Installation Manual for Residential Mechanical Ventilation Systems

Student Reference Guide

1992 Edition

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Terms and Reference Guide
System Reference Guide
Component Reference Guide
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Buchan, Lawton, Parent Ltd
Ottawa, March 1992

PREFACE

The course, for which this manual is a resource document, is intended to instruct members of the heating, refrigerating and air conditioning trade in the proper installation of ventilation systems. The course is intended for personnel who have a good basic understanding of duct work installation but have not had extensive experience in ventilation system installation.

The course does not cover the details of ventilation system design. It deals with the basic principles of design required by a system installer in order to review a design and make necessary adjustments to the design to suit field conditions.

It is the objective of the HRAI and the federal government, who co-operated in the development of this course, to equip industry personnel to deal with current and proposed requirements in the area of residential ventilation.

This *Installation Manual for Residential Mechanical Ventilation Systems*, referred to as the *Installation Manual* is intended to be a stand-alone reference guide for the use of course participants after the completion of the course.

This reference guide is generic in nature and covers the basic approaches taken by the National Building Code of Canada and national CSA standards in addressing ventilation issues. In all cases, specific provincial and municipal requirements in your area must also be addressed.

The main body of the *Installation Manual* is presented in five sections with a series of five supplements included at the back of the manual.

The first section, Basics, introduces the basic concepts of building science and the need for ventilation in residential buildings. An examination is made of indoor air quality concerns in Canadian homes and the strategies used for dealing with them. The most important terms and definitions an installer should understand are introduced and the important concept of the house as a system are discussed. The types of ventilation and air distribution systems used by the low-rise residential industry are briefly introduced and the first section concludes with a discussion of the concept of using ventilation as a means of air quality control.

Section 2, Installation Requirements, presents the characteristics of a good ventilation system and highlights the link between these characteristics and the relevant codes and standards. The critical aspects of each element of the ventilation system are discussed separately. The requirements and recommendations of the National Building Code, CSA-F326 and the R-2000 standard with respect to ventilation issues are individually addressed. The concepts and concerns presented in the second section are brought together under an examination of the code and standard requirements for the various types of ventilation systems.

In the third section of the Installation Manual, the application of the requirements for ventilation systems as set out in the applicable codes and standards is examined. The installation practices for the installation of components specified in the design are highlighted. As well, the selection and installation of components which may not have been specified by the system designer are discussed.

The fourth section examines the steps involved in the design review of a ventilation system. Students will learn how to uncover obvious errors in a design, how to review site conditions that could affect the original design, and how to evaluate whether substitution of equipment in the field will affect the system design.

The fifth section deals with the steps involved in starting up and testing a new system The student will learn how to conduct a visual review of the system, conduct tests of the system and document the system start-up.

The five supplements provide background and resource materials to support the main body of the text.

The first supplement, the Terms and Definitions Reference Guide contains the definitions of terms used in the Installation Manual that may not be known by ventilation system installers. It is essentially a glossary with diagrams and can be referred to whenever the user of the manual is unfamiliar with a term.

The second supplement is a system reference guide providing detailed information on the various types of ventilation systems.

The third supplement is a detailed component reference guide.

The fourth supplement outlines an accurate procedure for sizing ducts.

The final supplement contains the procedures for undertaking a variety of ventilation system tests.

RÉSUMÉ

Le cours dont ce manuel constitue le document de référence vise à enseigner aux gens de métier oeuvrant dans les domaines du chauffage, de la réfrigération et de la climatisation comment installer correctement les systèmes de ventilation. Il s'adresse aux personnes qui possèdent une bonne compréhension de base de la pose des conduits, mais qui ne jouissent pas d'une vaste expérience dans l'installation des systèmes de ventilation.

Ce guide de référence est de nature générale et couvre les méthodes de base prescrites par le Code national du bâtiment du Canada et les normes nationales de la CSA touchant la ventilation. Dans tous les cas, les exigences provinciales et municipales s'appliquant à votre région doivent également être respectées.

Le corps du manuel d'installation compte cinq sections auxquelles on a ajouté cinq suppléments.

La première section, intitulée Basics, présente les principes fondamentaux de la science du bâtiment et la raison d'être de la ventilation dans les bâtiments résidentiels. On y examine les problèmes de qualité de l'air intérieur des habitations canadiennes ainsi que les stratégies permettant de les régler. Les termes et définitions que l'installateur doit comprendre sont expliqués et l'importance du concept de la maison en tant que système est exposé. On présente brièvement les types d'installation de ventilation et de distribution d'air utilisés par l'industrie du bâtiment résidentiel de faible hauteur et la première section se termine par un commentaire sur le recours à la ventilation comme moyen de régir la qualité de l'air.

La deuxième section, Installation Requirements, porte sur les caractéristiques d'une bonne installation de ventilation et fait ressortir le lien qui les unit aux codes et normes pertinents. Les aspects critiques de chaque élément du système de ventilation sont traités individuellement. Les exigences et recommandations du Code national du bâtiment, de la norme F326 de la CSA et de la norme R-2000 touchant la ventilation sont abordées séparément. Les concepts et préoccupations présentés à la deuxième section sont réunis par l'examen des exigences des codes et des normes quant aux divers types d'installation de ventilation.

Dans la troisième section du manuel d'installation, on explore l'application des exigences relatives aux systèmes de ventilation telles que les établissent les codes et les normes en vigueur. Les méthodes d'installation des composants indiqués par les plans sont mises en évidence. En outre, on commente le choix et l'installation de composants qui peuvent ne pas avoir été demandés par le concepteur du système.

La quatrième section explique les étapes à suivre pour réviser la conception d'un système de ventilation. Les étudiants apprendront comment découvrir les défauts de conception évidents, déterminer comment le lieu d'installation peut entraîner la modification des plans d'origine et évaluer si la substitution d'équipement sur le terrain influera sur la conception du système.

La cinquième section explique de quelle façon mettre en marche et à l'essai un système neuf. L'étudiant apprendra comment inspecter le système, mener des essais et documenter le démarrage du système.

Les cinq suppléments offrent des renseignements généraux et du matériel de référence à l'appui du corps du texte.

Le premier supplément, Terms and Definitions Reference Guide, définit les termes utilisés dans le manuel d'installation que pourraient ignorer les installateurs. Il s'agit essentiellement d'un glossaire avec diagrammes auquel l'utilisateur du manuel peut se référer chaque fois qu'il rencontre un terme peu connu.

Le second supplément constitue un guide de référence offrant des renseignements détaillés sur les divers types de système de ventilation.

Le troisième supplément est un outil de référence détaillé portant sur les composantes des systèmes.

Le quatrième supplément fait état d'une méthode précise servant à déterminer les dimensions des conduits.

Quant au dernier supplément, il explique comment faire subir une série d'essais aux systèmes de ventilation.

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1 BASICS

Purpose of Section

This first section of the Installation Manual for Residential Ventilation Systems is an introduction to the basic concepts of building science and the need for ventilation in residential buildings.

An examination is made of indoor air quality concerns in Canadian homes and the strategies used for dealing with them. The most important terms and definitions an installer should understand are introduced and the important concept of the house as a system is discussed. The types of ventilation and air distribution systems used by the low-rise residential industry are briefly introduced and the section is concluded with the concept of using ventilation as a means of air quality control.

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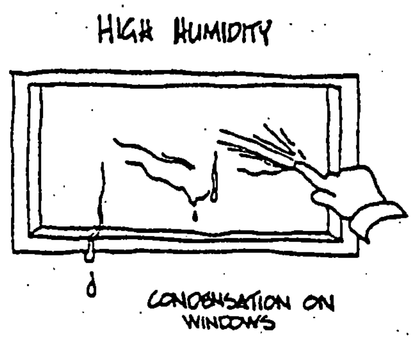
1.1 Basic Indoor Air Quality Concerns

In recent years, indoor air quality has become an increasing concern in all types of buildings. Indoor air quality in residential buildings has been the subject of a wide variety of research and product development efforts over the past two decades in Canada. The concerns with indoor air quality range from indoor humidity levels to the spillage of combustion products from fuel burning appliances in the house.

There are numerous pollutant sources in a house. High levels of pollutant generation or low levels of ventilation can adversely affect the health of occupants.

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



Changes in the way houses are built and used have contributed to the increased interest in air quality issues. New houses are generally much tighter, synthetic materials are much more common, and modern heating systems contribute far less to the ventilation of houses.

The control of humidity is of special concern. Where elevated levels of humidity are allowed to persist, significant damage to the fabric of a house can result.

Excess condensation on windows is often the first sign of a moisture problem.

An indication of elevated humidity levels is excessive condensation on cold surfaces, such as windows. Condensation around windows can cause deterioration of painted surfaces, deterioration of drywall and rotting of the wooden parts of the windows.

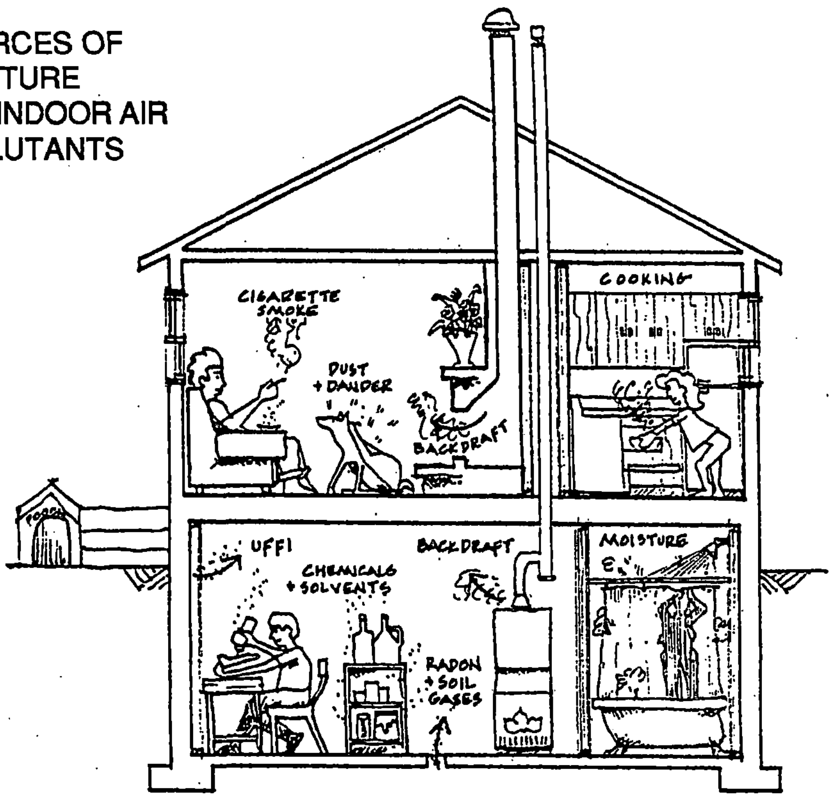
Much of the damage done by excessive humidity, however, cannot be easily seen. This includes the damage done by condensation occurring inside the structure of the walls and roof. The potential for damage can be greatly reduced by adequately controlling humidity levels.

The following table highlights some of the air pollutants commonly encountered in homes and the potential mechanisms for dealing with them.

Air Pollutants Commonly Encountered in Homes

Air Pollutant	Description	Sources	Health & Welfare Guidelines	Effects of Ventilation on Concentration
Formaldehyde (HCHO)	Colourless gas with a pungent odour at higher concentrations	Furnishings, rugs, glues, some glued or processed wood products, some insulation	0.10 ppm	Lowers concentration
Radon		From ground through cracks in basement walls and floor, from ground water (wells)	21 pCi/L (800 becquerels/m^3)	Lowers concentration Depressurization of house can increase concentration
Carbon Dioxide (CO_2)	Colourless and odourless gas	Respiration (human and animal), fuel burning equipment, smoking	3,500 ppm	Lowers concentration
Carbon Monoxide (CO)	Colourless and odourless gas	Combustion appliances, fireplaces, (can enter house if chimney/ vents backdraft), smoking, automotive engines (can enter house through improperly located air intakes)	11 ppm maximum for 8 hour exposure 25 ppm maximum for 1 hour exposure	Lowers concentration
Nitrogen Dioxide (NO_2)	Colourless, odourless and tasteless gas formed during combustion	Combustion appliances (for example: kerosene heaters, wood stoves), smoking	0.05 ppm maximum for 8 hour exposure 0.25 ppm maximum for 1 hour exposure	Lowers concentration Should not be present in home if appliances vented properly
Volatile Organic Compounds (VOCs)	Most are visibly undetectable but often have a detectable smell	Furnishings, pesticides, hobbies, crafts, adhesives, solvents, and cleaning and cooking products	Varies depending on compound	Lowers concentration unless outside air has greater concentration
Water (H_20)	Humidity in the air Condensation on cooler surfaces in walls and on windows	Household activities such as washing, bathing, showering, cooking New furnishings Leaky basements	Suggested: Minimum 30% RH Maximum 55% RH	Winter: generally lowers RH Summer: generally raises RH
Respirable Suspended Particulates (RSPs)	Particles less than 0.25 microns in size suspended in the air	Smoking, wood smoke, unvented appliances, kerosene heaters	40 mg/m^3 maximum for 8 hour exposure 100 mg/m^3 maximum for 1 hour exposure	Lowers concentration unless outside air has greater concentration

SOURCES OF MOISTURE AND INDOOR AIR POLLUTANTS



1.2 Strategies for Dealing With Indoor Air Quality Concerns

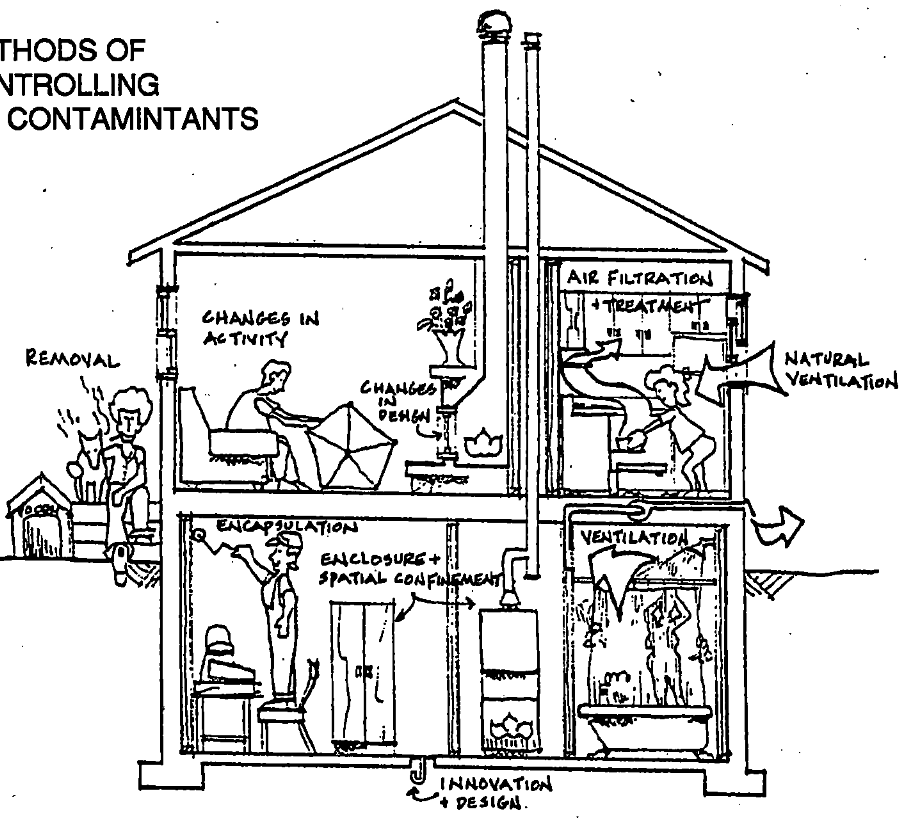
A ventilation system will always be a necessary part of the design of a house. However, ventilation alone cannot solve all indoor air quality problems.

A wide variety of methods are available for controlling indoor air quality in a home. No single solution is acceptable or fully satisfactory in all cases. Often a combination of several approaches offers the best solution.

The most common methods of air quality control include:
- removing the pollutant source
- substituting polluting products or activities with non-polluting ones
- sealing, enclosing or encapsulating the source
- changes in design
- air treatment
- humidification or dehumidification
- ventilation

Regardless of the other strategies employed, some level of ventilation is always necessary. This manual focuses on the proper installation of residential ventilation systems.

METHODS OF CONTROLLING AIR CONTAMINTANTS

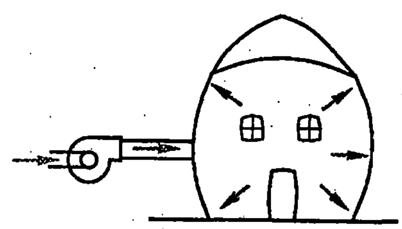


1.3 Terms and Definitions

The residential ventilation industry uses a wide variety of technical terms. A number of these terms must be understood to effectively deal with the installation of ventilation systems. The following are important terms and definitions in the industry. These, along with other relevant definitions, are also included in the Terms and Definitions Reference Guide in the Supplements section of this manual.

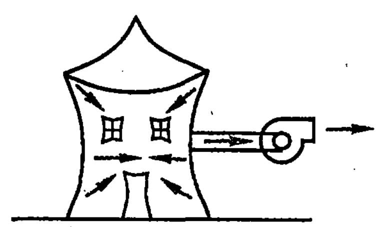
Pressure

Positive Pressure: also referred to as pressurization, positive pressure means that the air pressure inside the house is greater than the pressure outside the house. This happens when the amount of air supplied to the house by mechanical or other means exceeds the amount of air removed by mechanical or other means (in other words, the air being added to the house exceeds the air being taken from the house). As the pressure inside the house increases (relative to outdoors), it forces the excess air out through any openings in the building envelope.



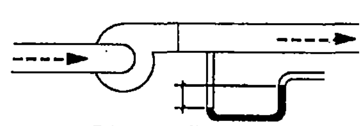
Positive Pressure

Negative Pressure: - also referred to as depressurization, negative pressure means that the air pressure inside the house is lower than the pressure outside the house. This happens when the amount of air removed from the house by mechanical or other means exceeds the amount of air supplied by mechanical means or other (the air being removed from the house exceeds the air being added to the house). As the pressure inside the house decreases (relative to outdoors), outside air is sucked in through any openings in the building envelope to make up the difference in air flow. The openings through which this air flows may include the chimney.



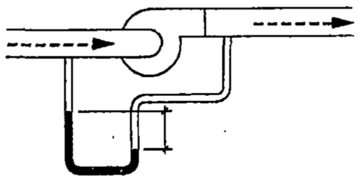
Negative Pressure

Static Pressure: a measure of pressure available from a fan to move a given amount of air or the pressure required to use or deliver a given amount of air across a resistance (for example, a filter, coil, length of duct, etc).

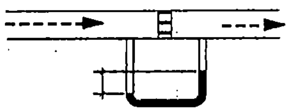


Static Pressure

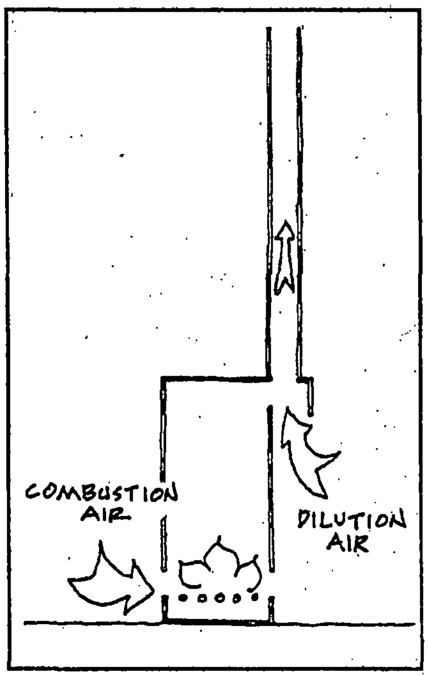
External Static Pressure: is the pressure difference developed from the inlet port to the outlet port of a packaged ventilator (for example, an HRV) when the unit delivers a specific air flow. External Static Pressure is



External Static Pressure



Pressure Drop



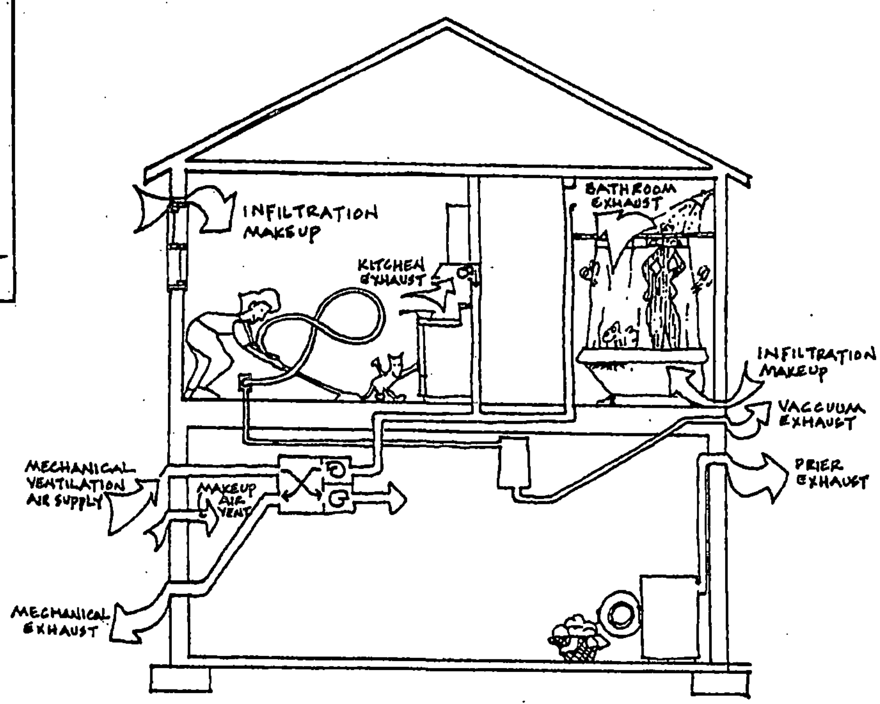
the pressure available from a fan to push air through the ductwork after pressure drops across filters, cores or coils, etc. inside the ventilator case have been factored out.

Pressure Drop: the static pressure loss caused by air movement through a duct, filter coil, HRV core, etc.

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. 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 (for example, dryer exhaust, kitchen exhaust, central vacuum 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.*

Natural Ventilation: outdoor air which is supplied to a habitable space by natural forces through openings in the building envelope (for example, open doors and windows and cracks or holes in the envelope). Natural ventilation tends to be unreliable and random.

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

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 (it is the opposite of make-up air).

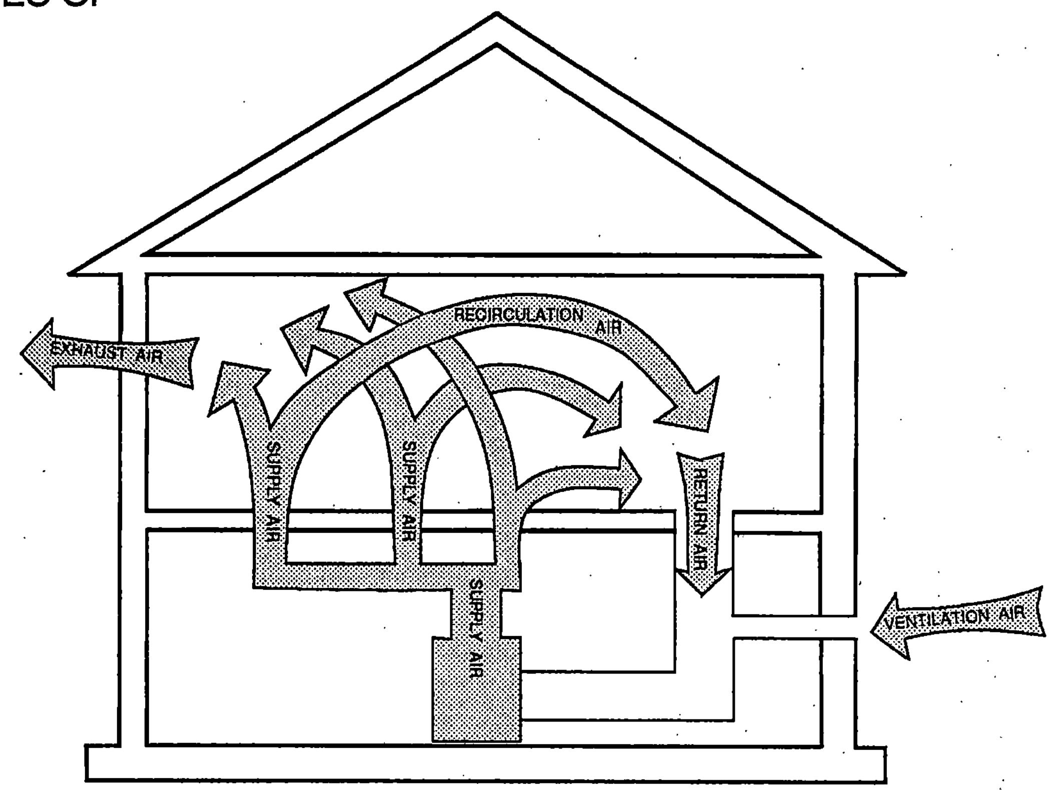
Recirculation Air: air which is removed from a space for conditioning (heating, cooling, cleaning, humidifying, or dehumidifying) and then returned to the space. Houses without forced-air heating or cooling systems have no recirculation air.

Return Air: recirculation air being removed from a space.

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

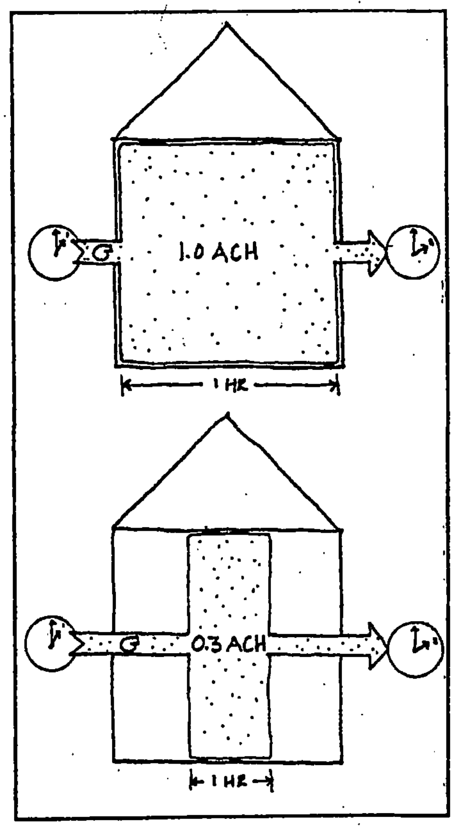
Ventilation Supply Air: outdoor air intentionally supplied to a habitable space by mechanical means.

TYPES OF AIR


EXHAUST AIR
RECIRCULATION AIR
SUPPLY AIR
SUPPLY AIR
SUPPLY AIR
RETURN AIR
VENTILATION AIR

Miscellaneous Terms

Air Change Rate: refers to the number of times in one hour that the air changes within a given space. It is measured in air changes per hour (AC/h). 1.0 AC/h 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. 0.3 AC/h is 30% of 1 AC/h.



Building Envelope: the surfaces formed by all components of the building which enclose the conditioned volume.

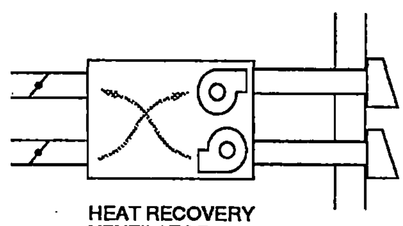
Heat Recovery Ventilator: a factory-assembled unit incorporating a means to circulate air for ventilation and providing the transfer of heat between two isolated air streams.

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

Packaged Ventilator: a factory assembled unit which incorporates a means to supply ventilation air and/or to remove exhaust air, and is intended for continuous or intermittent operation, such as heat recovery ventilators and bathroom fans.

Spillage Susceptible Combustion Appliance: a vented combustion appliance that is not vented with a positive mechanical means or does not employ sealed combustion.

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.



HEAT RECOVERY
VENTILATOR

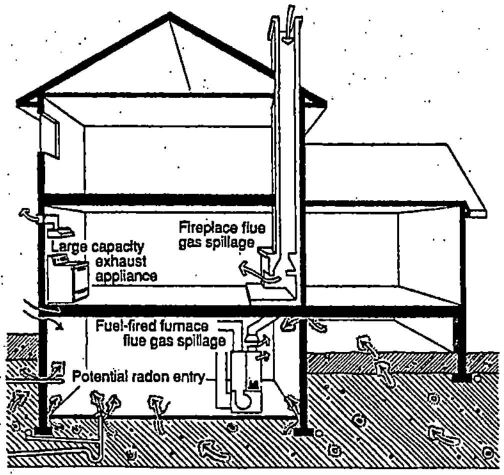
1.4 The Concept of the House as a System

An underlying concept in this manual is the "House as a System." All the components of the house are interlinked, and a change to one aspect of the house may affect the operation of other components.

A house is a building consisting of a roof, walls, windows, doors, and many other structural parts. It includes systems for heating, air conditioning, and ventilating. It is also a place where people live.

In looking at the house as a system, the components can be grouped into three basic areas:

- the building envelope
- mechanical and electrical equipment
- the occupants



EFFECTS OF THE OPERATION OF LARGE CAPACITY EXHAUST FANS IN A HOUSE

When people think of a house, they generally think of the building envelope or shell of the house. The shell consists of all components that separate the outside environment from the inside environment.

The indoor space, defined by the building envelope, is controlled or conditioned by a variety of systems and devices in the house. The most obvious systems are those designed specifically to control the indoor environment. For example, the heating system is installed to maintain a comfortable temperature in the house throughout the heating season. Other obvious systems or devices are those intended specifically to cool the indoor space, add or remove moisture from the air, and to circulate air or provide fresh air.

The less obvious systems or devices are those that affect other aspects of the indoor environment while performing their intended function. There are numerous systems and devices of this type in a house. Lighting, for example, can contribute significant heating both when it is beneficial and when it is not. A clothes dryer, intended simply to dry clothes, can provide significant space heating, introduce moisture and pollutants to the indoor environment, and add to the ventilation of the house.

The occupants of a house include the people, pets, and plants living in the house. They release moisture into the indoor space and emit and absorb a variety of pollutants. People also exercise a wide range of control over the indoor environment by operating heating and cooling systems, cooking, washing, and undertaking various other activities.

Almost any change in one aspect of a house, either in the way it is constructed or the way it is used, will have an effect on other aspects of the house. Nothing can be looked at in isolation. Tightening the envelope of a house, for example, cannot be achieved without having an effect on not only air infiltration, but also on indoor air quality.

In the area of house operation, the operation of exhaust only ventilation equipment or appliances can affect the draft of a naturally aspirated furnace, possibly causing it to backdraft and degrade the 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, it is assumed that turning on the exhaust fan will improve indoor air quality. By looking at all the implications and considering "the house as a system," turning on an exhaust fan may result in a significant reduction in indoor air quality of the house and possibly create a health or safety hazard.

> The design of a ventilation system must take into account the effect it may have on other aspects of the house including the building envelope, other mechanical systems, and the building occupants. Looking at the "house as a system" allows you to take all of these factors into account.

When looking at the "house as a system", three basic building science principles must be understood. These principles relate to the three types of flow found in every house:

- Heat flow
- Air flow
- Moisture flow

The interrelation of these flows determines the state of the house system at any given moment in time. It is desirable to create a condition which maintains the structural integrity of the house over time, while affording safety and comfort to the building occupants at a minimum cost to the homeowner. Although heat flow and moisture are an important consideration when making alterations on the house as a system, for the purposes of this manual they play a minor role and are not discussed. Air flow, however, can have a significant effect on the combustion venting process.

Air Flow

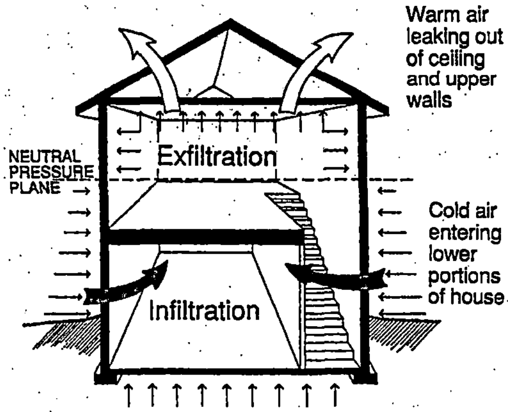
In much the same manner as heat flows through a material because of a temperature difference, air will flow into or out of a structure due to a difference in air pressure. Air flows from higher to lower pressure.

Pressure differences result from:

- the difference between indoor and outdoor air temperature (the resulting pressure difference produces the so-called stack effect)
- wind direction and velocity
- ventilation and exhaust fans
- the operation of chimneys for combustion appliances or fireplaces
- leaks in the ductwork of a forced-air heating system

The number, size and location of holes in the envelope, while they do not actually generate air flow, significantly affect the volume of air flow resulting from other factors in this list. Air flow will not occur if there are no holes through which the air can pass. Air flowing in through these openings is called "infiltration" and air flowing out is called "exfiltration".

These factors influence the air flow in all houses, therefore, they must be taken into account when assessing air flow conditions in a given house.



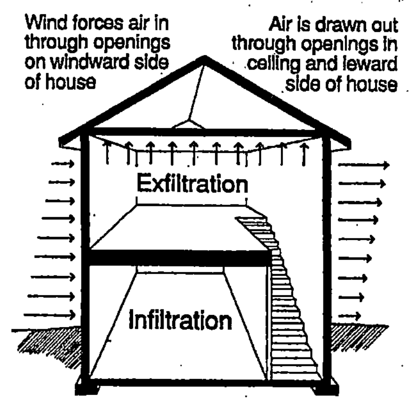
STACK EFFECT

Stack Effect: The difference in temperature between indoor air and outdoor air creates a pressure difference due to the difference in air densities. The pressure difference causes the house to act as a large chimney--cold air enters or infiltrates through holes in the lower levels, is heated, rises, and exits or exfiltrates through the upper levels. This is called the stack effect. An example can be found in many two or three storey houses where the windows on the lower floor(s) are clear and those on the upper floor have condensation on the inside surface of the outer glazing of double glazed windows. Warm, moisture laden air is leaking out of the upper storey window and the moisture is condensing on the inside of the cold outer glass pane.

The level at which infiltration changes to exfiltration is called the "neutral pressure plane". Its location changes with conditions. The greater the temperature difference between the indoor and outdoor air, the larger the stack effect.

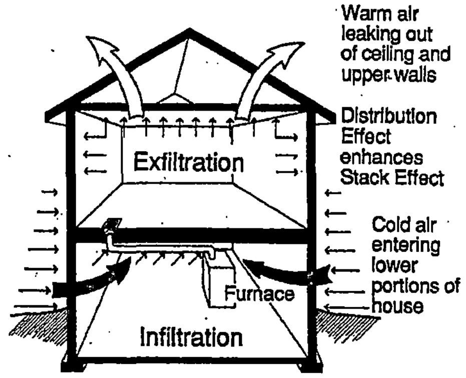
Wind Effect: Wind causes positive pressure on the windward side of the house and negative pressure (suction) on the leeward side and the sides parallel to the direction of flow .

Pressures inside the house due to wind action depend on the resistance to flow of cracks and openings in the building exterior and their location in relation to wind direction. Pressures must adjust so that inflow equals outflow. Wind action does not usually pressurize or depressurize the house, however, if most of the openings occur on the windward side, pressures inside the house will increase. The converse will occur when most of the openings are on the leeward side. The overall effect of wind action is that localized "pockets" of positive pressure may develop in some areas of the house, but these will be balanced by negative pressures in other areas.



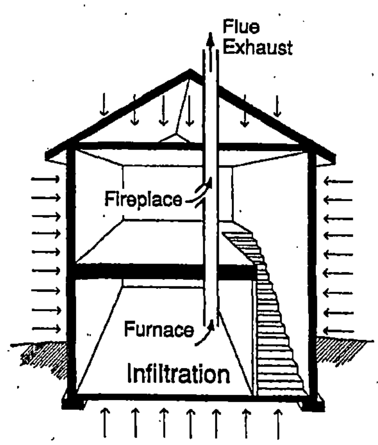
WIND EFFECT

Distribution System Effect: Forced-air heating systems distribute warm air through pressurized supply ducts and return cool air through depressurized return ducts. Since most return-air systems utilize a joist space over which sheet metal is nailed, it tends to be very leaky. However, because the return duct system is depressurized (it contains a negative pressure), air does not leak out of the return system, it leaks in, usually from the basement. This enhances the stack effect by further depressurizing the basement. The effect can be compounded by basement return-air inlets, poor fitting external furnace filter assemblies and leaky furnace blower doors.

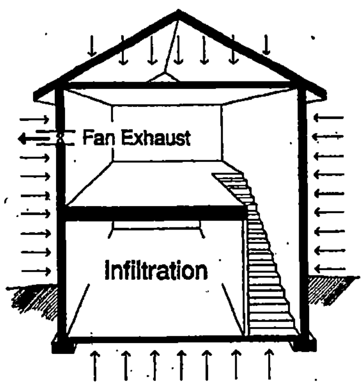


DISTRIBUTION EFFECT

Flue Effect: A fourth, less obvious effect is the pressure difference caused by a combustion appliance or fireplace with a chimney. The heating appliance or fireplace takes in air for combustion and dilution causing a lower pressure in the house, usually in the basement in the case of the furnace. (The amount of depressurization caused by a gas or oil furnace or boiler is very small compared to an open fireplace.) This causes increased infiltration. The process is called the Flue Effect.



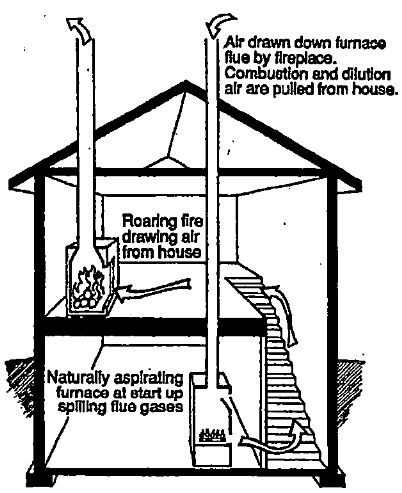
FLUE EFFECT



VENTILATION EFFECT

Ventilation Effect: The Ventilation Effect results from the operation of mechanical devices that exhaust air. Common examples are bathroom fans, kitchen range hoods, clothes dryers and central vacuum systems. These devices, when operated, expel air from the house and reduce the indoor air pressure. This "ventilation effect" is similar to the flue effect described above. By removing air and reducing indoor air pressure, it causes an equal amount of air to infiltrate.

House Depressurization: When household exhaust equipment, such as exhaust fans, clothes dryers, and fireplaces operate, they blow air out of the house. This lowers the indoor pressure relative to the outside. This lowering of indoor pressure is referred to as "house depressurization". The amount of house depressurization that occurs depends on the number and capacity of the exhaust devices in the house and the tightness of the building envelope. The greater the exhaust, and the tighter the building, the more a house will be depressurized.

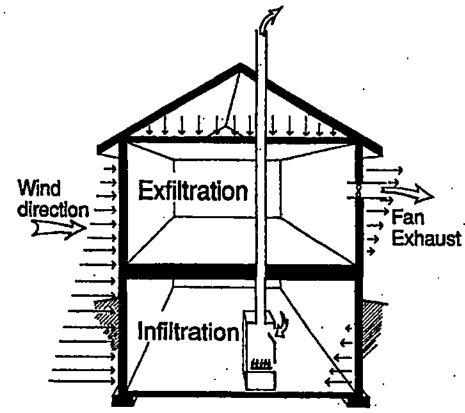


BACKDRAFTING AND SPILLAGE

Backdrafting: As house depressurization increases, the chimney must increasingly compete against the suction exerted by the exhaust devices. As a result, it becomes less and less capable of venting all the combustion gases it was installed to vent. In some cases, house depressurization is great enough to cause the flow of combustion gases in the chimney to reverse. This results in a backdraft situation in which all of the combustion gases are spilled into the house rather than venting safely up the chimney. Backdrafting of combustion gases can have a significant impact on the safety of the occupants of the house. Carbon monoxide and the other gases given off during combustion can easily kill a sleeping person with no warning. Backdrafting is unlikely to occur once the heating appliance is actually operating since the chimney is warm and its draft is high. Reversal of flow in a chimney during heating appliance operation is rare.

Spillage: Chimneys are least effective in combatting house depressurization when they are cool, since cool chimneys have a weak draft. For this reason, it is more common for chimneys to backdraft when the heating appliance is not operating. When the appliance eventually begins to operate, it must fight against the backdrafting current of cold air. Often an appliance will spill combustion gases into the house for prolonged periods of time before it manages to re-establish an upward draft in the chimney if it manages to at all. Spillage produced in this manner can be referred to as "pressure-induced" spillage since it is the depressurization created by the operation of household exhaust devices which causes the spillage to occur.

Combined Effect: The combined effect on air flow of stack, distribution system, flue, ventilation and wind effects will change as environmental factors (outdoor temperature, wind, etc.,) change.



COMBINED EFFECT

1.5 Ventilation as a Means of Air Quality Control

Ventilation is the process of supplying or removing air by either natural or mechanical means to or from a space. The purpose of a residential ventilation system is to:

- control odours and air contaminants (indoor air quality control)
- control indoor levels of moisture (humidity control)

These goals must be achieved while not contributing to the discomfort of the occupants, unduly increasing the operating cost of the house, adversely affecting the building envelope or adversely effecting the operation of other mechanical systems in the house.

The typical new house of today is much more airtight than a typical house constructed only a few years ago.

Until recently, mechanical ventilation had not been considered important in housing. It was assumed that the natural ventilation through the actions of wind and "stack effect" (caused by the difference of temperature between indoors and outdoors) and the operation of heating appliances, would create sufficient air movement through the leaks and cracks in the building envelope to flush out any contaminants produced in the home.

In a drafty, old house, this may have been true. *In a modern house, it is no longer sufficient to rely solely on this "accidental ventilation".* A number of factors are involved:

Recent studies show that natural ventilation does not provide adequate fresh air to houses during parts of the heating season.

- Recent studies indicate inadequate natural ventilation in many Canadian houses during portions of the heating season - primarily in fall and spring.

- Recent studies confirm that we are building increasingly air-tight envelopes.

- Better insulation means that heating appliances operate less frequently and new high efficiency heating appliances vent considerably less combustion and dilution air. This combustion and dilution air requirement can greatly increase the air exchange rate in a house.

- Building materials and products contain increasingly complex compounds and contaminants.

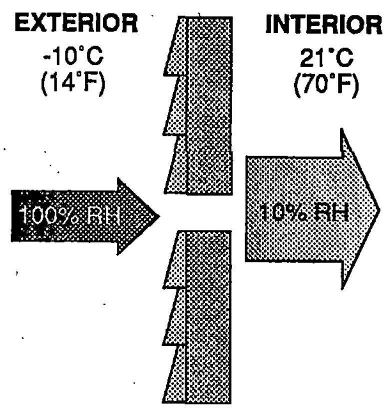
- The increased use of powerful exhaust appliances creates the potential for spillage of combustion by products.

