air pass when it is subjected to a differential pressure.

Air Pressure
The pressure exerted by the air. This may refer to static (atmospheric) pressure, or dynamic components of pressure arising from air flow, or both acting together.

Air Sealing
The practice of sealing unintentional gaps in the building envelope (from the interior) in order to reduce uncontrolled air leakage.

Air, Tempered
Air taken from the external atmosphere that has been warmed.

Air-To-Air Heat Exchanger (AAHX)
A mechanical ventilation system or device with heat recovery. The preferred terminology is heat recovery ventilator (HRV).

Airtightness
The degree to which unintentional openings have been avoided in a building's structure.

Ambient Temperature
Temperature of the air surrounding the object in question. It often refers to outdoor air or room air temperatures.

Anemometer
An instrument for measuring the velocity of air.

Apply (Applied) (Application)
Making practical or active use of design theory and guidelines. Equipment applied means the equipment selected by the system designer for use in the HRV system.

ASHRAE
American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Automatic Flue Damper
A damper added to the flue pipe downstream of a furnace or boiler and connected with automatic controls to the burner. Its function is to reduce heat loss up the chimney when the unit is not operating; consequently, it provides the greatest savings during relatively mild weather when the furnace is on infrequently.

Backdrafting (flow reversal)
The reverse flow of chimney gases into the building through the barometric damper, draft hood, or burner unit. It can occur when the pressure differential is too high for the chimney to draw.

Balanced System
Means a ventilation system in which the flow rate of the exhaust air leaving the building is equal to the supply air entering the building within 10% as measured at the heat recovery ventilator.

Calibrated Flow Measurement Devices
Those devices which provide for measurement of mass flow performed in accordance with the Air Movement and Control Association (AMCA) Standard 210.

Category A Rooms
Rooms which may be occupied for extended periods and are not sources of high moisture levels.

Category B Rooms
Rooms which are typically not occupied for extended periods and/or are sources of moisture and/or odor.

Category I Fuel-Burning Appliances
Fuel-burning appliances which take combustion and dilution air from the dwelling unit, are approved for use and installed with draft hoods, draft regulators, or other sources of dilution air and depend upon natural draft to vent products of combustion to outdoors.

Category II Fuel-Burning Appliances
Fuel-burning appliances which take combustion air from the dwelling unit and are approved for use and installed with sealed flues with no openings through which combustion gases can enter the dwelling unit and with gas-tight and corrosion-resistant flue surfaces (e.g. induced draft furnaces).

Category III Fuel-Burning Appliances
Fuel-burning appliances which take combustion air directly from outdoors through a connection sealed from the atmosphere into the dwelling unit, and are approved for use and installed with sealed flues with no openings through which combustion gases can enter the dwelling unit and with gas-tight and corrosion-resistant flue surfaces (e.g. high efficiency furnaces).

Cold Side
The air stream (or ductwork) between the outdoors and a ventilator.

Combustion Air
The air required to provide adequate oxygen for fuel burning appliances in the building. The term 'combustion air' is often used to refer to the total air requirements of a fuel burning appliance including both air to support the combustion process and air to provide chimney draft (dilution air).

Condensation
l) The beads or drops of water (and frequently frost in extremely cold weather) that accumulate on the inside of the exterior covering of a building (most often windows) when warm, moisture-laden air from the interior reaches a point where the temperature no longer permits the air to sustain the moisture it holds. 2) The process of changing a vapor into liquid by extracting heat. Water vapor will condense when warm, moist air contacts a cold surface that is below the dew point temperature. The result is the formation of beads or drops of water on the colder surface. If the surface is below freezing, the condensed moisture will change phase and become ice.

Conduction
The transfer or travel of heat through a body by molecular action.

Control
Any device for regulating a system or component in normal operation by responding to changes of pressure, temperature, humidity or any other property whose magnitude is to be regulated.

Controlled Ventilation
Ventilation brought about by mechanical means through pressure differentials induced by the operation of a fan.

Convection
The transfer of heat from one point to another by the mixing of one portion of the air with another.

Damper
A device used to vary the volume of air passing through an air outlet, inlet or duct.

Dehumidification
Removal of water vapor from air by chemical or physical methods.

Dehumidistat
A name for humidistats which control dehumidification equipment by closing a switch on the rise of humidity levels.

Degree Day
The number of degrees of temperature difference on any one day between a given base temperature and the mean day outside temperature. The base is usually 65 degrees F. The total number of degree days over the heating season indicates the relative severity of the winter for a specific location.

Design Air Flow Capacity
The ventilation rate to be provided by a mechanical ventilation system.

Design Heat Losses
A term expressing the total predicted envelope losses over the heating season for a particular house design in a particular climate.

Dewpoint Temperature
The temperature at which a given air/water vapor mixture is saturated with water vapor (i.e. 100% relative humidity). Consequently, if air is in contact with a surface below this temperature, condensation will form on the surface.

Diffuser
An air terminal device designed to supply air to the conditioned space.

Dilution Air
The air required by some combustion heating systems in order to isolate the furnace from outside pressure fluctuations and to maintain an effectively constant chimney draft.

Draft Hood
A device installed on a gas fired appliance to protect the appliance from chimney draft disturbances.

Effective Duct Length
The sum of actual measured duct length, plus equivalent duct length.

Envelope
The exterior surface of a building including all external additions, e.g. bay windows, etc.

Equivalent Duct Length
The pressure drop through duct system components, expressed as equivalent length of straight duct of the same diameter.

Equivalent Leakage Area (ELA)
The total area of all the unintentional openings in a building's envelope, generally expressed in square inches.

E.S.P.
Acronym for External Static Pressure.

Evaporation
Change of state from a liquid to a vapor.

Exfiltration
The uncontrolled leakage of air outward through a wall or membrane.

Exhaust Duct
A duct through which air is conveyed from a room or space to the outdoors.

External Static Pressure
The pressure developed, external to the unit (filters, core, housing and fans) to deliver a specific air flow, expressed as Pascals, or inches of water column.