Exhaust fans can overcome the natural draft of combustion appliances, particularly in a tight house.

One of the first symptoms indicating a need for mechanical ventilation was the increased frequency of humidity and condensation-related moisture problems in houses. Building codes responded with requirements for exhaust fans, particularly in houses without chimneys and rooms without windows.

Humidity Control

Excess humidity is one of the most frequent air quality problems in the home. While not always considered a contaminant or pollutant, excessive levels of water vapour in the air can lead to aesthetic, structural and even health problems.



CHANGE IN RELATIVE HUMIDITY OF COLD OUTSIDE AIR WHEN IT MOVES INTO A HEATED SPACE

In the winter, the humidity level can be reduced within a building by simply replacing the inside air with outside air (for example through ventilation). The rate of mechanical ventilation required to control the humidity level in a home will usually be adequate to control contaminants and odours. In some cases, the ventilation system in the house may be so effective in removing water vapour, that humidification may be required.

But why is outside air so dry? In the winter, the relative humidity of outdoor air can approach 100 per cent, yet the air contains a very small amount of water vapour. A closer look at the definitions of humidity is needed to understand this.

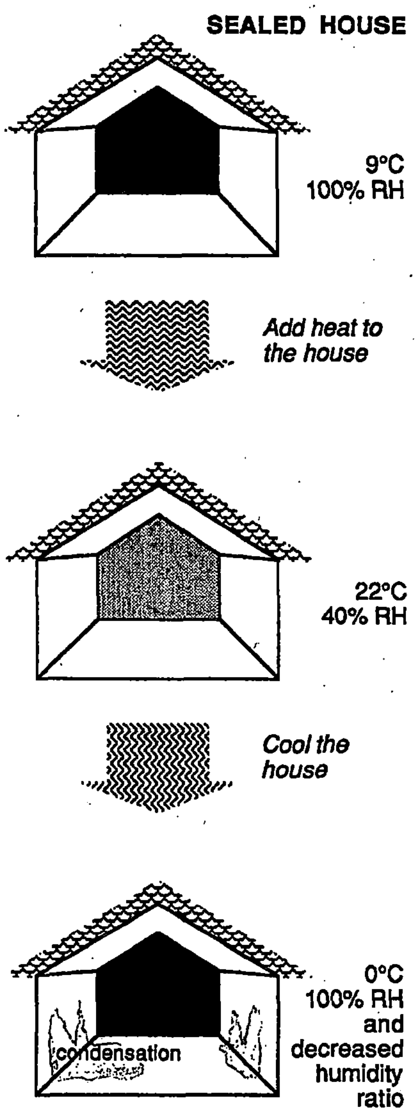
Quite simply, humidity is defined as the amount of **water vapour** contained within a given volume of air.

There is a limit to the amount of water that can exist as a vapour (gas) in a given space or volume of air. This limit varies with temperature. The warmer the air, the greater the amount of water vapour it can contain. This characteristic of air and water vapour mixtures has given rise to a number of ways of describing humidity. The most straightforward is:

***Humidity Ratio**--defined as the mass of water divided by the mass of air containing the water vapour.*

The term most commonly used when describing humidity is:

CHANGES IN RH AS TEMPERATURE CHANGES



***Relative Humidity (RH)**--defined as the amount of water vapour contained in the air expressed a percentage of the maximum amount that could be contained in the air at that same temperature.* Air measured to have an RH of 50 per cent contains half the amount of water vapour that it could hold at that temperature. Air at 100 per cent relative humidity cannot contain more water vapour and is said to be **saturated**. Saturated air has no potential for "drying".

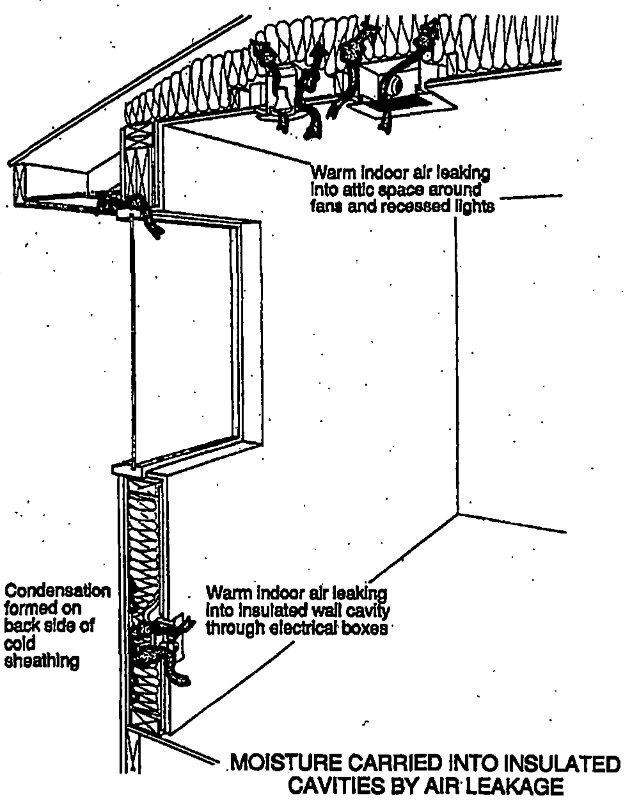
A simple way to clarify the various humidity terms is through an example. Consider a volume of air and water vapour enclosed in a sealed house. If the sealed house is heated, the relative humidity will decrease (the higher temperature air can contain more moisture), but the humidity ratio will remain the same (the amount of water vapour in the given volume of air has not changed as a result of heating).

If the house is cooled on the other hand, the relative humidity will increase until it eventually reaches saturation at 100 per cent RH. The temperature at which this occurs is the ***dew point*** of the mixture. Continued cooling of the house below the dew point temperature will result in some of the water vapour condensing into liquid water (clouds are suspended condensation droplets). Water vapour will condense on a cooling surface rather than into little droplets dispersed in the air, if a cooler surface is available. In this example, a film of liquid water would form on the inside surfaces of the house.

As the temperature decreases below the dew point, the ***humidity ratio*** of the remaining water vapour/air mix will decrease since some of the water vapour has been removed from the air in the form of condensate. The relative humidity, however, will continue to remain at 100 per cent.

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 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. This ***interstitial condensation*** (condensation occurring in chinks and crevices) is illustrated in the following diagram.

Interstitial Condensation



To minimize the potential for problems caused by moisture, 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 a 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 dehumidifier or air conditioner may be required.

Humidity is not the only issue. Formaldehyde emitted by many building products and furnishings, carbon dioxide emitted by occupants and radon entering the house through foundation cracks or in the water supply are but a few of the contaminants that can be found at elevated levels as a result of increased air tightening of Canadian houses.

Need For Improved Ventilation Standards

Ventilation and air quality have been the subject of much research in Canada and internationally. In every jurisdiction where these issues have been examined, the need for improved ventilation standards in residential buildings has been accepted. The development of appropriate standards, however, is very complex. Some of the issues which must be taken into account include:

- What ventilation capacity is needed to meet peak requirements?
- What is the average level of required ventilation?
- How should the ventilation system be controlled?
- How should cold winter air be introduced into a building without creating discomfort and complaints?
- How much intrusion, in terms of drafts and noise, should an occupant be willing to accept?
- How should the adverse impacts of other equipment in the house (such as combustion product spillage from fuel-fired appliances) be avoided?

- How should the negative effects on the building envelope (such as moisture in the envelope) be minimized?
- How important is fresh air distribution around the house?
- How can the operating costs of ventilation be minimized?
- How much additional capital cost can be justified?

1.6 Types of Ventilation and Distribution Systems

Three basic concerns relate to the mechanical ventilation of a house:

- bringing the proper amount of ventilation air into the house
- distributing the air to the required locations in the house
- avoiding excessive pressurization or depressurization of the house

Ventilation Systems

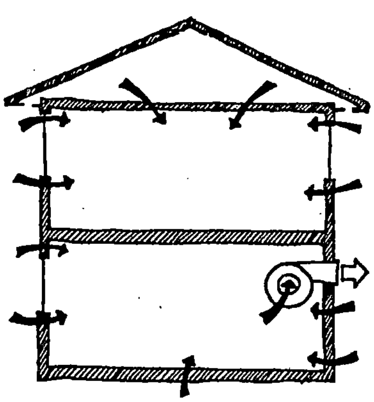
Ventilation systems bring air into the house. Three basic types exist:

(1) those which use only exhaust fans

(2) those which use only supply fans (bringing outdoor air into the house)

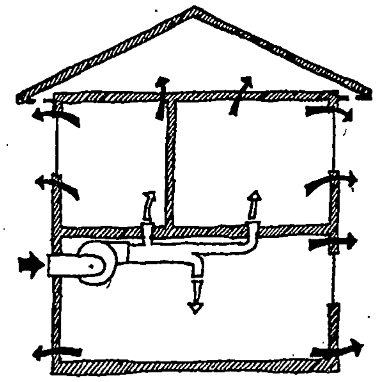
(3) balanced systems using both.

Each approach has significant advantages and disadvantages.


EXHAUST SYSTEM

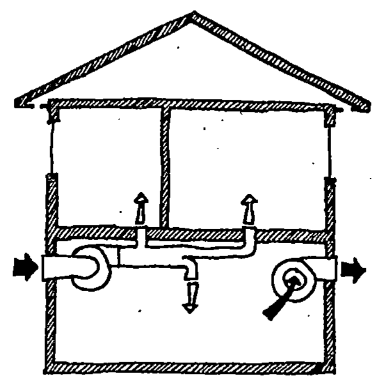
Exhaust Fan Systems: These systems are easy to install and have been used for years. Their operation, however, creates a suction force in the house. The tighter the building envelope, the higher the suction force for the same amount of exhaust flow. This negative pressure can create problems. It can accentuate drafts through the remaining holes in the envelope. If the suction forces are high enough (for example, if the exhaust fans is strong enough or the building envelope is tight), it can cause problems with the venting action of fuel-fired appliances, creating combustion product spillage or backdrafting. There is also a concern that contaminants produced inside the building envelope (formaldehyde) or outside it (radon) can become a greater concern with high negative pressures.

Supply Fan Systems: These systems draw fresh air into the house and create a positive pressure in the building. This eliminates the concerns listed above, but the positive pressure can force warm, moist indoor air through holes in the building envelope and increase the risk of problems due to condensation in walls and attics. Supply fan systems should only be used in buildings with very good air barriers. Another problem with supply systems is that, in the winter, relatively large quantities of cold outdoor air are brought into the house at one or two locations. The outdoor air should be pre-heated, mixed with indoor air, and distributed in a manner which avoids cool air blowing on the occupants of the house. This can increase installation costs.



SUPPLY SYSTEM

Balanced Systems: These systems are designed to have no impact (either negative or positive) on the pressure balance of the house. This eliminates the problems caused by both positive and negative pressures, but at some additional cost. In most cases, two fans work in tandem to provide ventilation These fans must be interconnected electrically and may be connected physically. As with supply systems, the incoming air must be warmed before distribution.

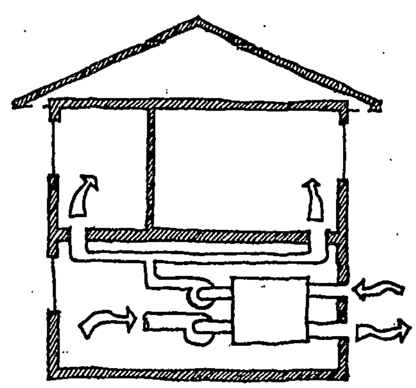


BALANCED SYSTEM

Running a ventilation system will increase the operating costs of a home when compared to the costs of operating a poorly ventilated dwelling. Exchanging warm indoor air with cold outdoor air will require more heating, and electricity will be consumed to operate fans. Any increase in the operating cost, however, will be directly associated with the improved indoor environment provided by the ventilation system.

It should be noted that controlled ventilation in a house with a tight envelope will cost less than the uncontrolled ventilation resulting from 'leaky' construction techniques.

One way to minimize additional heating costs is to extract heat from the outgoing air--using it either to heat the incoming air or to meet some other energy requirement, such as domestic hot water.

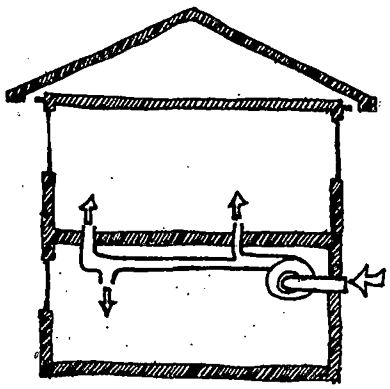


BALANCED HRV SYSTEM

Distribution Systems

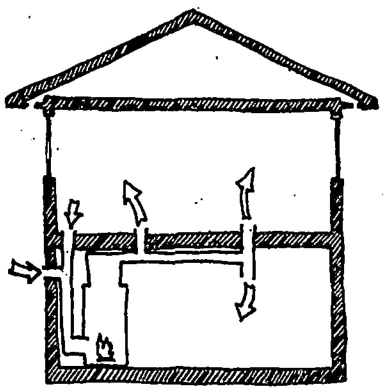
The ventilation air distribution system distributes the ventilation air to the appropriate locations in the house.

Three types of ventilation air distribution systems are described below. In all cases, exhaust air is exhausted from odour 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 supply air throughout the house.



SEPARATELY DUCTED SYSTEM

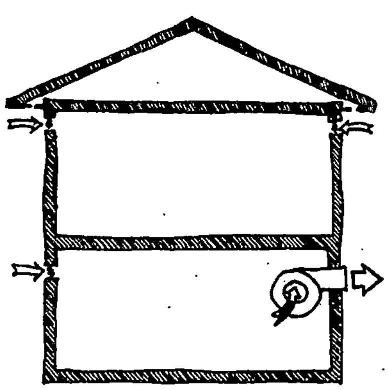
Dedicated, Independent or Separately Ducted Distribution Systems: These systems distribute ventilation air using an independent or dedicated set of ductwork. Each habitable room in the house should have its own ventilation air supply outlet or exhaust air inlet. This type of system is commonly used in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



COMBINED DISTRIBUTION SYSTEM

Integrated or Combined Distribution Systems: These 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 be capable of operating continuously) distributes the ventilation air throughout the house while mixing it with return air.

Through-the-Wall Distribution Systems: These systems utilize exhaust fans to induce infiltration into the house. Through-the-wall diffusers introduce outside air directly to each room in a controlled fashion.



THROUGH-THE-WALL SYSTEM

Regardless of the type of system to be installed, the installer must keep in mind that the house functions as a system. The installer must be aware of the implications of installing ventilation systems in houses that are too tight or too loose, or houses that have too much ventilation or too little.

If a house is well sealed, for example, and a series of through-the-wall exhaust fans are installed, their operation can lead to serious health hazards. The depressurization that would result from operating the exhaust fans could cause the furnace or fireplace to backdraft and draw poisonous gases into the house.

Installing a supply-only system in a leaky house can lead to problems with moisture laden air being driven into the wall cavities. Condensation in the wall cavity can lead to rotting wood and structural damage.

Too much ventilation can end up costing the homeowner more than necessary to adequately ventilate his home. If the cost is significant, the homeowner may be tempted to turn it off–defeating the purpose of installing the system.

Too little ventilation can lead to the build up of pollutants in the air. In new houses, for example, furnishings, floor coverings and building materials give off formaldehyde. If the ventilation system is inadequate to dilute the levels of formaldehyde, health problems may develop in some individuals.

1.7 Codes and Standards

Two key documents address ventilation from the point of view of codes and standards :

- the 1990 National Building Code of Canada (NBC 1990)
- the Canadian Standards Association Standard F326 (CSA-F326)

In addition to these codes and standards the R-2000 Program has addressed the ventilation issue in its requirements.

NBC 1990

The National Building Code (NBC) is the model Code for Canada. Some provinces have adopted the NBC; others have developed more or less stringent requirements.

The NBC is a model national code which forms the basis for codes written and made law in the various provinces. Some provincial requirements vary from those laid out in the NBC.

CSA-F326

CSA F326 details much more comprehensive ventilation system requirements than the NBC.

The NBC may include CSA F326 in the 1995 Code.

CSA-F326 is a standard detailing the design and installation requirements for all types of residential ventilation systems. CSA-F326 is a performance standard, not a procedure manual. It describes what the ventilation system must achieve, but it does not define how this end goal is to be achieved.

The standard was recently made permanent, with the next review scheduled for 1992. Should substantial revisions be necessary they will be made at that time in preparation for the anticipated inclusion of the standard in the NBC 1995.

Details of how codes and standards address the ventilation issue are discussed in Section 2 of this manual.

1.8 Costs and Constraints

Costs

Two types of costs are associated with providing ventilation:

- capital costs, or the cost of installing the system, and
- operating costs, or the costs of heating additional outside air and the costs of operating fans.

Constraints

All builders will soon be required to install at least a minimum ventilation system. For the builder who wishes to provide a higher quality system, several obstacles may be encountered:

- it may be difficult to provide a new product when other builders are not
- the market in many areas may not be ready to accept more sophisticated and more expensive ventilation systems
- for balanced ventilation systems to work properly, the building envelope may need to be significantly tighter than is common practice for that builder

1.9 The Need for Mechanical Ventilation

At least eight factors have heightened the concern about mechanical ventilation in Canadian homes.

Increased Airtightness of Canadian Homes
In a national study carried out in 1989, typical new houses were found to be 30 per cent tighter than houses measured seven years earlier. Today's building products are more air tight and building codes are encouraging good air sealing practice. Builders are generally building more air tight homes. These factors have significantly reduced the natural ventilation that occurs through cracks and holes in walls, floors and ceilings of new homes.

Accidental Nature of Natural Ventilation
The driving forces which cause natural ventilation vary with the time of year and the local weather conditions. Although a house may be leaky, it may not be appropriately ventilated for a number of reasons, including:

- the random location of cracks in a leaky house can result in the over ventilation of some areas while other areas are under ventilated
- the cold outside air in winter can result in over ventilation due to the stack effect and increased flow through the chimney
- the warm outside air in spring, summer and fall (similar in temperature to the inside of the house) can result in little or no stack effect or inadequate stack effect
- the wind can double or triple the air change rate in an exposed, leaky house. During periods of calm, there may be very little air change

Inefficiency Conventional Ventilation Systems
Conventional exhaust fans often perform well below their rated capacities. Their poor performance may be due to undersized ductwork, too many elbows, rough ductwork (flex duct) or blockages.

Reduced Natural Ventilation Rates due to More Efficient Heating Appliances

Low efficiency space and hot water heating appliances provide continuous ventilation by drawing combustion and dilution air from the house and exhausting it up the chimney. Fresh air from outside is drawn into the house to replace the exhausted air. Medium and high efficiency combustion appliances, however, exhaust far less air from the house and, therefore, require less fresh air as a replacement. As well, heating systems in electrically heated houses don't require combustion air or a flue. The reduced ventilation rates that result from medium and high efficiency combustion appliances and electrical heating systems can lead to increased moisture and air quality problems.

Increased Use of Synthetic Materials in Building Products and Furnishings

Many of the materials used during the construction, finishing and furnishing of today's homes give off gasses and chemicals. Formaldehyde, for example, is commonly used in wood products, drapery materials and carpets. If there is inadequate ventilation in the home, the concentrations of these airborne pollutants can build up to levels where they can cause discomfort and, potentially, adverse health effects.

Movement of Moisture into Concealed Cavities

The moisture in warm indoor air, when it comes in contact with a sufficiently cool surface, will condense on that surface. When this happens on windows, frost and, perhaps, water will appear on the glass and, if enough water collects, it may pool on the window sill. The same process can occur in exterior wall cavities and attics where, hidden from sight, the moisture from condensation can cause significant structural problems. A correctly sized and installed ventilation system can help to avoid excess condensation by:

- lowering indoor relative humidity levels during the heating season, and
- controlling house pressures and, therefore, reducing the entry of warm air into insulated cavities.

Installation of Powerful Exhaust Appliances

With the construction of tighter homes in recent years, it has been observed that, under certain circumstances, chimneys or other flues in a home could spill combustion gases back into the building. This spillage or backdrafting of poisonous combustion gasses can be triggered by the operation of one powerful exhaust appliance or several smaller exhaust appliances.

Concern About Indoor Air Quality

Homeowners and potential homeowners are expressing a concern about the quality of the indoor air in homes. An effective ventilation system can ensure a minimum ventilation flow and prevent the build up of pollutants from low level sources.

2 INSTALLATION REQUIREMENTS

Purpose of Section

The purpose of this section is to present the characteristics of a good ventilation system and highlight the links between these characteristics and the relevant codes and standards.

The critical aspects of each element of the ventilation system are discussed separately. The requirements and recommendations of the 1990 NBC, CSA-F326 and the R-2000 standard are then reviewed individually in relation to the aspects of the ventilation system.

The section is concluded with an examination of the various ventilation approaches that comply with the Code and Standard requirements.

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2.1 A Good Ventilation System

A good ventilation system has:

- the overall capacity to adequately ventilate the dwelling unit
- fresh air distribution to each habitable room
- mechanisms to control pollutants and contaminants through removal at source
- provision for make-up or relief air if required
- properly located and sized ducts
- an appropriate control system

Many ways exist to provide ventilation to dwellings. There is no "right system" that is appropriate for all homes and home owners. Ultimately, the ventilation system installed in a house will be partly dictated by the codes and standards, but it will be strongly influenced by factors such as:

- choice of heating system(s)
- local supplies of equipment and parts
- owner preferences
- size, type and budget of the house

The ventilation equipment installer will have to possess the knowledge of how to make all system types meet the requirements of the National Building Code 1990 and conform to good building practices, such as those specified in CSA-F326.

2.2 Overview of Codes and Standards Requirements

National Building Code, 1990

The key installation requirements for residential mechanical ventilation systems are those stated in the provincial Building Codes. The National Building Code is the model for the various provincial codes and Section 9.32 of the NBC states the requirements for mechanical ventilation systems in all new dwellings. Criteria are set out for:

- sizing the system
- selecting fans and ventilators
- controls (switches)
- acceptable types of ducting
- providing make-up air or proving it is not needed
- accessibility of equipment for cleaning and servicing
- grilles and exhaust hoods

> The NBC requirements for ventilation are the minimum measures to satisfy health and safety concerns. Better systems can be used, and their use is encouraged.

In most respects, the NBC 1990 requires the installation of basic ventilation systems. These requirements are considered to be the minimum to meet health and safety concerns and do not preclude the use of better systems.

Part 9
The NBC provides guidelines for a "simple exhaust system" (kitchen and bathroom fans) which complies with the requirements of Section 9.32 and is totally contained in the provisions of Part 9.

Part 6
Systems, other than a simple exhaust system, must conform to NBC Part 6. This section of the code requires that systems be designed in accordance with "good engineering practices".

Appendix to the NBC
The Appendix to the NBC discusses the rationale and intent of the code requirements and provides **suggestions** for dealing with many ventilation issues. The Appendix provides additional guidance on Part 9 and 6 systems with respect to:

- sizing make-up air inlets
- tempering of make-up air

- testing of spillage-susceptible heating equipment
- avoiding noisy fans
- set-up of ventilation systems

The Appendix identifies CSA-F326 "Residential Mechanical Ventilation Requirements", as well as, ASHRAE Standard 62 - "Ventilation for Acceptable Indoor Air Quality" as references. They contain guidelines that can be expected to meet or exceed the requirements of NBC Section 9.32.

The R-2000 Program ventilation requirements also exceed the requirements of the NBC.

CSA-F326

CSA-F326 is not referenced as mandatory in the NBC. Its requirements, however, represent a key direction for the evolution of the Code and can be considered as an appropriate method of meeting the requirement of "good engineering practices".

> CSA F326 provides guidance for the design of systems meeting the "good engineering practice" requirement of Part 6 of the NBC.

For the purposes of this manual, the requirements set out in CSA-F326 have been used as the basis of determining compliance with Part 6 of the NBC.

R-2000

In most respects, the R-2000 requirements are identical to CSA Standard F326, where there are differences these are highlighted in this manual.

> The R-2000 requirements are very similar to those of CSA F326.

A key area where differences do exist relates to the issue of heat recovery from ventilation air. R-2000 builders must produce designs which meet or exceed a prescribed "Energy Target". The efficiency of the mechanical systems figures into the evaluation of the home; thus, any substitution of equipment with less efficient equipment may jeopardize the ability to label the house as R-2000.

2.3 Characteristics of a Good Ventilation System

Overall Capacity

The justification for establishing the minimum ventilation rate at 0.3 AC/h is based on empirical studies undertaken for the R-2000 Program and the Association of Space Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) in the United States.

Table 2.1 from the CMHC publication *Complying with the Residential Ventilation Requirements of the 1990 National Building Code* presents the ventilation capacities required for a range of house volumes and floor areas.

TABLE 2.1 Minimum Required Ventilation Capacity

Interior Floor Area Including Basement		Max. Total Interior Volume (1)		Min. Ventilation Rate @ 0.3 Air Changes per hour	
(m^2)	(ft^2)	(m^3)	(ft^3)	(L/s)	(cfm)
50	(579)	122	4,300	10	(20)
75	(770)	183	6,500	15	(30)
100	(1028)	244	8,600	20	(40)
150	(1542)	366	13,000	31	(62)
200	(2056)	488	17,500	41	(82)
250	(2570)	610	22,000	51	(102)
300	(3084)	732	26,000	61	(122)
400	(4112)	975	34,500	82	(162)
500	(5140)	1219	43,000	102	(204)
600	(6168)	1463	52,000	123	(246)

(1) Based on Standard 2.44 m (8 ft) ceiling height.

A ventilation rate of 0.3 AC/h may not be adequate for smaller dwelling units with a high occupancy. In addition, the minimum ventilation rates specified in the various standards are not necessarily adequate in all instances. Consideration should be given to ensuring that no special circumstances exist that would lead to a need for additional ventilation. Most commonly this would be unusual pollutant sources.

Distribution of Ventilation Air

It is important to consider how ventilation air will be distributed throughout the building. Fresh ventilation air is essential for each habitable room in a dwelling unit.

Bedroom areas are of particular importance and careful consideration must be given to ensure they receive an adequate supply of fresh air.

The delivery temperature of the ventilation air must be such that it does not cause undue discomfort for occupants. The acceptable minimum temperatures are 18°C for floor distribution and 13°C for ceiling distribution.

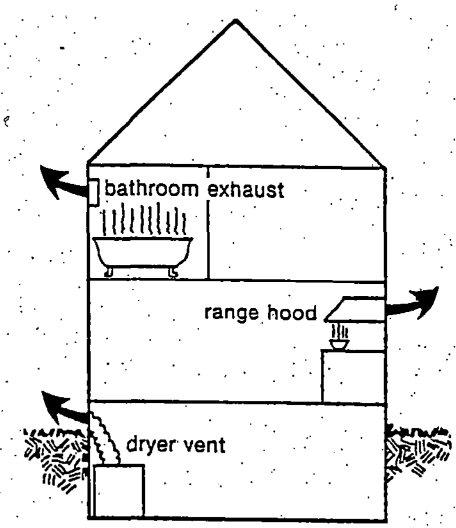
In systems where fresh air is introduced to the heating system for distribution, the heat exchanger of the furnace must not be subjected to excessively low temperatures. As a general rule, the heat exchanger should be not exposed to a temperature below 12°C.

Where either a supply-only or an exhaust-only mechanical ventilation system is used, the distribution of ventilation air can be achieved by promoting flow between rooms. This may be accomplished by undercutting doors or installing grilles to provide a path for air movement.

Pollutant and Contaminant Removal at Source

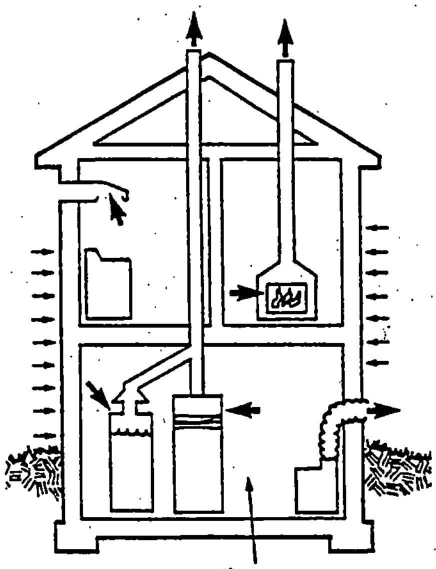
One of the most compelling reasons to ventilate houses is to control moisture and remove air pollutants and contaminants. When examining the layout of a system, this can best be accomplished by controlling the moisture or contaminant at its source, by exhausting air from the so-called "wet rooms" and locations where pollutants are generated. Typically, these are the kitchen, bathrooms, laundry, and utility rooms in a house.

Exhausting moisture and contaminants from their source may be achieved either through the use of dedicated exhaust fans or through branches of a central exhaust system.



Controlling pollutants at their source is one of the best ways of dealing with indoor air quality problems.

Provision of Make-up and/or Relief Air



Make-up air inlets may be required to limit the negative pressure in a house. A 5 Pa negative pressure can cause a naturally aspirated combustion device to spill combustion gases.

Make-up Air: As was discussed in Section 1, it is important to consider the concept of the "House as a System". There may be a requirement to provide make-up air openings for combustion appliances in order to control negative pressures caused by the house's ventilation system. These pressures might have an adverse effect on the house envelope or heating systems.

When a house is at a negative pressure there are two main concerns: the potential for spilling combustion products from fuel burning equipment such as furnaces, domestic water heaters and fireplaces, and the potential to increase the entry of soil gases.

Make-up air is intended to address two important issues:

- to ensure no more than 5 Pa of depressurization for dwelling units with "spillage susceptible" heating equipment
- to ensure no more than 20 Pa of depressurization for dwelling units without "spillage susceptible" heating equipment in order to minimize the influx of soil gases

Tempering of make-up air to avoid cold drafts must be considered.

In practice, calculating the size of the make-up air inlet based on the capacity of exhaust equipment will result in very large make-up air inlets. Calculation methods assume a very tight building envelope. An alternate method for determining the size of a required make-up air inlet is by measuring actual pressures achieved with the operation of exhaust equipment. Leakage in the envelope may significantly reduce the size of or completely eliminate the need for a make-up air inlet. The appropriate test procedure is included in the Test Procedure Reference Guide.

Relief Air: In order to minimize driving moisture into the building structure, positive pressurization should be avoided. Where excessive positive pressures are encountered, a relief air opening may be provided.

Combustion: Combustion air for fuel-burning heating equipment should be provided as specified in the applicable equipment installation standards. Combustion air provides oxygen for the combustion process and does not preform the same function as make-up air. It is important to ensure adequate supplies of each.

Duct and Controls Layout / Design / Materials

Duct Requirements: Ducting systems must be designed to provide the necessary distribution of fresh air and collect the stale air as required.

Insulation may be necessary on ducting where the temperature of the air in the duct work may, at times, be significantly different from the air temperature surrounding the duct. Where significant temperature differences exist, the potential exists for condensation to form either inside or outside the duct. Adequate insulation with an air/vapour barrier will eliminate condensation problems.

Equipment Selection: A number of issues need to be addressed when selecting the equipment for the ventilation system including:

- duct resistance
- noise
- energy
- tempering
- heat recovery

Duct resistance is an important consideration when designing a ventilation system. Duct runs should be designed to minimize flow resistance. The use of flex duct, for example, should be minimized. Elbows and other fittings, as well, create significant resistance and their use should be minimized.

Excessive noise is the single most important reason to cause a homeowner to disable a ventilation system. Both the actual equipment chosen and the installation methods effect the noise generated by the equipment and the level of vibration transferred to the adjoining structures.

The efficiency of the ventilation equipment is an important consideration. The energy consumed in moving the same amount of air varies greatly between various ventilation devices. The cost difference between high efficiency devices and low efficiency devices is often very small, particularly when the overall cost including installation is considered.

Ventilation air must be tempered in many cases to avoid cold drafts. This can be done by mixing the ventilation air with circulating air, using preheating or installing a heat recovery ventilator.

Heat recovery is a consideration where ventilation air tempering is required and where it is important to minimize energy use.

2.4 The Specifics of the Codes and Standards

The following information examines the specific requirements presented in the relevant codes and standards as they relate to ventilation in low-rise residential buildings. The 1990 National Building Code of Canada (NBC 1990) is examined first, followed by Canadian Standards Association Standard F326 (CSA-F326) and the R-2000 Technical Requirements.

This section of the manual does not attempt to discuss all of the the details of the relevant codes and standards. The respective codes and standards documents should be referred to for complete details.

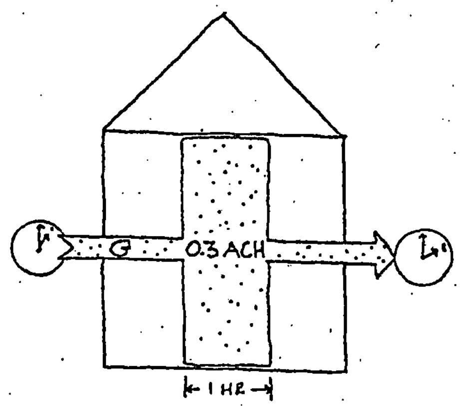
NBC 1990

The requirements of the NBC are shown in boxes throughout this document.

The NBC deals with several basic requirements of ventilation systems:

- overall capacity
- distribution of ventilation air
- exhaust areas
- make-up/relief air
- combustion air

Overall Capacity: The mechanical ventilation requirements of the NBC 1990 are relatively simple. The National Building Code has separate ventilation requirements for "dwelling units" and for individual rooms within the dwelling unit.



The NBC requires a minimum ventilation capacity of 0.3 AC/h. A 0.3 AC/h flow rate is approximately equal to changing 1/3 of the heated volume of the house each hour.

The dwelling unit ***must*** have a mechanical ventilation system with capacity to ventilate the dwelling unit at 0.3 air changes per hour (AC/h) averaged over a 24 hour period.

The Code does not require a "continuously" operating ventilation system. However, it is intended that the system be capable of continuous operation when desired or required by the occupants.

The installed capacity must take into account any factors which reduce the ventilation capacity (air flow reductions caused by frosting or icing of inlet ducting) or factors which interrupt operation (such as defrost mode). If the system must be periodically shut down, the air change rate, when running, must be proportionately higher in order to achieve the required average rate.

The capacity of the ventilation system does not preclude the occupant of the house affecting the operation of the ventilation system and hence reducing the actual ventilation rate below the prescribed ventilation capacity.

> The capacity of the mechanical ventilation for the dwelling unit ***must*** be calculated using the total interior heated volume.

It is intended that the required ventilation system be sized based on the total heated volume of the dwelling unit including heated basements and crawl spaces.

Distribution of Ventilation Air: The NBC does not require ventilation air be distributed throughout the dwelling, but requires that:

> If Natural Ventilation (for example, a window) is not provided to a given room, mechanical ventilation shall be provided to that room at a rate of:
>
> - 0.5 AC/h if the room is mechanically cooled in summer,
> - 1.0 AC/h if it is not.

Pollutant and Contaminant Removal at Source: The key requirements of the NBC are:

> - exhaust ducts discharge directly to the outdoors, and,
>
> - ducts passing through unheated spaces, such as attics and crawl spaces, must be insulated to prevent condensation in the duct.

It is generally recognized that for the purposes of odour and moisture control, exhausts from kitchens and bathrooms are highly desirable. The NBC does not specify where exhaust fans should be located or give guidance on the distribution of exhaust capacities between the various wet rooms.

Provision of Make-up and/or Relief Air:
Make-up Air: The NBC provides specific installation requirements for make-up air openings in order to control pressures caused by the house's ventilation system.

> The NBC requires that, for a system designed under Part 9, make-up air inlets, of a suitable size, must be installed to prevent excessive depressurization of dwelling units when all fans of the ventilation system are operating.

This requirement is intended to address two important issues:

- to ensure no more than 5 Pa of depressurization for dwelling units with "spillage-susceptible" heating equipment (the figures on the following page illustrate the difference between spillage and non-spillage susceptible heating systems)

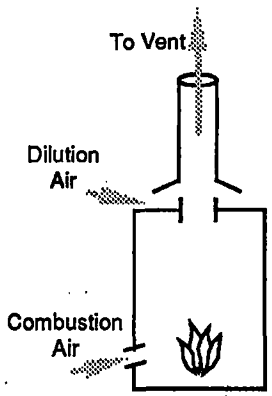
- to ensure no more than 20 Pa of depressurization for dwelling units without "spillage-susceptible" heating equipment in order to minimize the influx of soil gases

The NBC provides no limits for positive pressurization but suggests that it should be avoided in order to minimize driving moisture into the building structure.

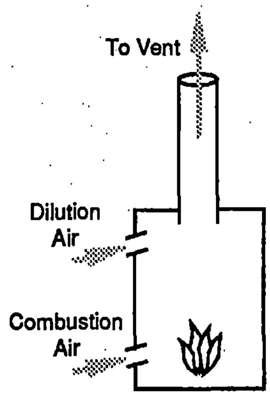
Combustion / Relief Air: The NBC assumes that combustion air for fuel-burning heating equipment will be provided as specified in the applicable equipment installation standards. The NBC differentiates between it and make-up air stating:

> Systems designed to provide combustion and/or dilution air for fuel-burning appliances shall not be used to supply make-up air for ventilation systems unless their capacity is sufficient to supply both functions simultaneously.

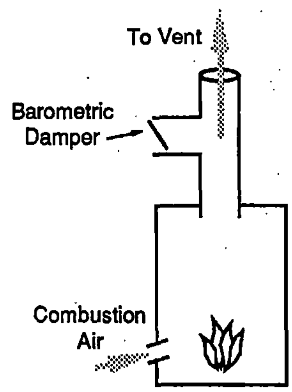
SPILLAGE-SUSCEPTIBLE HEATING SYSTEMS



Conventional Gas Furnace or DHW



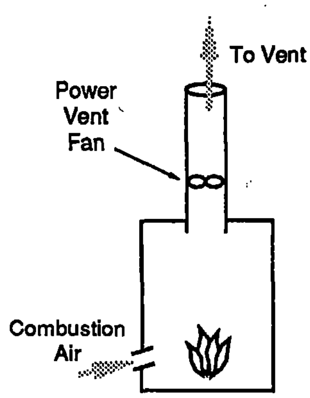
Conventional Gas Furnace



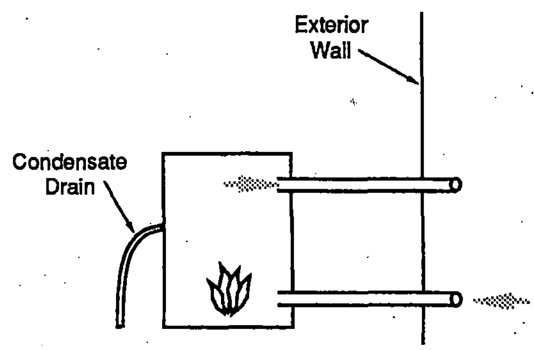
Conventional Oil Furnace

Note: Most fireplaces are spillage-susceptible

NON -SPILLAGE-SUSCEPTIBLE HEATING SYSTEMS



Forced Draft

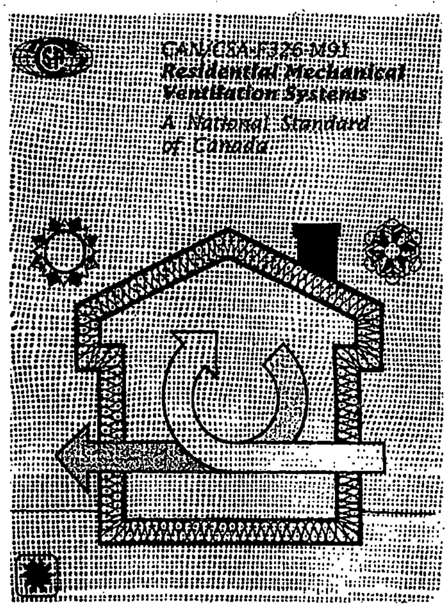


Sealed Combustion

Duct Layout/Design/Materials: The NBC states that:

> **Ducting shall conform to the Part 6 requirements for "supply ducts" with the exception that ducts from bathrooms and water closets can be combustible, providing the duct is reasonably airtight and impervious to water.**

CSA-F326



The intent of the CSA-F326 standard is to ensure that fresh air is delivered to all portions of the house, that the ventilation system is a quality installation and that a method exists for verifying the actual operation of the systems.

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

- The standard describes the conditions that ventilation systems must meet. It states that all new housing must be able to provide *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.

- The standard 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.

- The standard 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.

CSA-F326 addresses only single family dwellings falling under Part 9 of the NBC that are self contained with respect to heating, ventilation and air conditioning. The standard assumes that only normal household pollutant sources are present and that the quality of the outside air is suitable for indoor ventilation purposes.

The standard does not address the need for combustion air.

Sizing ventilation systems based on the number and type of rooms is a good approximation of occupancy.

Overall Capacity: CSA and ASHRAE indicate that ventilation requirements will be influenced by occupancy and that 0.3 AC/h may not be enough ventilation in some cases. In small houses or houses with small rooms, it may be desirable to size the system based on the number of rooms. This provides a rough approximation for occupancy. CSA-F326 provides a method of calculating the required ventilation capacity based on the number of rooms in the house as indicated on the following page:

CSA-F326 Minimum Ventilation Air Requirements

Room Type/Classification	COLUMN 1 Minimum Ventilation Capacity		COLUMN 2** Intermittent Exhaust		COLUMN 3** Continuous Exhaust	
	L/s*	cfm*	L/s*	cfm*	L/s*	cfm*
Category A Rooms						
Master Bedroom††	10	20				
Basement†	10	20				
Single Bedrooms	5	10				
Living Room≈	5	10				
Dining Room≈	5	10				
Family Room	5	10				
Recreation Room	5	10				
Other Habitable Rooms~	5	10				
Category B Rooms						
Kitchen≈	5	10	50	100≈≈	30	60
Bathroom	5	10	25	50	10	20
Laundry	5	10				
Utility Room	5	10				

* Based on an air temperature of 20° C.

† Where a basement incorporates rooms of the types designated in this Table, the ventilation requirements for each room shall be as specified above. Basement areas used for other purposes that exceed 2/3 of the total basement area shall have a minimum ventilation requirement of 20 cfm; those that are less than 2/3 of the total area shall have a minimum requirement of 10 cfm. This Standard does not require ventilation of mechanical service and storage rooms.

≈ Ventilation requirements for any combined living room, dining room, and kitchen shall be determined as if they were individual rooms.

~ 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, storage rooms, service closets, and furnace rooms.

** Either intermittent or continuous exhaust is required.

†† Master bedroom is the bedroom most likely to be occupied by two adults.

≈≈ This minimum rate assumes that a higher flow rate is not required due to range hood requirements. With other exhaust configurations such as ceiling, wall, and range-top fans, higher rates of flow may be required; see manufacturer's literature.

Category A rooms are those types of rooms to which ventilation air would normally be supplied directly. Category B rooms are those associated with the generation of moisture and, hence, are the types of rooms from which air would generally be exhausted.

The required ventilation capacity is simply the sum of the room-by-room capacity requirements. *It should be remembered that, in no case, should the system sized on a room-by-room basis be such that the ventilation capacity provided is less than 0.3 AC/h.*

Continuous ventilation is desirable but not mandated by the standard. The standard requires that the occupant have control over the operation of the systems.

Distribution of Ventilation Air: CSA-F326 does not detail how air is to be distributed to various rooms in the house. Where distribution of fresh air is combined with recirculation air in a forced-air heating system, specific requirements are provided to ensure that fresh air reaches all rooms of the house. The requirements are that:

- the air handling system has the capability to operate continuously
- in simple terms, the rate of air supply or withdrawal is not less than twice the minimum rate specified above for Category A rooms and not less than 10 cfm (5 L/s) for Category B rooms. This would mean that the master bedroom would require a flow rate of at least 40 cfm (20 L/s). The standard also provides a series of charts that may be used in lieu of this simple solution. These more detailed calculations take into account the percentage of fresh air in the recirculation air or the direct delivery of fresh air to the room.

Where either a supply-only or an exhaust-only duct/fan has been provided, distribution of the ventilation air may be achieved by promoting flow between rooms. This may be accomplished by undercutting doors or installing grilles to provide a path for air movement.

Pollutant and Contaminant Removal at Source: CSA-F326 requires the following minimum exhaust rates from these rooms:

Kitchens	• 60 cfm (30 L/s) exhaust, if operating continuously, or • 100 cfm (50 L/s), if operating intermittently
Bathrooms	• 20 cfm (10 L/s) exhaust, if operating continuously, or • 50 cfm (25 L/s), if operating intermittently

These exhaust flow rates may be achieved either through the use of dedicated exhaust fans or through branches of a central exhaust system. The continuous rates are for those systems which operate on a continuous basis. Intermittent rates are for systems designed to be activated only on an as-required basis.

Provision of Make-up and/or Relief Air:
Make-up Air: CSA-F326 provides specific installation requirements for make-up air openings in order to control pressures caused by the house's ventilation system.

CSA-F326 is more conservative than the NBC in its approach to issues of depressurization and pressurization. It requires:

- no more than 5 Pa of depressurization for dwelling units with "spillage-susceptible" heating equipment

- no more than 10 Pa of depressurization for dwelling units without "spillage-susceptible" heating equipment

- no more than 10 Pa positive pressurization for all dwelling units

The specific requirements for sizes of make-up air inlets and relief outlets to meet either the NBC or CSA-F326 requirements are discussed in the Component Reference Guide.

In practice, calculating the size of the make-up air inlet based on the capacity of exhaust equipment will result in very large make-up air inlets. The calculation methods assume a very tight building envelope. An alternate method for determining the size of a required make-up air inlet is by measuring the actual pressures achieved with the operation of exhaust equipment. Leakage through the building envelope may significantly reduce the size of or completely eliminate the need for a make-up air inlet. The appropriate test procedure is included in the Test Procedure Reference Guide.

Duct Layout/Design/Materials: CSA-F326 basically reiterates several items of good building practice. (See Component Reference Guide.)

R-2000 Technical Specifications

The requirements for the installation of ventilation systems under the R-2000 Program closely follow those laid out in CSA-F326. A system designed to the requirements of CSA-F326 will meet the requirements of the R-2000 Program.

2.5 The Specifics of Ventilation Approaches

The requirements for ventilation ducting, make-up air, fans and other pieces of ventilation equipment are influenced by the type of heating system and the ventilation strategy used.

The following is a summary of the code and standard requirements for the various types of systems. *For more detailed descriptions of these systems, refer to the Systems Reference Guide.*

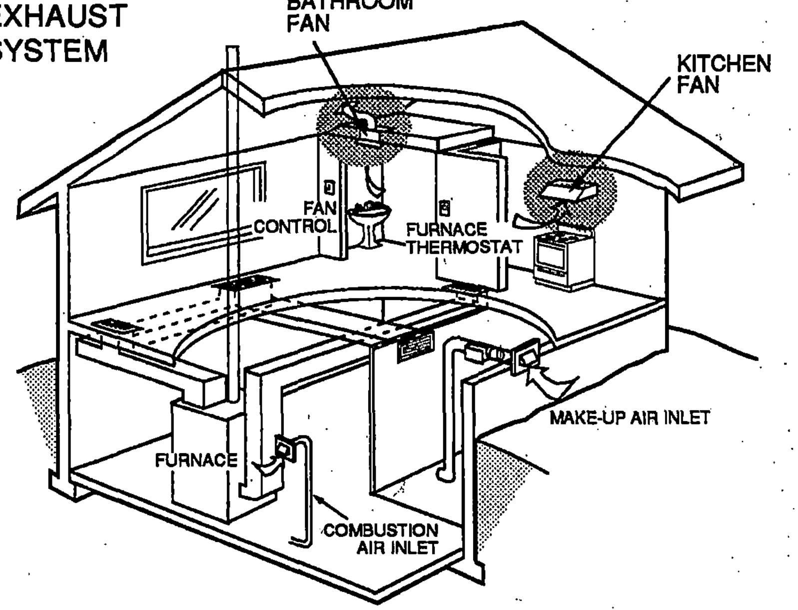
Simple (Point) Exhaust Systems

Simple exhaust systems are defined as systems employing point exhaust fans (kitchen and bathroom fans, for example), without a ducted air circulation system.

Point exhaust systems meet the requirements of Part 9 of the NBC. However, these types of systems have significant limitations.

Characteristics: This approach requires a combination of kitchen and bathroom exhaust fans to meet the NBC. In this instance, the capacity of the ventilation system shall be taken as the sum of the capacities of individual ventilation exhaust fans rated at 25 Pa of static pressure.

A SIMPLE EXHAUST SYSTEM



Note that clothes dryers, central vacuum systems and downdraft cook tops are not to be considered part of the ventilation system.

The system must meet the following requirements:

- Fans must be selected based on the air flow they provide at a minimum of 25 Pa of static pressure.
- Exhaust fans must conform to CSA C22.2 No. 113 "Fans and Ventilators" which deals with electrical safety.
- Fans must be controlled by a manual switch or humidistat.

Make-up air inlets should be provided for this system unless it can be shown by a test that they are not required.

Because the NBC requires that the ventilation system be capable of operating continuously, a better quality bathroom and kitchen fan is generally required when the simple exhaust fan approach is used.

Fans should be rated according to CSA-C260 which deals with performance issues.

Advantages:

- one of the more appealing approaches to meeting the mechanical ventilation requirements of the NBC because of its simplicity and modest cost
- it is covered completely within the requirements of Part 9 of the NBC (the system need not be designed according to any specific requirements, such as CSA-F326)
- it represents very little change from existing practice
- a good selection of appropriate equipment is available (i.e. kitchen and bathroom fans)

Drawbacks:

- it encourages air leakage through the building envelope which may cause drafts. It may also increase the entry of radon and soil gas.
- large make-up air inlets may be required to avoid high negative house pressures
- without a heater on the make-up air inlet, drafts may cause complaints
- blockage of make-up air inlet is possible by the occupant
- poor distribution of ventilation air, particularly in houses without ducted heating systems, may result
- fresh air will enter the building via the easiest route which may not necessarily be where the ventilation air is needed
- *The air distribution requirements of CSA-F326 may not be met.* There are conditions where a point exhaust ventilation system can be designed to meet the requirements of CSA-F326. To meet the air distribution requirements, a forced-air heating system or air recirculation system will be required.

Systems other than Point Exhaust Systems

For systems other than simple point exhaust systems, the following should be considered:

- Systems must meet the requirements of NBC, Section 9.23.3
- Fans and ducting must be designed in accordance with NBC, Part 6
- higher levels of static pressure should be accounted for in the selection of fans
- NBC, Section 6.2 requires:
  "good engineering practice appropriate to the circumstances" in the design and installation of systems

The appendix to NBC, Part 9 identifies CSA-F326 as a suitable reference for system design and installation,

THEREFORE, CSA-F326 provides a means of complying with NBC, Part 6 .

Central Exhaust Systems

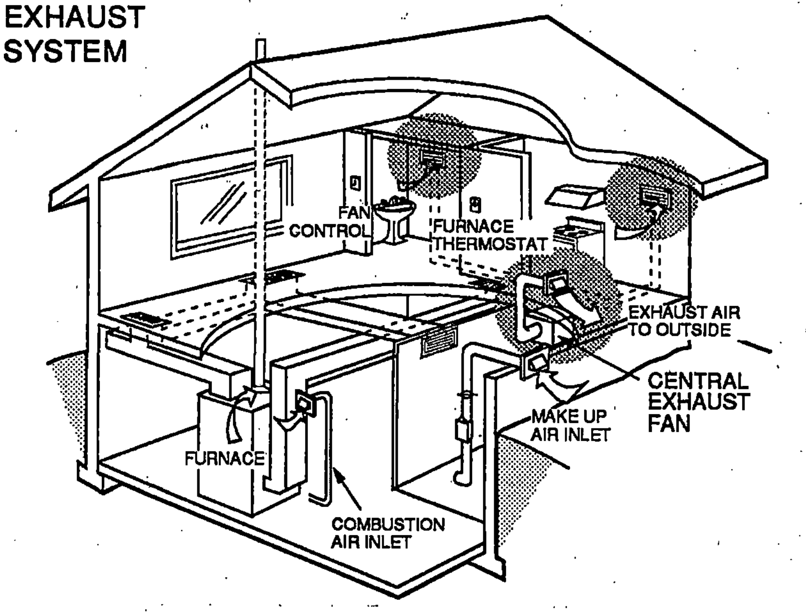
These systems use a packaged ventilator and draw exhaust air from several pickup points in a house through a ducting system.

Because significant ducting is required, these systems fall under the requirements of Part 6 of the NBC.

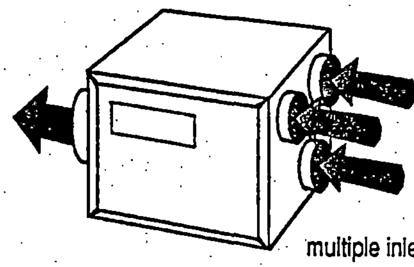
Central exhaust systems have many of the same disadvantages of point exhaust systems, but must also meet the requirements of Part 6 of the NBC.

Characteristics: This type of system must be designed in accordance with Part 6 of the NBC. In this instance, the capacity of the ventilation system is the capacity of the central ventilation exhaust fan. Individual exhaust fans may also be considered in the calculation of ventilation capacity, if their capacity is rated at 25 Pa. Note that clothes dryers, central vacuum systems and downdraft cook tops are not to be considered part of the ventilation system.

A CENTRAL EXHAUST SYSTEM



- Fans must be selected based on good design practice. (Selection based on the flow they provide with a minimum of 50 Pa of static pressure is recommended because of the added ducting which is required with a central approach.)
- Exhaust fans must conform to CSA C22.2 No. 113 "Fans and Ventilators".
- Fans should be installed according to manufacturers' instructions and should be controlled by a manual switch or humidistat.



Make-up air inlets should be provided for this system unless it can be shown by a test that they are not required.

Fans should be rated according to CSA-C260 which deals with performance issues.

Advantages:

- fans can be located away from quiet areas of the dwelling
- a single penetration of the building envelope is required
- the ducting provided for this system in a forced-air heated house requires only minor modification to adapt for a Heat Recovery Ventilator

Drawbacks:

- it encourages air leakage through the building envelope which may cause drafts. It may also increase the entry of radon and soil gas.
- large make-up air inlets may be required to avoid high negative house pressures
- without a heater on the make-up air inlet, drafts may cause complaints
- blockage of make-up air inlet is possible by the homeowner

- there may be poor distribution of ventilation air because fresh air will enter the building via the easiest route

Because these systems will not meet the air distribution requirements of CSA-F326 if coupled with a radiant/baseboard heating system (and CSA-F326 is a reference cited for Part 6 designed systems), they may not meet the NBC.

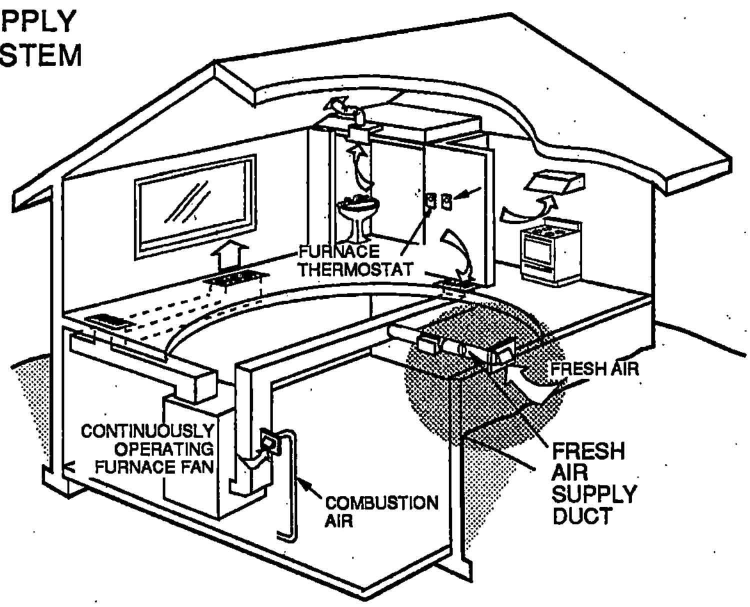
Central Supply Systems

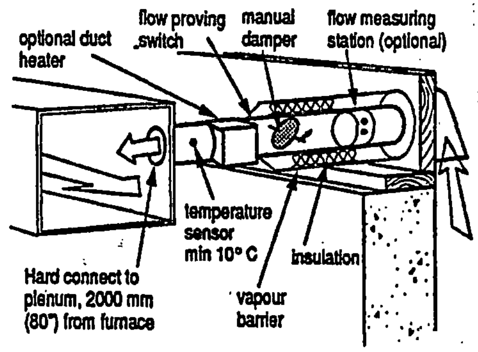
Central supply systems are usually used in conjunction with a forced-air heating system and use the furnace fan and ducting systems for drawing in and distributing fresh air.

In most cases, these systems are essentially an air duct bringing the required amounts of ventilation air into the return air plenum of a forced-air heating system. Generally, a central air supply is not practical in houses employing radiant/baseboard heating because of the requirement for a dedicated ducting system for air distribution.

In houses employing radiant/baseboard heating systems, it has been generally found that the installation of a balanced ventilation system is a more reasonable approach.

A CENTRAL SUPPLY SYSTEM





Characteristics: These systems avoid some of the pitfalls of exhaust systems yet create some new problems. Again this is a system which must be designed in accordance with Part 6 of the NBC.

In this instance, the capacity of the ventilation system is the capacity of the central ventilation supply. Individual exhaust fans may only provide relief of positive pressures and minimize exfiltration through the building envelope. Their capacity cannot be added to the supply capacity to derive total ventilation capacity.

- The duct to the return air plenum must be sized based on good design practice.
- A means of adjusting flow must be provided in the supply duct.
- If kitchen and bathroom fans are installed in the dwelling, exhaust fans must conform to CSA C22.2 No. 113 "Fans and Ventilators".

If kitchen and bathroom fans are installed in the dwelling, make-up air intakes should be provided unless it can be shown by a test that they are not required.

The inlet duct is normally designed based on the flow that will be provided with a suction pressure in the return air plenum of 20 Pa. Where possible, an actual pressure measurement should be used to determine the available static pressure.

Kitchen and bathroom exhaust fans should be rated according to CSA-C260 which deals with performance issues.

If kitchen and bathroom fans are installed in the dwelling, fans should be installed according to manufacturers' instructions and should be controlled by a manual switch or humidistat.

Advantages:

- this approach holds some advantages over the previous exhaust only approaches in that it will not draw soil gasses into the house and won't affect the safe operation of spillage-susceptible heating equipment

- the forced-air furnace fan can be used to distribute ventilation air into the house and minimize installation cost
- low cost point exhaust fans can be used to meet CSA-F326 kitchen and bathroom exhaust requirements for local odour and moisture control
- a single penetration of the building envelope is required to meet the NBC
- no relief air inlet is required to meet NBC, 1990
- the ducting required for this system is minimal

Drawbacks:

- it encourages exfiltration of moisture-laden air through the building envelope–increasing the risk of condensation damage in concealed spaces, such as walls and attics. Such a system should only be considered in a home with a very good air barrier and low occupancy/moisture loads.
- a relief air outlet may be required to avoid high positive house pressures as recommended in CSA-F326
- incoming air must be tempered or delivered in such a way so as to avoid complaints about drafts
- care should be taken to avoid cold air (less than 12°C) contact with the furnace heat exchanger
- there may be poor distribution of ventilation air

Balanced Systems

Balanced ventilation systems provide the best approach to residential ventilation. They often use a heat recovery ventilator to minimize operating costs and temper incoming cold air.

These packaged ventilators use both a supply and exhaust air stream supplying and exhausting air at more or less equal rates.

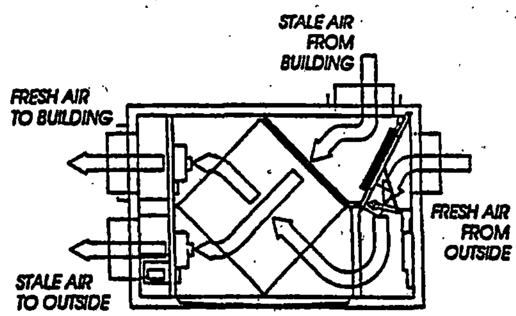
Characteristics: These systems avoid some of the pitfalls of other systems. The ventilator can incorporate heat recovery, such as with a Heat Recovery Ventilator (HRV), although this is not mandatory. Similarly, the operation of the central ventilator can be supplemented by the operation of optional special purpose exhaust fans and inlets (for example, a bathroom fan in a remote location) to meet specific ventilation needs. A forced-air heating system can be used as the distribution ductwork. This system must be designed in accordance with Part 6 of the NBC.

In this instance, the capacity of the ventilation system is the greater of:

- the supply or exhaust of the balanced ventilator (HRV)

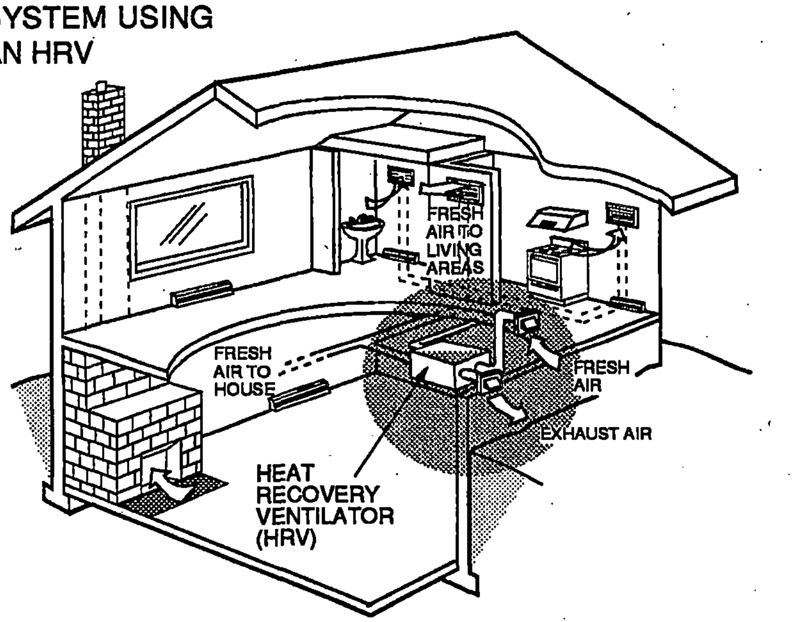
  - or-

- all exhaust fans including the exhaust flows of the balanced ventilator.



Individual exhaust fans can be considered, if their capacity is rated at 25 Pa. Clothes dryers, central vacuum systems and downdraft cook tops are not to be considered part of the capacity of the ventilation system.

A BALANCED SYSTEM USING AN HRV



To meet the air distribution requirements of CSA-F326, a full duct distribution system may be required in baseboard electric, radiant electric and hydronically heated dwellings.

Advantages:

- fans can be located away from quiet areas of the dwelling
- moisture-laden air is not driven into concealed spaces as with supply-only systems
- the operation of the ventilator does not normally cause high negative pressures to develop in the building
- heat recovery tempers incoming air, minimizing energy and comfort concerns
- the systems have been laboratory tested and in common use for more than 10 years, making them an "off-the-shelf" solution to ventilation problems
- the ducting provided in a forced-air heated house minimizes the requirements for distribution ducting

Drawbacks:

- it involves a higher installed cost
- there may be additional maintenance requirements (for example, cleaning of filters)
- depending on the defrost strategy and optional exhaust fans in the dwelling, make-up air may still be required
- a fully ducted distribution system is needed in baseboard/radiant heated houses
- in severe climates where a heat recovery ventilator is used, the defrost cycle may reduce the average ventilation rate significantly.

3 INSTALLATION PRACTICES

Purpose of Section

In this third section of the Installation Manual for Residential Ventilation Systems, the application of the requirements for ventilation systems as set out in the applicable codes and standards is examined.

The installation practices for the installation of components specified in the design are highlighted. As well, the selection and installation of components which may not have been specified by the system designer are discussed.

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3.1 General

Many ways exist to provide ventilation to dwellings. There is no "right system" that is appropriate for all homes and home buyers. Ultimately, the ventilation system installed in a house will be partly dictated by the codes and standards, but it will be strongly influenced by factors such as:

- choice of heating system(s)
- local supplies of equipment and parts
- buyer preferences
- size, type and budget of the house

The ventilation equipment installer will have to possess the knowledge of how to make all system types meet the requirements of the National Building Code 1990 and conform to good building practices, such as those specified in CSA F326.

The task is not as onerous as it sounds. As previously indicated, there are three basic approaches (Exhaust only, Supply only, and Balanced) to ventilating a house. With exhaust only systems there is a choice of point exhausts and a central exhaust system.

When these approaches are blended with the choices of a ducted versus a non-ducted heating distribution system, the generic options for mechanical systems are as follows:

- Forced-Air/Point Exhaust
- Forced-Air/Central Exhaust
- Forced-Air/Central Supply
- Forced-Air/Balanced (HRV-type) Systems
- Radiant Baseboard/Point Exhaust
- Radiant Baseboard/Central Exhaust
- Radiant Baseboard/Balanced (HRV-type) Systems

The ease and effectiveness of distributing ventilation air will be affected by the choice of heating systems (ie. a ducted forced-air system or non-ducted radiant baseboard system).

3.2 Practical Concerns

An installer arriving on site should have a good idea of what's being installed in terms of:

- equipment
- air distribution, approximate duct sizes and routing
- controls
- tempering of outdoor air

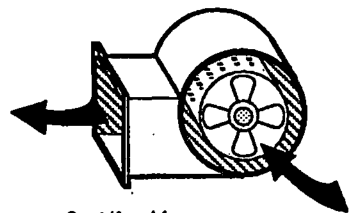
Regardless of whether the system has been laid out by a designer, some installation detail decisions will be required regarding:

- integrating the ventilation and heating system
- setting up air distribution ductwork including dampers, and grills
- avoiding the build-up of condensation on ducts and in equipment
- equipment mounting and noise control
- the control system
- tempering incoming ventilation air

These and other issues are dealt with in the following discussion. The Component Reference Guide also presents details on installation practices.

3.3 Overall Capacity

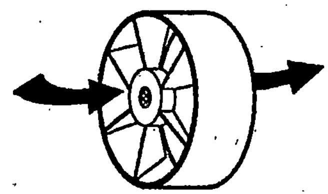
Although the minimum required ventilation rate is 0.3 AC/h, this may not be adequate under certain circumstances (small dwelling sizes and/or high pollutant concentrations. Consideration must be given to the actual proposed installation and the factors involved.



Centrifugal fan

Fan Capacity

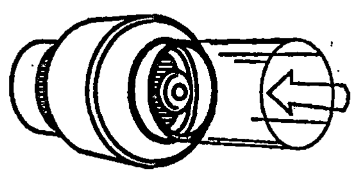
The actual capacity of many residential exhaust fans used in Canada in 1990 was significantly less than there rated values. The following table from the CMHC publication *Complying with the Residential Ventilation Requirements of the 1990 National Building Code* presents the results of a field test of exhaust fans from across the country.



Axial Flow Fan (Propeller)

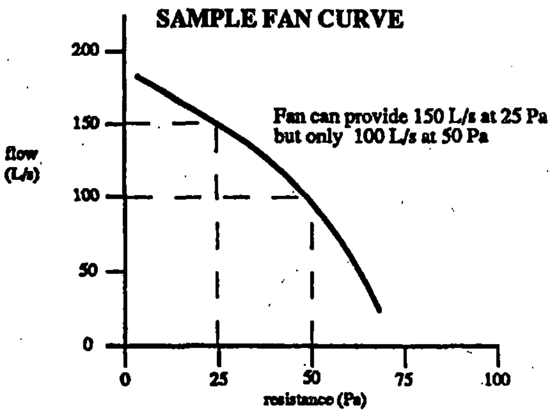
FIELD TESTING OF EXHAUST APPLIANCES

	Rated Airflow (L/s @ 25 Pa)	Field Measured
Bathroom Fans	24	4 - 15
	38	13
Kitchen Range Hoods	75	15 - 52
	140	27 - 32



In-line fan

It is recommended that fans for ducted systems be selected based on the rating of 50 Pa. The rated capacity for a fan is available from the fan curve provided in the manufacturer's literature for each fan. The following chart contains a sample fan curve for a hypothetical fan. For easy comparison, the fan should be rated to CSA-260.



3.4 Distribution of Ventilation Air

Ducts

With the exception of bathroom fan ducts, all ducting must meet the requirements of Part 6 of the National Building Code for supply ducts.

In practice, this has several implications:

- ducts must be non-combustible
- all flexible ducts shall meet ULC Standard 181, Class 1 duct requirements
- ducts should be properly secured and mounted
- the ducting must be designed in accordance with good engineering practices

Reducing restrictions in a ducting system will improve flow rates

Duct fittings restrict air flow through a duct run. Designers use the concept of "equivalent length" of straight duct to measure the resistance introduced by fittings. The equivalent length of many of the common fittings used in residential ventilation systems is shown in the Duct Design Reference Guide at the end of the document. *Flexible duct doubles the effective length of any duct run or fitting. Its use, therefore, should be minimized.*

FLEX DUCT NOT RECOMMENDED

Ventilation equipment should be located such 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 to minimize the number of fittings.

The sealing of ventilation ductwork represents good building practices.

All ductwork joints and seams should 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.

A simplified method of duct sizing is presented in the Duct Design Reference Guide, at the end of the document.

The following chart presents a simplified guide for exhaust fan duct sizing.

SIMPLE GUIDE FOR EXHAUST FAN DUCTING

Maximum Exhaust Ventilation Rate		Minimum Exhaust Duct Diameter			
		Smooth		Flex	
cfm	L/s	(mm)	(inches)	(mm)	(inches)
21	10	75	3	100	4
53	25	100	4	125	5
95	45	125	5	150	6
148	70	150	6	175	7

To produce the air flows shown above:

(1) the exhaust fans must be rated at 50 Pa (0.2" H_2O)

(2) maximum duct length 15 metres

(3) maximum of two 90 degree elbows or four 45 degree elbows

Dampers

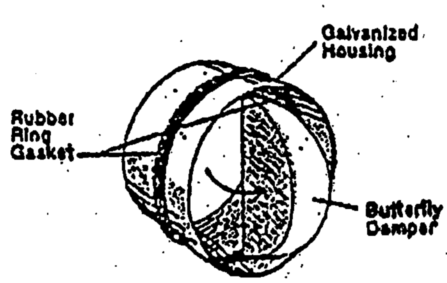
A method of adjusting air flows must be provided:

- in all continuously operating ventilation systems to permit balancing total air flows, and
- in all branch lines of central systems.

Balancing dampers are required to make adjustments to flow rates.

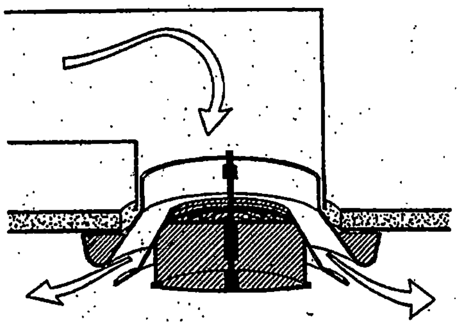
Balancing dampers must be easily adjustable and have a method of locking the damper at the set position. If ductwork is not accessible (for example, trunk ducts which branch off inside finished walls), it may be necessary to locate flow balancing dampers behind the room grille.

Balancing dampers on HRVs are usually located in the warm side ductwork. This is done to avoid the damper being located in the insulated/vapour 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.

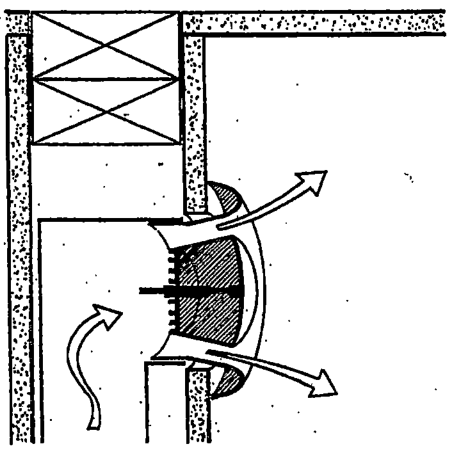


Backdraft Dampers

Backdraft dampers are not required, but are a good building practice on exhaust ductwork. If used, they must have tight sealing blades and be suitable for extended use in harsh climates. Never install backdraft damper-type exterior hoods on ventilation supply, make-up, or combustion air inlets.


Ceiling Fresh Air Supply Diffuser

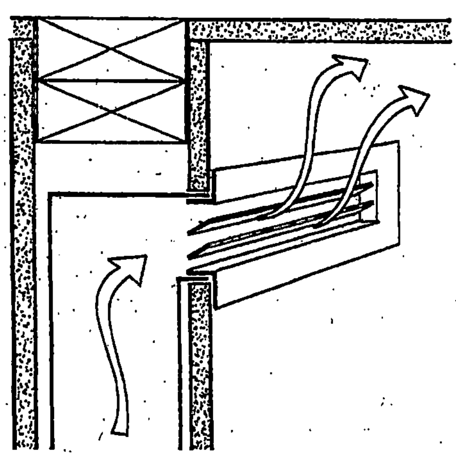
The ventilation air supply must have an insect screen and/or a filter to meet NBC and CSA-F326. The filter can be located in the inlet hood, in the ductwork or as an integral part of the ventilator case as is done in most HRVs. If in line filters are located in the ductwork, ensure they are sized for the application (the face area of the filter should be at least double the cross sectional area of the duct it is in) and ensure the filter housing is well sealed against air leaks. Filters must be easily accessible for cleaning or replacement, without requiring special tools.


High Side Wall Ventilation Diffuser

Grilles / Registers

Properly locating ventilation supply and exhaust grilles and proportioning 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 (no cold spots or drafts).

Ventilation air must be introduced into the occupied zone in a way that avoids causing discomfort to the occupants. If the ventilation supply air design temperature can fall below 17°C (65°F), high-wall or ceiling outlets which discharge the air horizontally are recommended. These 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 and can result in more duct fittings and increased installation costs.


High Side Wall Ventilation Diffuser

High-wall registers should be located within 150 to 300 mm (6 to 12 inches) from the ceiling and should incorporate louvers that aim 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.

- The intake must be located at least 450 mm (18 in) above grade or other nearby horizontal surfaces and above the expected depth of snow accumulation to avoid sucking in debris and snow. If the opening is protected from snow accumulation, this clearance may be reduced to 250 mm. The higher the intake can be located, the better.

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

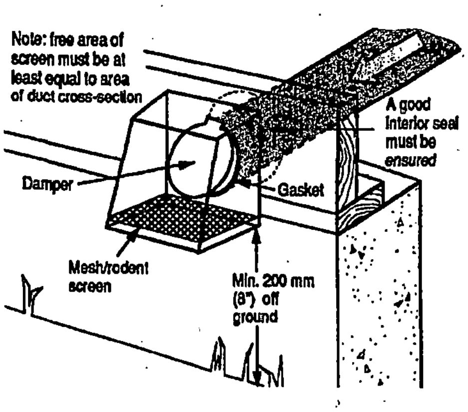
Other important points pertaining to ventilation air intake hoods are:

- The intake must have a rodent screen. If the mesh is less than 6 mm (1/4 in) it must be removable for cleaning. An insect screen is not advisable due to it tendency to frost over in cold weather.

- The intake must have an insect screen filter. Most HRV manufacturers supply a filter box and a filter as a component of the HRV.

- Filters should be installed in accordance with the manufacturer's instructions.

Exhaust Hoods: The location of the exhaust duct outlet is not as critical as the ventilation air intake. The following points are important:



EXHAUST HOODS

- The location should be at least 1800 mm (6 ft) from the ventilation air intake to ensure 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 must be at least 100 mm (4 in) above finished grade or any nearer permanent horizontal surface.

- The outlet should be located at least 1000 mm (3 ft) away from the corner of the building to avoid areas of high turbulence.

- Do not locate the outlet near a gas meter, electric meter or walkway where fog or ice could create a hazard.

- Do not exhaust house air into a garage, workshop or other unheated space.

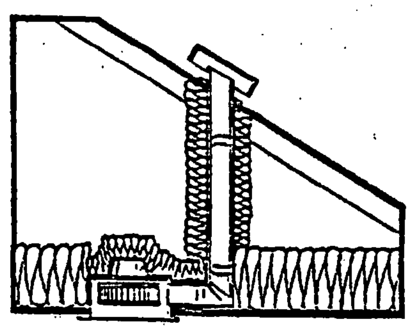
- Do not exhaust near an operable window where exhaust air might re-enter the building.

- The outlet must have a rodent screen. If the mesh is less than 6 mm (1/4 in) it must be removable for cleaning.

  An insect screen should not be used because of its tendency to frost up in cold weather.

Insulation

Insulated ducting is needed in the following situations:



1. on distribution ducts in unheated spaces (attics and crawl spaces)

2. on exhaust ducting in unheated spaces

3. on cold ducts in heated spaces. Moisture will have a tendency to condense on the cold side of insulation, therefore, the warm side needs a good air and vapour retarder.

In situations 1 and 2, the warm side of the insulation is on the duct side of the insulation. The duct itself, therefore, forms the air and vapour retarder *provided it is well sealed.*

In situation 3 (for example, on cold air ducts to/from the outside from/to an HRV), the warm side is on the exterior of the duct. A vapour retarder (for example, polyethylene sleeve) must be added on the outside of the insulation. Care should be taken to seal the vapour retarder membrane to make it airtight. Also, avoid placing dampers and flow measuring penetrations in such ducts because they will destroy the integrity of the membrane.

Collars are available or can be fabricated to facilitate sealing the membrane at equipment and at wall terminations/hoods as they penetrate the building envelope.

Tempering Incoming Ventilation Air

NBC requirements regarding tempering incoming ventilation air are vague. While it is indicated that tempering is needed to avoid occupant discomfort, the requirements for acceptable approaches (in-duct heaters) are not clearly laid out. It is necessary to interpret items pertaining to safety and good building practice with these devices.

A properly sized in-duct heater can add a significant amount of heat locally into the ductwork. Improperly installed in-duct heaters could constitute a safety concern.

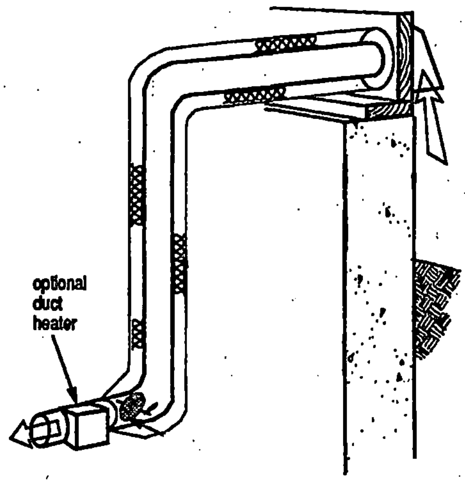
In-duct heaters should be installed with the following controls:

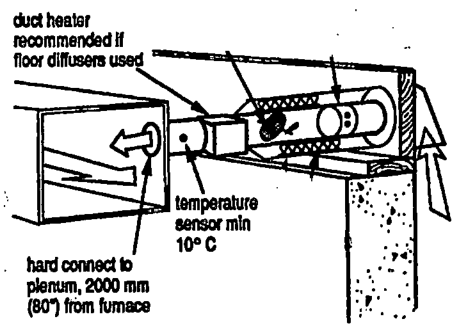
- a flow proving switch (pressure switch) to prove air is moving through the duct
- a low temperature thermostat to activate the heater
- a manually resettable safety switch to disconnect power to the element should a temperature of 100°C be exceeded (many of the units available have this safety feature)

In addition, it would be recommended to keep combustible materials (framing materials, vapour barrier membrane, etc.,) at safe distances from these devices.

Given these cautionary notes, it can be seen why, if at all possible, tempering make-up air and ventilation supply air should be done using the furnace itself.

Care should be taken, however, to avoid excessive amounts of cold air coming in contact with the furnace heat exchanger. A distance of 2 metres between the inlet to the return air plenum and the furnace should provide suitable mixing and tempering of air before it reaches the furnace heat exchanger.

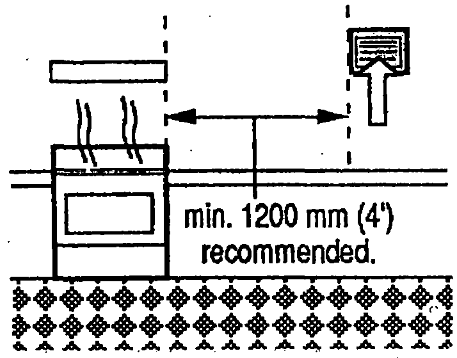




MAKE-UP AIR INLETS
(SPILLAGE SUSCEPTIBLE COMBUSTION EQUIPMENT ONLY)

3.5 Pollutant and Contaminant Removal at Source

The efficient removal of moisture and air contaminants is achieved through the proper location of ventilation supply and exhaust grilles, and proportioning air flows around the house. The previous subsection on air distribution and, in particular, the discussion on grilles and registers covered the practical concerns of pollutant and contaminant removal at source.



KITCHEN AND BATH EXHAUSTS

3.6 Provision of Make-up and/or Relief Air

Two practical considerations must be examined when dealing with the provision of make-up and/or relief air.

- Is it needed?
- If its needed, does the air require tempering?

In practice, calculating the size of the make-up air inlet based on the capacity of exhaust equipment will result in very large make-up air inlets. Calculation methods assume a very tight building envelope. An alternate method for determining the size of a required make-up air inlet is by measuring the actual pressures achieved with the operation of exhaust equipment. Leakage in the envelope may significantly reduce the size of or completely eliminate the need for a make-up air inlet. The appropriate test procedure is included in the Test Procedure Reference Guide.

The considerations related to tempering incoming air are discussed in subsection 3.4 on air distribution and, in particular, under Tempering Incoming Ventilation Air.

3.7 Duct and Controls Layout/Design/Materials

Duct Requirements

Ducting systems must be designed to provide the necessary distribution of fresh air and collect the stale air as required. See subsection 3.4 on air distribution for a discussion of practical concerns about ducts, including the issues of duct resistance, tempering and heat recovery.

Equipment Mounting and Noise Control

Noise from a ventilation system may be one of the most common complaints. Therefore, the reduction of noise should be carefully addressed during installation.

Noise complaints represent one major area of homeowner dissatisfaction with ventilation systems and equipment. In most cases, these problems are easily avoided with proper installation techniques:

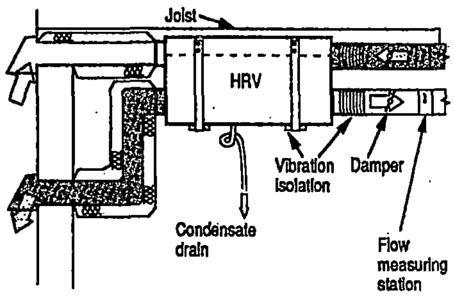
- In general, avoid directly suspending or mounting fans and ventilators from the midspan area of floor or ceiling joists. Mounting in this way can increase resonance and aggravates noise complaints.
- Use manufacturer-supplied mounting kits which typically include mounting straps or grommets to minimize noise.
- Use vibration isolation collars or flexible ducting in the vicinity of the fan to minimize noise transmission through the duct.
- Use duct insulation or silencers to further limit noise.

As a general rule, it is desirable to locate equipment away from quiet rooms of the house (bedrooms, living rooms, etc).

Specific Practices for Packaged Ventilators and HRVs: For heavier pieces of equipment, such as Central Exhaust Fans and HRVs, it may be desirable to go to more elaborate lengths to limit sound transmission.

The three options commonly used to mount the unit are:

- on rubber straps suspended from floor joists
- on brackets attached to the foundation wall
- on a floor-mounted table



Manufacturers of this equipment typically provide mounting straps and flexible ducting for connections to their unit.

Because of their airtight construction, new houses are much quieter than older houses and fan noise are more noticeable. The homeowner may be more sensitive to fan noise if the heating system is not forced-air.

HRVs will also be supplied with a condensate drain which should be run to the house drain. HRVs and all condensate lines must be installed in a space where the temperature is maintained above the freezing point.

HRVs must not be connected to any of the following:

Certain exhaust devices must never be connected to an HRV.

- dryers
- range hoods
- cooktop fans
- central vacuum systems

HRVs should not be connected to any of the following without explicit instruction from the manufacturer:

- other heat recovery ventilators
- directly to forced-air heating systems

Note: Most manufacturers of HRVs provide specific instructions for linking their equipment to forced-air heating systems. (This issue is also covered later in this chapter under "Integration of Ventilation Equipment with Heating Systems".)

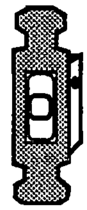
Also note that all ventilation equipment must be located to allow easy access for servicing.

Controls

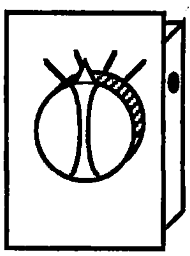
The ventilation strategy selected for the ventilation system operation will largely define the controls required for the system.

Many central ventilators have low voltage humidistat controls supplied either as an option or as standard equipment. Humidistats and timers make sense, if the control is near an exhaust point or if it controls a large capacity system from a central location. The following guidelines should be considered when selecting and locating the controls:

Manual Switch



Crank Timer



De-humidistat

- Bathroom on/off or high-low switches or timer switches should be located next to the light switches.
- The switches in the kitchen should be convenient to the stove and other working areas.
- Humidistats 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 per cent relative humidity as well as an "OFF" position. The humidity level is set at the discretion of the occupants, normally around 30 to 50 per cent in the winter and OFF in the summer.
- Do not locate controls behind doors or in other awkward places.
- Do not mix control functions. For example, do not install a humidity controller where a high-low switch is needed. Although the humidistat can be used as a high-low switch, this will confuse the homeowner.

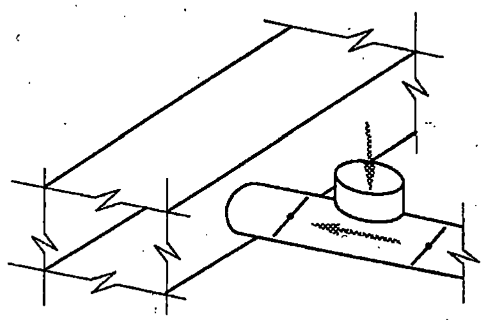
Integration of Ventilation with Heating System

Integrating the ventilation system with a forced-air heating system becomes an issue of concern with balanced HRV systems. In some instances, the furnace fan is powerful enough to draw the HRV out of balance and freeze the core of the unit.