Fail Safe
A control strategy or mechanism which automatically switches a mechanical or electrical device to a safe (off) mode in the event of a component or system failure. Fail safe controllers can be used to turn off HRV duct heaters and HRV fans whenever airflows or air balance falls below defined limits.

Fan Depressurization
A large fan is used to exhaust air from a building in order to create a pressure difference across the building envelope; an analysis of the flow rate through the fan at different pressure differences provides a measurement of air-tightness.

Flow Rate
The rate at which air flows expressed in litres per second (L/s) or cubic feet per minute (cfm).

Free Area
Unobstructed area for air flow through grille, register or hood. The total minimum opening area in an air inlet or outlet though which air Can pass. The free area of a typical heating type grille will be 1/2 the total area covered by the grille.

Grille
A louvered or perforated covering for an air passage opening into a conditioned space.

Hard Wired
Wired directly from the electrical junction box without the use of a plug or receptacle.

Heat Exchanger
A device specifically designed to transfer heat between two physically separated fluids.

Heat Recovery
The process of extracting heat (usually from a fluid) that would otherwise be wasted. For example, heat recovery in housing generally refers to the extraction of heat from exhaust air.

Home Ventilating Institute (HVI)
A division of the Air Movement and Control Association, a nonprofit organization of ventilation equipment manufacturers.

Hoods
Exterior wall terminals for the supply air inlet and exhaust air outlet.

HRAI
Heating, Refrigerating and Air Conditioning Institute of Canada.

HRV
Acronym for Heat Recovery Ventilator.
Humidify
To add water vapor to the atmosphere.

Humidistat
An electronic sensing and control device used to regulate mechanical ventilation according to relative humidity in the building. A humidistat is recommended for use with HRVs.

Impermeable
Not permitting water vapor or other fluid to pass through.

Indoor Air
Air contained inside the conditioned space.

Infiltration
The uncontrolled leakage of air into a building.

Intrinsic Heat
Heat from human bodies, electric light bulbs, cooking stoves, and other objects not intended specifically for space heating.

Intake Air
The outdoor air stream passing from the exterior of the house to the house ventilation system.

Latent Heat
Heat added or removed during a change of state (for example, from water vapor to liquid water), the temperature remaining constant.

Louver
An assembly of sloping vanes intended to direct the passing air flow.

Manometer
An instrument for measuring pressures, consisting of a u-tube partially filled with a liquid, so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Mechanical Systems
A term widely used in commercial and industrial construction, referring to all the mechanical components of the building; i.e. plumbing, heating, ventilation, air conditioning and heat recovery.

Negative Pressure
A pressure below atmospheric. In residential construction, negative pressure refers to pressure inside the house envelope that is less than the outside pressure; negative pressure will encourage infiltration.

Net Ventilation
The amount of outdoor air entering the building through the heat recovery ventilator.

Occupant Controls
Those controls or switches located in the living areas of the house and intended for the occupant to operate.

Outside Air
External air; atmosphere exterior to refrigerated or conditioned space; ambient (surrounding) air.

Pascal
A unit measurement of pressure. House air tightness tests are typically conducted with a pressure difference of 50 Pascals between the inside and outside. 50 Pascals is equal to 1/4 inch of water at 55° F.

Permeance
Water vapor permeance is the rate of water vapor diffusion through a sheet of any thickness of material (or assembly between parallel surfaces). It is the ratio of water vapor flow to the differences of the vapor pressures on the opposite surfaces. Permeance is measured in perms (one grain of water vapor/ft^2/hr/in of mercury pressure diffused).

Positive Pressure
A pressure above atmospheric. In residential construction, this refers to pressure inside the house envelope that is greater than the outside pressure; a positive pressure difference will encourage exfiltration.

Pressure Difference
The difference in pressure of the volume of air enclosed by the house envelope and the air surrounding the envelope.

Pressure Drop
The static pressure loss caused by air movement, through the duct, expressed as Pascals or inches of water column. In duct design, pressure drop is often expressed as Pascals per meter, or inches per 100 ft. of straight duct. (The chart supplied is imperial units.)

Pressure Drop/100 ft
A standardized method of expressing the Pressure Drop of a system that allows an Equal Friction Chart to be used in the duct sizing process (in. W.G./100 ft).

Purchaser
The person or persons having ownership or control at a date two weeks following the start-up or sooner.

Qualified
Acceptable to the regulatory authority.

Readily Accessible
Available to the average person in order to maintain, and accessible without the use of special tools or ladders.

Relative Humidity
The amount of moisture in the air compared to the maximum amount of moisture that air at the same temperature could retain. This ratio is expressed as a percentage.

Resistance Value (RSI or R)
Thermal resistance value. Measurement of the ability of a material to resist heat transfer.

Sealants
Flexible materials used on the inside of a building to seal gaps in the building envelope, thereby preventing uncontrolled air infiltration and exfiltration.

Service Controls
Those controls or switches which are not intended for routine adjustment by house occupants. Examples are the controls used to turn the HRV off for servicing or to adjust low speed fan setting.

Simulator
A portable, generic mechanical ventilation system to be used for training demonstration and hands-on testing purposes.

Stack Effect
Pressure differential across a building caused by differences in the density of the air due to an indoor-outdoor temperature difference.

Supply Duct
A duct through which fresh or conditioned air is conveyed to a room or space.

Vapor Barrier
A moisture impervious layer applied to a surface to prevent moisture travel to a point where it may condense due to lower temperature. Vapor barriers are located on the warm side of an insulated surface.

Vapor Pressure
The pressure exerted by a vapor either by itself or in a mixture of gases. For example, when refering to water vapor, the vapor pressure is determined by the concentration of water vapor in the air.

Warm Side

The air streams going between the conditioned space and the ventilation device.