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 recommended. This is to prevent pressure fluctuations in the return air duct (caused by changing re-circulation 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 unless a direct connection is specifically allowed by the manufacturer.

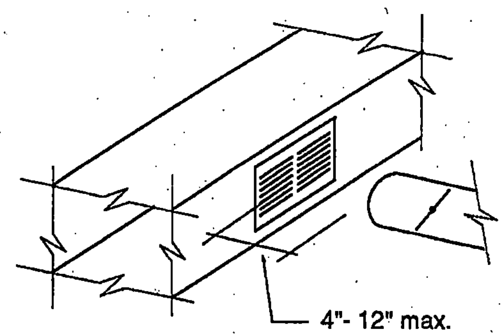
The indirect connection approach requires that the ventilation air be supplied to the recirculation air return duct through a "breathing tee" or return air grille in the heating system ductwork.



A "breathing tee" is a ventilation air supply duct with an open tee located within 300 mm (1 ft) of the return air duct. It allows the HRV to function without ventilation supply air flow rates being affected by the recirculation fan speed.

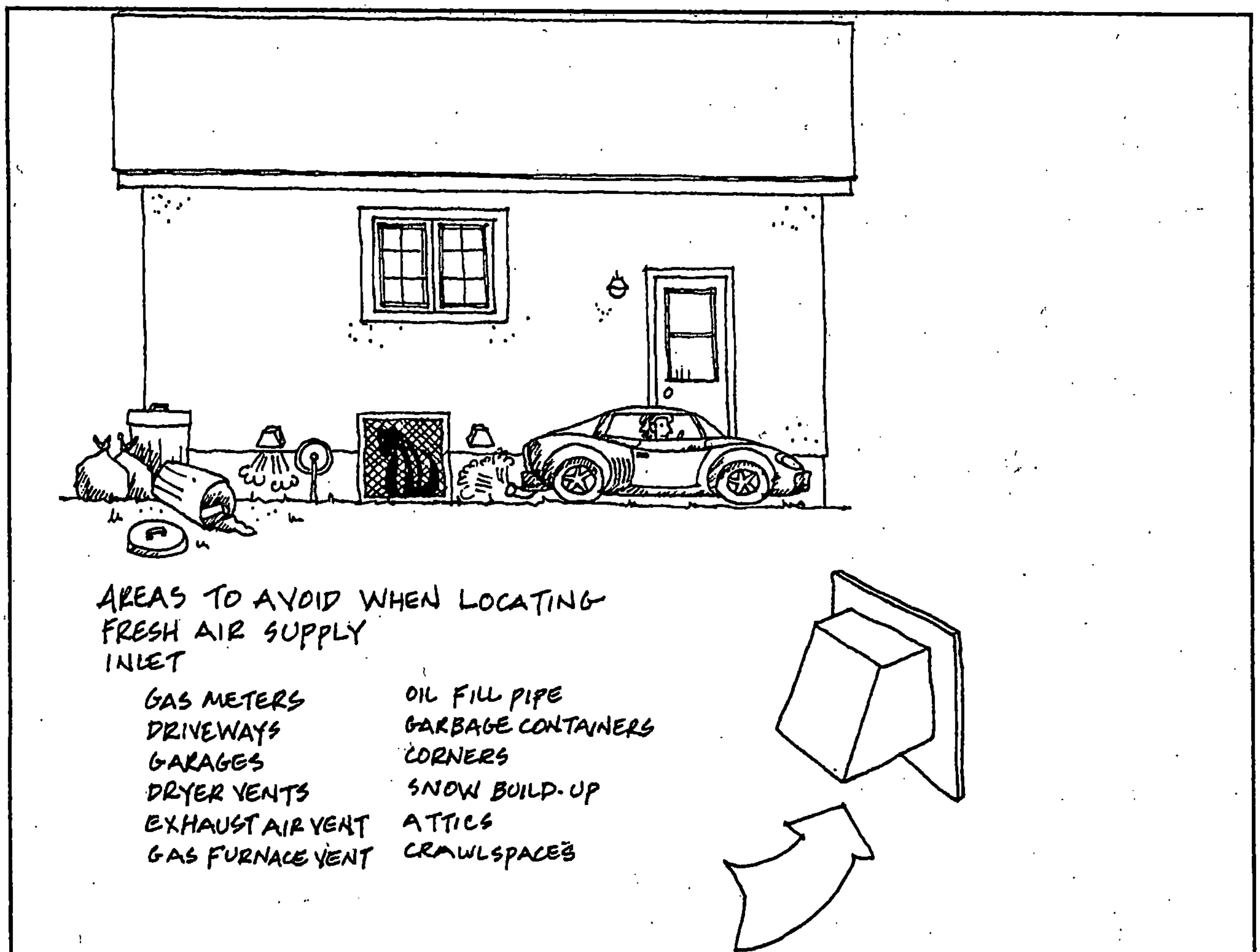
Simply leaving a gap in the ventilation air supply duct in place of the breather tee is acceptable but not recommended. Numerous call backs have been recorded because the customer thought something had been accidentally left out of their system.

With the return air grille approach, HRV ventilation supply air is "dumped" near a grille in the return air duct just upstream of the re-circulation fan. The HRV ventilation air supply duct outlet should point at the grille and end within 300 mm (1 ft) of the return air grille. Oversizing the return air grille will reduce the furnace's ability to draw air through the ductwork from other areas of the house. Undersizing it 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 installed to allow 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.

Building codes prohibit locating return air grilles in an enclosed furnace room with vented combustion 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 1.8 m (6 ft) from the vented combustion appliance.



4 DESIGN REVIEW

Purpose of Section

This section examines the steps involved in the design review of a ventilation system. Students will learn how to uncover obvious errors in a design, how to review site conditions that could affect the original design, and how to evaluate whether the substitution of equipment in the field will affect the system design.

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4.2 Review the Design for Obvious Errors............ 4 - 3
4.3 Site Conditions .... 4 - 8
4.4 Field Substitution of Equipment..................... 4 - 10

4.1 Steps in the Installer's Design Review

The installer of a ventilation system must know enough about the design process to:

- review the design for obvious errors
- deal with special site conditions unforeseen by the designer
- make field substitutions for equipment and system components, where field conditions dictate, in a way that will not degrade the performance of the resulting system

The installer needs to:

- ❑ check the overall sizing of the ventilation system
- ❑ check whether kitchen and bathroom exhausts are specified
- ❑ check whether provisions for ventilation air distribution are adequate
- ❑ check the need for combustion air
- ❑ check whether make-up air is likely to be required
- ❑ check whether relief air is likely to be needed
- ❑ check whether provisions for preheating make-up or supply air are adequate
- ❑ check the duct layout against the original house plans
- ❑ check the location of air inlets
- ❑ check the location of exhausts

The design review should be done after visiting the actual installation site.

4.2 Review the Design for Obvious Errors

Step 1
Check Overall System Sizing

The table on the following page will allow the installer to check the basic ventilation capacity of the ventilation equipment necessary for a particular house. The numbers are based on the NBC, 1990 requirement of 0.3 AC/h. The values in the chart are approximate and are not to be used for design purposes but rather to ensure that the ventilation rate specified in the design is in the correct range.

Where the house configuration or size cannot be found in the chart, an approximation can be made. If concern exists with the overall ventilation rate, reference should be made to Section 2 of this manual for more detail on system sizing.

VENTILATION REQUIREMENTS PER FLOOR

Area of each floor		Living Areas (8 ft ceiling)		Basement Level (7 ft ceiling)		Heated Crawl Space (4 ft headroom)	
m²	*ft²*	*L/s*	*(cfm)*	*L/s*	*(cfm)*	*L/s*	*(cfm)*
46	(500)	10	(20)	9	(18)	5	(10)
56	(600)	12	(24)	10	(21)	6	(12)
65	(700)	14	(28)	12	(25)	7	(14)
74	(800)	16	(32)	14	(28)	8	(16)
84	(900)	18	(36)	16	(32)	9	(18)
93	(1,000)	20	(40)	17	(35)	10	(20)
102	(1,100)	22	(44)	19	(39)	11	(22)
111	(1,200)	24	(48)	21	(42)	12	(24)
121	(1,300)	26	(52)	23	(46)	13	(26)
130	(1,400)	28	(56)	24	(49)	14	(28)
139	(1,500)	30	(60)	26	(53)	15	(30)
149	(1,600)	32	(64)	28	(56)	16	(32)
158	(1,700)	34	(68)	30	(60)	17	(34)
167	(1,800)	36	(72)	31	(63)	18	(36)
177	(1,900)	38	(76)	33	(67)	19	(38)
186	(2,000)	40	(80)	35	(70)	20	(40)

Use this chart to determine the ventilation requirements for the following house examples.

Example 1:

A single storey house with a full basement and exterior dimensions of 20 ft by 30 ft (600 sq ft/floor).

	Area of Floor	Living Area	Basement	Crawl Space	TOTAL
1st Storey	600 sq ft	24 cfm			24 cfm
2nd Storey	none				
Basement	600 sq ft		21 cfm		21cfm
Crawl Space	none				
TOTAL HOUSE					45 cfm

The chart indicates a ventilation flow rate of 24 cfm for the main floor plus 21 cfm for the basement. The total ventilation requirement would be 45 cfm.

Example 2:

A two storey house with a full basement and exterior dimensions of 25 ft by 30 ft (750 sq ft/floor).

Since the house size or the house configuration is not exactly covered by the chart,use an approximation based on the chart information.

	Area of Floor	Living Area	Basement	Crawl Space	TOTAL
1st Storey	750 sq ft	30 cfm			30 cfm
2nd Storey	750 sq ft	30 cfm			30 cfm
Basement	750 sq ft		27 cfm		27 cfm
Crawl Space	none				
TOTAL HOUSE					87 cfm

Using the average of flow rates for a 700 and 800 square foot house, the chart indicates an approximate flow rate of 30 cfm per floor and 27 cfm for the basement for a total ventilation rate of 87 cfm.

Example 3:

A single storey house with a full basement under 50 per cent of the house and a four foot crawl space under the remainder. The exterior dimensions are 30 ft by 40 ft or 1200 sq ft/floor.

	Area of Floor	Living Area	Basement	Crawl Space	TOTAL
1st Storey	1200 sq ft	58 cfm			58 cfm
2nd Storey	none				
Basement	600 sq ft		21 cfm		21 cfm
Crawl Space	600 sq ft			12 cfm	12 cfm
TOTAL HOUSE					91 cfm

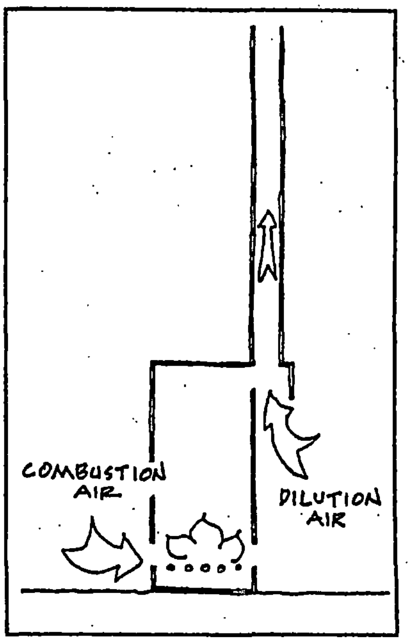
The chart indicates a flow rate of 58 cfm on the main floor, 21 cfm for 600 sq ft of basement and 12 cfm for 600 sq ft of crawl space for a total of 91 cfm.

Step 2
Check Kitchen and Bathroom Exhausts

All kitchens and bathrooms should be supplied with a means of exhaust. The exhaust may be through point exhausts or branch ducts to a central exhaust system. Although kitchen and bathroom exhausts are not a specific requirement of the NBC 1990, a system without these exhaust provisions will have questionable performance, particularly in the area of moisture control.

Step 3
Check Ventilation Air Distribution

For a ventilation system to be effective, air must be circulated to all areas of the house. This may be accomplished with either a dedicated ducting system or by means of the ducting system of a forced-air furnace. Where the ducting system of a forced-air furnace is used, the furnace fan must be able to operate continuously. In this case, a two speed furnace fan is desirable in order to permit the furnace air flow rate to be reduced during periods when the furnace is not firing.



Step 4
Check Whether Combustion Air is Needed

Combustion air is required for all fuel-fired space and domestic water heating equipment. Space or domestic water heating equipment that does not directly use outside air for combustion (a sealed combustion appliance) does not require a combustion air duct. This provision applies to all types of fuels including oil, gas, wood and coal.

Step 5
Check Whether Make-up Air is Likely to be Required

Make-up air is likely to be required where any of the following conditions exist:

- installation of a spillage susceptible appliance such as a naturally venting furnace or domestic water heater

- the house has a fireplace
- an exhaust only ventilation system is used
- an exhaust device of a large capacity is installed in the house such as a down draft range vent

If make-up air is not included in any of the above cases, a test of the house will be required to prove it is not needed.

Step 6
Check Whether Relief Air is Likely to be Needed

Relief air will counteract the influence of equipment providing excess (positive) pressurization of the building.

Relief air may be required in:

- houses with supply-only ventilation systems
- houses with outside air ducts directly connected to the furnace return

If relief air is not provided, a test will be required to prove it is not needed.

Step 7
Check Whether Provisions for Preheating Make-up or Supply Air are Adequate

It is important that cold make-up or supply air not be delivered to any occupied space (including a basement) in such a way to cause discomfort to building occupants or potential damage to the heating system equipment. Where either is a possibility, the air should be preheated.

Preheating can be accomplished by mixing outdoor air with warm inside air or by directly preheating.

Where make-up or supply air is directly connected to the return air side of a furnace ducting system, the air must not cause the furnace heat exchanger to be cooled below approximately 12°C when the furnace is not firing.

4.3 Site Conditions

Often, design details for the house are not complete at the time of the design of the ventilation system. In other cases, a ventilation system is designed for a generic house plan but custom alterations are made to the interior layout without the necessary changes being made to the ventilation system.

As well, the information available to the ventilation system designer often does not include information on the adjoining properties. This may impact on the location of inlets and exhausts.

Duct Layout

The following checklist should be used to determine whether alterations in the duct layout are required.

- ☐ Does the constructed house approximately match the house plans on which the ventilation system is based?

  If the number of rooms has changed and the ventilation system was designed in accordance with CSA-F326, the system capacity may require alteration.

- ☐ Has the location or number of bathrooms or kitchens been changed?

  If there have been changes, the duct design, as well as the system capacity, may require alteration.

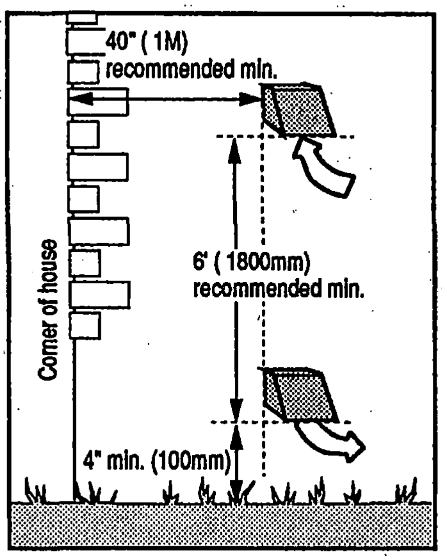
Location of Inlets

The following checklist should be used to ensure the locations of the ventilation air inlets are appropriate.

- ☐ Can the inlet be installed at least 18" above the finished grade?
- ☐ Can the inlet be accessed easily for cleaning of the screen?

- ❑ Is the inlet location away from sources of contaminants:
  - ❑ driveways
  - ❑ furnace exhausts
  - ❑ dryer exhausts
  - ❑ vacuum systems
  - ❑ gas meter
  - ❑ walkways

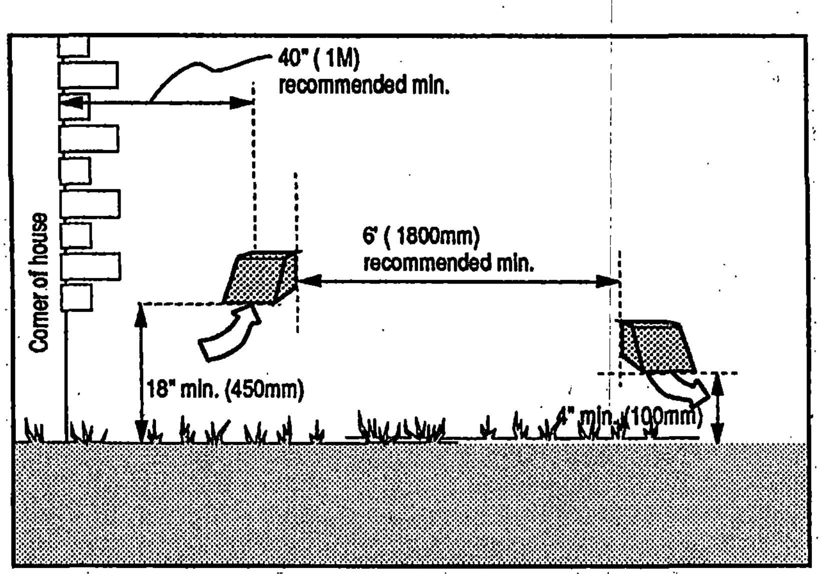
  It is important to consider not only the exhausts from the house in which the ventilation system is being installed but adjoining properties as well.



Location of Exhaust Outlets

The following checklist should be used to ensure the locations of the ventilation exhaust outlets are appropriate.

- ❑ Are the exhaust outlets accessible?
- ❑ Will the exhaust outlets adversely affect the ventilation inlets of adjoining properties?



4.4 Field Substitution of Equipment

Many cases will arise where an equipment substitution will be required in the field. Most often this will result from an availability problem with a particular item. In other instances, space or other installation considerations will dictate a substitution.

If the specification for the original and the substituted unit are identical, no problems should arise. A substitute unit, however, seldom has identical specifications.

Equipment designed to move air, such as fans and heat recovery ventilators, are rated for flow under specific conditions. If a substitution of a ventilation device must be made, the replacement device must be rated for at least the same flow rate at the same static pressure drop. If this is not the case, the ventilation device may not have sufficient capacity to deliver the required air with the designed ducting.

Heat recovery ventilators have specific installation requirements which may require more extensive system changes. For example, some heat recovery ventilators are designed to be directly connected to the return air side of a forced-air furnace while others are not. If the original system design called for a direct connection, changes to the ducting, as well as consideration of the need for preheating, may be required.

When a ventilation system designer sizes the ducting, consideration is given to:

- the capacity rating of the ventilation device
- the length of ducting required
- the number of elbows and fittings in the system

If, during the installation process, any of these items is changed, a change may be required in the duct sizing to compensate for increased duct losses. If changes are required, refer to the Duct Sizing Reference Guide at the end of the document.

5 SYSTEM START-UP

Purpose of Section

This section deals with the steps involved in starting up and testing a new system. The student will learn how to conduct a visual review of the system, conduct tests of the system and document the system start-up.

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5.1 The Need for a System Start-up Procedure 5-2

5.2 The Steps in a Visual Review of the System 5-2

5.3 Specific Tests That Should be Undertaken 5-5

5.4 Required Documentation of System Start-Up 5-11

5.1 The Need for a System Start-up Procedure

The system start-up procedure may be the most important single step in the design and installation of a ventilation system. Proper ventilation system start-up checks will isolate and allow the correction of minor problems which, if left undetected, can lead to unnecessary homeowner complaints and costly callbacks.

The documentation associated with the start-up procedure can also be useful to the installer at a later date, if concern with the operation of a system arises.

5.2 The Steps in a Visual Review of the System

Once the installation is complete, the installer should do a visual inspection of all components in the ventilation system. The following checklist will assist in an orderly review and can be used to check both simple and complex systems. Where simple systems are concerned, many of the parts of this checklist can be ignored.

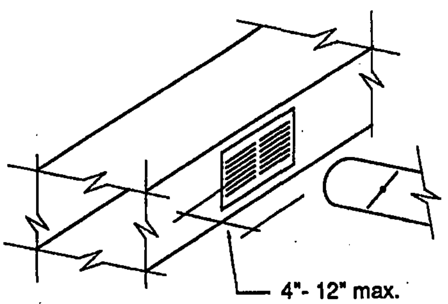
Ventilator and Fan Mounting

- ❑ Is all equipment mounted securely?
- ❑ Are supports properly fastened to the joists?
- ❑ Are vibration isolators in place, as specified by the manufacturer?
- ❑ Is all excess material trimmed and smoothed from mounting brackets and hardware?

Ducts

- ❑ Are the ducts properly supported?
- ❑ Is all flexible duct firmly attached to its connectors?

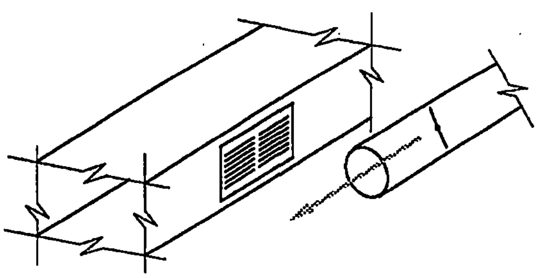
- ❑ Are all splices and terminations in the flex ducting done according to the supplier's recommendations?
- ❑ Are all duct joints taped or sealed?
- ❑ Are all cold ducts travelling through heated spaces insulated?
- ❑ Are all warm ducts in cold spaces insulated?
- ❑ Are all joints or tears in the vapour barriers on the insulated ducts patched and sealed?
- ❑ Are all ducts sealed to the house vapour barrier wherever they pass through it?
- ❑ Are ducts sealed to the vapour barrier at the outside wall?
- ❑ Is all flex ductwork supported to ensure it does not sag?
- ❑ Is all flex duct liner properly stretched, to provide the smoothest air flow surface possible?
- ❑ Are all ducts connected to the appropriate ventilator or HRV ports?



Acceptable

Outside Duct Termination

- ❑ Are inlets and outlets properly located?
- ❑ Do outside duct terminations have bird screens and hoods?
- ❑ Are outdoor air intakes labelled as air intakes?


Not Acceptable

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, is the ventilation air supply

outlet or breather tee within one foot of the return air pick up?

- ❑ Are the grilles and diffusers properly secured?
- ❑ Are ducts sealed to the vapour barrier at the outside wall?
- ❑ Are grilles that require filters, equipped with filters?

Wiring and Controls

- ❑ Has all wiring been properly secured?
- ❑ Are all electrical connections enclosed?
- ❑ Are all occupant controls installed in accessible locations and properly labeled?

Drains (HRV)

- ❑ Are the drains equipped with traps and filled with water?

Filters

- ❑ Are all system filters in place and clean?
- ❑ Are all system filters easily accessible?

5.3 Specific Tests That Should be Undertaken

Testing of Basic Operation

Once the visual inspection has been completed and any deficiencies corrected, the installer may start up the ventilation system and check its operation. The testing requirements will vary significantly between a simple system and a complex system. For a simple system, the only requirement may be to turn on and check exhaust fans. For a complex system, such as one incorporating an HRV, all of the various controls and modes of operation must be checked. The test procedures laid out in this section relate to the most complex type of system. Test procedures for simple systems can be simplified accordingly.

Test Procedure for a Complex System

Each of the occupant controls should be checked separately. It may not be possible to test all operation modes of a ventilator (for example, 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 and turn the ventilator to be tested 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 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 in the ducts.

- ❑ Turn the control switches to the normal operating position. The system being tested should now function at its normal or **minimum ventilation capacity.**

  If not, check the occupant controls to see if any are in the "ON" or "high" position. Once the system is functioning at the minimum ventilation capacity, check the operation of each of the occupant controls.

- ❑ Dehumidistats are checked by lowering the humidity setting below the house humidity level. 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 the manufacturer's instructions describe a method of checking the HRV's defrost cycle or duct heater controls, check their operation.

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

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 method of measurement used must be accurate to within 15% of the flow rate being measured. Air flow measurement and balancing stations are permanently installed in the warm side of ventilation systems of registered R-2000 houses.

Preparing the House: Before the ventilation air supply and exhaust flow rates can be measured and balanced, the building envelope must be sealed in its normal "closed up" condition.

- ❑ The air/vapour 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 to the outdoors.
- ❑ The furnace and hot water tank,if fuel fired, should be in their non-firing mode.
- ❑ The ventilation system must be complete and all filters and register dampers set to their operating positions.

Air Flow Measuring Equipment: Instruments 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.

Several HRV manufacturers market air flow 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 devices is simple and straightforward but the air flow grid must be located in a section of duct away from the turbulence caused by fans, fittings and dampers. A flow measuring grid may be temporarily installed in the ducting for flow measuring purposes.

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 the air flow at the 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.

Measuring the Air Flows: When measuring air flows, the house is closed as in the normal winter mode described above. The ventilators are turned off and the main balancing dampers are moved to the fully open position.

- ❑ The air flow grid, or another air flow measuring probe, is then inserted into the warm side ducts. It is best to begin with the side with the longest equivalent duct length (i.e., highest pressure drop, thus the lowest air flow rate).

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.

- ❑ Confirm that fans are operating (and at the correct speed).
- ❑ 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 as system modification may be necessary.

Balancing the System: If both the ventilation air supply and exhaust flow rates individually meet or exceed the design requirements, but the air flow imbalance exceeds the allowable maximums for HRV systems of more than 10%, the system must be balanced.

- ❑ To balance the system, the excessive air flows are reduced by adjusting the balance damper in the duct with the higher flow until the air flow falls within the design limitations.
- ❑ Once the flows are balanced, lock the dampers 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 "minimum ventilation capacity" design conditions.

  While HRV air flows are required to be balanced within 10 per cent of each other, by using the above procedure, it should be possible to achieve a near balanced condition at the time of adjustment.

House Pressure Test

Where the possibility exists for excessive pressurization or depressurization of the house due to the operation of ventilation equipment, a house pressure test must be performed. This test is most important where fuel-fired devices are installed that are susceptible to spillage. The procedure to be followed is detailed in the Test Procedures Supplement, but a summary of the field test method is included below.

Summary: The following measurement technique can be used to determine pressures developed across the building envelope. The test must be performed with an instrument capable of measuring pressure differences in the 0 to 60 Pa (0.0 to 0.25 inches W.G.) range, with a sensitivity of 2 Pa (0.008 inches W.G.). The Dwyer Durablock Manometer, Model 115 and the magnehelic gauge, are examples of suitable instruments.

The test must be performed with wind conditions of less than 15 km/h (9 mph).

- ❑ Ensure that all windows, doors, and other openings are properly closed and latched. Floor drains and plumbing traps must be filled with water or sealed.
- ❑ Combustion air inlets and chimneys/flues for combustion appliances, including fireplaces and wood stoves, should be sealed before performing the test.
- ❑ Set an exterior pressure tap (0.25 inch inside diameter tubing) approximately 8 metres (25 feet) from the dwelling unit and connect to the "high side" of the differential measuring device, which should be located inside the dwelling unit at or near grade.
- ❑ Switch off ventilation equipment and any other appliances that exhaust air to the exterior. Record the pressure difference measured on the instrument

- ❑ Switch on all equipment used for minimum continuous ventilation. Record the pressure difference.

- ❑ Switch on the dryer and the individual piece of exhaust equipment or single appliance that creates the highest intermittent air exhaust. Record the pressure difference.

- ❑ Unseal any openings that were sealed for the test.

5.4 Required Documentation of System Start-Up

CSA Standard F326 requires that the installer certify completion of the installation and correct air flow measurement and balancing adjustments by completing CSA F326 "Mechanical Ventilation System Installation Data" 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).

SAMPLE FORM A

Residential Mechanical Ventilation System Installation Data — CSA Standard CAN/CSA-F326

(See Clause 8.15.)

Copies to:
Purchaser
Regulatory Authority
Manufacturer
Installing Contractor

Location of Installation	Installing Contractor	Regulatory Authority
Name ______	Name ______	Name ______
Address ______	Address ______	Permit No. ______
City and Province ______	City and Province ______	Approved by: ______
Telephone No. ______	Telephone No. ______	Date: ______

1.0 Ventilation Characteristics

1.1 Volume of habitable space including basement ______ m^3 (A)

1.2 Required ventilation:
Either – Master bedroom 10 L/s
– Other bedrooms,
Kitchen, dining room ______ rms at 5 L/s ______
Family, recreation room
– Basement – at 10 L/s and/or ______ L/s
______ rooms at 5 L/s ______ L/s
Total ______ L/s (B)
or Habitable Space (A) ÷ 12 ______ L/s (C)

(letters in brackets refer to values in the right hand column)

1.3 Designed ventilation rate ______ L/s

1.4 Actual measurement of total house ventilation capacity: outdoor air supply ______ L/s (D)
exhaust ______ L/s (E)

(Note that not all systems require both a centralized supply and an exhaust. Either supply or exhaust must be measured. If only one is measured, the other must be determined by design for completion of 3.5.1(c).)

Method used for airflow measurement ______

(Continued)

April 1991

CAN/CSA-F326-M91

2.0 Ventilation Check

2.1 To comply with the Standard, Item (D) or (E) should be equal to or greater than the larger of Item (B) or (C). ☐

2.2 If the system includes a heat recovery ventilator, the lesser of Item (D) or (E) shall be 90% or more of the greater of Item (D) or (E), or shall comply with the value recommended by the manufacturer (see Clause 8.13.3(d)) ☐

2.3 Air supply and/or exhaust from all rooms ☐

2.4 Air exhaust from kitchen and bathrooms directly to outside operating ☐

2.5 Controls operating and adjustable for all modes of operation ☐

2.6 Noise and vibration within reasonable limits ☐

2.7 Supply air inlet(s) located to minimize possibility of admitting contaminated air ☐

3.0 Pressure Check

3.1 Depressurization

Classification of combustion system (if installed):

☐ 5 Pa (eg, open fireplace, standard gas DHW)

or ____ Pa manufacturer's rated listing

If ventilation system is balanced go to Clause 3.3. ☐

If not balanced go to next section. ☐

3.2 With ventilation system operating:

Compliance with depressurization limit determined by

i) Design ☐ or ii) Test ☐ (Check one)

3.3 With ventilation system operating plus dryer plus one exhaust fan:
Compliance with depressurization limit determined by

i) Design ☐ or ii) Test ☐ (Check one)

3.4 Make-up air not required ☐
or required, properly sized and installed ☐

3.5 Pressurization

3.5.1 Allowable Excess of Outdoor Air Intake
(a) Interior surface area of dwelling unit _____ m^2 (F)
(b) Maximum allowable excess of outdoor air intake: (F) × 0.12 ______ L/s (G)
(c) Actual excess of outdoor air intake: (D) – (E) _____ L/s (H)
(d) System complies with allowable excess of outdoor air intake: ((H) is not greater than (G)) _____

(Continued)

April 1991

COPY

INSTRUCTOR'S MANUAL —

Installer's Course

COURSE CURRICULUM

Day 1

Module 1 Indoor Air Quality and Ventilation (9:00-10:15)

Section 1. Learning Objectives *(5 min.)*

Training Process: *Interactive Discussion*

The object of this module is to introduce the concept of indoor air quality control and to introduce the role of ventilation.

This section is aimed at getting across the key factors which will be dealt with in Module 1.

Use Overhead 1-1 to introduce the concepts. Invite input from the course participants.

Background Information:

Key concepts to communicate to the students include:

- developing an understanding of the many reasons for ventilating houses
- understanding the role of humidity as an indicator of poor indoor air quality; emphasize that a lack of humidity problems does NOT mean that there isn't an indoor air quality problem, many contaminants are colourless and do not produce a detectable odour
- ventilation is just one means of controlling indoor air quality
- new requirements are being implemented with respect to ventilation (ie. NBC 1990, and CSA F326)
- to understand the requirements for ventilation, an understanding of the "House as a System" concept is required
- it is also necessary to understand some of the terminology used in codes and standards.

Resource Materials:

- Overhead 1-1: Lists the learning objectives for this section.

Training Process: *Slide Presentation*

A series of slides is presented in rapid succession to introduce concepts of why ventilation is necessary, the problems it avoids, and the objectives of instructor training (avoiding installation problems.)

Background Information:

The key reason why lack of ventilation is becoming more widely recognized as a problem is the increase in moisture problems in new houses.

The first group of slides are aimed at showing common moisture problems; problems at windows and cold corners.

Condensation occurs in these areas because they are the coldest surfaces; mould growth requires Relative Humidities above 80% and temperatures above 5°C; both occur in cold corners and around windows.

If condensation is visible on cold surfaces, it is likely that more serious problems are occurring in concealed spaces (eg. in walls and attics).

Moisture problems can even be aggravated by poor installation of ventilation equipment (eg. leaky ducts in attics).

Spillage of combustion by-products from fuel-fired heating equipment is partially addressed by installation codes for that equipment, but must also be addressed in installation standards for ventilation systems (eg. avoiding high negative pressures).

Backdrafting and spillage are both safety and a health issues.

Resource Materials:

Moisture problem slides:

- Slide 1.1: Condensation on window
- Slide 1.2: Moisture damage to a drywall return at a window
- Slide 1.3: Mould growth at a "cold corner"

Concealed moisture problem slides:

- Slide 1.4: Mould growth in a stud cavity behind an electrical outlet
- Slide 1.5: Moisture in attic insulation
- Slide 1.6: Frost on attic sheathing

Poor equipment installation slides:

- Slide 1.7: Leaky ducting from a bathroom fan in an attic
- Slide 1.8: Jungle of ductwork
- Slide 1.9: Jungle of ductwork again
- Slide 1.10: Passive inlets that frost up

Slides of other issues to be addressed:

- Slide 1.11: Fireplace Spillage indicated by soot on brickwork
- Slide 1.12: Spillage of DHW tank indicated by overheating at draft hood

Section 3. Ventilation as a Means of Air Quality Control
(10 minutes)

Training Process: *Interactive Lecture*

Ask the group what their impressions are of why ventilation is needed; use a question like "In your opinion what are the major air quality problems in houses?"

Tie together the discussion by introducing Overheads 1-2 and 1-3:

- Overhead 1-2 presents indoor air quality problems; moisture will probably have been emphasized in the previous discussion
- Overhead 1-3 presents sources of moisture in the home

Introduce the concept of air quality control with Overhead 1-4:

- Most other options for controlling air quality are preferable to ventilation because they will likely be more effective and probably cost less
- Emphasize that ventilation is used control problems which cannot be avoided (ie. by diluting the pollutant)

Use Overhead 1-5 as a way of leading a discussion on ventilation rates in new housing:

- Most factors on the list are causing ventilation rates / air quality to decrease, therefore, mechanical ventilation is needed

Background Information:

Recent studies by CMHC, EMR and NRC have indicated the following:

- new houses are increasingly becoming more airtight (most houses fall into the 2-3 AC/h @ 50 Pa range) in random tests of airtightness
- this data suggests that new houses are more like R-2000 houses (which must be less than 1.5 AC/h @ 50 Pa) than older houses (which usually test at 5-8 AC/h @ 50 Pa)
- airtight houses (eg. R-2000) with mechanical ventilation generally have better indoor air quality than conventional houses
- use of sheet goods, caulking and glues, synthetics, etc. are increasing and all have negative impact on air quality

- conventional heating systems are susceptible to backdrafting and spillage at very low pressures (5 Pa for a gas furnace)
- only recently have we had the technology to measure air quality problems in houses and this is uncovering some previously unknown concerns
- particle boards and glues can be strong sources of volatile organic compounds such as formaldehyde
- occupant activities and furnishings emit pollutants so eliminating sources in construction materials is not the only answer to indoor air quality problems

Radon is an example of a pollutant where ventilation alone is not the answer. A more appropriate solution might be to divert radon from even entering the building though basement air sealing and under-slab ventilation.

Ventilation rates of 0.3 -0.5 AC/h keep many air quality problems in check.

Resource Materials:

Overheads to lead the discussion:

Overhead 1-2: Indoor air quality problems
Overhead 1-3: Sources of moisture
Overhead 1-4: Air quality control
Overhead 1-5: Changes in residential construction

Training Process: *Group Excercise*

Break class into two groups and provide them with the overhead acetates for discussing their problems.

Have them elect a group leader and write down their solutions. Allow groups to have 15 minutes to arrive at solutions to their problem.

Have group leaders present the solutions.

Wrap up the discussions having groups provide input as to points the other group may have missed.

Problem 1 introduces moisture problems as a key air quality concern. Try to emphasize the lifestyle related sources of moisture. Drying firewood indoors, an unvented dryer, excessive numbers of plants can all create a high moisture load. Minimal insulation, cold climates, poor windows can all create local condensation problems. *Ventilation alone may not solve the problems.*

Problem 2 introduces combustion spillage as an indoor air quality problem. A ventilation system may have no effect or may aggravate the problems. Lack of combustion air may be aggravated by high house pressures. *Again, ventilation alone may not solve the problems*

Background Information:

Moisture sources include the items listed on Overhead 1-3, as well as unvented dryers, plants, high occupancy, lifestyle (cooking, showers jacuzzi's), humidifiers, high water table in the soil etc. Note that window condensation may also be linked to low R-value (eg. single-glazed) windows.

Solutions include: controlling sources, exhaust from wet areas, ventilation, dehumidification. Note: Emphasize that an HRV is not the only ventilation option.

Combustion devices are the likely source of a "smoky smell" in a house. However, negative pressures created by exhaust fans are not the only reason the smell might be in the house. Also look for:

- furnace problems / an old furnace (cracked heat exchanger)
- blocked flue (collapsed or plugged chimney)
- inadequate draft (local wind effects or short chimney)
- sources near a ventilation air intake

Solutions might include: balancing ventilation flows, adding a combustion or make-up air inlet, repair/replacement of the furnace, repair / replacement of the chimney, relocating the ventilation air intake.

NOTE: Opening a window as a solution should be discussed even if it is not brought up by the group because it is persists as a recommendation in popular myth; emphasize that carbon monoxide is colourless and odourless; occupants (who may even be asleep) can not be depended upon to detect its presence.

Resource Materials:

Problems are laid out on the following overheads:
Overhead 1-6: Problem 1
Overhead 1-7: Problem 2.

Additional use can be made of:
Overhead 1-3: Sources of moisture.

Section 5. Code Requirements / Responses to Problems
(10 minutes)

Training Process: *Lecture*

This section is intended as a general introduction to the various ventilation codes and standards; dealing with specifics should be deferred so that the interrelationships between the codes can be seen.

Introduce the material on Overheads 1-8 and 1-9.

Introduce the National Building Code as the model of Provincial Building Codes and CSA F326 as reference standard for design and installation of ventilation systems.

Some introductory remarks may be needed to introduce the difference between Part 9 and Part 6 of the NBC. Perhaps use a flip chart to note:

- Part 9 Code Requirements for houses
- Part 6 Mechanical Systems in all other buildings.

Use Overhead 1-9 to introduce the enforcement and interpretation of codes.

Then introduce Overheads 1-10 to 1-12 to provide an overview of Codes and Standards.

- NBC 1990 requires a mechanical ventilation system for all new buildings
- CSA F326 is a key reference for design and installation of residential ventilation systems
- CSA C22.2, CSA C260, and CSA C439 are all equipment standards
- ASHRAE 62-89 is a general ventilation design and installation standard. CSA F326 is probably more appropriate for Canadian housing.

Then use Overhead 1-12 to present the R-2000 Program Requirements. Note these requirements have been presented on their own overhead because some course participants have specifically come to the course as a requirement of the R-2000 Program.

Background Information:

The National Building Code of Canada 1990 must be adopted into law provincially to come into force. This process is in various states of progress provincially (eg. in Ontario, the NBC requirements for ventilation have essentially been adopted already while in other provinces the same may not be true).

CSA F326 is now a permanent standard. Up to September 1990, it existed as a Preliminary Standard.

CSA C260 was a seldom used standard. With recent changes to it and the NBC 1990 calling for use of fans rated at 25 Pa for Part 9 systems it is expected to be used more frequently.

CSA C22.2 is part of the Canadian Electrical Code. Previously sections of the Code prevented use of resistance heating and other electrical components in ducts carrying cold outdoor air because of the danger of condensation occurring in controls etc. Those requirements have been deleted.

R-2000 Requirements are basically the requirements of CSA F326 with the additions noted on Overhead 1-12.

Resource Materials:

Discussions should be guided with the following overheads:

Overhead 1-8	Hierarchy of Codes
Overhead 1-9	Codes Implementation
Overhead 1-10	NBC Requirements
Overhead 1-11	Ventilation Standards
Overhead 1-12	R-2000 Requirements

Section 6: Terms and Definitions

Training Process: *Lecture and Slide Presentation*

Introduce the fact that an understanding of terminology is needed to understand what is meant in the various codes and standards.

Introduce the terms with the aid of Overheads 1-13 to 1-17. The terms are shown visually to be more or less self-explanatory.

Introduce the slide presentation. A few more terms are added to develop the "house as a system concept".

Background Information:

Air Changes per hour or AC/h appears in several places in construction technology. For instance, it is used as the units to describe:

- natural air leakage
- mechanical ventilation rates
- the results of an air tightness test (eg. AC/h @ 50 Pa)

Some time spent differentiating mechanical ventilation from natural air leakage, even though both provide an air change, will assist understanding of terms touched on throughout the course.

Types of air not shown on the figure in Overhead 1-12 include:

- make-up air
- combustion air

These items are on Overhead 1-13.

For the most part, fireplace inserts, woodstoves, induced draft furnaces and DHW heaters have not been tested to see the types of pressures they can withstand resisting combustion spillage. CSA F-326 places the responsibility on the ventilation designer to check to see if the combustion device has been tested for resistance to combustion spillage. If not he is obliged to assume the device can resist no more than 5 Pa. THEREFORE, ALL COMBUSTION

DEVICES ARE "SPILLAGE-SUSCEPTIBLE" UNLESS PROVEN OTHERWISE.

Flawed as it is, "Spillage-Susceptible" is the term used by the NBC 1990 so to be consistent, this is the term which should be used to describe this problem.

Resource Materials:

Discussions should be guided with the following overheads:

- Overhead 1-13: Definitions: Air Change Rates
- Overhead 1-14: Definitions: Types of Air
- Overhead 1-15: Definitions: Types of Air Cont'd
- Overhead 1-16: Definitions: Pressure
- Overhead 1-17: Spillage-Susceptible Heating Systems

Slide Presentation on House as a System:

- Slide 1-13: Infiltration and Exfiltration--(introductory slide)
- Slide 1-14: Neutral Pressure Plane
  Warm air rises creating infiltration and exfiltration, placing lower parts of a house in negative pressure. This explains the greater tendency of basement fireplaces to have a poor draft.
- Slide 1.15: The Flue Effect
  Warm air rises up a flue creating infiltration placing lower parts of a house in negative pressure.
- Slide 1.16: The Ventilation Effect (Exhaust fans only)
  Warm air is sucked out of the house adding to the infiltration placing lower parts of a house in negative pressure.
- Slide 1.17: The Wind Effect
  Wind creates infiltration on the windward and exfiltration on the leeward sides of the house.
- Slide 1.18: The Combined Effect
  Things get complicated depending on fan operation, winds etc.
- Slide 1.19: The Air Flow
  And air flows are just one part of the house as a system.
- Slide 1.20: The Occupants
  Occupant Activities add to pollutant and moisture generation.

Slide 1.21: Example
Occupants drying clothes indoors.

Slide 1.22: The Building Envelope
The building envelope has effects based on its resistance to heat, moisture and air.

Slide 1.23: The House as a System
The interaction has been summed up by looking at the House as a System.

-- Break (15 Minutes) --

Module 2: Installation Requirements (10:30-12:00)

Section 1: Learning Objectives *5 minutes)*

Training Process: *Lecture*

Introduce objectives on Overhead 2-1.

Emphasize that, in this section of the course, complete systems or approaches to ventilation are dealt with as opposed to pieces of equipment.

Background Information:

Seven generic systems are introduced in this section.

This is an appropriate time to distribute the document "How to Comply with the Mechanical Ventilation requirements of the 1990 NBC". Hereafter this document is simply referred to as the "How to" manual.

Resource Materials:

Overhead 2-1: Learning Objectives

Section 2: *Workings of the National Building Code*

(15 minutes)

Training Process: ***Interactive Discussion / Lecture***

Use Overhead 2-2 to introduce the general requirements for Ventilation Systems in the NBC Part 9. Emphasize the need for make-up air in houses with spillage susceptible heating equipment.

Use Overhead 2-3 to initiate a discussion on what is meant by a Ventilation system. Let the discussions go until items like fans, ducting, controls, and make-up air inlets have been raised. If Combustion Air inlets are mentioned, use this as the opportunity to differentiate between Combustion Air and Make-up Air.

Use Overhead 2-4 to introduce the simplest NBC Compliance option - the Part 9 system. Emphasize the differences from existing practice:

- installing or testing for make-up air requirements.
- discusssion of pressure limits should be avoided at this point -- defer it to the discussion of make-up air inlets.

Overhead 2-5 introduce CSA F326 requirements for ventilation; if two overhead projectors are used, this overhead should remain up while the next six overheads are being presented.

Introduce the CSA F326 calculatations of ventilation capacity and exhaust capability using Overhead 2-6. Reinforce the learning process by performing a room by room count on the floor plan from Overhead 2-3.

Then use Overheads 2-7 and 2-8 to return to a more general look at Code requirements. Sum up the discussion pointing out that anything other than the simple point exhaust system must be designed and installed in conformance with Part 6 (ie. CSA F326).

Background Information:

The simple exhaust system represents the least change from existing practice. It utilizes a combination of kitchen and bathroom fans to provide ventilation. It does not necessarily constitute a good ventilation system. Particularly in baseboard heated houses, it may not provide satisfactory ventilation because ventilation air is not distributed.

A simple calculation might be worthwhile to emphasize the required ventilation capacity:

Example: Take a 20' X 40' house with a full basement:

Capacity = 0.3 AC/h X 20' X 40' X (8' main floor height + 7' basement)
= 3600 cu. ft. per hour
= 3600 / 60 (min/hr)
= 60 cfm

The simple system in a forced air heated house is shown in the "How to" manual as "System A" and in a non forced-air house it is "System E".

Resource Materials:

Use the following Overheads to lead the discussion:

Overhead 2-2:	General requirements of the NBC
Overhead 2-3:	Question (re. elements of a ventilation system)
Overhead 2-4:	Simple exhaust system requirements
Overhead 2-5:	CSA F326 requirements
Overhead 2-6:	CSA F326 calculation of minimum capacity
Overhead 2-7:	Choice of system (1)
Overhead 2-8:	Choice of system (2) code implications

Section 3: Systems: Advantages and Drawbacks

(30 minutes)

Training Process: *Lecture and Discussion*

Two overhead projectors might be desirable for this section of the course.

Use Overheads 2-9 and 2-10 to review the simple point exhaust system. Emphasize the reasons why another approach may be desired.

Overhead 2-11 introduces the Part 6 systems; indicate that, from here on in the course, a Part 6 system is assumed to be one which complies with CSA F326. No other approach is as reasonable an interpretation of the NBC 1990.

Introduce the room-by-room sizing technique outlined in the standard. Also, introduce the exhaust requirements indicating that this need not represent extra capacity; it simply identifies where supply and exhaust ducts should be located (ie. exhaust from Category B rooms).

Use Overheads 2-12 to 2-17 to present the various generic approaches: central exhaust, central supply and balanced (HRV)-type systems. Refer to the "How to" manual. *(Helpful Hint : colour in the ventilation components of the overheads 2-12, 2-14, & 2-16 to assist students in seeing the elements of the various systems).*

Background Information:

Builders will likely push installers for the simple exhaust system. Note the many disadvantages of this approach.

Costing data is estimated in the "How to" manual for each of the systems. On the basis of cost, builders may also opt for supply only systems. This may be detrimental to the house as it forces interior air into concealed spaces (walls and attics.) It would be desirable to point out the drawbacks of this approach.

There is lingering concern that CSA F326 mandates the use of HRVs. Point out that F326 does not require these devices, however, it highlights their advantages. Their use may be desirable for several reasons, ranging from balanced air flows through heat recovery.

Note that the ductwork for the Central Exhaust System is similar to that required for an HRV in a forced-air heated house. Some authorities have suggested that there will be a number of builders who will market this type of system indicating it is easily retrofitted with an HRV if they become more cost-effective in the future.

Resource Materials:

Overheads for this section are as follows:

Overheads 2-9 and 2-10:	Point Exhaust Systems
Overhead 2-11:	Systems Other than Simple Exhaust Systems
Overheads 2-12 and 2-13:	Central Exhaust Systems
Overheads 2-14 and 2-15:	Central Supply Systems
Overheads 2-16 and 2-17:	Balanced (HRV-type) Systems

Section 4: Selecting Components of a System

(30 minutes)

Training Process: *Group Exercise*

Break the class into two groups as before.

This exercise is aimed at summarizing the previous discussion on selecting elements of a complete and pointing out some gaps in the knowledge which still exist (ie. criteria for installing equipment.)

Use Overheads 2-18 and 2-19 to introduce the object of the exercise. By this point the groups should be able to locate equipment, suggest routing of ductwork, suggest the supply and exhaust rooms, size the system, identify the need for a make-up air inlet and locate inlets and outlets.

Ensure the work is reasonably complete because the exercise sheets will be re-used in subsequent exercises. Have a represenative of each group present the group's findings.

Background Information:

Builders will likely ask for the simple exhaust system for the reasons indicated previously. Participants should now be able to show at least some of the implications of this decision.

The exercises consist of preparing two different approaches to ventilating the same house: one is a simple exhaust system, the other is using an HRV.

Resource Materials:

Overheads for this section are as follows:

Overhead 2-18:	Problem 1 (Prepare a Simple Exhaust System)
Overhead 2-19:	Problem 2 (Prepare an HRV System for the same house)

Training Process: Interactive Discussion

Review the key points of the NBC and CSA F326 using Overheads 2-2, 2-4, 2-5 and 2-6.

Summarize with Overhead 2-1.

Background Information:

N/A.

Resource Materials:

Overheads for this section are as follows:

Overhead 2-1:	Learning Objectives.
Overhead 2-2:	General Requirements of the NBC
Overhead 2-4:	Simple Exhaust System Requirements
Overhead 2-5:	CSA F326 Requirements
Overhead 2-6:	CSA F326 Calculation of Minimum Capacity.

-- Lunch Break (1 hour)--

Module 3: Installation Practices (1:00-5:00)

General Introductory Note: In this module code requirements, equipment and installation guidelines for ventilation systems are provided on overheads and the module is summarized with a slide presentation of details. An alternate approach is to distribute the slide presentation throughout the afternoon, both, to break up the presentation providing variety to maintain interest, and, to reinforce the teaching elements.

Section 1: Learning Objectives *(5 minutes)*

Training Process: *Lecture*

Introduce the objectives of this section using Overhead 3-1.

Emphasize that this section of the course material presents Components of ventilation systems.

Background Information:

Again in this module, a 2 projector format for materials is preferred so that installation details can be presented on one screen while codes and standards requirements are displayed on the other.

Resource Materials:

Discussions should be guided with the following overheads.

Overhead 3-1: Learning Objectives

Section 2. Ventilation Installer's Olympics (45 minutes)

Training Process: *Game*

In order to target the presentation of the material in Module 3 it will be desirable to pinpoint the level of knowledge of the group. A game format provides a suitable non-threatening way of pinpointing the skill level of the class.

This section can be run in one of two ways: either as a competative game or as a simple exercise. Two teams only should be used due to time limitations.

Overhead 3-2 provides the introduction and rules if a game format is used.

Overheads 3-3 to 3-6 provide questions.

Use Overheads 3-7 to 3-10 to deal with any points missed by the groups.

Background Information:

Answers to the questions are pretty well self-explanatory.

Blank acetates should be used to record answers of groups or, alternatively, additional copies of the question sheets can be made so each group has 4 blank question sheets.

Resource Materials:

Discussions should be guided with the following overheads.

Overhead 3-2	Ventilation Installer Olympics (rules)
Overheads 3-3 to 3-6	Questions 1 to 4
Overheads 3-7 to 3-10	Answers 1 to 4

Training Process: *Interactive Discussion*

Build on the items listed in the previous exercize. Do not dwell on items the groups have identified, rather add to and clarify the points they have brought out.

Use Overhead 3-11 and 3-12 to introduce requirements for ducting.

Starting with Overhead 3-13, begin to develop a set of rules of thumb (eg. equivalent length of flex duct is double that of smooth duct).

Use Overhead 3-14 and 3-15 to provide an introduction to fans and ventilators. Some knowledge of fan characteristics will be beneficial in the duct sizing layout following, so emphasize aspects of decreasing capacity to move air as static pressure is increased on the sample fan curve.

Introduce rules of thumb for duct sizing using Overheads 3-16 to 3-21. Utilize the worksheet on Overhead 3-19 to work through the process for sizing ducts for the ventilation system shown in Overhead 3-17.

Having sized the ductwork, introduce requirements for locating dampers with Overheads 3-22 and 3-23.

Return to Overhead 3-17 to invite input as to locations of dampers in the ducting.

Background Information:

In the course of the discussion, the following points will be worth touching upon:

- ventilation fans are typically much less powerful than furnace fans; relatively speaking, they require larger ducts to move the same amount of air
- typically ventilation ducts will be 6" and 7" on trunk ducts and 4", 5" and 6" on branch ducts

Training Process: *Interactive Discussion*

Build on the items listed in the previous exercize. Do not dwell on items the groups have identified, rather add to and clarify the points they have brought out.

Use Overhead 3-11 and 3-12 to introduce requirements for ducting.

Starting with Overhead 3-13, begin to develop a set of rules of thumb (eg. equivalent length of flex duct is double that of smooth duct).

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Return to Overhead 3-17 to invite input as to locations of dampers in the ducting.

Background Information:

In the course of the discussion, the following points will be worth touching upon:

- ventilation fans are typically much less powerful than furnace fans; relatively speaking, they require larger ducts to move the same amount of air
- typically ventilation ducts will be 6" and 7" on trunk ducts and 4", 5" and 6" on branch ducts

- though the NBC requires that bathroom and kitchen fans must be selected based on flows with 25 Pa of static, central ventilation equipment is selected assuming more ducting is required (75 to 100 Pa of static is a better assumption)

Damper locations should account for the likelihood of basements being finished rendering the damper inaccessible.

Resource Materials:

Discussions should be guided with the following overheads.

Overheads 3-11 and 3-12 :	Ductwork Installation Requirements
Overhead 3-13:	Duct Fittings and Equivalent Lengths
Overhead 3-14:	Fans and Ventilators
Overhead 3-15:	Example: Fan Curve
Overhead 3-16:	Steps to Size Ducts
Overhead 3-17:	Problem Layout
Overhead 3-18:	Duct Sizing Worksheet
Overhead 3-19:	Rules of Thumb for Bathroom Fans and Range Hoods
Overhead 3-20:	Rules of Thumb for Central Ventilation Systems
Overhead 3-21:	Circular/Rectangular Duct Equivalents
Overheads 3-22 and 3-23:	Damper Locations

- - Break (15 minutes) - -

Training Process: *Interactive Discussion*

Build on the items listed in the previous exercizes. A variety of formats can be used. Slides which are presented in the last session of the day as a wrap-up/summary can alternately be paced to appear throughout this section.

Use Overhead 3-14 to re-introduce requirements for ventilators and as general introduction to ventilating equipment requirements.

It will probably be most useful to adopt a "highlights" approach to overheads; some of the requirements for one type of fan will duplicate requirements listed for other types of fans for example.

Introduce requirements for bathroom fans with Overhead 3-24; in-line centifugal fans (Overhead 3-25) and low-sone fans (Overhead 3-26) might be required to control noise if fans operate continuously. A bathroom fan will be required to be capable of operating continuously if it is part of the ventilation system.

Introduce requirements for range hoods with Overheads 3-27 and 3-28; note the higher noise levels of these fans (Overhead 3-29) and how much flows drop with 50 Pa (0.2" W.G.) of static pressure. Overhead 3-30 presents installation alternatives; highlight the potential of condensation in the duct with a through the roof installation. A range hood fan will be required to be capable of operating continuously if it is part of the ventilation system.

Overhead 3-31 presents requirements for kitchen exhausts (Note this is a fan which exhausts from the kitchen area.) Note the differences of NBC and CSA on the requirements for a grease filter. CSA F326 requires a grease filter on all installations. NBC only requires that, if a filter is not supplied, ductwork should be accessible throughout its length for cleaning. Again, this type of fan will be required to be capable of operating continuously, if it is part of the ventilation system.

Overhead 3-32 highlights the definitions and system components of make-up air inlets and relief outlets. Overheads 3-33 and 3-34 show the pressure limits of the NBC and CSA F326 respectively. Note the differences of NBC and CSA on the requirements for a a relief outlet. CSA F326 requires one on all installations where pressures in the building would otherwise exceed 10 Pa. The NBC does not require an outlet, although the Appendix to the NBC discourages positive pressurization. Also note, make up air is not needed under the NBC if the house does not have spillage-susceptible heating (but a 20 Pa limit is suggested for these houses). CSA F326 defaults to a 5 Pa limit, unless the manufacturer of the heating equipment provides data to the contrary.

Overheads 3-35 and 3-36 show alternate makeup air inlet configurations. Discourage use of configuration in Overhead 3-35 because of fire and safety concerns with in-duct heaters. Note however, that a new safer heater is coming on the market. (Avoid recommendations of equipment, however, the new equipment in this case is being developed by Chromalox. No product data is available as of the time of preparing this manual.)

Overhead 3-37 shows sizing of makeup air inlets.

Introduce Heat Recovery Ventilator installation requirements listed on Overheads 3-38 and 3-39. Use Overhead 3-40 to introduce the parts of a typical HRV. Introduce the ORF test data sheets in Overhead 3-41 highlighting flows at 75 Pa and 100 Pa of static, noting heat recovery efficiency, etc. Indicate only tested HRVs are allowed in R-2000 houses. Use Overhead 3-42 to introduce options for indirect connections to the furnace. Use Overheads 3-43 and 3-44 to locate Flow Measuring Stations, dampers, etc.

Deal with in-duct heaters using Overhead 3-46. Indicate that proving flow in a passive inlet duct and avoiding overheating may be a significant problem.

Present grilles and registers using Overheads 3-47, 3-48, 3-49 and 350. Note the requirements for kitchen grease filters as identified in previous discussions.

Intakes and exhausts can be presented using Overheads 3-51 to 3-57. Highlights should make note of avoiding contamination of intake air, guidelines for sealing at penetration of the air barrier of the building, tips for avoiding freeze ups and blockage.

The areas of ductwork requiring sealing and insulation can be introduced using Overhead 3-54.

Overhead 3.58 identifies insulation and sealing requirements for ducts.

Control options are listed in Overheads 3-59 and 3-60. Highlight the fact that there is no reason why only one control type need be used; Overhead 3-60 shows several controls in parallel.

Overheads 3-61 and 3-62 indicate filter and labelling requirements.

Background Information:

Manufacturer's data sheets have been used for examples to make this segment more relavent.

The Appendix to the NBC indicates that only low-sone fans should be selected (ie. 2.0 sones or less) for continuous operation. The model shown in Overhead 3-25 is the only bathroom fan currently available which is less than 2 sones. Several fans are available which are 2.5 sones or less.

There is some debate as to whether an in-line fan meets the requirements for ease of access for maintenance and cleaning as set out in CSA F326.

Resource Materials:

Discussions should be guided with the following overheads.

Overhead 3-24:	Bathroom Exhausts
Overheads 3-25 to 3-26:	Bathroom Fan types
Overhead 3-27:	Range Hood Requirements
Overheads 3-28 to 3-30:	Range Hood Equipment / Installation Options
Overhead 3-30:	Range Hood Venting Configurations
Overhead 3-31:	Kitchen Exhaust Requirements.
Overheads 3-32 to 3-34:	Make-up Air Inlet Requirements
Overheads 3-35- 3-37:	Make-up Air Inlet Sizing and Installation Details

Overheads 3-38 to 3-41:	HRV Requirements and Spec. Sheet Sample
Overheads 3-42 to 3-44:	HRV Details: Equipment Parts, Indirect Connections, Damper Locations
Overhead 3-45:	Make-Up Air Test
Overhead 3-46:	In Duct Heaters
Overheads 3-47 and 3-48:	Grilles and Registers
Overheads 3-49 to 3-50:	Grilles/Filter Details
Overheads 3-51 to 3-53:	Exterior Intake and Exhaust Hood Requirements
Overheads 3-54 to 3-57:	Exterior Hood Details
Overhead 3-58:	Duct Insulation and Sealing Requirements
Overhead 3-59:	ControlsRequirements
Overhead 3-60:	Parallel Control Installation Details
Overhead 3-61:	Filter Requirements
Overhead 3-62:	Labelling Requirements

Training Process: *Group Exercise*

Introduce the exercise using the systems created in Module 2.

Have groups review details of their Part 9 and Part 6 systems.

Background Information:

This exercise can be handled equally well with group discussion focussed on an overhead at the front of the class.

Resource Materials:

Discussions should be guided with the following overheads:
- Overhead 2-18: Problem 1
- Overhead 2-19: Problem 2

Training Process: *Slide Show and Review*

Introduce installation details using a number of different slides.

Sum up the discussion with Overhead 3-1.

Background Information:

This part of the course can be used as a review of Module 3 (ie., at the end of the day or in the midst of delivering sections on details throughout the afternoon.

Resource Materials:

Slide presentation items to be covered:

Central ventilators - equipment mounting slides:
- Slide 3.1: Central Exhaust system mounted directly on joists
- Slide 3.2-3: HRV mounted on straps
- Slide 3.4: HRV on vibration pads
- Slide 3.5: HRV - basement wall mounting

Condensate drain alternatives slides:
- Slide 3.6: Direct discharge into a laundry tub
- Slide 3.7: Trapped drain into wastewater plumbing
- Slide 3.8: Condensate pump

Bathroom fan slides:
- Slide 3.9: Typical bathroom fan
- Slide 3.10: Propeller-type (axial) fans are easier to stall

Range fan slides:
- Slide 3.11: Typical installation - emphasize maximum dist off cooking surface
- Slide 3.12: Must be equipped with a grease filter

Filter types and options slides:

- Slide 3.13: Grease filters required on all kitchen ducts (CSA F326) or duct must be accessible for cleaning throughout its length (NBC 1990)
- Slide 3.14: Central Fans often have filters in the equipment (HRV shown)
- Slide 3.15: Filter in the ductwork
- Slide 3.16: Filter at the hood and fine screens must be easily removed for cleaning

Implications when this equipment is assembled into a system:

- Slide 3.17: Simple exhaust system (Part 9 NBC) -- Note make-up air inlet
- Slide 3.18: HRV system (Part 6 NBC & F326) -- Note air distribution and other features of this system

Duct slides:

- Slide 3.19: Installation Principles - List
- Slide 3.20: Typical installation - how could it be improved? Replace 90's with 45's, move equipment to avoid placing ducts under heatin ducts, seal joints in ductwork etc.
- Slide 3.21: Locate dampers in all branches in an accessible location or in the grille
- Slide 322: High wall delivery/exhaust preferred

Indirect connection slides:

- Slide 3.23: O.K.
- Slide 3.24: Poor
- Slide 3.25: Poor

Duct insulation and sealing slides:

- Slide 3.26: Sealing of joints required for ducts in unheated spaces (attics, crawlspaces, etc.) Its good practice everywhere
- Slide 3.27: Insulation is required on cold ducts within the heated space as shown. Note: wide cloth straps to avoid damage to insulation vapour air/vapour retarder
- Slide 3.28: Seal vapour retarder well both to the unit and to the wall air barrier. Note: this type of installation will have a tendency to frost up because of the compression of the insulation at the end of the duct run
- Slide 3.29: Avoid excessive bend and constrictions especially in flex duct

Slide 3.30: On warm ducts in cold spaces the duct itself will form the vapour and air retarder
Slide 3.31: No insulation is required for cold ducts passing through cold spaces (eg. this intake passing through a garage)
Slide 3.32: Foam provides connection of air retarder of house to duct air/vapour retarder
Slide 3.33: Sheet metal fitting provides a collar to ensure continuity of air and vapour retarder

Supply and exhaust port slides:

Slide 3.34: Items to avoid when locating intakes
Slide 3.35: Inlet too low. Note: grouping of exhausts is a good practice
Slide 3.36: Inlet near garbage
Slide 3.37: Inlets should be located to avoid exhausts (2 m recommended)
Slide 3.38: Riser can be used
Slide 3.39: Inlet protected from snow but protection may promote short circuiting of inlet and exhaust. Note: lower resistance style of inlet
Slide 3.40: Avoid this type of inlet outlet grouping!

Grilles and registers slides:

Slides 3.41& 3.42: High wall supply and exhaust registers
Slides 3.43 & 3.44: Recommended ceiling (air conditioning-type) supply air registers
Slide 3.45: Entrained air sometimes causes dust staining of ceilings
Slide 3.46: Floor register (avoid it)

Other elements of a ventilation system slides:

Slide 3.47: Duct heater
Slide 3.48: Flow proving and overheat controls needed for safe operation of a duct heater
Slide 3.49: Flow-cal for measuring flows
Slide 3.50: Magnehelic gauge for reading Flow-cal
Slide 3.51: Combustion air inlet--note cold air entry issues
Slide 3.52: Motorized damper--may provide some relief from cold air
Slide 3.53: Switch and crank-timer controls
Slide 3.54: Humidistat control

-- End of Day 1 --

COURSE CURRICULUM

Day 2

Module 4. Indoor Air Quality and Ventilation (9:00-10:15)

Section 1. Learning Objectives *(5 min.)*

Training Process: *Interactive Discussion*

The object of this module is to introduce the concept of a design review before the installer goes on site.

This module is intended as both an overview of concepts covered in Day 1 of the course and as a useful activity in itself.

Indicate that design review is the first task of the installer. We have presented it at this point in the course to ensure students have an adequate grounding in the fundamentals.

Background Information:

The installer may be faced with complete redesign of the system based on site conditions. Room layouts and acceptable equipment equipment locations may be moved significantly from the original plan. Certain pieces of equipment may be unavailable and substitutions may be necessary, etc.

The installer may arrive on site and note a spillage-susceptible piece of heating equipment in the building which was not anticipated.

Resource Materials:

Overhead 4-1: Lists the learning objectives for this section

Section 2. Introduction of Basic Review Process (25 min.)

Training Process: *Interactive Discussion*

This discussion in this section is aimed at reviving many of the learning points from the previous day; use of slides and overheads from Day 1 will be extremely helpful in reinforcing key points.

Introduce the design review process with Overheads 4-2 and 4-3 and leave 4-3 on the second overhead.

Use a sample design (eg. work with the plan from Module 2 to work through the process.) to emphasize points like:

- sizing either use Overhead 4-4 or perform a quick room count to check sizing.
- check for kitchen and bathroom exhaust capability (Part 6 systems only)
- check for air distribution (Part 6 systems only)
- if there are unbalanced exhausts, (eg. a Part 9 system) refer to Overhead 3-31 to check sizing. Recommend installers carry a copy of the chart for quick sizing if tests show an inlet is needed.
- look for contaminant sources in the vicinity of the air intakes (including make-up air intake (driveways and exhaust outlets should be visible or easily inferred from the plan.

Introduce the Mechanical Ventilation Form in Overhead 4-5 as one means of reviewing the design.

Background Information:

Filling out a mechanical ventilation report is a key requirement of the R-2000 Program. Because the Program has been "regionalized" it is probably the case that a customized version of the form is in use in the Region.

Resource Materials:

Overhead 4-2: Steps in a Design Review
Overhead 4-3: The Installer should be capable of checking . . .
Overhead 4-4: Overall System Sizing
Overhead 4-5: Mechanical Ventilation Form

Training Process: Group Exercise

Place Overhead 4-6 on the overhead projector and break the group into groups of 4 or 5.

Introduce the design review process again with Overhead 4-3 and leave 4-6 on the second overhead.

Have the groups review the design and present results.

Background Information:

The groups will have to make a few assumptions to fill in the blanks. The furnace is a pulse furnace and, therefore, it is not spillage-susceptible. The DHW tank is induced draft, therefore, it is also not spillage-susceptible. It will require a combustion air inlet. The HRV is balanced even during defrost. The house has a full basement (not shown).

Suggest the equipment is to be located under the bathroom in the basement. The driveway is on the stairway side of the house; identify the possibility of contamination of the inlet.

Resource Materials:

Overhead 4-6: Design Review Problem 1
Overhead 4-3: The installer should be capable of checking. . .

Training Process: *Interactive Discussion*

Overhead 4-3 should remain on the projector for the review of this module.

If time permits, a few of the system sheets in the "How to" manual should be critiqued.

Wrap up the discussion with Overhead 4-1.

Background Information:

Many of the system sheets in the "How to" manual show an optional duct heater. In practice there are few suppliers of this type of equipment and there is considerable debate as to their advisability in this application.

Emphasize the advisability of performing a test to avoid the installation of a make-up air inlet.

Also note that, even though a design has been reviewed, problems may still appear on site due to unanticipated changes.

Resource Materials:

Overhead 4-1: Reviews the learning objectives for this section.
Overhead 4-3: Reviews the design review process.

-- Break (15 Minutes) --

Module 5. Indoor Air Quality and Ventilation (10:45-12:00)

Section 1. Learning Objectives *(5 min.)*

Training Process: *Interactive Discussion*

The object of this module is to introduce the key points of a visual review of the system and testing procedures on site.

Indicate that an installation should not be considered complete unless all elements have been checked as a system.

Overhead 5-1 provides a suitable summary of the items to be covered.

Background Information:

The installer may be faced with complete redesign of the system based on site conditions. The start-up check is another way of insuring nothing has been missed

The installer may only be installing one aspect of the ventilation system. If this is the case, when it comes time to commission the system, no one person is responsible. Highlight the need for one person to install ventilation equipment.

Certain tests can avoid excessive costs for ventilation systems. Testing to see if make-up air is needed is an obvious example. But also mention the role of balancing HRV's and setting ventilation flows to control operation problems, callbacks and energy costs. A financial incentive for performing a task with get people's attention.

Resource Materials:

Overhead 5-1: Lists the learning objectives for this section.

Training Process: *Interactive Discussion*

This discussion in this section follows the overheads. It is probably best to vary the presentation. Ask participants to suggest items which should be checked on various aspects of a ventilation system.

Summarize the process with Overheads 5-2, 5-3, 5-4 and 5-5 using a flipchart to augment the list.

Introduce the Mechanical Ventilation Form in Overhead 4-5 as one means of reviewing the design, but suggest that it does not cover basic items such as ductwork, wiring, grilles etc. in any detail.

Background Information:

Most manufacturers provide a reasonable checklist for their equipment.

Slides from Module 3 can be used to highlight some items.

Resource Materials:

Overhead 5-2:	Steps in a Visual Review
Overhead 5-3:	Checklist: Ducts
Overhead 5-4:	Checklist: Terminations, Grilles and Diffusers
Overhead 5-5:	Checklist: Wiring and Controls, Drains, Filters

Training Process: Group Exercise and Demonstration

Introduce Tests which should be performed on a house with Overhead 5-6.

Introduce Test Procedure Supplement of Participants Manual- Use Overheads 5-7 and 5-8 to introduce the CMHC Combustion Safety Checklist.

Assemble and demonstrate flow measurements on duct rig apparatus .

Allow participants to try a few duct combinations. With a run of flex duct, a few elbows and fittings flows should reduce significantly.

Wrap up the demonstration with slides of alternate test equipment.

Background Information:

The groups will have to play with the rig a bit to get a feel for measuring flows etc. Typically, 5 to 10 minutes per group of 4 or 5 is enough.

CMHC field test data indicates that bathroom and kitchen fans installed in the field move air at a rate which is substantially below the manufacturer's nameplate data. Most of the decrease is linked to duct resistance and installation procedures.

75 cfm rated bathroom fans moved 25 cfm in the field

150 cfm kitchen fans moved 30 to 100 cfm in the field

Resource Materials:

Overhead 5-6:	Tests which should be undertaken
Overhead 5-7 and 5-8:	Combustion Safety Checklist

The following slides can be used to illustrate test equipment which might not be available in the instructors kit at the workshop.

Slide 5.1:	Block Manometer
Slide 5.2:	Magnehelic
Slide 5.3:	Flow-cal
Slide 5.4:	Fan Depressurization Door
Slide 5.5:	Pitot Tube (avoid)

Training Process: Interactive Discussion and Presentation

Overheads 3-62 and 4-5 should be used to lead a discussion which summarizes documentation requirements.

If time permits, a few slides should be introduced to show items like damper settings, hoods, flow measuring stations being marked.

Background Information:

Filling out a mechanical ventilation report is a key requirement of the R-2000 Program. Because the Program has been "regionalized" it is probably the case that a customized version of the form is in use in the Region.

The system sheets in the "How to" manual show specifications for equipment; installed equipment must conform to these specifications.

Emphasize the need to document tests performed to avoid the installation of a make-up air inlet. Documentation of same should be left on site with the builder and/or the homeowner.

Resource Materials:

Overhead 3-62: Reviews the Labelling Requirements..
Overhead 4-5: Presents the Mechanical Ventilation Form.

Section 5. Review *(5 minutes)*

Training Process: Interactive Discussion

Overhead 5-1 should be used to wrap up the discussion and Overhead 5-6 can be used to summarize testing requirements.

Background Information:

Additional time can be allocated to "playing" with the duct test rig in the lunch break.

Resource Materials:

Overhead 5-1: Reviews the learning objectives for this section
Overhead 5-6: Reviews the tests which should be undertaken

--Lunch Break (1 hour)--

Module 6- Review and Test (1:00-2:15)

Section 1. Review *(1 hour 15 minutes)*

This is an unstructured module allowing the instructor to review key points. As a lead in, the learning objectives from each section might be used to invite questions and feedback.

The instructor should be prepared to review some key requirements of the 1990 NBC and CSA F326.

-- Break (15 Minutes) --

Section 2. Test *(1 hour)*

The test is an open book test.

Copy

OVERHEADS

MODULE 1

LEARNING OBJECTIVES

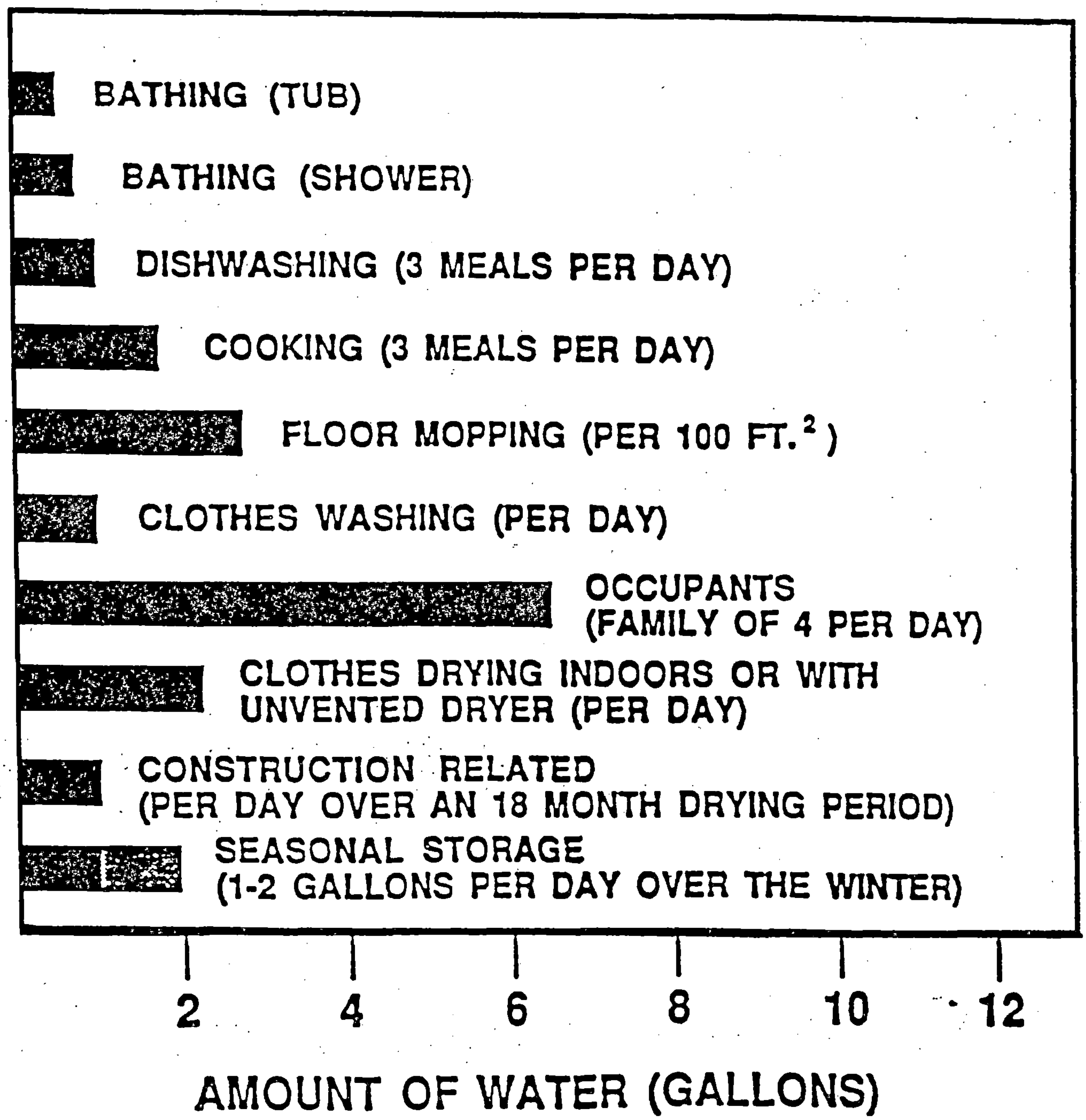
- Recognize basic air quality concerns
- Understand strategies for controlling indoor air quality problems
- Understand role of ventilation in controlling indoor air quality
- Introduce codes & standards addressing ventilation in low-rise construction
- Introduce concept of the "House as a System"
- Introduce ventilation terms and definitions
- Identify basic approaches to ventilation

Student Reference Guide Section: ______

INDOOR AIR QUALITY CONCERNS AND SOURCES

- Moisture (occupants, occupant activities, basement, construction materials)
- Formaldehyde (synthetic materials, glues)
- Radon (soil gas)
- Carbon Dioxide (combustion processes, occupants, respiration)
- Carbon Monoxide, Oxides of Nitrogen (combustion processes)
- Volatile Organic Compounds (synthetics, glues, solvents)
- Moulds, Fungi (usually associated with particular humidity and temperature conditions; eg., high humidity)

SOURCES OF MOISTURE IN THE HOME



Student Reference Guide Section: ______

AIR QUALITY CONTROL

Options:

- remove sources of pollution
- substitute non-polluting sources for polluting ones
- seal or encapsulate sources
- change design
- treat air, humidify, dehumidify
- provide ventilation or dilution of air

Student Reference Guide Section: ______

List some of the changes that have occurred in Residential Construction over the last 15 years. Identify their impacts on air quality.

Characteristics	Changes over the last 15 years	Air Quality Impact (better/worse)
House Construction - Envelope Insulation - Materials - Airtightness - Components (windows/doors)		
Mechanical Systems - Heating - Cooling - Fireplaces/ Woodstoves - Fans/Ventilation		
Occupancy - occupant habits - baths/showers - plants - spas		

Student Reference Guide Section: ______

PROBLEM 1

A homeowner is reporting severe condensation on his/her windows. List some of the possible causes. List some possible solutions.

CAUSES:

SOLUTIONS:

Student Reference Guide Section: ______

PROBLEM 2

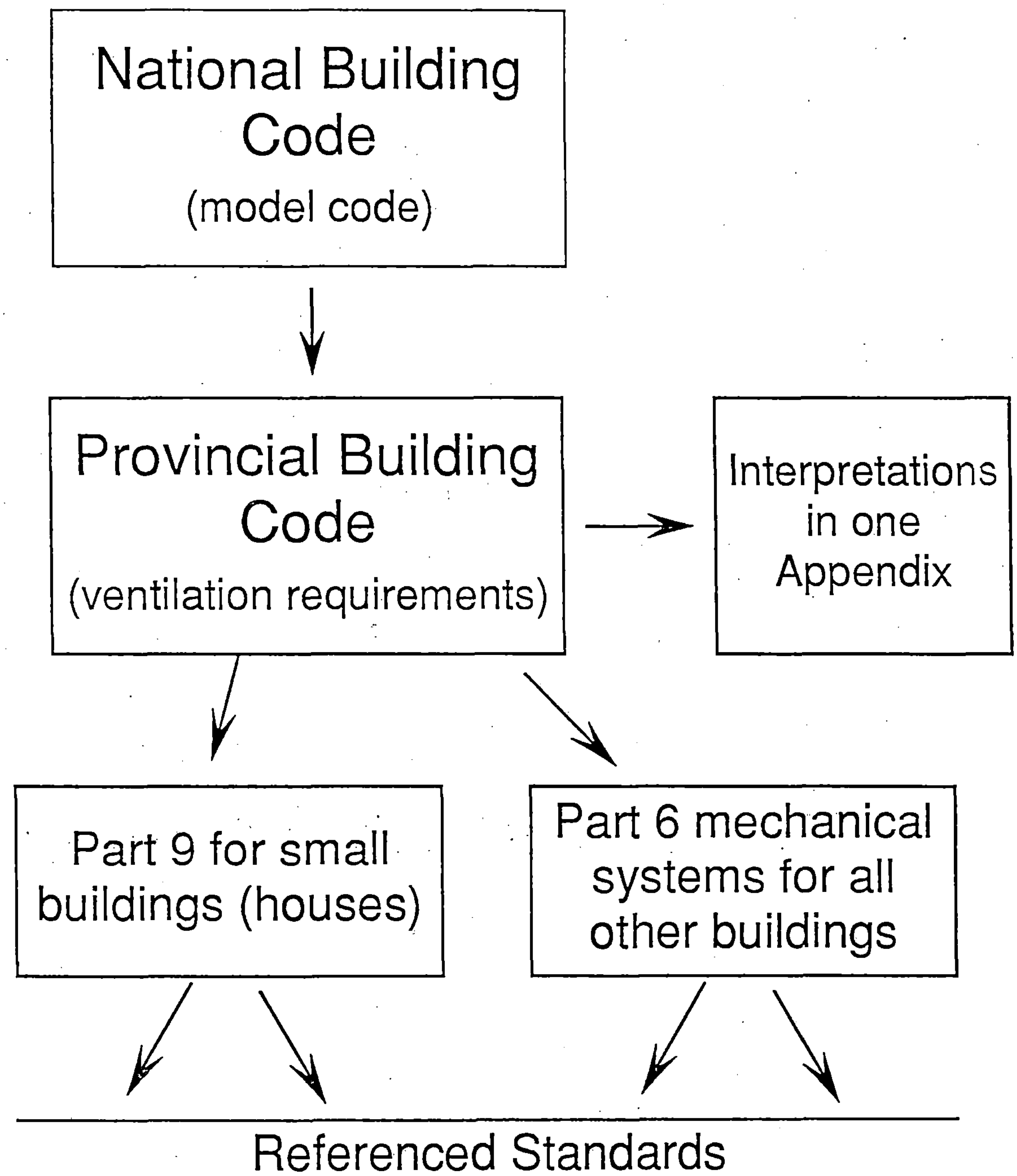
A homeowner is reporting a lingering smokey smell in his/her house. List some of the possible causes. List some possible solutions.