CODES AND STANDARDS

1. CSA Preliminary F326. 1 - Residential Mechanical Ventilation Requirements
2. CSA F326.2 - Residential Mechanical Ventilation System Installation Requirements
3. CSA Preliminary Standard F326.3 - Methods for Determination of Compliance of Ventilation Systems
4. CSA Standard C260.2-19 - Residential Ventilating Equipment
5. CSA Standard B228.1-1968 - Pipes, Ducts and Fittings for Residential-Type Air Conditioning Systems
6. HRAI Residential Air System Design Manual (RASDM) (First Edition), December, 1986
7. ULC 110 Standard for Air Ducts
8. ULS Standard 181 - 1981 - Factory-Made Air Ducts and Connectors
9. CSA Standard B139-1976 - Installation Code for Oil-Burning Appliances
10. CSA Standard B385-M85 - Installation Code for Solid Fuel-Fired Equipment
11. CGA Standard B149.1-M86 - Natural Gas Installation Code
12. CGA Standard B149.2-M80 - Installation Code for Propane-Burning Appliances and Equipment
13. CGSB Draft Standard CAN/CGSB-51.71-M - Methods to determine Potential for Pressure-Induced Spillage from Fuel-Fired Space Heating Appliances, Water Heaters, and Fireplaces
14. CAN/CSA-B365-M87 - Installation Code for Solid-Fuel-Burning Appliances and Equipment
15. CAN/CSA-F280-M86 - Determining the Required Capacity of Residential Space Heating and Cooling Appliances
16. CSA 22.2 #113 - Fans & Ventilators

17. 1989 ASHRAE Standard 62-1989

18. ASHRAE Standard 62-1981R

STANDARDS ORGANIZATIONS

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

HRAI: Heating, Refrigerating and Air Conditioning Institute of Canada

UL: Underwriters Laboratories Inc.

CGSB: Canadian General Standards Board

CSA: Canadian Standards Association

CGA: Canadian Gas Association

ACHP VENTILATOR CHECK LIST

The installer should:

_____Have attended an ACHP installers' workshop or been trained by an accredited association.

_____Install the ventilation system according to the Alaska Craftsman Home Program ventilation requirements.

_____Provide a completed copy of a Mechanical Ventilation Systems Report.

_____Provide you or the homeowner with all system documentation, and maintenance and operation manuals.

Ventilating equipment should be located where it will be:

_____In the heated interior of the house away from noise-sensitive living areas (dining room, living room, bedrooms).

_____Close to an outside wall to minimize insulated duct runs.

_____Convenient to a drain (for condensate) and to an electrical supply.

_____Easily accessible for maintenance purposes.

_____Away from hot chimneys, electrical panels, and other possible fire sources.

The ventilator should be installed:

_____With vibration isolators (such as rubber feet and a short section of flexible duct between the unit and the main ductwork).

_____With an accessible control system capable of providing continuous low-speed operation plus humidity controlled and manually controlled high speed override.

Two cold-side ducts should connect the HRV to the outside, with one bringing in fresh air and the other exhausting stale air. The ducts should:

_____Be as short and straight as possible.

_____Be free of kinks or depressions in ducting where water might accumulate.

_____Be insulated with a minimum R-4 insulation.

_____Be sealed from end to end (outside the insulation) with a carefully sealed vapor barrier.

_____Be carefully sealed to the main air barrier to the house.

_____Be clearly marked identifying which is for fresh air and which for exhaust air.

_____Terminate in two accessible rain hoods, each equipped with a 1/4 inch or coarser wire-mesh bird screen. If finer insect screens are used, they must be accessible for regular cleaning.

The cold-side fresh air inlet should:

_____Be located, at least 18 inch above ground, (more if it is exposed to a blockage such as snow), and at least six feet from the exhaust outlet.

_____Be located away from sources of contamination such as carports, drive-ways, garages, bushes, tall grass, garbage, dryer vents, central vacuum exhausts, other vents, oil fill pipes, or gas regulators.

_____Be equipped with a filter in the duct or at in duct or at the inlet, if the HRV does not have a filter.

The cold-side exhaust outlet should:

_____Be located away from walkways and other areas where ice accumulation could be a problem. (Moisture in the exhaust air may condense and freeze).

_____Be terminated outdoors (not in a garage or attic), at least 18 inch above ground (more, if practical).

Warm-side ducts should connect the HRV to the house, with one duct system distributing fresh air while a second collecting exhaust air.

_____Either an exhaust or fresh air duct should be provided for every room.

_____Duct system should be designed to minimize their length and complexity, that is, use as few turns and right angles as possible.

_____Rigid ducts should be used wherever possible instead of flexible ducts.

_____Duct runs in unheated spaces and in exterior walls should be avoided.

_____Duct joints should be securely fastened and taped.

ACHP Ventilator Check List (con't)

_____Air flow measuring stations must be installed in both the supply and exhaust ducting.

Exhaust ducts should:

_____Run from such areas as bathrooms and kitchens, and other areas where contaminants are generated.

_____If the HRV does not have a filter, the exhaust ducts should contain a filter in the duct or at the grilles.

In the kitchen:

_____The range hood must not be connected to the HRV.

_____Range hoods over gas stoves must be vented directly outside with provision made for make-up air.

_____The general kitchen exhaust (connected to the HRV) must be horizontally removed from the cooking surface by at least four feet .

_____Total exhaust capacity (including control system) must be 100 cfm.

In the laundry:

_____Clothes dryers should be vented directly to the outside.

In the bathroom:

_____Total exhaust capacity (including control system) must be 50 cfm, either directly to the exterior or through the centralized system.

Fresh air can be distributed throughout the house by a separate system or ducts or by a forced air furnace.

If a separate system of ducts is used:

_____Registers should be positioned to minimize discomfort due to cold drafts, for example, at ceiling level, or in hallways.

If a forced-air furnace is used to distribute fresh air:

_____The HRV integrated with a two-speed fan heat distribution system should dump fresh air 12 inches from a furnace cold air return, and the return should be at least six feet from the plenum if an indirect connection is being used.

_____A direct connect can only be used if the heat distribution system employs a single-speed circulating fan.

Once the unit is operational, the installer should:

_____If the HRV has its own distribution ductwork, check and adjust flows in all ducts to ensure that sufficient air flow is provided to all rooms.

_____Adjust the total air flow to provide the continuous ventilation rate as specified in the Alaska Craftsman Home Program ventilation requirements.

_____Balance the flow of the control system, where appropriate, to equalize flow rates of the fresh air and exhaust air.

_____Ensure that the controls work as designed. This includes the dehumidistat and one or both of an interval timer and manual override.

_____Check that any imbalance in the flow of installed systems can be supported by the equivalent leakage area of the house as determined in the depressurization test. If not, make-up air duct will be required.

Mechanical Ventilation Form

Location of Installation

R-2000 I.D. # ____________________
Builder Name ____________________
Address ____________________
City & Prov. ____________________
House Address ____________________
____
____

Installing Contractor

Name ____________________
Company ____________________
Address ____________________
City & Prov. ____________________
Postal Code ____________________
Telephone # ____________________
H.R.A.I. Registration # ____________________

Supply Ventilation

'Rooms'		L/s	cfm
Bsmt & Master Bdrm _____	@ 10 L/s (20 cfm)	___	___
Other Bedrooms _____	@ 5 L/s (10 cfm)	___	___
Bathrooms & Kitchen _____	@ 5 L/s (10 cfm)	___	___
Other Habitable Rooms _____	@ 5 L/s (10 cfm)	___	___
	Total	___	___

OR

Area of Habitable Space __________ ft^2 or m^2
Volume of Habitable Space __________ ft^2 or m^2

Flow to produce 0.3 air changes/hour

0.3 ACH = (__________ ft^3 x 0.005) = ________ cfm
0.3 ACH = (__________ m^3 x 0.0833) = ________ L/s

Supply Required [   ]

Exhaust Ventilation

Continuous		L/s	cfm
Kitchens _____	@ 30 L/s (60 cfm)	___	___
Bathrooms _____	@ 15 L/s (30 cfm)	___	___
	Total	___	___
Intermittent			
Kitchens _____	@ 50 L/s (100 cfm)	___	___
Bathrooms _____	@ 25 L/s (50 cfm)	___	___
	Total	___	___

Exhaust Required [   ]

Outside Vented Mechanical Exhaust Systems	L/s	cfm
___ Clothes Dryer	___	___
___ Central Vacuum	___	___
___ Kitchen Range Hood	___	___
___ Bathroom	___	___
___ Other ____________	___	___

Type of Heating System

___ Forced Air	___ Oil	___ Type I
___ Baseboard	___ Gas	___ Type II
___ Other	___ Electricity	___ Type III
____________	___ Other	
	____________	

Measured Ventilation

Supply Air
Hi __________ Continuous __________ cfm
Exhaust Air
Hi __________ Continuous __________ cfm

Manufacturer: ____________________
Model: ____________________

Air flow measuring equipment.
(HRVs must be balanced when in Continuous.)

Start Up Check

___ wiring
___ controls functioning
___ filters
___ air distribution to all rooms
___ bathroom exhaust capability
@ __________ L/s or cfm
___ kitchen exhaust capability
@ __________ L/s or cfm
___ make-up air for exhaust equipment

Purchaser Received:

___ operating instructions
___ warranty data
___ operation & maintenance manuals
___ advice & caution re combustion air

Installation Contractor Certification

In hereby certify that this ventilation system has been installed in accordance with Installation Guidelines for Residential Ventilation systems.

Name ____________________
Signature ____________________
Date ____________________

Revised 1990

HRV SPECIFICATION SHEET

Testing Agency: ____________________ Model: ____________________
Date Tested: ____________________ Serial Number: ____________________
Manufacturer: ____________________ Options Installed: ____________________
Address: ____________________
____
Telephone: ____________________ Electrical Requirements: ________ Volts ________ Amps

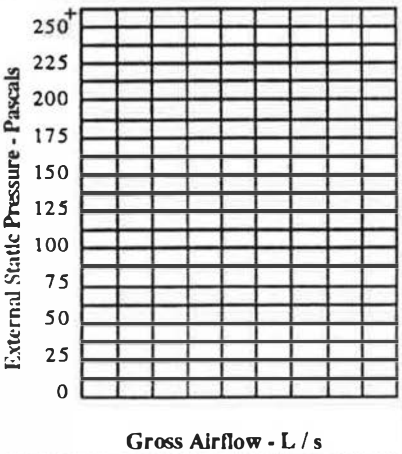
VENTILATION PERFORMANCE

Maximum Rated Airflows:
____ L / s @ ____ C
____ L / s @ ____ C

Airflow Range for Multispeed Units:
High Speed:________L/s Low Speed:________L/s

Lowest Temperature Unit Tested To: ______ C
Low Temperature Ventilation
Reduction During Lowest Temperature Test: ________
Maximum Unbalanced Airflow During Lowest Temperature Test: ________L/s
Exhaust Air Transfer Ratio: ____________

External Static Pressure		Net Supply Air Flow		Gross Air Flow			
				Supply		Exhaust	
Pa	in. W.G.	L/s	cfm	L/s	cfm	L/s	cfm



ENERGY PERFORMANCE

		Supply Temperature		Net Airflow		Supply / Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
		oC	oF	L/s	cfm					
HEAT-ING	i	0	32							
	ii	0	32							
	iii	0	32							
	iv							***		
	v									
	vi							***		
COOL-ING	vii	35	95					**		
	viii	35	95					**		

Comments from Test Agency:

• Description of Defrost;

•

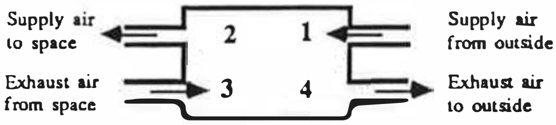
** Indicates Total Recovery Efficiency, not Sensible Recovery Efficiency.
+ 250 Pascals = 1" of Water: 0.47 L/s = 1 cfm.
*** Calculated for R2000 Rating Purposes.

ORF Reference Report:

Testing was performed in general accordance with CSA Standard C439-M, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators and was conducted in accordance with normal professional standards. Neither the Ontario Research Foundation nor their employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission. Specification Sheet format revised August, 1988.