CAUSES:

SOLUTIONS:

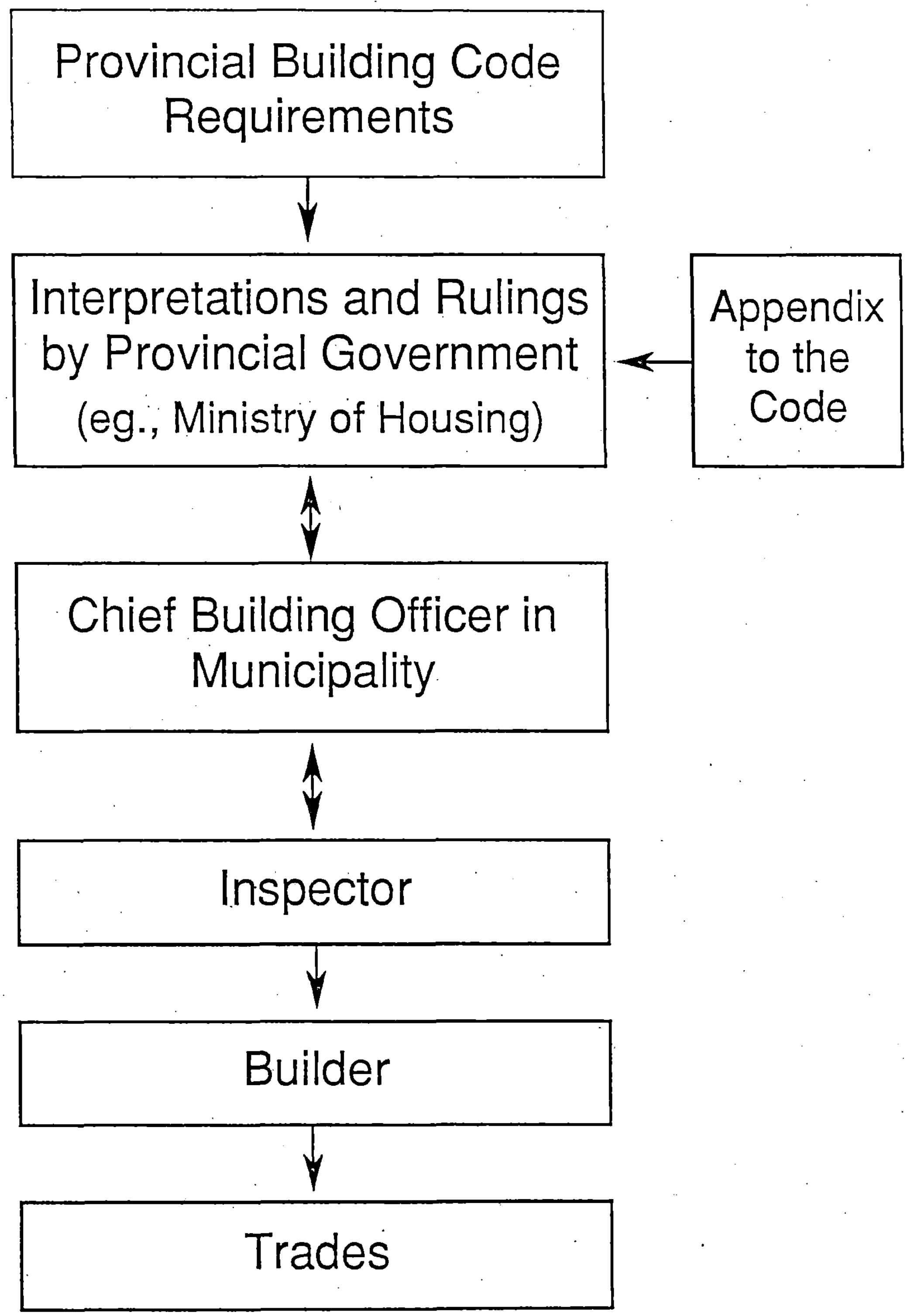
Student Reference Guide Section: ______

HIERARCHY OF CODES RELATING TO VENTILATION



Student Reference Guide Section: ______

CODE IMPLEMENTATION



BUILDING CODE VENTILATION REQUIREMENTS

National Building Code

- sets basic requirement for a minimum capacity of mechanical ventilation in all new houses

- defines two basic sets of design guidelines:

  - simple exhaust systems (follow NBC, Part 9)
  - all other (ducted) systems (follow NBC, Part 6)

VENTILATION STANDARDS

CSA F326 "Residential Mechanical Ventilation Requirements"

- referenced by the Appendix to the NBC
- specifically for low-rise residential systems
- incorporates many items of good building practice

CSA C22.2, No. 113. "Fans & Ventilators"

- electrical performance/safety of equipment

CSA C260. "Rating the Performance of Residential Mechanical Ventilating Equipment"

- rates ventilation characteristics of equipment

CAN/CSA C439. "Standard Methods of Test for Rating the Performance of HRVs"

- rates HRVs

ASHRAE 62. "Ventilation for Acceptable Air Quality"

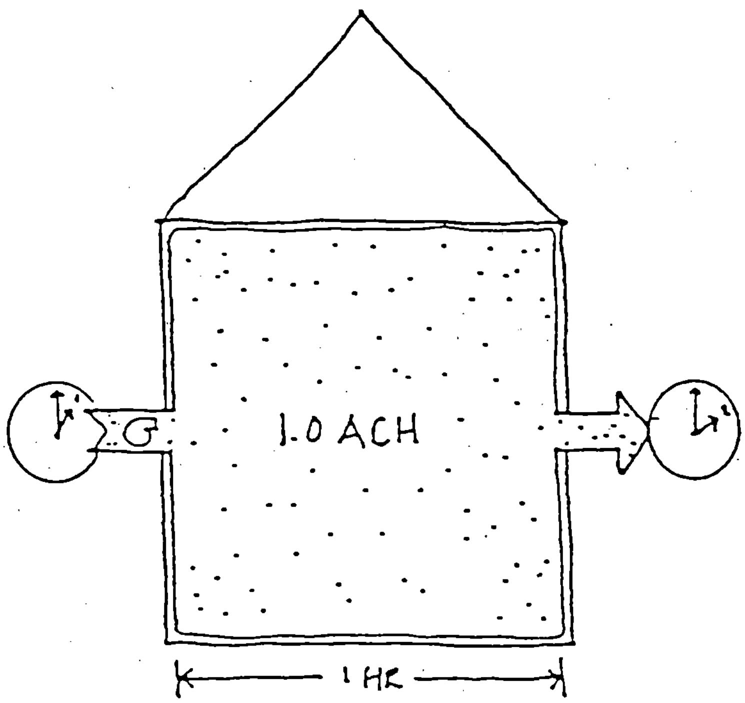
- a general ventilation standard

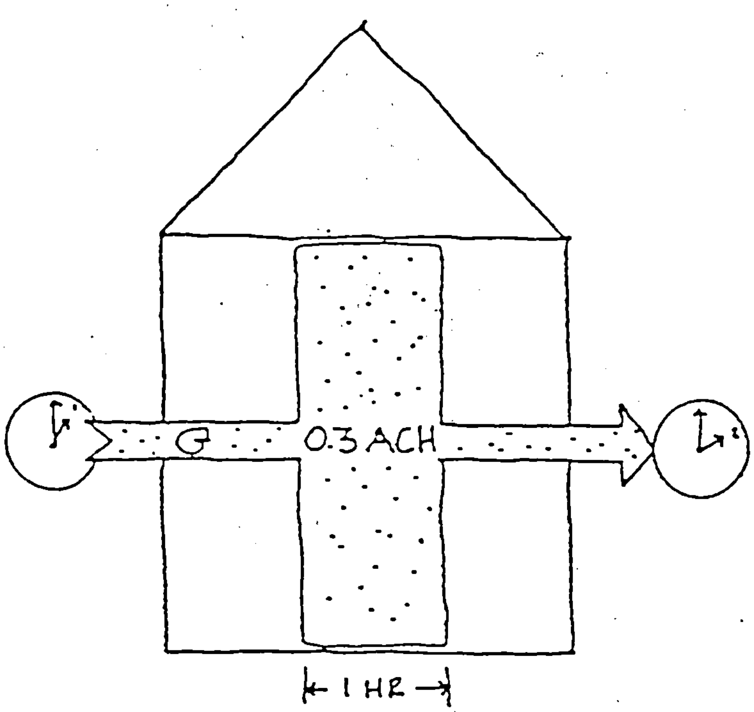
R-2000 REQUIREMENTS

- Virtually same as CSA F326 Requirements
- Recommended minimum ventilation rate settings must be identified on controls
- HRVs must be tested to CSA C439 and a rating sheet must be produced
- HRAI Certified Installer must be used
- Some regions require flow measurement stations be left in duct
- "Mechanical Ventilation System" report must be completed
- A specified level of heat recovery on ventilation air may be required to meet R-2000 Program Energy Performance Target
- Ventilation equipment must be left operating when installer leaves building due to airtightness of R-2000 houses

DEFINITIONS:

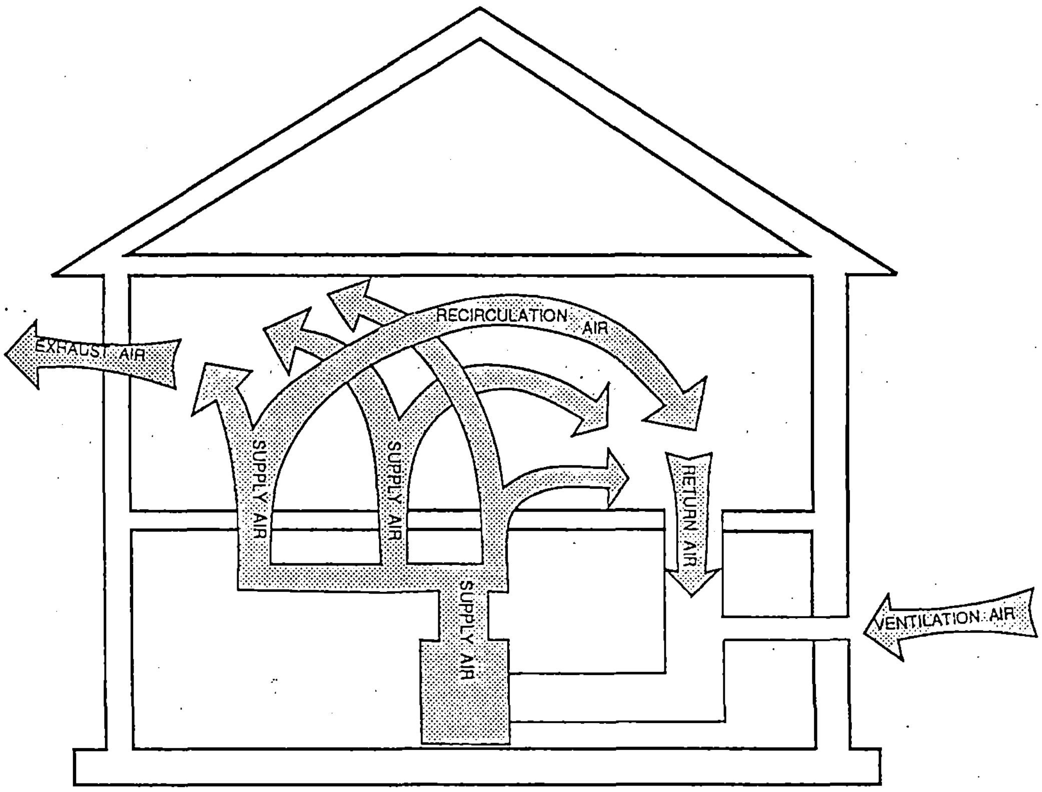
VENTILATION AIR CHANGE RATE





DEFINITIONS:

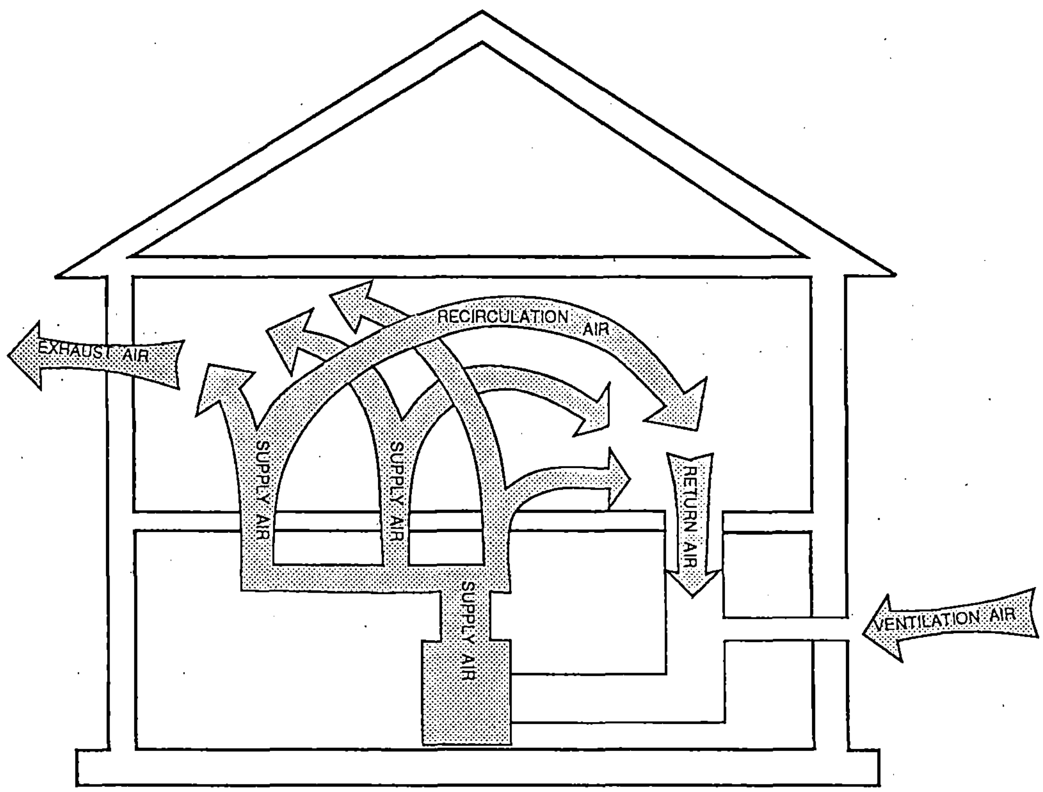
TYPES OF AIR



Student Reference Guide Section: ______

DEFINITIONS:

TYPES OF AIR

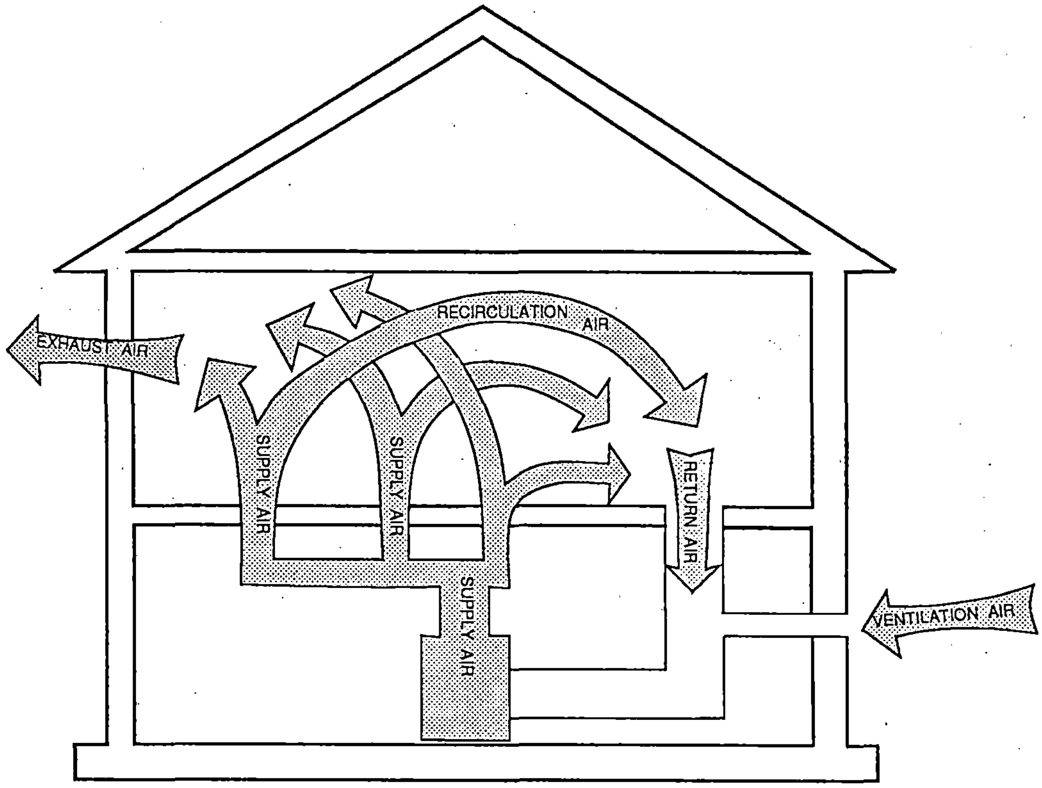


Student Reference Guide Section: ______

DEFINITIONS:

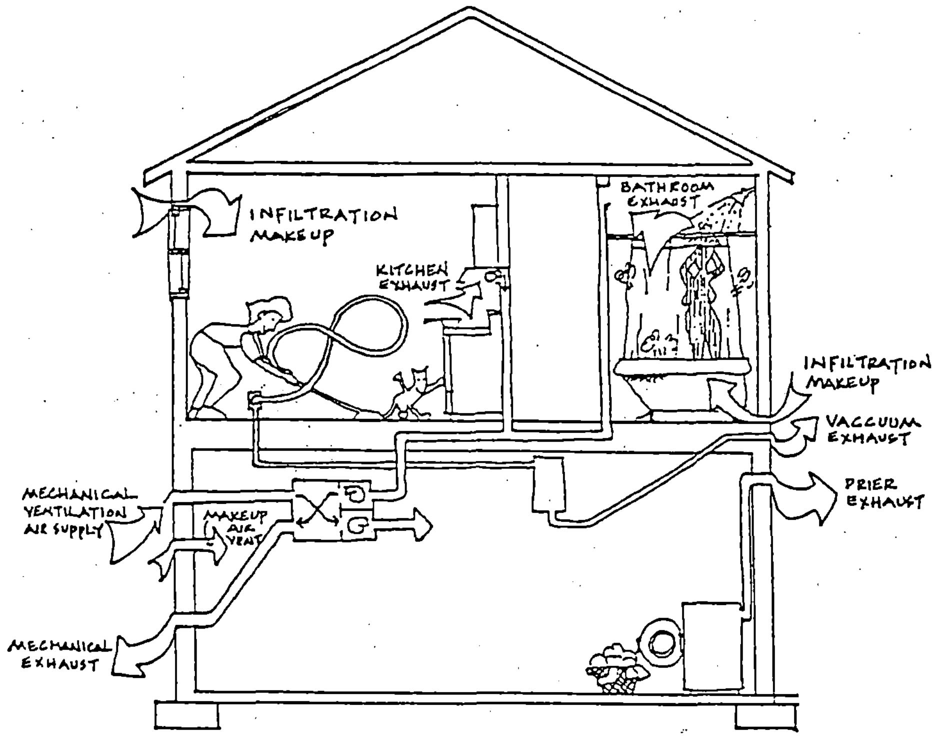
ORIGINAL

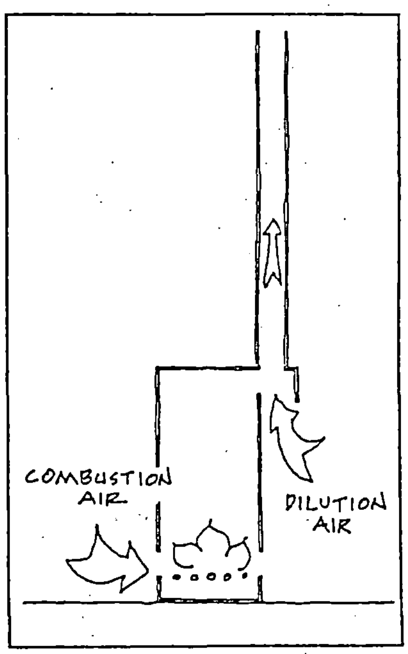
TYPES OF AIR



Student Reference Guide Section: ______

DEFINITIONS:
MAKE-UP AND COMBUSTION AIR

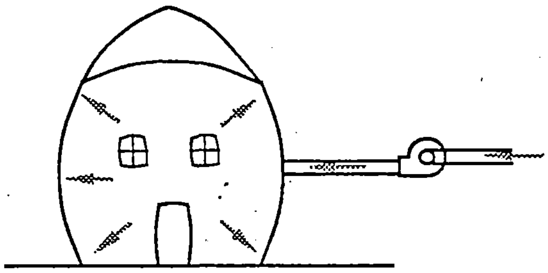




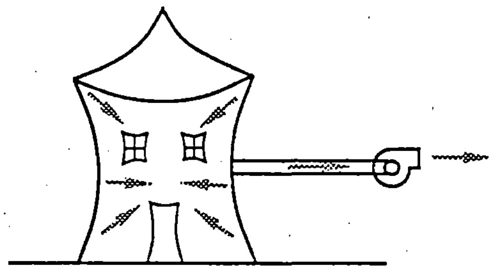
Student Reference Guide Section: ______

DEFINITIONS:

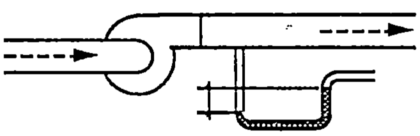
PRESSURE



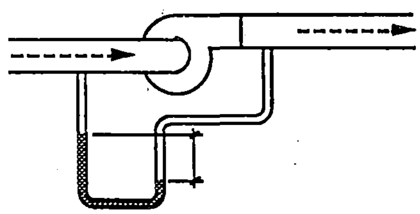
Positive Pressure



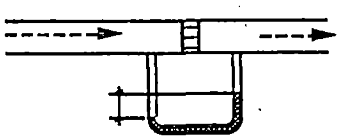
Negative Pressure



Static Pressure

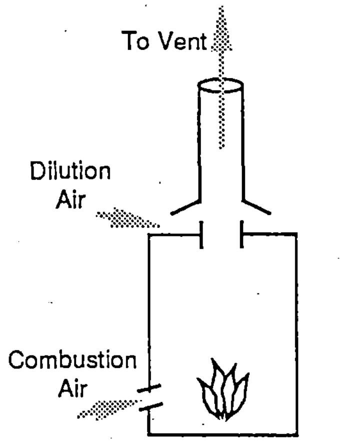


External Static Pressure

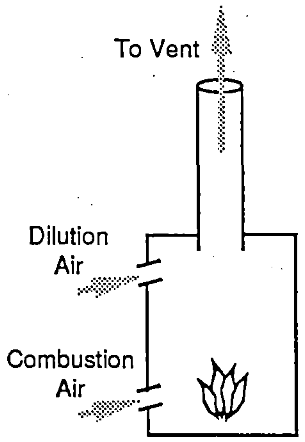


Pressure Drop

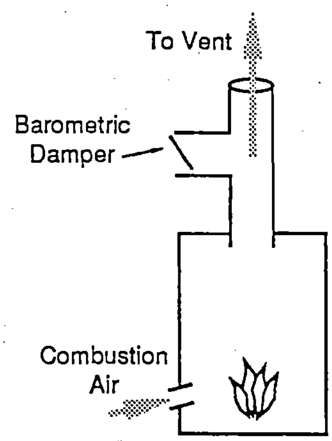
SPILLAGE-SUSCEPTIBLE HEATING SYSTEMS



Conventional Gas Furnace or DHW



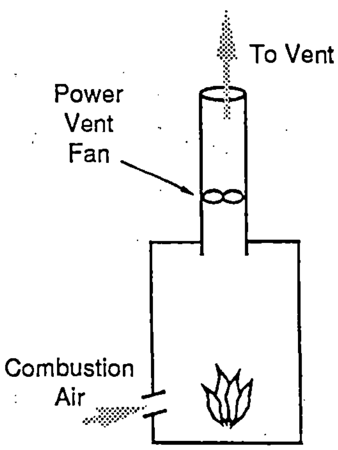
Conventional Gas Furnace



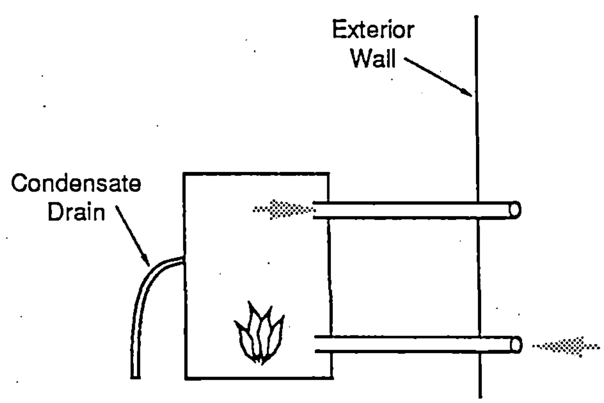
Conventional Oil Furnace

Note: Most fireplaces are spillage-susceptible

NON -SPILLAGE-SUSCEPTIBLE HEATING SYSTEMS



Forced Draft



Sealed Combustion

MODULE 2

LEARNING OBJECTIVES

- To provide an overview of the requirements of the codes and standards as they apply to mechanical ventilation systems

- Identify key requirements of the codes and standards as they apply to the installation of various types of residential mechanical ventilation systems

GENERAL REQUIREMENTS OF NBC

NBC Section 9.32.3 - Mechanical Ventilation"

- Requires capacity of 0.3 Air Changes/hour (24-hour average) calculated using ***entire heated volume of house***

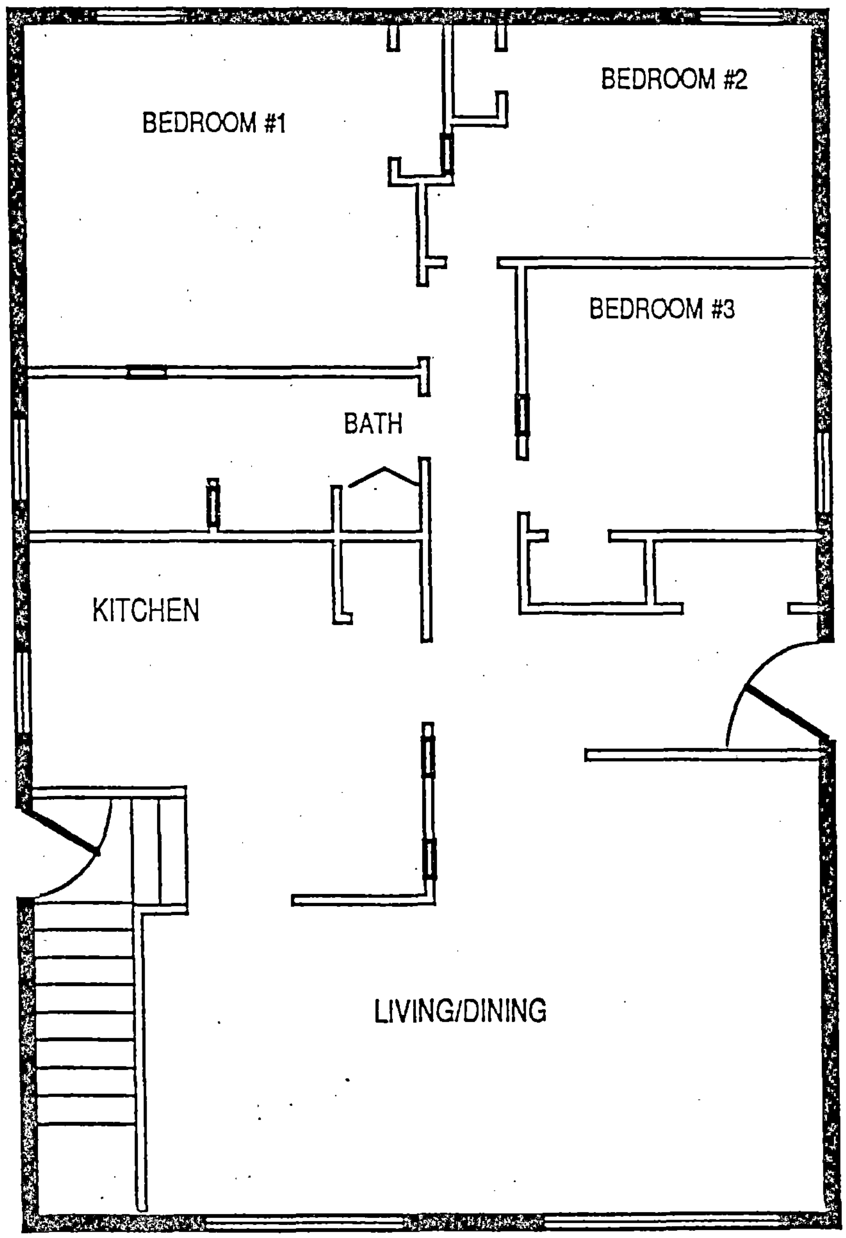
- Rooms to which no natural ventilation is provided must be provided with mechanical ventilation at a rate of 0.5 AC/h if air conditioned and 1.0 AC/h if not

- Fans to be selected based on performance with ducting attached (at least 25 Pa of static assumed)

- Make-up air is required or it must be proven (by test) that it is not needed

QUESTION

How much mechanical ventilation would be required in the 20' x 40' house shown below? What would be the components of this system?



Student Reference Guide Section: ______

SIMPLE EXHAUST SYSTEM REQUIREMENTS

National Building Code, Part 9

Definition: "Simple Point Exhaust Systems without air circulating ductwork"

- Must meet "general requirements" of NBC, Section 9.32.3
- Each fan must meet CSA C22.2 "Fans & Ventilators"
- Fans must be selected based on flow at 0.1 in. W.G (25 Pa) static pressure
- Make-up air required to control "excessive depressurization"

Student Reference Guide Section: ______

CSA F326 REQUIREMENTS

- Somewhat different procedure for calculating Minimum Ventilation Capacity requirements

- Air distribution is required

- Supply air must be provided in such a way as to avoid:
  - occupant discomfort
  - temperatures of less than 12°C entering heating devices (eg., furnaces)

- Controls must be provided:
  - to adjust ventilation rates to less than the required minimum capacity
  - to enable system to be shut off

- Specific guidelines given regarding installation of components (eg., hoods, insulated ducts, grilles, etc.)

- Systems must avoid creating excessive house pressures.

Student Reference Guide Section: ______

CSA F326 CALCULATION OF MINIMUM CAPACITY

- the system shall be capable of:
  - providing ventilation at a rate which is the greater of 0.3 AC/h or the sum of the individual room requirements in the table below:

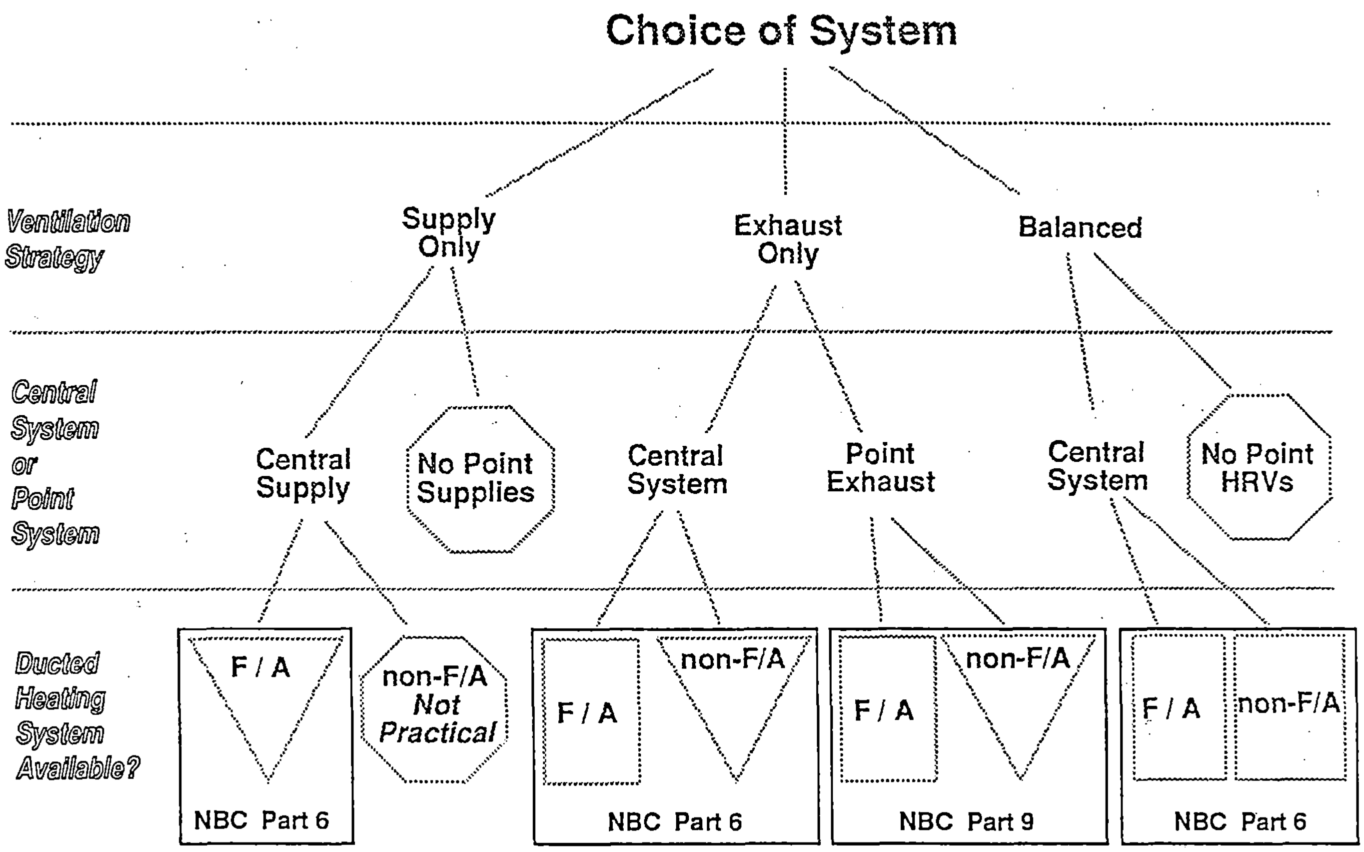
CSA Minimum Ventilation Capacities

Room Type/Capacity	Minimum Ventilation Classification
Category A Rooms	
Master Bedroom	20 cfm (10 L/s)
Basement	20 cfm (10 L/s)
Single Bedrooms	10 cfm (5 L/s)
Living Room	10 cfm (5 L/s)
Dining Room	10 cfm (5 L/s)
Family Room	10 cfm (5 L/s)
Recreation Room	10 cfm (5 L/s)
Other Habitable Rooms	10 cfm (5 L/s)
Category B Rooms	
Kitchen	10 cfm (5 L/s)
Bathroom	10 cfm (5 L/s)
Laundry	10 cfm (5 L/s)
Utility Room	10 cfm (5 L/s)

  - exhausting from kitchens and bathrooms as indicated below,

If operating:	Continuously	Intermittently
Kitchen	60 cfm (30 L/s)	100 cfm (50 L/s)
Bathroom	20 cfm (10 L/s)	50 cfm (25 L/s)

Student Reference Guide Section: ______

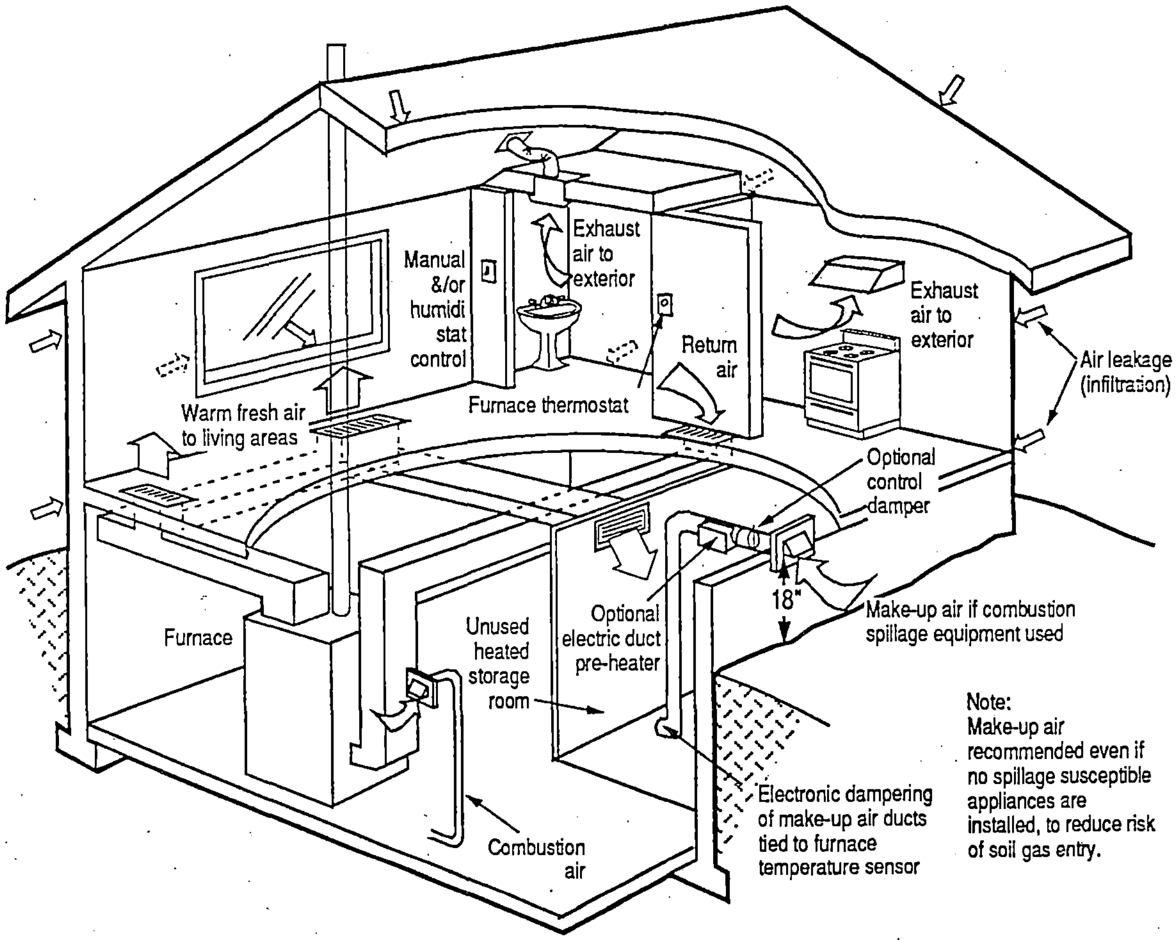


Choice of System
Ventilation Strategy
Supply Only
Exhaust Only
Balanced
Central System or Point System
Central Supply
No Point Supplies
Central System
Point Exhaust
Central System
No Point HRVs
Ducted Heating System Available?
F / A
NBC Part 6
non-F/A Not Practical
F / A
non-F/A
NBC Part 6
F / A
non-F/A
NBC Part 9
F / A
non-F/A
NBC Part 6

Choice of System

Ventilation Strategy 1. Exhaust Only 2. Supply Only 3. Balanced	3 choices
	x
System Type 1. Point (local) 2. Central	2 choices
	x
Distribution 1. Forced Air 2. Radiant	2 choices
	=
	~~12 choices~~

POINT EXHAUST SYSTEMS



POINT EXHAUST SYSTEMS

Advantages

- covered completely in NBC, Section 9--qualified HVAC designer not needed
- little change from existing practices
- good selection of equipment

Drawbacks

- air infiltration encouraged
- large make-up air inlets may be needed if "spillage susceptible" heating equipment is used
- safety concerns if make-up air inlets blocked by homeowner
- may increase soil gas entry into house
- poor distribution of ventilation air possible if non forced-air heating distribution system is used or if forced-air fan does not run continuously

SYSTEMS OTHER THAN SIMPLE EXHAUST SYSTEMS

- systems must meet the capacity requirements of NBC, Section 9.32.3
- fans and ducting must be designed and installed in accordance with NBC, Part 6
- higher levels of static pressure should be accounted for in the selection of the fans
- NBC, section 6.2 requires:

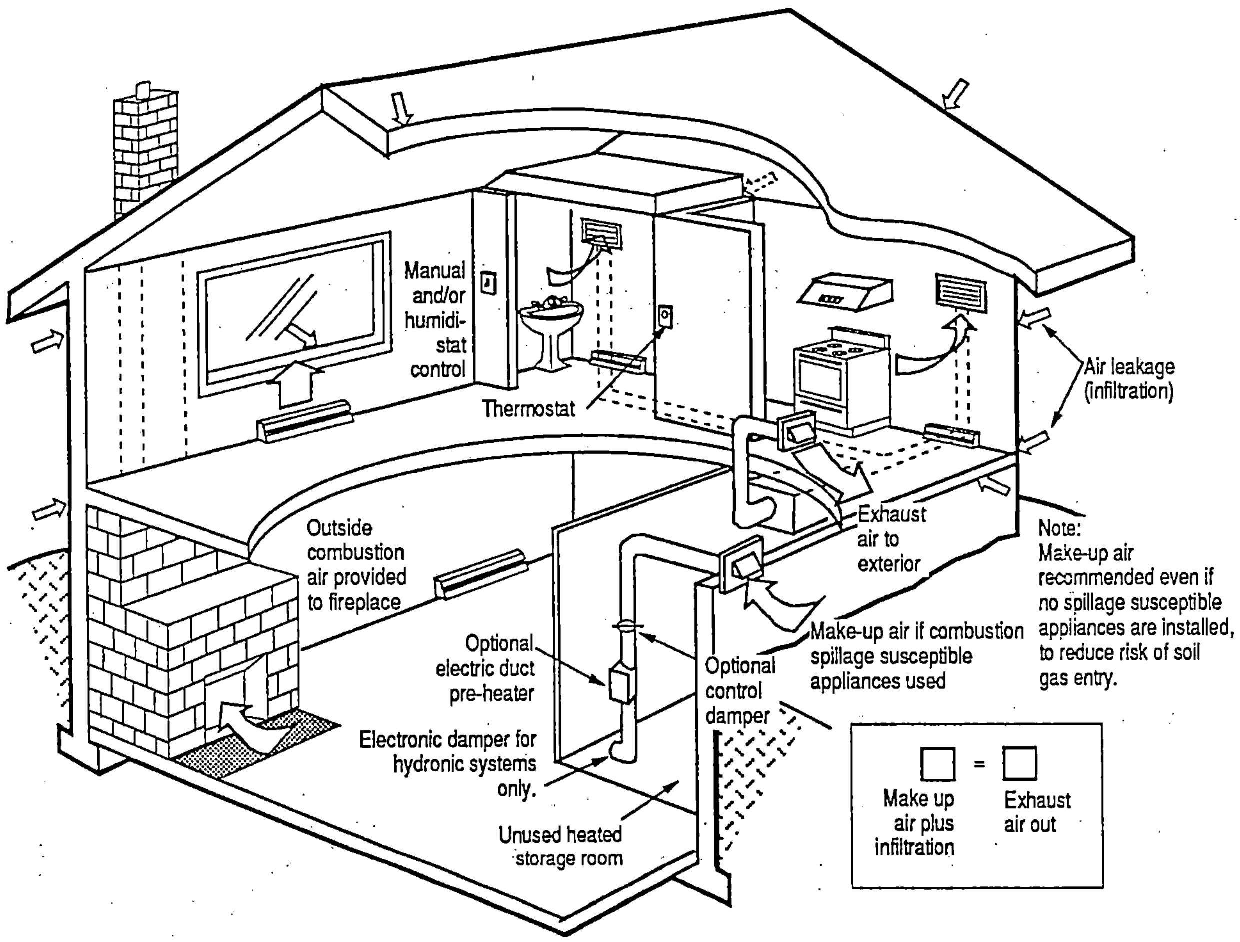
  "good engineering practice apprpriate to the circumstance" in the design and installation of systems

  The appendix to Part 9 identifies CSA F326 as a suitable reference for system design and installation.

THEREFORE, CSA F326 provides a means of complying with NBC, Part 6.