EXPLANATION OF HRV SPECIFICATION SHEET

A heat recovery ventilator provides controlled ventilation while preventing undue loss of heat. The supply side of the device brings fresh air into the home, while the exhaust side vents stale air to the outside. Heat is transferred from the warmer to the cooler air as the two streams flow past one another in the core of the unit. Points 1 through 4 on the diagram refer to air from outside to equipment (1), air from equipment to space (2), air from space to equipment (3), and air from equipment to outside (4) respectively.



The HRV Design Specification Sheet shows test results and values calculated from test data. The unit tested was supplied by the manufacturer or Canadian distributor, who claims that it is representative of models offered for sale at the date of testing. The model number is the distributor's designation of the unit tested. The tests determined ventilation performance; percentage of exhaust air carried over into the supply air; the capability of the ventilator to recover heat from one air stream and transfer it to the other under varying conditions; and performance during cold weather (referred to as "the 72-Hour Cold Weather Test").

All air flow data are corrected to standard conditions of air density of 1.201 kg/m3 (0.075 lb/cu.ft.). In order to make precise calculations, please refer to CAN / CSA - C439 - 88, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators. **It is important to recognize that for comparison of equipment, only data at equivalent supply temperature and net air flow should be used.** For an explanation of the terms used, refer to the list below.

PERFORMANCE SUMMARY

Maximum Rated Airflow
Maximum net outdoor airflow selected by manufacturer for rating of the unit.

Lower Speed Airflow
Airflow achieved by setting unit at Maximum Rated Airflow, then using unit controls to reduce flow. Fixed speed units will have individual rating points. Variable speed units will have a range of flows shown.

Exhaust Air Transfer Ratio
Ratio of the quantity of exhaust air found in the air supply to the total air supply flow. This ratio can be expressed as a percentage if multiplied by 100.

$$\text{Exhaust Air Transfer Ratio} = 1 - \left(\frac{\text{Net Supply Air Flow}}{\text{Gross Supply Air Flow}} \right)$$

Low Temperature Ventilation Reduction
The percentage reduction in net outdoor air flow rate at the end of the 72-Hour Cold Weather Test, compared with operation at 22 C conditions. The final flow rate is taken as the average from the last 12 hours of the test.

Maximum Unbalanced Airflow During Low Temperature Test
This represents the depressurization potential during normal operation (including defrost). Short term transients caused by dampers moving are not considered, nor is depressurization caused by equipment or component failure, or blockage.

Lowest Temperature Unit Tested to
The supply temperature at which the 72 hour test was carried out.

VENTILATION PERFORMANCE

External Static Pressure
The total differential measured between Points 1 and 2 (supply) or Points 3 and 4 (exhaust).

Net Supply Air Flow
The gross supply air flow minus cross-leakage (EATR). This is the actual amount of outside air supplied by the unit and is used only for sizing the equipment for the required ventilation rate.

Gross Exhaust and Supply Airflows
The measured volume of air at Points 2 and 3 which may contain recirculation air from cross-leakage (EATR). These values are used only for selecting ductwork.

ENERGY PERFORMANCE

Values are listed for various test points of supply (outside air) temperature, and corresponding air flow points are selected according to specific pressure or Net Supply Air Flow. The number of test points listed depends upon the manufacturer.

Supply Temperature
This column shows (i) steady state tests at 0 C (32 F) at maximum rated air flow and at other test points selected by the manufacturer; (ii) the 72-Hour Cold Weather Test, carried out at temperature shown at maximum rated air flow (All values are taken as the average over the last 12 hours of the test).

Net Air Flow
Average net maximum air flow during test period adjusted for cross - leakage (EATR).

Average Power (kilowatts)
The average power consumption (watts) during the specific test for fans and controls. See also Description of Defrost.

Sensible Recovery Efficiency (SRE)
The sensible energy recovered minus the supply fan energy and preheat coil energy, divided by the sensible energy exhausted plus the exhaust fan energy, corrected for cross - leakage (EATR). This value is used to determine and compare HRV heat recovery performance.

Apparent Sensible Effectiveness (ASE)
The measured temperature rise of the supply air stream divided by the temperature difference at Points 1 and 3 and multiplied by the mass flow rate of the supply divided by the minimum of the mass flow rate of the supply or exhaust streams. This value is used principally to predict final delivered air temperature at a given flow rate.

Total Recovery Efficiency (TRE)
The total energy recovered minus the supply fan energy and the preheat coil energy, divided by the total energy exhausted plus the exhaust fan energy, corrected for cross-leakage (EATR). It is used principally to predict and compare performance for cooling applications.

Net Moisture Transfer (NMT)
Moisture recovered divided by moisture exhausted and corrected for the effect of cross leakage. NMT=0 indicates that moisture was not transferred (other than that associated with cross leakage from the exhaust to the supply air). NMT=1 would indicate complete transfer of moisture at test conditions.

Description of Defrost
Describes defrost operating system. For units with an electric defrost system, the electrical energy required during cold weather operation over and above the normal operating requirements for fans and controls is also described.

WORKSHEET 1 – DETERMINE VENTILATION REQUIREMENTS

Step 1.1 – List Ventilation Standards Applied

Step 1.2 – Determine the Conditioned Volume of the House

FLOOR AREA OF HOUSE = ____________ ft^2
(to change square feet to square meters, divide square feet by 10.78)

CONDITIONED VOLUME OF HOUSE ____________ ft^3
(From figure D1 or as calculated)

Step 1.3 – Determine Minimum Base Flow Rate to Meet CSA F326 Requirements

ROOM BY ROOM (use Figure D1.2)
______ double /master bedrooms at 20 cfm each = _______cfm
______ other rooms not including mechanical rooms, storage rooms, halls or vestibules, at 10 cfm each = _______cfm
unfinished basement (if applicable) at 20 cfm = _______cfm
MINIMUM ROOM BY ROOM REQUIREMENT _______cfm

0.3 ACH REQUIREMENT
From Figure D1.1 or calculated from

$$\frac{\text{CONDITIONED VOLUME OF HOUSE}}{12} (ft^3) = \_\_\_\_\_\_\_ \text{cfm}$$

The minimum base flow rate is the greater of the ROOM BY ROOM and the 0.3 ACH values calculated above.
MINIMUM BASE FLOW RATE = ________cfm

Step 1.4 – Determine Minimum Required Exhaust Capability

Room	Location	If Continuous	If Intermittent
Kitchen		50 cfm	100 cfm
1st Bath		30 cfm	50 cfm
2nd Bath			
3rd Bath			
4th Bath			

Step 1.5 – List optional exhausts to be installed and describe their operation.

Optional Exhausts:
Laundry
Other (specify)

WORKSHEET 2

Conceptual Design

Type of ventilation equipment ______________________

Type of heat recovery or pre-heat ______________________

Type of distribution system ______________________

Location of heating and ventilation equipment ______________________

Category of vented combustion equipment ______________________

Method of dealing with pressure imbalance ______________________

Fan operation (continuous or intermittent) for each fan ______________________

____

____

____

____

Describe Control strategy/ integration with other systems ______________________

____

____

____

____

WORKSHEET 3A — DETERMINE ALLOWABLE AIR FLOW IMBALANCES

Step 3.1 – Calculate Building Envelope Area
(to change square meters into square feet, multiply square meters by 10.76)

Slab and basement floors ____________ ft^2
Overhanging floors ____________ ft^2
Wall areas (includes below grade) ____________ ft^2
Envelope ceilings ____________ ft^2

TOTAL ENVELOPE AREA ____________ ft^2 *Line 301*

Step 3.2 – Determine Governing Combustion Appliance Category

List category of all Combustion Appliances Planned or Installed.

Appliance (type, make & model)	Category
1. ____________	____________
2. ____________	____________
3. ____________	____________
4. ____________	____________
5. ____________	____________
6. ____________	____________

The appliance(s) with the lowest Category number is (are) the governing appliance(s). Identify the governing appliances, their Category, Pressure Decrease Limits and Leakage Factors from Figure D3.1 for this Category. Be sure to use the correct units (Imperial).

Governing Appliances – 1

2

3

Category of governing appliances ____________
(If there are no combustion appliances, Category is 3)

Leakage Factor at Base Flow Rate Condition ________ cfm/ft^2 *Line 302*

Pressure Decrease Limit at Base Flow Rate Condition ________ in. W.G. *Line 303*

Leakage Factor at Reference Exhaust Condition ________ cfm/ft^2 *Line 304*

Pressure Decrease Limit at Reference Exhaust Condition ________ in. W.G. *Line 305*

Step 3.3 – Determine Allowable Net Supply Flow Rate (pressurization limit)
(envelope area in ft^2, Leakage Factor cfm/ft^2)

Allowable Net Supply at the Base Flow Rate Condition = *Line 301* x 0.014

= ________ cfm *Line 306*

Step 3.4 – Determine Allowable Net Exhaust at the Base Flow Rate Condition
(envelope area in ft^2, Leakage Factor cfm/ft^2)

Allowable Net Exhaust at the Base Flow Rate Condition

= *Line 301* x *Line 302*

= ________ cfm *Line 307*

Step 3.5 – Determine Allowable Net Exhaust at the Reference Exhaust Flow Rate Condition
(envelope area in ft^2, Leakage Factor cfm/ft^2)

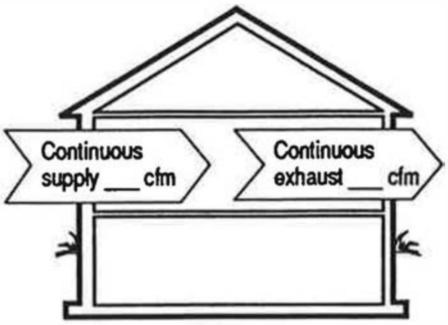
Allowable Net Exhaust at the Reference Exhaust Flow Rate Condition

= *Line 301* x *Line 304*

= ________ cfm *Line 308*

WORKSHEET 3B (Imperial) — DETERMINE DESIGN CONDITION AIR FLOW IMBALANCES

Step 3.6 – Determine the Net Air Flow at the Base Flow Rate Condition



Continuous Mechanical Exhaust ________ cfm

minus

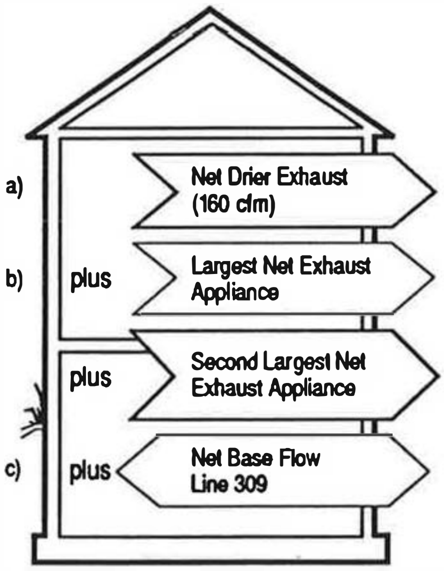
Continuous Mechanical Supply ________ cfm

equals

Net Air Flow at Base Flow
Rate Condition ________ cfm *Line 309*

(If exhaust exceeds supply, put a plus sign (+) in front of flow rate. If supply exceeds exhaust, put a minus sign (-) in front of flow rate.)

Step 3.7 – Determine the Net Exhaust Air Flow at the Reference Exhaust Flow Rate Condition



a) Net Drier Exhaust (default = 160 cfm) ________ cfm

plus

b) Net Exhaust of Exhaust Appliance with Largest Net Exhaust ________ cfm

plus

Net Exhaust of Exhaust Appliance with second Largest Net Exhaust ________ cfm

plus

c) *Line 309* above ________ cfm

(If there is a minus in front of this number, subtract it from the above total)

equals

Net Exhaust at Reference Exhaust
Flow Rate Condition ________ cfm *Line 310*

WORKSHEET 3C (Imperial)

Step 3.8 – Select and Size Relief and Make-up Air Systems

If there is a Net Supply Air Flow at the Base Flow Rate Condition (i.e. *Line 309* has a minus (-) sign) and it is larger than the Allowable Net Supply Flow Rate (*Line 306*) a relief air system sized to meet the airflow difference is required.