Student Reference Guide Section: ______

CENTRAL EXHAUST SYSTEMS



CENTRAL EXHAUST SYSTEMS

Advantages

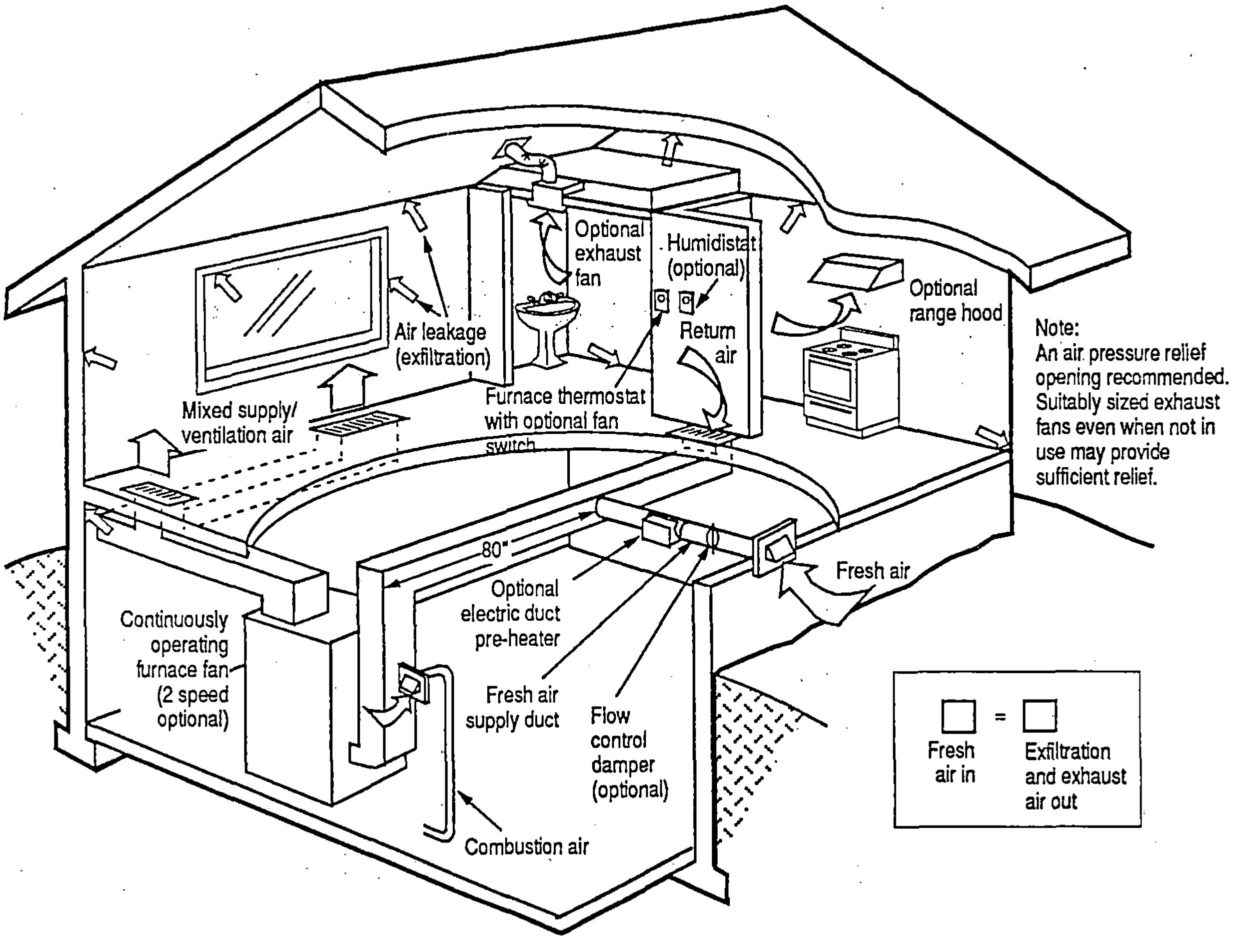
- fans can be located away from quiet areas of building
- single penetration of building envelope required
- in forced-air houses, only minor modifications in ductwork are required to retrofit system with an HRV

Drawbacks

- air infiltration encouraged
- large make-up air inlets may be needed if "spillage susceptible" heating equipment is used
- safety concerns if make-up air inlets blocked by homeowner
- may increase soil gas entry into house
- poor distribution of ventilation air possible if non forced-air heating distribution system is used or if forced-air fan does not run continuously

Student Reference Guide Section: ______

CENTRAL SUPPLY SYSTEMS



CENTRAL SUPPLY SYSTEMS

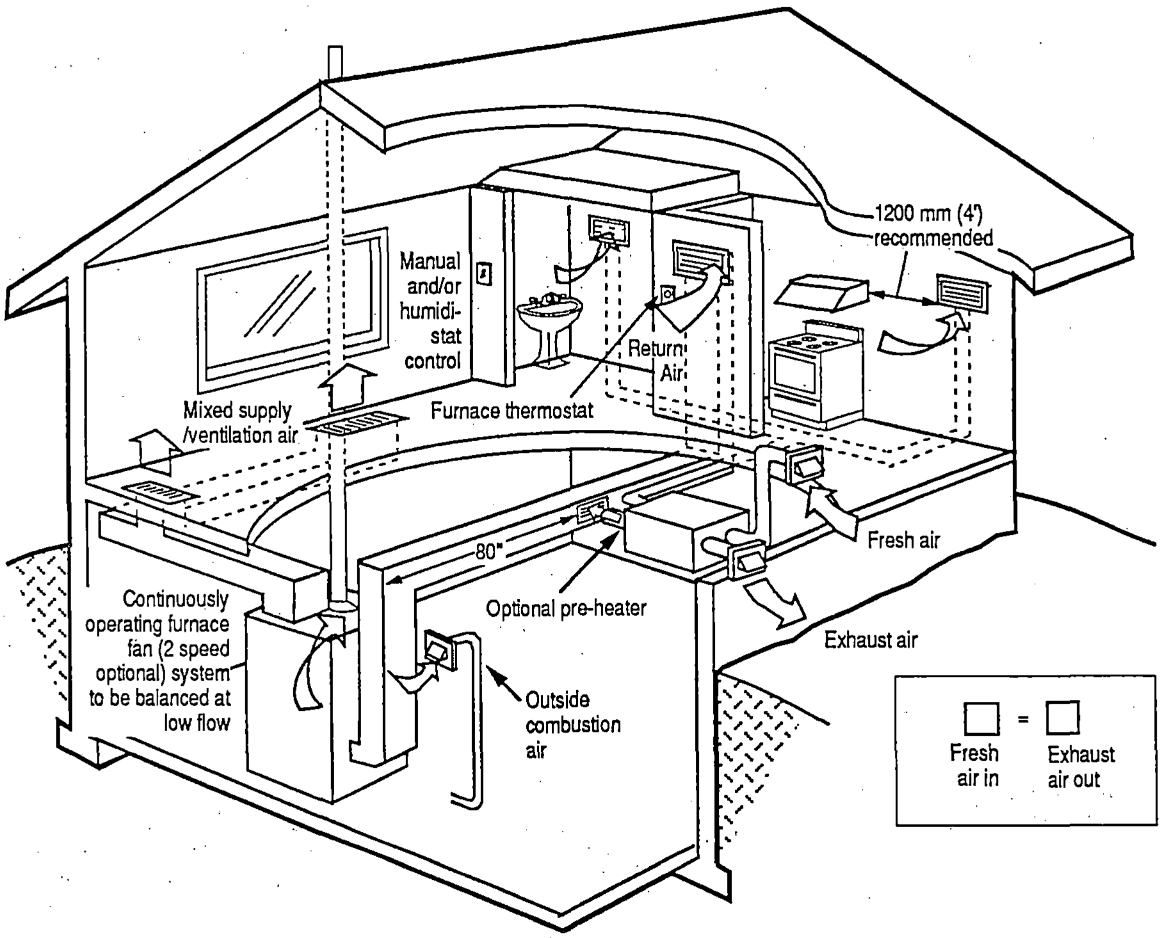
Advantages

- forced-air furnace fan can be used to drive supply, which minimizes costs
- optional low-cost fans can be used to meet (CSA F326) kitchen and bathroom exhaust requirements
- single penetration of the building envelope is required to meet NBC
- minimal ducting required

Drawbacks

- drives moisture laden air into concealed spaces
- not appropriate to houses with a poor air barrier
- incoming air must temper delivery
- relief air outlet may be needed to avoid high positive pressures

BALANCED (HEAT RECOVERY VENTILATOR) SYSTEMS



Student Reference Guide Section: ______

BALANCED (HEAT RECOVERY VENTILATOR) SYSTEMS

Advantages

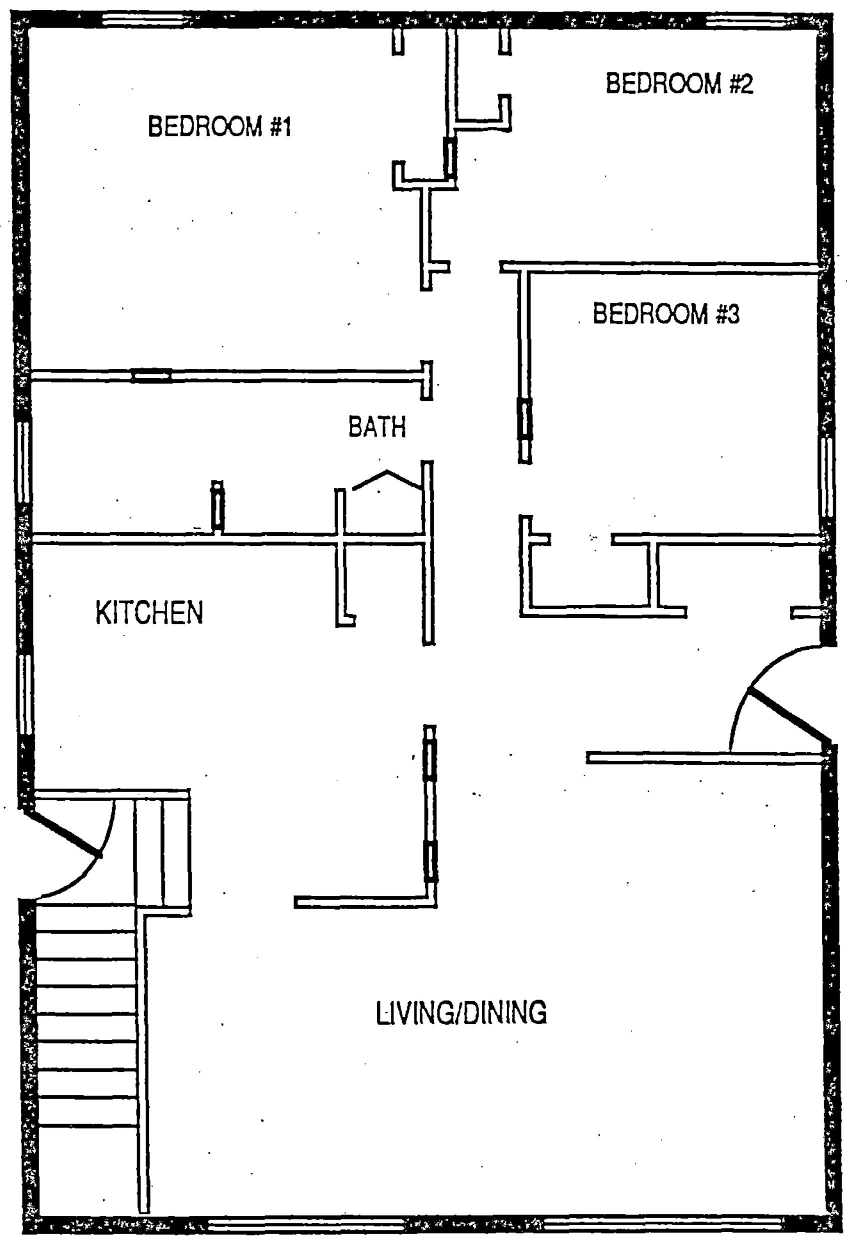
- can be located away from quiet areas of the dwelling
- moisture laden air not driven into concealed spaces
- does not normally cause high positive or negative pressures in the building
- heat recovery tempers incoming air, minimizing energy and comfort concerns
- laboratory tested systems and "off-the-shelf" solutions to ventilation problems
- appropriate to all types of houses

Drawbacks

- high installed cost
- additional maintenance requirements
- make-up air may still be needed depending on defrost system in HRV
- fully ducted supply/exhaust system needed in baseboard/radiant heated houses

PROBLEM 1

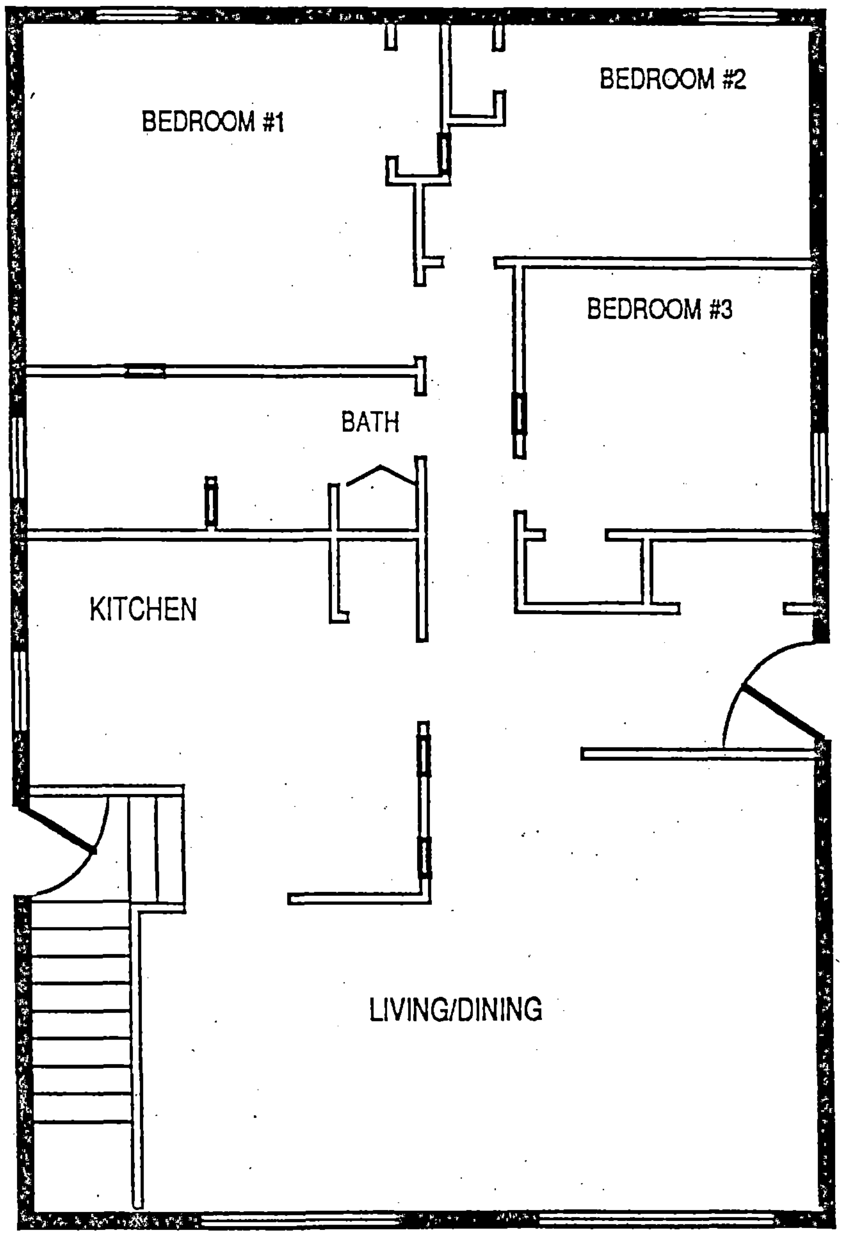
Locate equipment for a "Simple Exhaust System" in the house shown on the plan below. Indicate equipment that may be required in the system.



Student Reference Guide Section: ______

PROBLEM 2

Locate a Heat Recovery Ventilator in the house shown on the plan below. Indicate items that may be different from the "Simple Exhaust System".



Student Reference Guide Section: ______

MODULE 3

LEARNING OBJECTIVES

- To be able to apply the requirements for ventilation systems as set out in the codes and standards
- To become familiar with proper installation techniques for ventilating equipment specified in the design for a house
- To be able to select and install equipment which may not have been specified by a ventilation system designer

VENTILATION INSTALLER OLYMPICS

Rules:

1. All answers must be written.

2. Groups have 10 minutes to answer each question.

3. No points will be given for less than the minimum number of responses to the question.

4. Each question is worth 5 points.

5. Bonus points will be given for each answer beyond the minimum.

QUESTION 1

Suggest five (5) ways to minimize noise in a bathroom fan installation.

Student Reference Guide Section: ______

QUESTION 2

Suggest five (5) ways to increase air flow in a duct run.

Student Reference Guide Section: ______

QUESTION 3

Suggest five (5) contaminant sources to avoid when locating air intakes.

QUESTION 4

Suggest five (5) items in a ventilator ducting system that should be labelled.

QUESTION 1 ANSWERS

Ways to Minimize Fan Noise Include:

- use quieter equipment (low sone)
- lubricate bearings
- avoid mounting fan in middle of ceiling joists
- use flexible mounts and connections
- use sound isolators
- use an in-line fan
- duct through central system (eg., use an HRV) and eliminate fan
- install speed control

QUESTION 2 ANSWERS

Ways to Increase Air Flow Include:

- increase duct diameter
- minimize use of elbows and fittings
- minimize use of flex duct
- open the damper in the run
- increase fan size/pressure
- open the intake grille
- clean filter/fan/duct work
- use: - tapered reducers
  - long radius elbows
  - smooth straight duct
- install a booster fan

QUESTION 3 ANSWERS

Sources to Avoid Include:

- exhaust ports
- snow accumulation areas
- gas vents
- oil fill pipes
- dryer exhausts
- garbage
- driveways
- plumbing vents
- gas meters/propane tanks
- crawl spaces, attics
- garages
- neighbour sources

Student Reference Guide Section: ______

QUESTION 4 ANSWERS

Items to Label Include:

- filters
- exhaust ports
- outside air intakes
- make-up air/combustion air inlets
- damper settings
- controls
- equipment
- cleaning access ports
- maintenance items

Student Reference Guide Section: ______

DUCTWORK

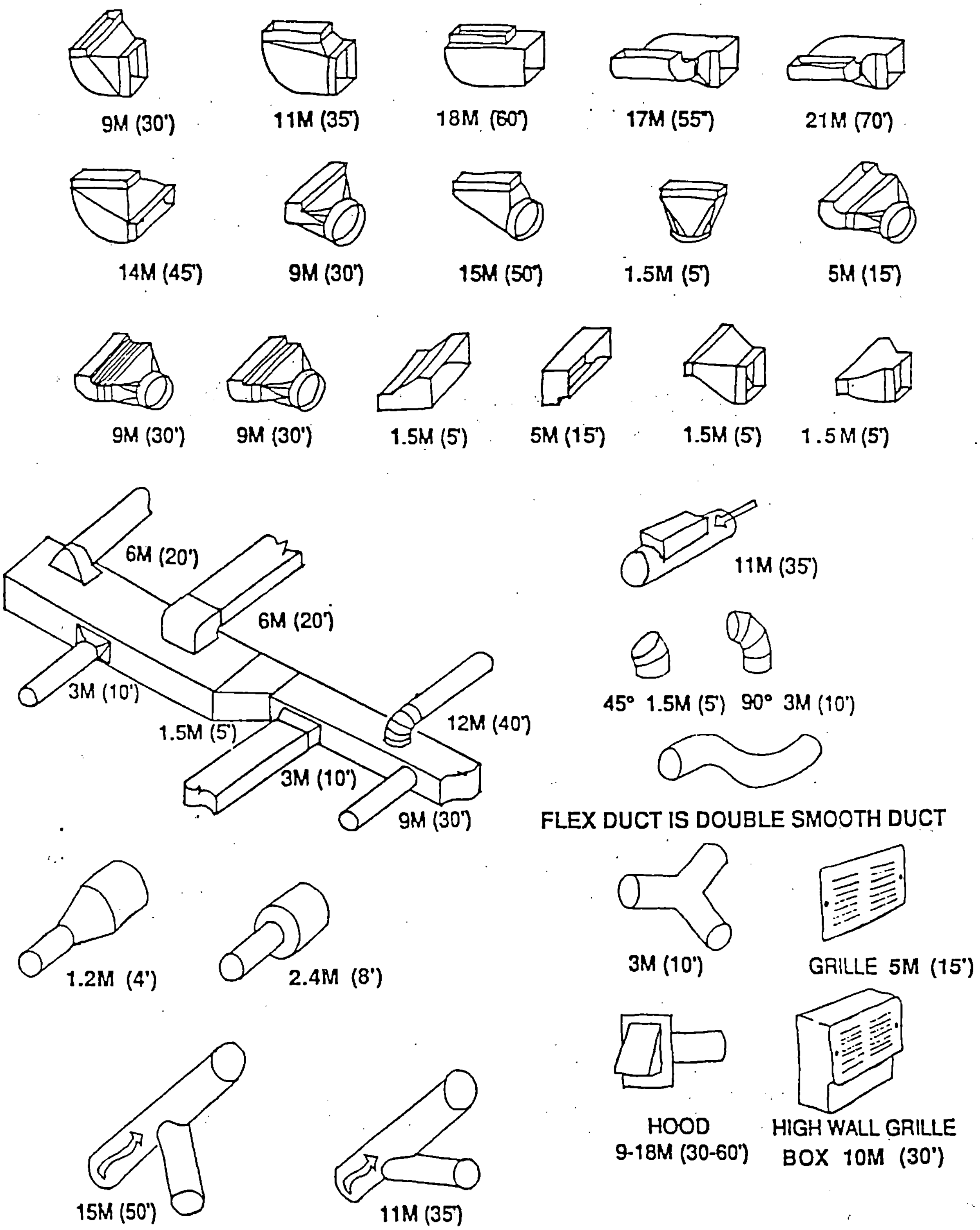
- Ductwork must be non-combustible and corrosion resistant
- Combustible duct materials may be used in ducts serving bathrooms and water closets, providing they are reasonably air tight and impervious to water
- Flex duct must be ULC Standard 181 - Class 1 Duct

DUCTWORK INSTALLATION

- Use short and straight ductwork
- Minimize use of:
  - fittings
  - flex duct
- Properly secure and mount ducts
- Seal joints (recommended)
- Filters and equipment should be accessible

Student Reference Guide Section: ______

DUCT FITTINGS AND EQUIVALENT LENGTHS



FANS AND VENTILATORS

- Avoid suspending from midspan of floor/ceiling joists

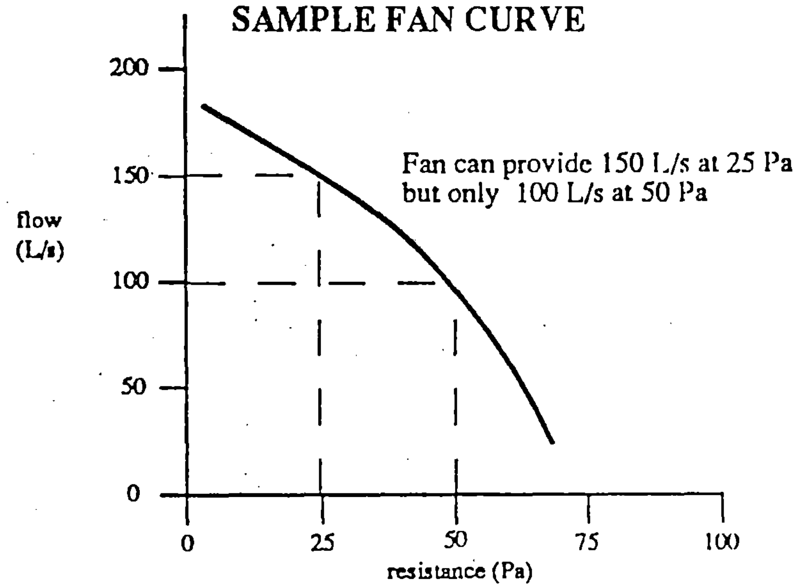
- Use mounting straps, grommets, etc., as per manufacturers' recommendations

- Use vibration isolation collars or flex duct at the unit to minimize noise transfer to ducts

- Avoid locating equipment in/near quiet areas (eg. bedrooms, living rooms, etc.)

- Locate equipment to minimize duct runs and number of fittings

EXAMPLE OF
TYPICAL FAN CURVE



Student Reference Guide Section: ______

STEPS TO DUCT SIZING

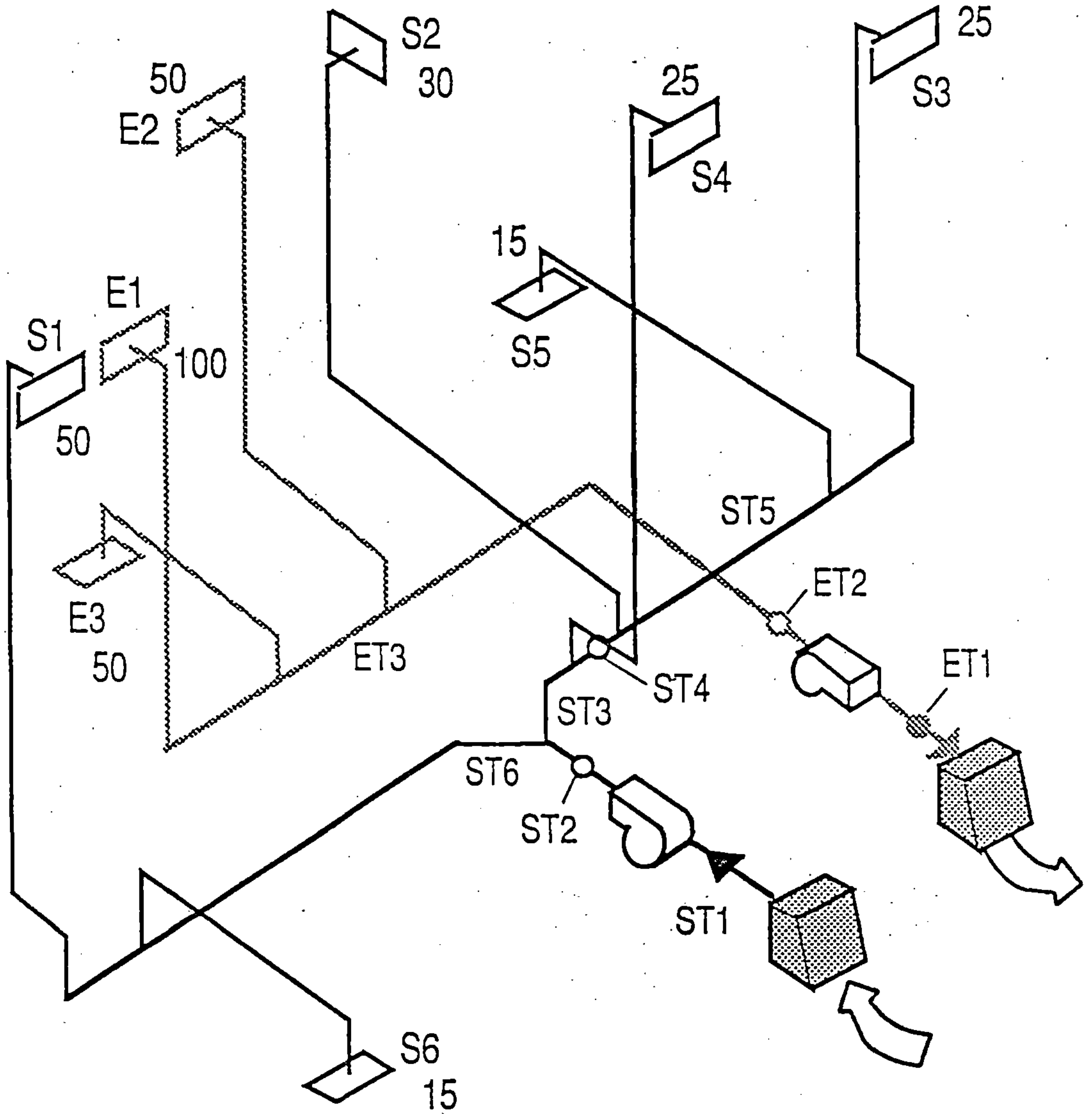
1. Determine air flow through each section (truck and branches)

2. Determine number of fittings in duct run

3. Size ducts

4. Convert to equivalent rectangular duct size (optional)

DUCT SIZING PROBLEM LAYOUT



DUCT SIZING WORKSHEET

1	2	3	4	5	6	7	8	9
Fan ID	Fan ESP *(in. W.G.)*	Duct Run ID	Air Flow *(cfm)*	Duct Type (smooth or flex)	Basic Duct Dia.	Fitting Count	Adjusted Duct Dia.	Rectangular Equivalent

Student Reference Guide Section: ______

RULES OF THUMB FOR BATHROOM FANS AND RANGE HOODS

Fan air flow rated at 0.1 in. W.G. (25 Pa)

Air Flow		**Minimum Duct Diameter** up to six fittings	
cfm	*L/s*	*inches*	*mm*
up to 25	up to 12	3	75
50	25	4	100
90	45	4	100
125	60	6	150
175	80	7	175
250	120	8	200
300	140	9	225

NOTES:

If fitting count for a duct is 7 to 15, increase duct one size larger than called for in Table.

If fitting count for a duct is more than 15, increase duct two sizes larger than called for in Table.

Fitting count is all the fittings down stream of the fan outlet plus the exhaust hood at the outside wall plus flex duct extra counts as outlined below.

Do not include balancing dampers or tapered reducers in count.

For each 3 m or part thereof of smooth ductwork, add one fitting count.

For flex duct: Increase flex duct one size larger and count each bend or elbow in flex duct as one fitting.

OR

Use flex duct size as noted above and add one to fitting count for each 1.5 m or part thereof of flex duct and count each bend or elbow in flex duct as two fittings.

Student Reference Guide Section: ______

RULES OF THUMB FOR DUCT SIZING FOR CENTRAL EXHAUST AND SUPPLY FANS

Design Air Flow		Fan ESP			
		Pa	25	65	100	150
		in. W.G.	0.1	0.25	0.40	0.60
cfm	*L/s*	Minimum Duct Diameter *inches*				
10	5		3	3	2*	2*
20	10		4	4	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

NOTES: If fitting count for a duct is 7 to 15, increase duct one size larger than called for in Table.

If fitting count for a duct is more than 15, increase duct two sizes larger than called for in Table.

Fitting count includes all fittings that air going 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.

Do not include balancing dampers or tapered reducers in count..

For flex duct: Increase flex duct one size larger and count each bend or elbow in flex duct as one fitting.

OR

Use flex duct size as noted above and add one to fitting count for each 3 m 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.*

CIRCULAR/RECTANGULAR DUCT EQUIVALENTS

Circular Duct Diameter inches	mm	Min. Rectangular Duct Dimension inches	Standard Stack or Risor Size inches
4	100	2.5 x 6 3 x 4.5 3.5 x 4	10 x 3.25
5	125	2.5 x 10 3 x 7.5 3.25 x 7 3.5 x 6 4 x 5.5	10 x 3.25
6	150	3 x 11 4 x 8 5 x 6	12 x 3.25
7	175	3.5 x 13 4 x 11 5 x 8 6 x 7	14 x 3.25
8	200	4 x 15 5 x 11 5.5 x 10 6 x 9 7 x8	
9	225	5 x 15 5.5 x 13 6 x 12 7 x 10 8 x 8	
10	250	6 x 15 7 x 12 8 x 11 9 x 9	

Student Reference Guide Section: ______

DAMPERS

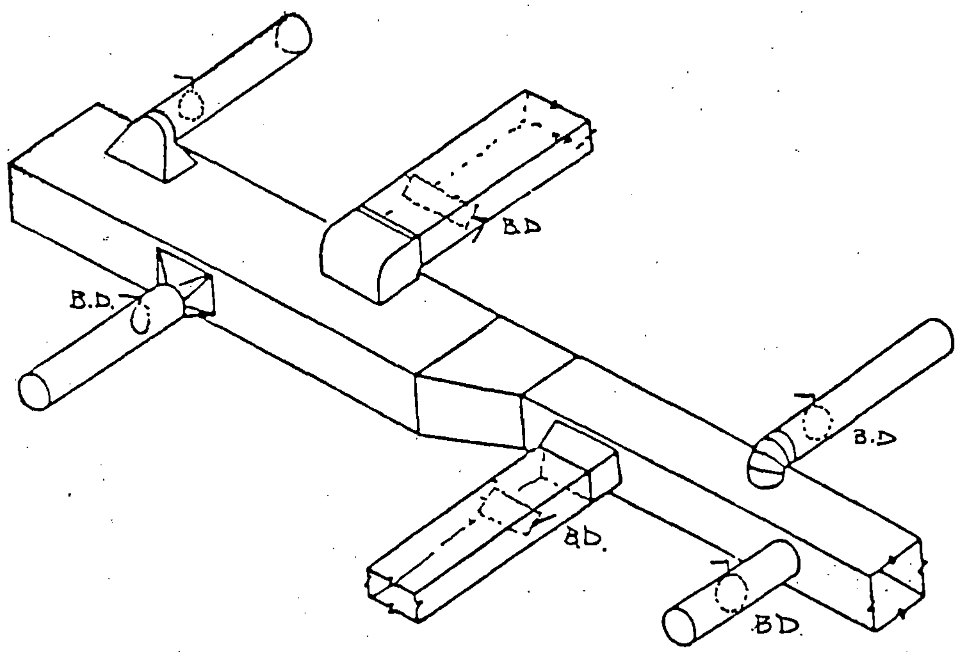
- Dampers are required:
  1. in trunk ducts for balancing and setting ventilation rates
  2. in branch ducts for adjusting flow to/from individual rooms
  3. in Make-up Air inlets and Relief outlets

- Dampers should not be installed in insulated ductwork (to avoid penetrating the air/vapour retarder)

- Dampers should be lockable and accessible for adjustment

- Dampers can be located in the stack head if otherwise accessible

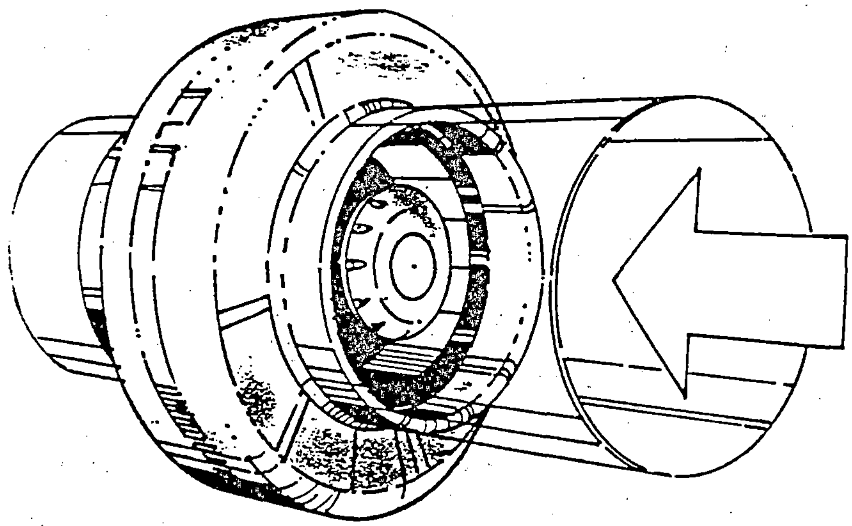
DAMPER LOCATIONS IN DUCTS AND PLENUMS

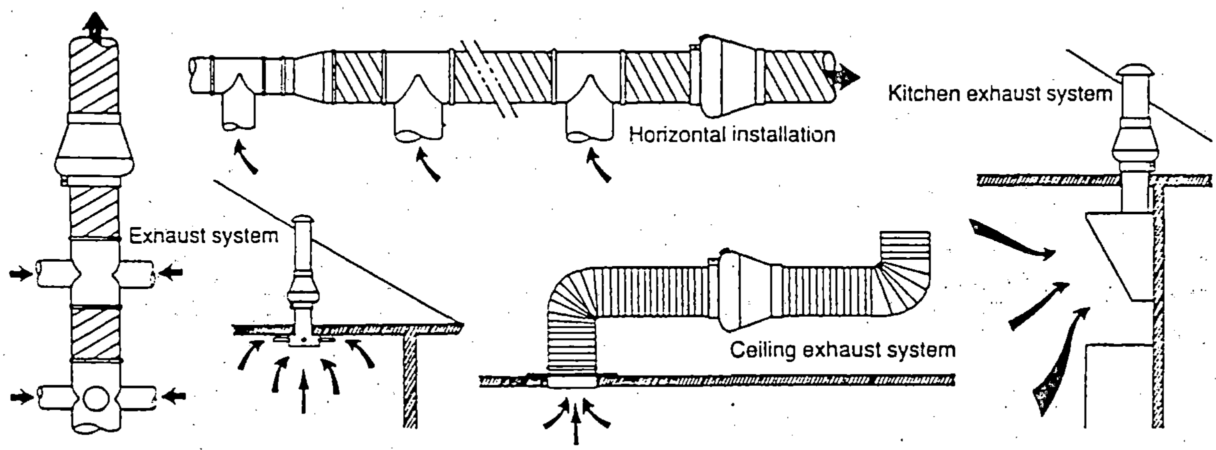


BATHROOM EXHAUSTS

- Select units based on performance--with at least 25 Pa (0.1" W.G.) static pressure, capable of continuous operation
- For NBC, Part 6 systems, select units which provide:
  - 20 cfm (10 L/s) continuous
  - 50 cfm (25 L/s) intermittent
- Must be controlled by at least a manual switch (NBC, Part 9)
- Locate intake grilles within 300 mm of ceiling to remove water vapours at ceiling level
- Combustible ducting is permitted(ductwork should be reasonably airtight and impervious to water)
- Undercut bathroom doors or provide a grille to ensure air exchange

IN-LINE CENTRIFUGAL FANS





Performance

MODEL	HP	FAN RPM	cfm VS STATIC PRESSURE 0"	1/8"	1/4"	3/8"	1/2"	3/4"	1"	1½"	2"	DUCT DIA.	SONES
NLINE 4	1/40	2800	80	70	60	50						4" (100mm)	2.1
NLINE 5	1/40	2800	110	100	90	70	50					5" (125mm)	2.1
NLINE 6	1/20	2150	270	255	235	200	180	140	110			6" (150mm)	2.8
NLINE 8-120	1/15	2150	410	375	340	285	225	180	135			8" (205mm)	3.2
NLINE 8-150	1/10	2300	520	500	470	445	415	310	230	200		8" (205mm)	4.5
NLINE 10	1/6	2400	700	670	640	612	582	470	410	250	115	10" (255mm)	5.6
NLINE 12	1/8	1250	900	801	718	624	557	456	359	254		12½" (320mm)	4.5

Student Reference Guide Section: ______

BATHROOM EXHAUSTS

AMCA

PERFORMANCE SHOWN IS FOR FAN WITH OUTLET DUCT.

MODEL NUMBER	SOUND@ 0.0"Ps LwiA(1)	CFM at Static Pressure (Inches of H_2O)					
		0.0	0.1	.125	.250	.375	.500
S90	53	98	94	93	84	52	0
S130	63	145	134	130	109	89	0

(1) $L_{wi}A$ is the Air Movement and Control Association's (AMCA) recognized unit of sound power. This single-number rating point is measured at the fan inlet in decibels (10^{-12} watt, $L_W = 10 \log_{10}$ (Watts x 10^{12}) and is A-weighted.* Its value is obtained by logarithmic addition of the octave-band values in the Sound Spectrum chart, in accordance with AMCA Standard 300 for sound test and AMCA Standard 301 for sound calculations.

Center Frequency HZ	63	125	250	500	1000	2000	4000	8000
Sound Power LwiA Model S90	56	53	51	53	48	42	35	34
Sound Power LwiA Model S130	60	59	60	62	58	53	49	45

*When inlet sound power, L_{wi}, is A-weighted the result is a conversion to perceived "sound level", $L_{wi}A$. The A-weighting scale is a widely accepted conversion formula specified in ANSI 1.4, which mathematically adjusts each frequency band in accordance with the response of the human ear to sound power.

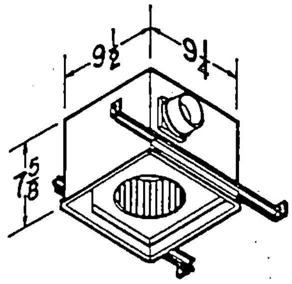
Certified ratings authorized by AMCA for Model S90 &S130 were obtained from tests conducted at the AMCA Testing Laboratory on October 2, 1989 in accordance with AMCA Std. 210, Figure 12 for air performance and AMCA Std. 300, Figure 2 for sound performance.

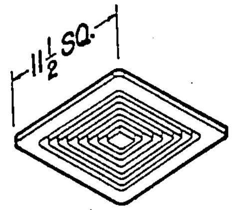
HVI

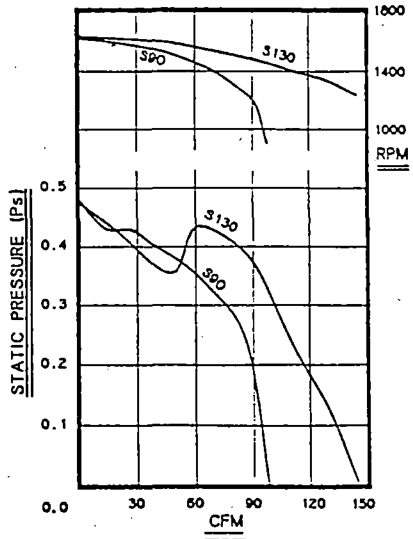
MODEL NUMBER	SONES (2)	CFM@0.1 Ps (2)
S90	1.5	90
S130	2.5	130

(2) HVI certified ratings comply with testing procedures prescribed by the Home Ventiling Institute and conducted at the ENERGY SYSTEMS LABORATORY at Texas A&M University. Ratings are a 0.1 in. static pressure. Sones are a measure of loudness and are measured in HVI's semi-reverbrant sound test room.

MODEL	VOLTS	AMPS	WATTS	NOMINAL RPM	DUCT SIZE	SHIPPING WEIGHT
S90	120	0.5	50	1050	4" DIA.	10.5
S130	120	0.7	90	1350	4" DIA.	10.5







Rpm Shown is Nominal and Performance is Based on Actual Speed of Test.

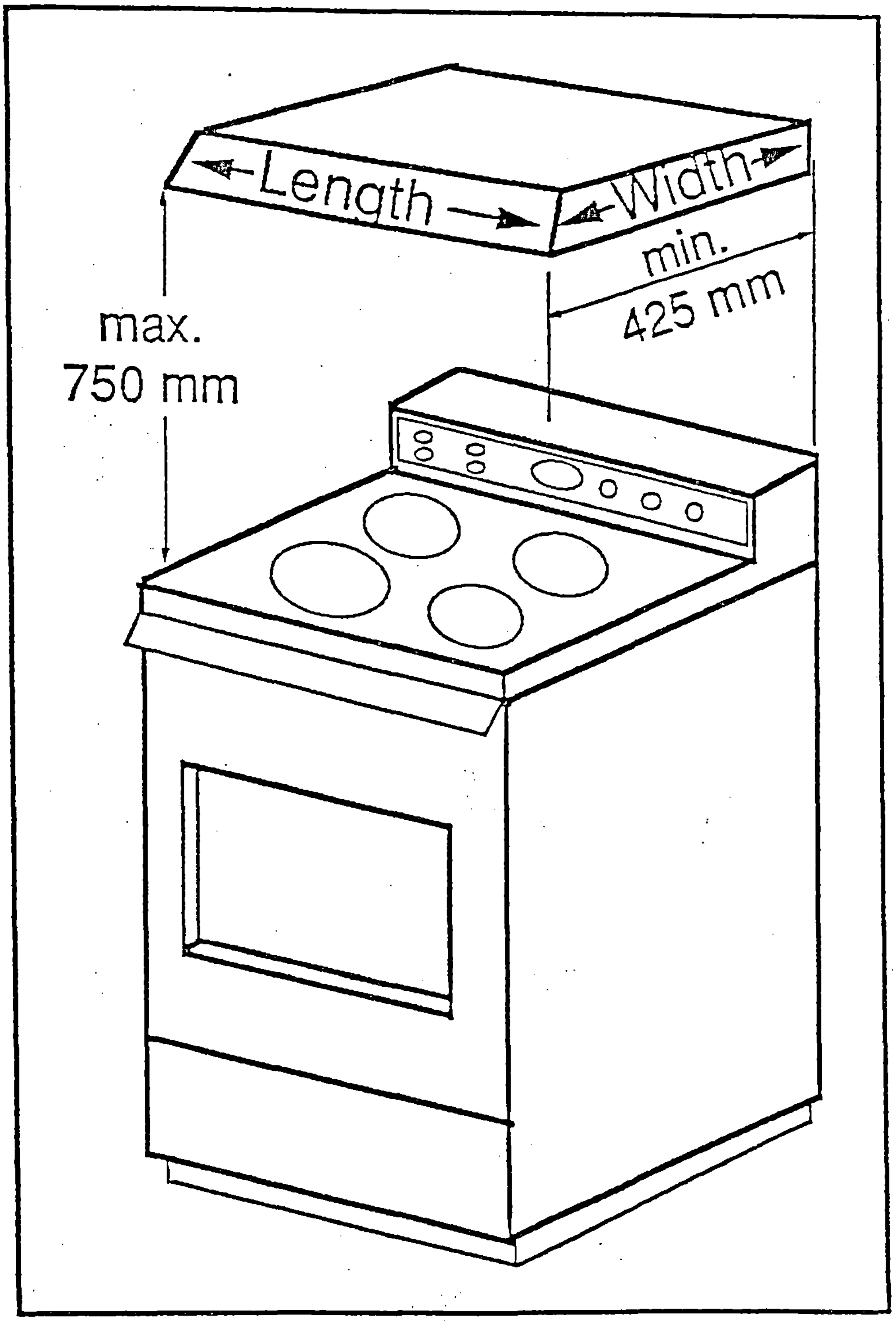
RANGE HOODS

- Select units based on performance--with at least 25 Pa (0.1" W.G.) static pressure, capable of continuous operation
- For NBC, Part 6 systems, select units which provide:
  - 60 cfm (30 L/s) continuous
  - 100 cfm (50 L/s) intermittent
- A grease filter is required
- Hood should be at least as wide as the range and meet the criteria set out below:

  Maximum height above cooking surface:
  30 inches (750 mm)

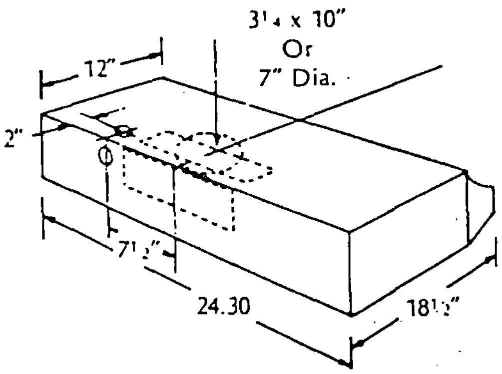
  Minimum distance front to back:
  17 in. (425 mm)
- Ductwork from the unit must be non-combustible and corrosion resistant

RANGE HOOD



Student Reference Guide Section: ______

RANGE HOODS



DIMENSIONAL DATA

SERIES 58000 — Vented installations as shown. If used duct-free, duct knock-outs not used.