Describe the relief air system and how it is to operate. A relief air vent for this purpose may be sized using the 10 Pa column of Figure D3.5. Specify the size and type of equipment to be applied.

____

____

____

____

If the Net Air Flow at the Base Flow Rate Condition (*Line 309*) is a net exhaust (i.e. has a plus (+) sign) which is bigger than the Allowable Net Exhaust at the Base Flow Rate Condition (*Line 307*) or the Net Exhaust at the Reference Exhaust Flow Rate Condition (*Line 310*) is bigger than the Allowable Ventilation Net Exhaust at the Reference Exhaust Flow Rate (*Line 308*) a make-up air system is needed to meet the difference in airflows at each condition.

A make-up air vent for this purpose may be sized using Figure D3.5. Use the Allowable House Pressure Decrease(s) in *Lines 303* and *305* to determine which column(s) to use in Figure D3.5. Note that for Category 3 houses, the Pressure Decrease Limits for the Base Flow Rate Condition are different than those at the Reference Exhaust Flow Rate Condition.

If vents are to be used to meet airflow imbalances at more than one of the above three conditions (i.e. Net Supply at the Base Flow Rate Condition, Net Exhaust at the Base Flow Rate Condition, Reference Exhaust), the largest vent will satisfy all conditions.

Describe the make-up air system and how it is to operate. Specify the size and type of equipment to be applied.

____

____

____

____

WORKSHEET 4 - DETERMINE AIR DISTRIBUTION

Step 4.1 - Is the Ventilation Air Supply to be Integrated with a Forced-Air Heating or Cooling System ?

Yes____
No ____

Step 4.2 - Determine Ventilation Supply Air Design Temperature

Design Outdoor Air Temperature _______ °F (from Appendix I)
DESIGN VENTILATION AIR FLOW RATE __________cfm

For HRV systems:

HRV Effectiveness _______ % (from HRV Spec Sheet)
HRV Supply Outlet Temperature _______ °F (from Figure D4.1)

For Mixed Air Systems:

LOW SPEED RECIRCULATION FAN AIR FLOW = total air flow = _______ cfm
VF= Design Ventilation air Flow Rate / Total air Flow x 100 = __________ x 100 = __________ %

Cold Air Temperature __________ °F
(use Outdoor Temperature or HRV Outlet Temperature)

Mixed Air Temperature __________ °F (from Figure D4.2)

Step 4.3 - Is Ventilation Air Preheating Required?

Yes _____
No _____

(Ventilation Air preheating is required if forced air heating is used and if the mixed air temperature (calculated in Step 4.3) can fall below 54°F).

Design Temperature Rise = Design Mixed Air Temperature - Mixed Air Temperature (Designer May Heat to Temperatures Above 54°.).

Design Temperature Rise = __________ °F

Preheater Size __________ watts (from Figure D4.3 or calculated as 1.2 x Total Air Flow cfm x Design Temperature rise (°F).

Step 4.4 - Should High-wall or Ceiling Supply Grilles be used?

Yes _____
No _____

(High-wall or ceiling supply grilles should be used if ventilation or mixed air temperatures (from Step 4.2) can fall below 65°F.)

Step 4.5 – Locate the Supply Air Grilles or Diffusers on drawings Record Grille ID and location on the drawings and Worksheet 5.

Step 4.6 – Proportion the Ventilation Air to Each Outlet (Dedicated Systems Only)

Ventilation Air supply to each room must meet or exceed Figure D1.2 requirements. Record air flows on Worksheet 5.

Step 4.7 – Check Supply Air Flow to Each Room (Integrated System Only)

Supply Air flows must be proportioned to ensure air flow requirements from Figure 1.2 to each room are met, or

Supply Air flow to or from each Category A room must be at least 20 L/s and to or from each Category B room must be at least 5 L/s. And forced air systems must have recirculation rate of at least 1 ACH (see Figure 1.1 for 1 ACH flow rate). Make adjustments as required to flow rates or design and record changes on drawings and on worksheets.

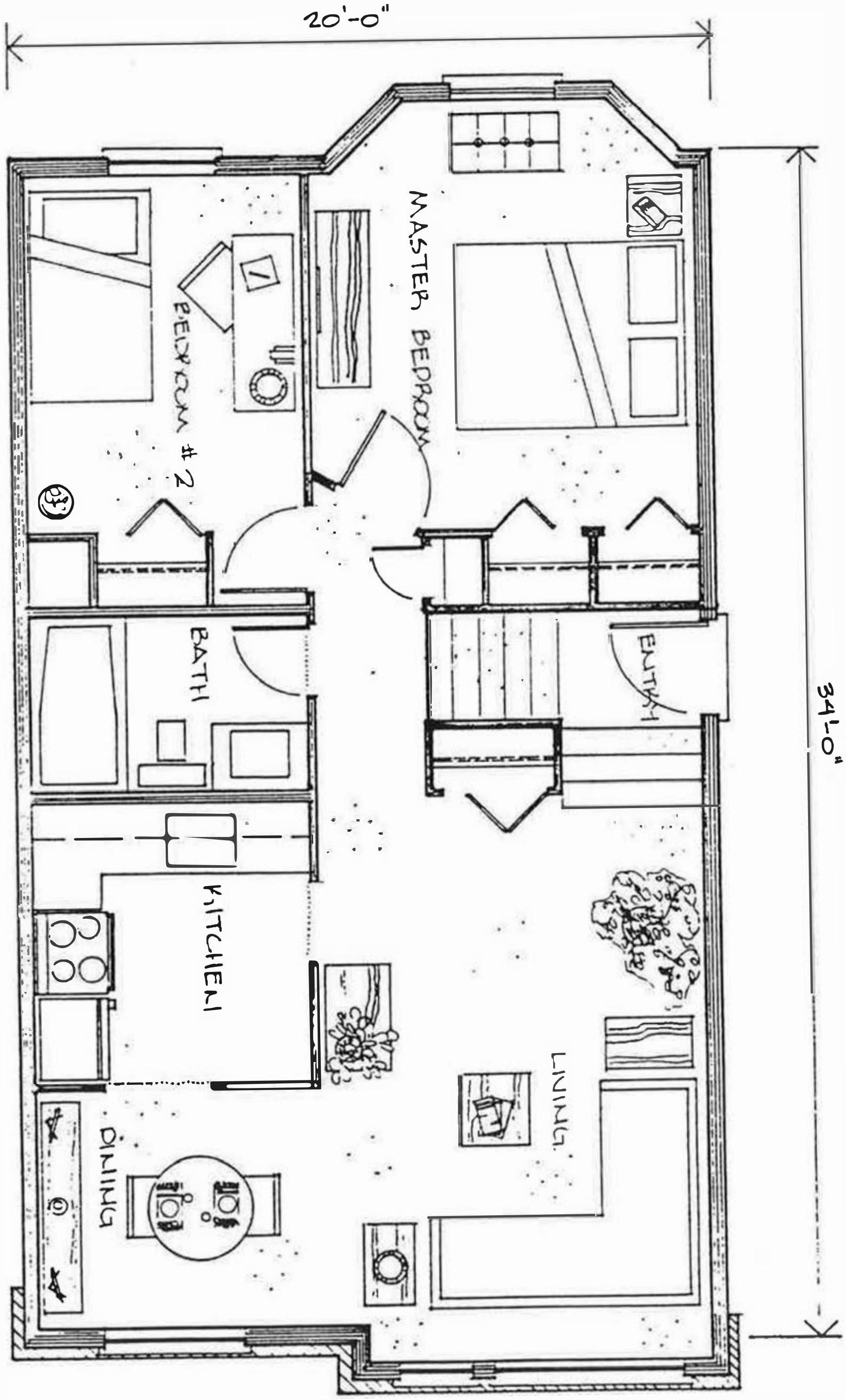
Step 4.8 – Locate Exhaust Air Grilles on drawings

Record grille ID, model, size and location on the drawings and on Worksheet 5.

Step 4.9 – Proportion Exhaust Air from Each Grille

Exhaust air flows must meet the minimum requirements from Figure D1.2. Record air flows on Worksheet 5.

WORKSHEET #4 Example



WORKSHEET 5 – SELECTION AND SIZING OF GRILLES

GRILLE ID SUPPLY	LOCATION	FLOW RATE (cfm)	GRILLE SIZE	GRILLE TYPE OR MODEL
RETURN				
EXHAUST				
DOOR UNDER-CUTS				

WORKSHEET 6A – SIZE FRESH AIR INTAKE TO FURNACE RETURN

Low Speed Return Side Static Pressure	___________	(in.Wg. or Pa)
High Speed Return Side Static Pressure	___________	(in.Wg. or Pa)
Required Ventilation Air Flow Rate	___________	(L/s or cfm)
Fresh Air Intake Diameter (from Figure D6.3)	___________	inches
Low Speed Ventilation Air Flow Rate	___________	(L/s or cfm)
High Speed Ventilation Air Flow Rate	___________	(L/s or cfm)

WORKSHEET 6B – SELECT VENTILATION FANS

Ventilator 1: Type:
Make:
Model:
Application:
Design Air Flow ____ cfm ESP ____ Pa

2: Type:
Make:
Model:
Application:
Design Air Flow ____ cfm ESP ____ Pa

3: Type:
Make:
Model:
Application:
Design Air Flow ____ cfm ESP ____ Pa

4: Type:
Make:
Model:
Application:
Design Air Flow ____ cfm ESP ____ Pa

WORKSHEET 6C – HRV SELECTION

Select approved HRV which meets flow requirements.

MAKE: ______________________________
MODEL: ______________________________

Step 6.4 – Determine LTAF

i) Find Low Temperature Ventilation Reduction for the HRV (from spec sheet)
_________ %

ii) From Figure D6.6, Temperature Zone is: ______________

iii) Low Temperature Adjustment Factor (LTAF) From Figure D6.7 =

Step 6.5 – Calculate Adjusted Design Ventilation Rate

i) LTAF x Minimum base flow rate (from Step 1.3) = Net Supply Air Flow Rate
______________ x ____________ cfm = ______________ cfm

ii) Select Gross Supply Air Flow Rate corresponding to Net Supply Air Flow Rate
______________ cfm

Step 6.6 – Determine Duct Design Air Flows

a) Design Ventilation Supply Air Flow Rate (Gross) ______________ cfm

b) Total Exhaust flow to be met by HRV ______________ cfm

Duct Design Ventilation Air Flow for balanced operation = ______________ cfm
(choose greater of a) and b) above)

Step 6.7 – Establish ESP for the HRV Fans at the design Air Flow Rate

Design Air Flow Rate _________ cfm (from Step 6.6 above)
Supply ESP at the Design Air Flow Rate _________ Pa
Exhaust ESP at the Design Air Flow Rate _________ Pa

Step 6.8 – Modify Room to Room Air Flows as Required

WORKSHEET 7 – LIST INSULATION LEVELS REQUIRED FOR DUCTWORK CARRYING WARM AIR THROUGH UNHEATED SPACES OR COLD AIR THROUGH HEATED SPACES

DUCT LOCATION	TYPE OF AIR IN DUCT	DESIGN TEMP OF SPACE	REQUIRED INSULATION LEVEL R

WORKSHEET 8 – SIZE DUCTS

FAN ID	FAN ESP (PA)	DUCT RUN ID	AIR FLOW (cfm)	DUCT TYPE	BASIC DUCT DIA	FITTING COUNT	ADJUSTED DUCT DIA	RECTANG EQUIVEL

*** When in doubt – Increase Duct Diameter ***

WORKSHEET 9 – SPECIFY VENTILATION SYSTEM CONTROLS

Step 9.1 – Describe Operating Strategy

Step 9.2 – Design the System Controls. Describe location, type and function of each control in the system.

Step 9.3 – Draw Controls onto System Plans

WORKSHEET 10 - CHECKLIST DESIGN

The ventilation system must not be used to provide combustion air for any vented combustion appliance. Fireplaces, furnaces and gas stoves require separate combustion-air supplies, designed specifically for the appliance they serve.