SERIES 48000 — As shown.

COLOURS AND SIZES AVAILABLE

	58000		48000	
COLOUR	24"	30"	24"	30"
WHITE	582401	583001	482401	483001
ALMOND	582408	583008	482408	483008
HARVEST	582412	583012	482412	483012
AVOCADO	—	583017	—	—
COFFEE	582419	583019	482419	483019

AIR PERFORMANCE CHART

STATIC PRESSURE INCHES OF WATER	0	.05	.10	.15	.20	.25
58000 — CFM	205	198	182	158	112	64
58000 — Liters/Sec.	97	93	86	75	53	30
48000 — CFM	190	180	160	129	90	44
48000 — Liters/Sec.	90	85	76	61	43	21

FAN RATINGS

MODEL	SHIP WT.	AMPS	SONES
58000	13	1.06	5.5
48000	13	1.3	5.5

RANGE HOOD VENTING CONFIGURATIONS

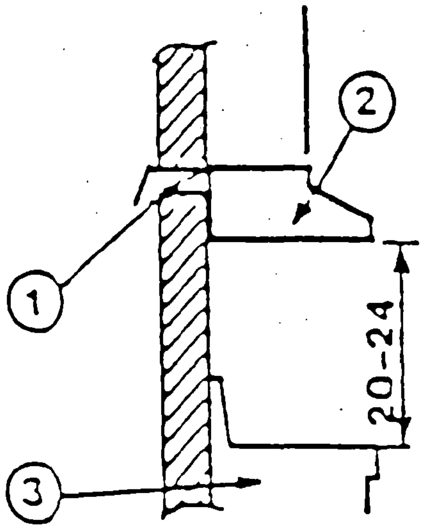


FIG. 3.

BACK DISCHARGE

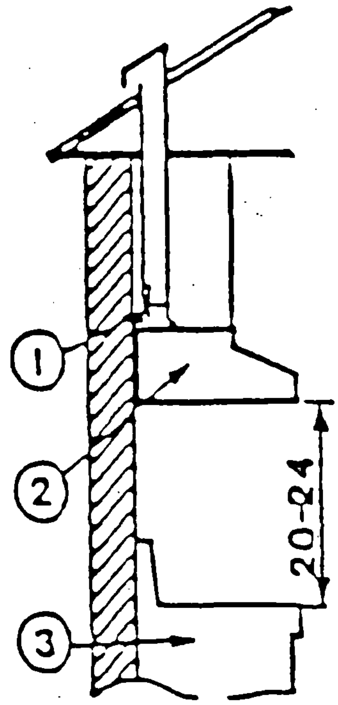


FIG. 4

TOP ROOF DISCHARGE

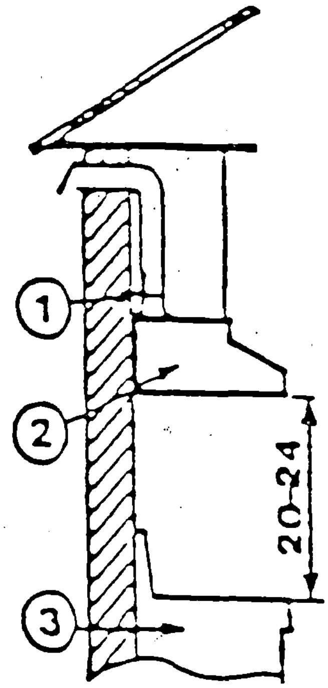


FIG. 5.

TOP WALL DISCHARGE

1. DAMPER SECTION
2. RANGE HOOD
3. COOKING STOVE
4. TRANSITION 3¼" x 10" to 6".

KITCHEN EXHAUSTS

- Select units based on performance--with at least 25 Pa (0.1" W.G.) static pressure, capable of continuous operation
- For NBC, Part 6 systems, select units which provide:
  - 60 cfm (30 L/s) continuous
  - 100 cfm (50 L/s) intermittent
- Ductwork from the unit must be non-combustible and corrosion resistant
- Grille should have a grease filter at intake end or duct should be accessible for cleaning
- Grilles should be located within 12 inches (300 mm) of ceiling to remove smoke and vapours at the ceiling level

MAKE-UP AIR INLETS AND RELIEF OUTLETS

Definitions:

Make-up Air replaces exhaust air

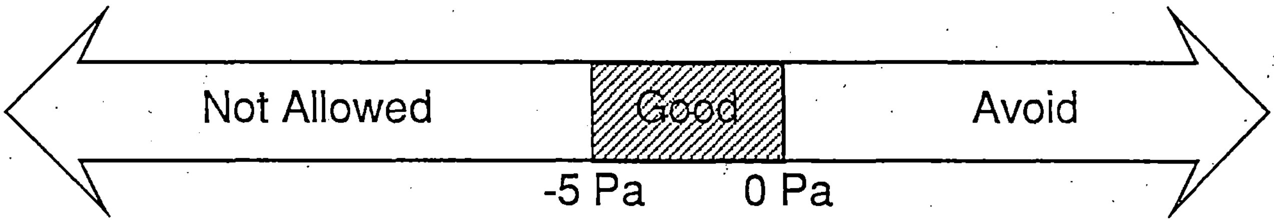
Relief Air allows air out--in the event of building pressurization

System Components:

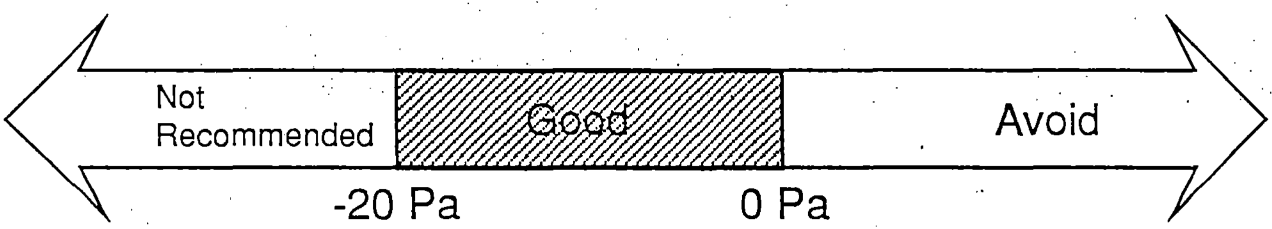
- exterior hood, screen
- insulated, sealed ductwork
- damper or flow controller
- means of heating make-up air
- automatic control damper

NBC HOUSE PRESSURE LIMITS

1. For houses with spillage-susceptible heating systems:



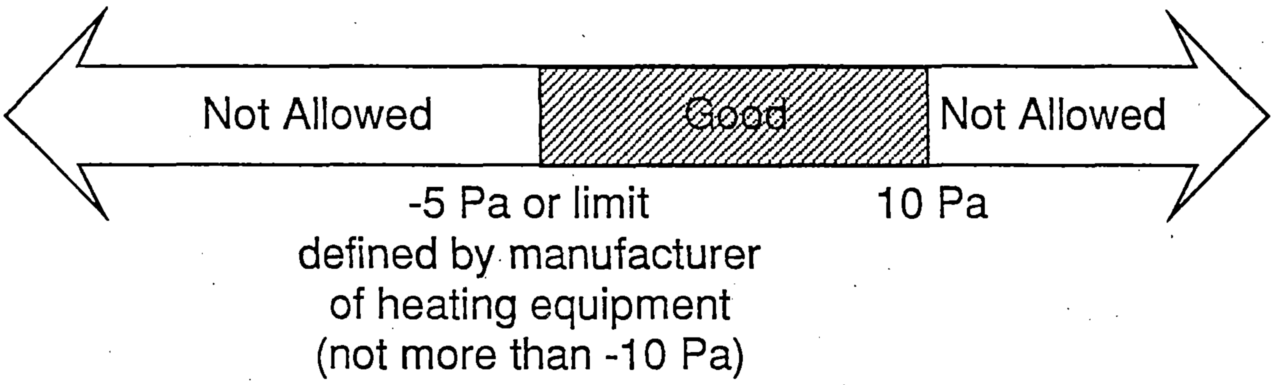
2. For houses with non-spillage-susceptible heating systems:



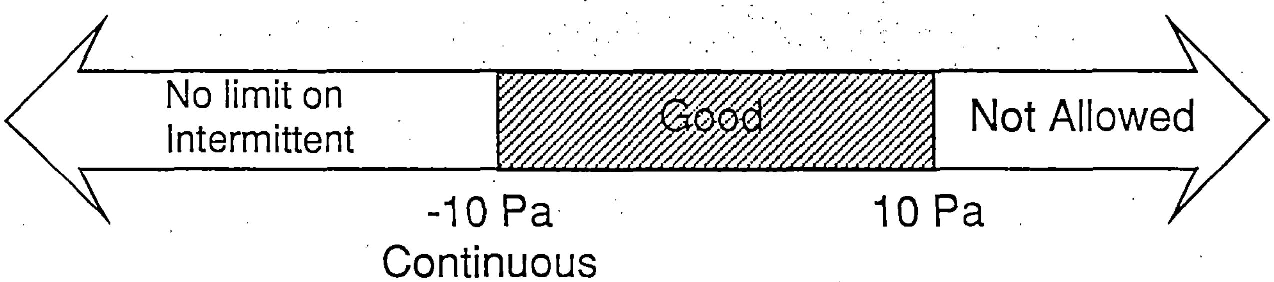
Note: *• Include all ventilation fans in test*
• Do not include: - central vacuums
- dryer
- etc

CSA F326 HOUSE PRESSURE LIMITS

1. For houses with combustion heating devices:



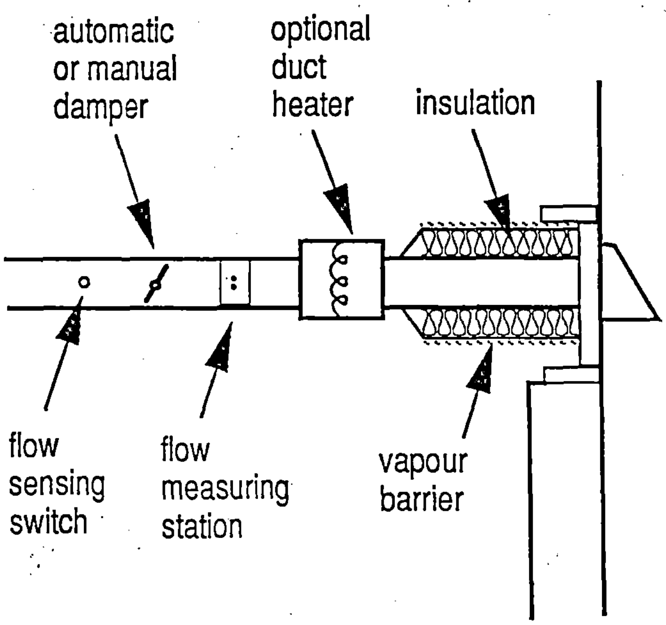
2. For houses with electric heat & no combustion devices such as fireplaces or woodstoves:



Note:	• *Include all ventilation fans in test* • *Also include the dryer and the next largest fan for intermittent (Reference Exhaust) pressure measurement*

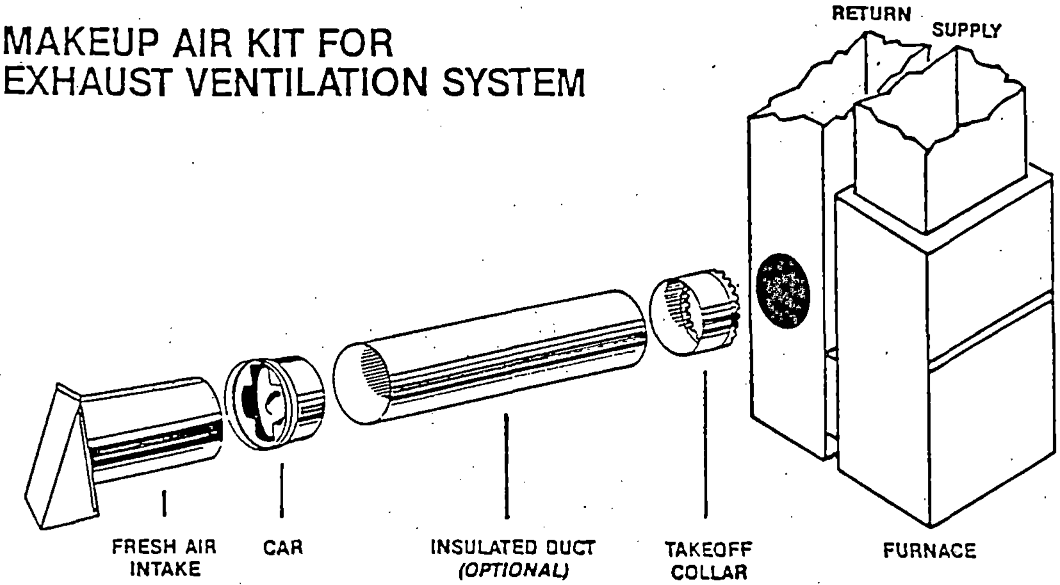
Student Reference Guide Section: ______

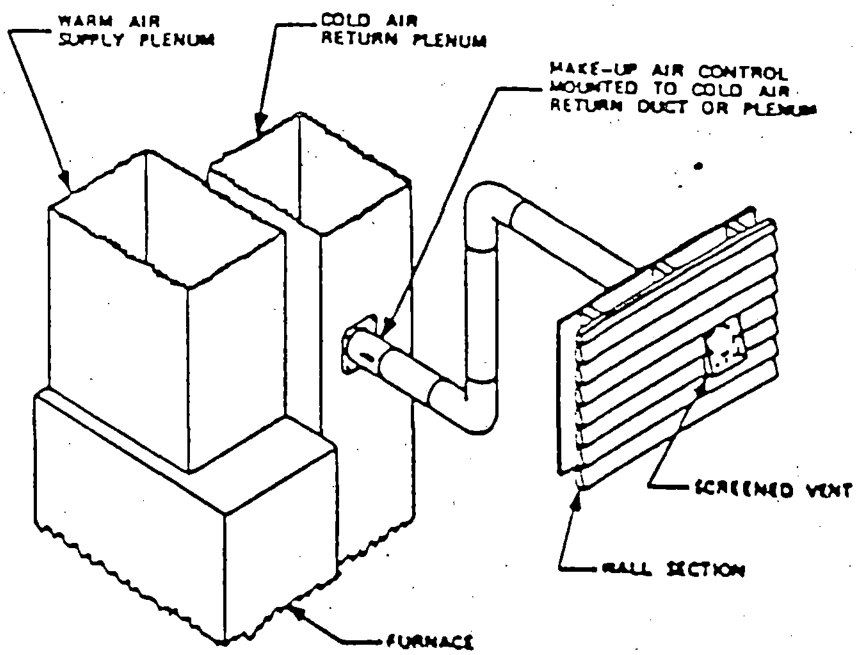
MAKE-UP AIR INLET



MAKE-UP AIR SYSTEMS

MAKEUP AIR KIT FOR
EXHAUST VENTILATION SYSTEM





Student Reference Guide Section: ______

SIZING OF INTAKE/MAKE-UP AIR OPENINGS

Sum of Fan Capacitites		Duct Diameters Necessary to Avoid Excess House Pressures					
		5 Pa pressure limit		10 Pa pressure limit		20 Pa pressure limit	
L/s	(cfm)	mm	(in)	mm	(in)	mm	(in)
25	(53)	150	(6)	125	(5)	100	(4)
30	(64)	175	(7)	150	(6)	125	(5)
35	(74)	175	(7)	150	(6)	125	(5)
40	(85)	200	(8)	175	(7)	150	(6)
50	(106)	200	(8)	175	(7)	150	(6)
60	(127)	225	(9)	200	(8)	175	(7)
70	(148)	225	(9)	200	(8)	175	(7)
80	(170)	250	(10)	225	(9)	175	(7)
90	(191)	250	(10)	225	(9)	200	(8)
100	(212)	250	(10)	225	(9)	200	(8)
120	(254)	300	(12)	250	(10)	225	(9)
140	(297)	300	(12)	250	(10)	225	(9)
160	(339)			250	(10)	250	(10)
180	(382)			300	(12)	250	(10)
200	(424)			300	(12)	250	(10)

HEAT RECOVERY VENTILATORS

- Equipment generally selected based on CSA C439 (requirement for R-2000) ratings for:
  - heat recovery efficiency
  - air flows at approximately 100 Pa (0.4" W.G.)

- ***NEVER*** interconnect HRVs with:
  - dryers
  - range hoods
  - cooktop fans
  - central vacuums

- Never do the following without explicit instructions from the manufacturer:
  - direct connect HRV to forced-air ductwork
  - connect two HRVs to the same ductwork

HEAT RECOVERY VENTILATORS

- Mounting options include:
  - on straps
  - on brackets attached to foundation wall
  - on floor-mounted table

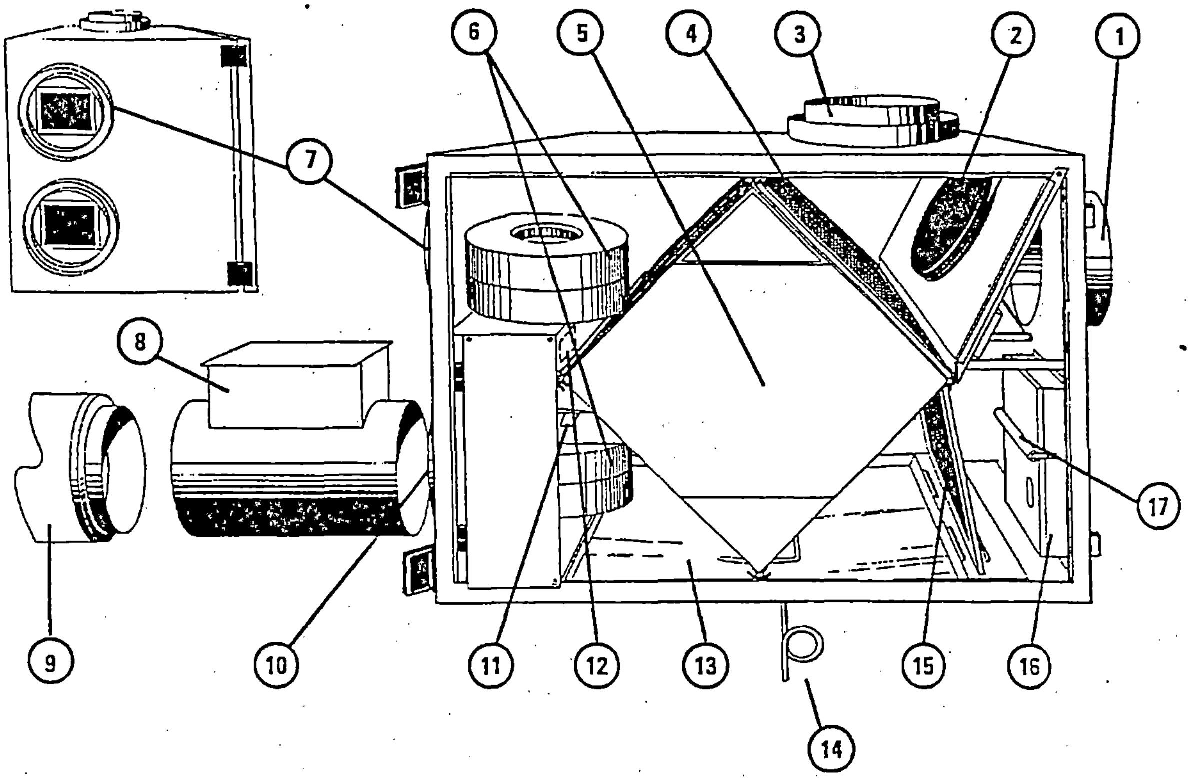
  Always mount away from an outside wall

- Avoid placing equipment in unheated space (drain will freeze)

- Use well-sealed insulated ducting on cold side of unit

- Remember to locate equipment near a drain (floor drain, laundry tub, etc.) for draining condensate

HEAT RECOVERY VENTILATOR



Legend

1 - Stale air port
2 - Automatic defrost unit
3 - Fresh air port
4 - Mechanical filter
5 - Heat recovery core
6 - Blowers
7 - Exhaust port
8 - Trim heater
9 - Silencer
10 - Distribution port
11 - Ionizer
12 - Capacitor
13 - Condensation tray
14 - Drainage tube
15 - Mechanical filter
16 - Electronic control circuit
17 - Variable power resistor

HRV SPECIFICATION SHEET

EXAMPLE ONLY

Testing Agency:		Model:	Featherblow B
Date Tested:	May 1989	Serial Number:	FXR-5
Manufacturer:	KP Engineering & Design	Options Installed:	Screaming Eagle Defrost
Address:	632 Hartless Drive Donville, Manitoba		
Telephone:		Electrical Requirements:	115 Volts 2.0 Amps

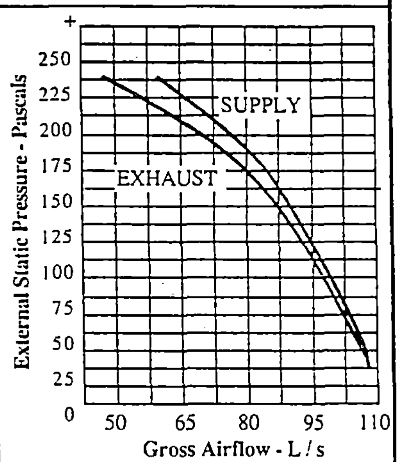
VENTILATION PERFORMANCE

Maximum Continuous Rated Airflows:
59 L/s @ -25 C
74 L/s @ 0 C

Airflow Range for Multispeed Units:
High Speed: 85 L/s Low Speed: 55 L/s

Lowest Temperature Unit Tested To: -25 C
Low Temperature Ventilation Reduction During -25 C Test: 4 %
Maximum Unbalanced Airflow During -25 C Test: 62 L/s
Exhaust Air Transfer Ratio: 0.02

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	105	223	107	228	106	226
50	.2	103	219	105	223	102	217
75	.3	99	210	101	215	100	213
100	.4	95	202	97	206	95	202
125	.5	90	191	92	196	92	196
150	.6	84	179	86	183	85	181
175	.7	79	168	81	172	78	166
200	.8	69	147	70	149	68	145
225	.9	58	123	59	126	48	102



ENERGY PERFORMANCE

		Supply Temperature		Net Airflow		Supply / Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
		°C	°F	L/s	cfm					
HEAT-ING	i	0	32	54	115	1.00	152	68	78	0.05
	ii	0	32	64	136	1.00	170	63	73	-0.01
	iii	0	32	74	157	1.00	182	64	73	0.05
	iv	0	32	55	117	----	154	68***	----	----
	v	-25	-13	59	126	0.93	140	59	75	0.04
	vi	-25	-13	55	117	----	132	61***	----	----
COOL-ING	vii	35	95	54	115	1.00	140	22**		
	viii	35	95	74	157	1.01	180	21**		

*Description of Defrost;

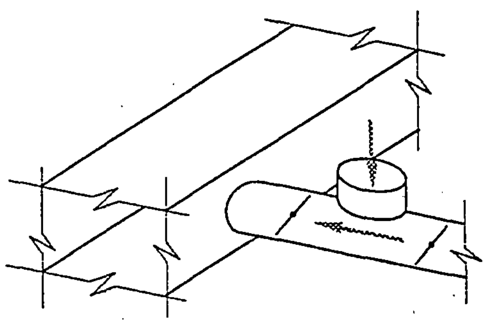
Comments from Test Agency:

** 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.

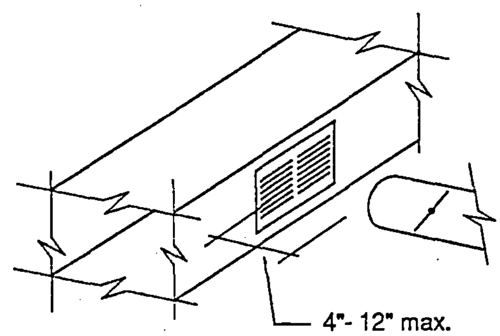
ORF Reference Report:

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 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 September, 1988.

INDIRECT CONNECTIONS TO HEATING SYSTEM



Acceptable



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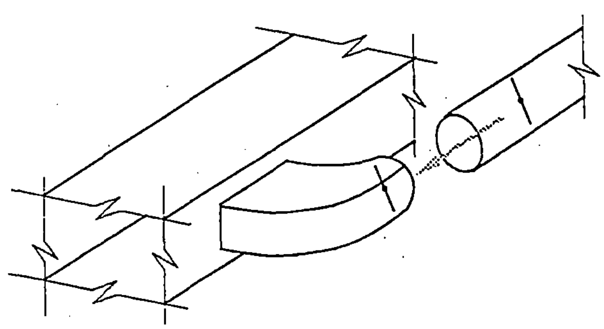

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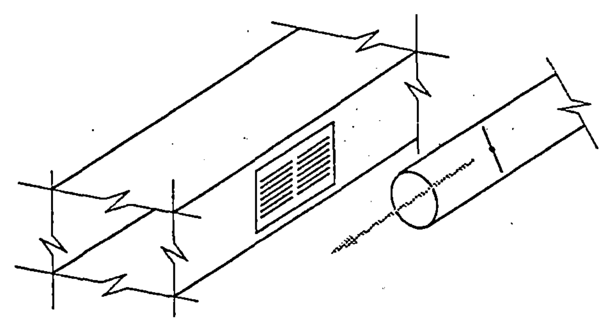
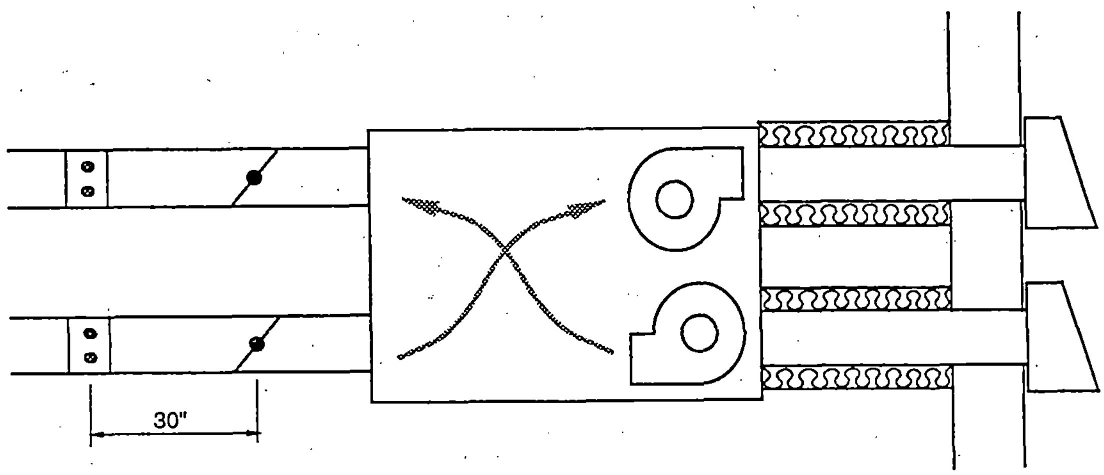


Not Acceptable

LOCATING DAMPERS AND FLOW MEASURING STATIONS



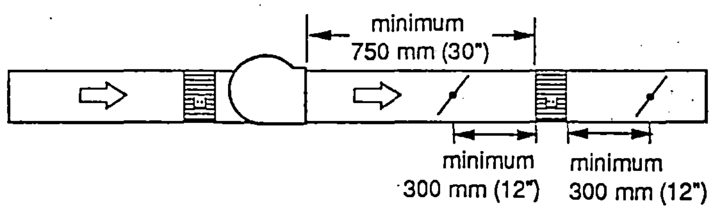
Warm Side

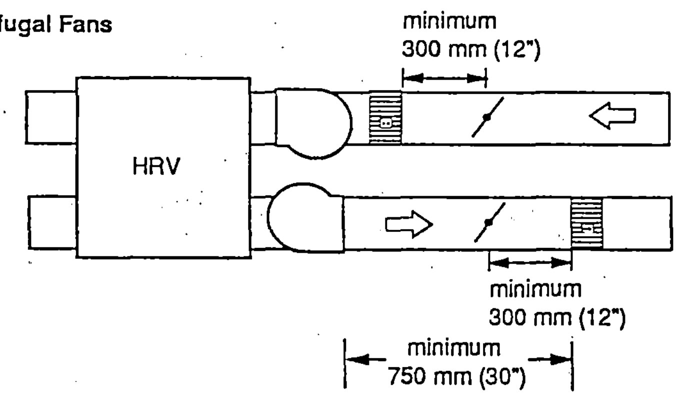
HRV

Cold Side
No dampers or flow measuring devices in this area

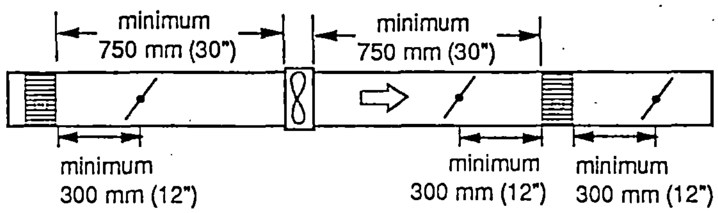
INSTALLATION PRACTICES/LOCATIONS FOR FLOW MEASURING STATIONS

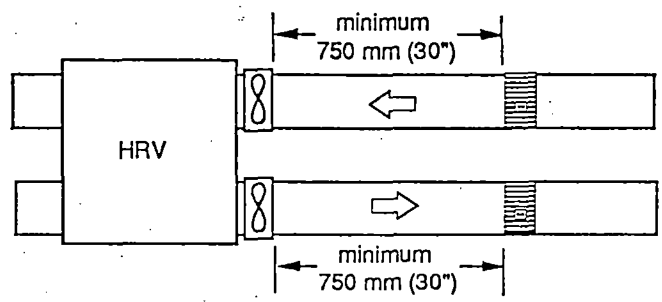
Straight Duct — Centrifugal Fans



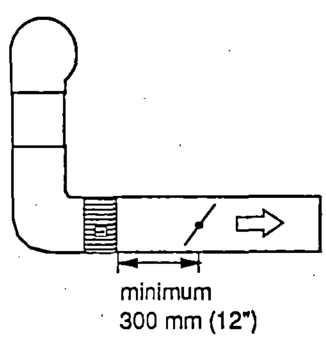


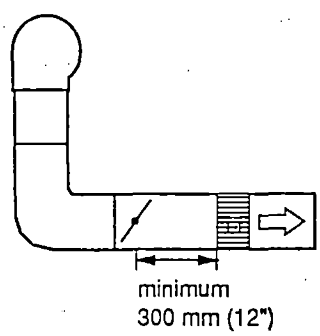
Straight Duct — Axial Fans

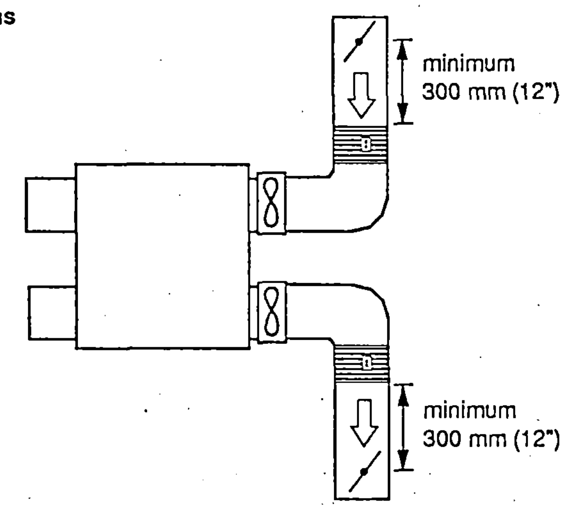




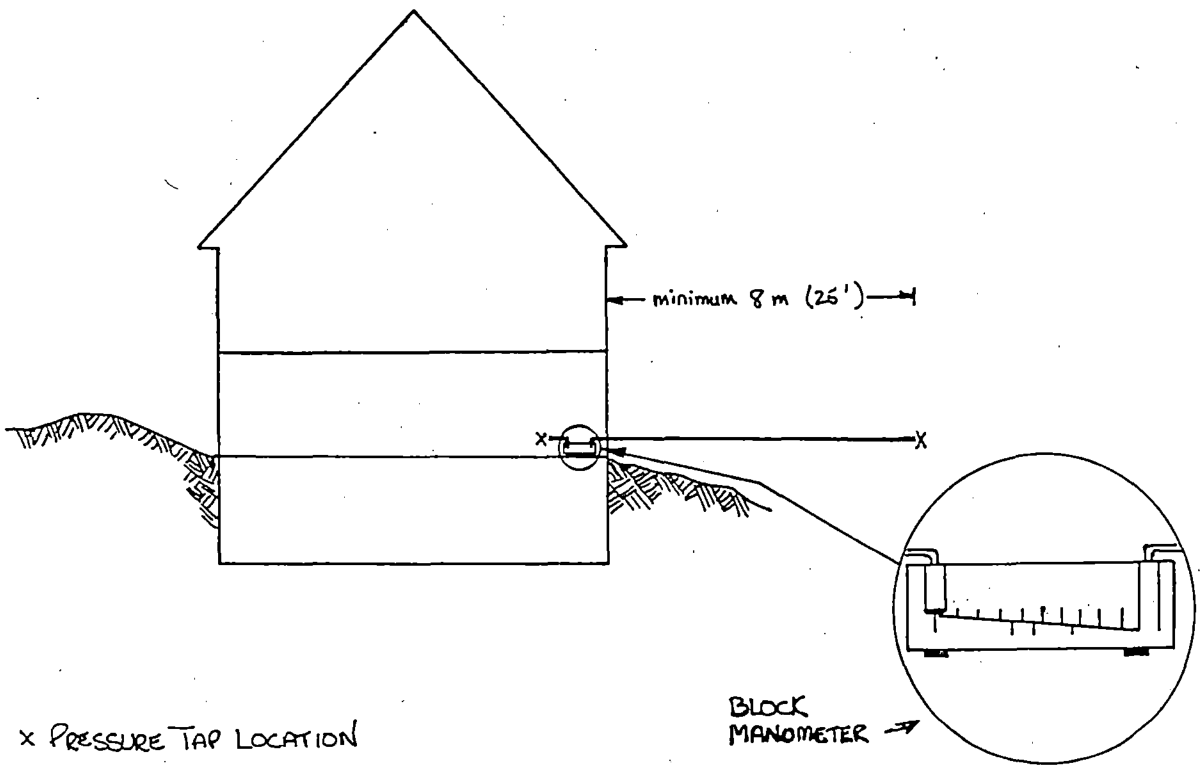
Elbows — All Fans







MAKE-UP AIR TEST



x PRESSURE TAP LOCATION

IN-DUCT HEATERS

- Install as per Canadian Electrical Code
- Heater should be approved by manufacturer for use with cold air
- In-duct heaters must be accessible for inspection, cleaning and maintenance
- Materials in the vicinity of the heater must be non-combustible
- Heater must be thermostatically controlled
- Suggested safety shut-offs:
  - manually resetting high temperature power cut-off sensor--activated if duct temperature exceeds 100°C
  - flow proving switch--prevents heater operation when insufficient air flow

SUPPLY GRILLES AND REGISTERS

- Locate supply air grilles within 12 inches (300 mm) of ceiling to promote diffusion without causing discomfort (drafts)
- Grilles and registers should be easily accessible for cleaning and maintenance without need for special tools
- Air conditioning grilles (high wall-type) suit ventilation supply applications best

EXHAUST
GRILLES AND REGISTERS

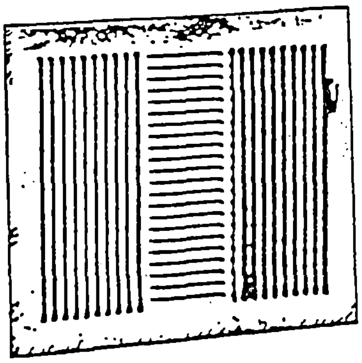
- Ehaust grilles in kitchens and bathrooms should be located high on wall to capture vapours and humidity

- Grilles and registers should be easily accessible for cleaning and maintenance without need for special tools

- Grease filter required on any kitchen exhaust duct (CSA F326)

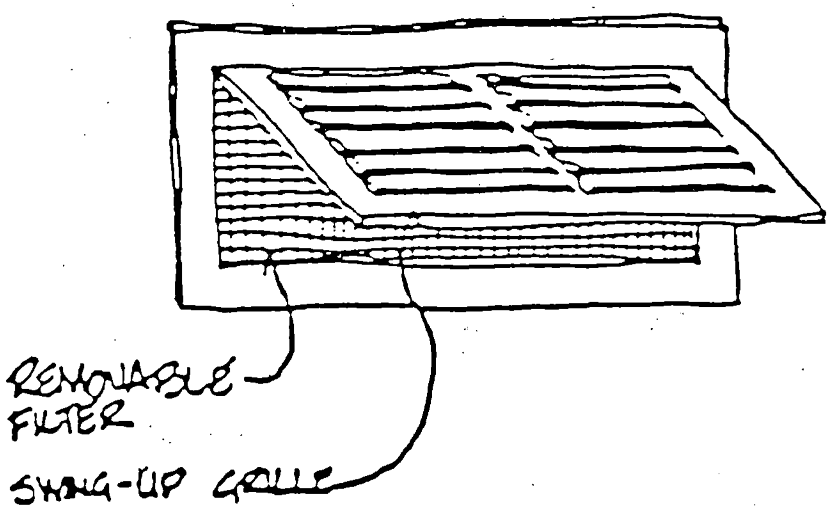
- For NBC, Part 9, if no grease filter is provided on a kitchen exhaust duct, it must be

HIGH SIDEWALL REGISTERS

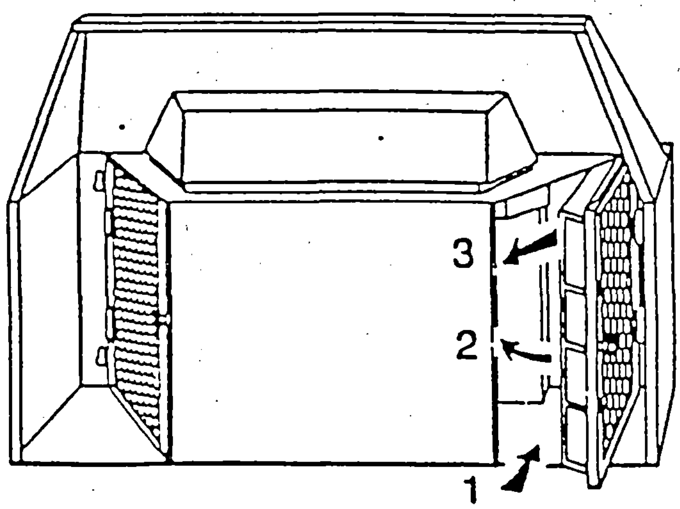


- Three-way Air Flow Pattern
- All Steel Construction with Foam Gasket
- Multi-shutter Valve
- Fixed Operator Handle

GREASE FILTERS



KITCHEN VENTILATION EXHAUST GRILLE



KITCHEN RANGE HOOD

EXTERIOR INTAKE HOODS

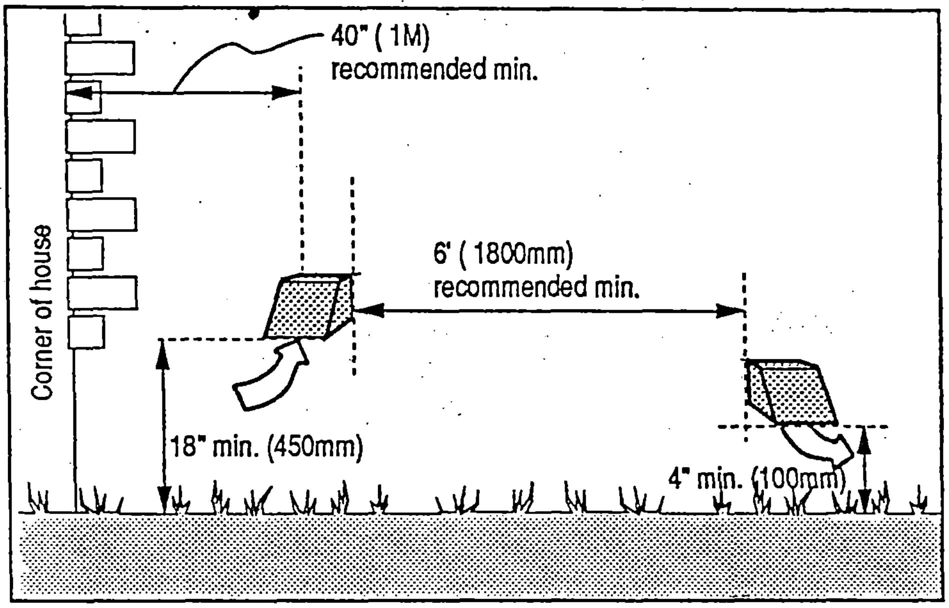
- Hood should be of sufficient size to protect the opening from wind, rain and snow
- Openings should be protected by 1/4 inch screens
- Filters designed to prevent the entry of insects and birds should be removable
- Screens on hoods should be made of a corrosion-resistant material
- Intake hoods are required to be clearly labelled for accurate identification

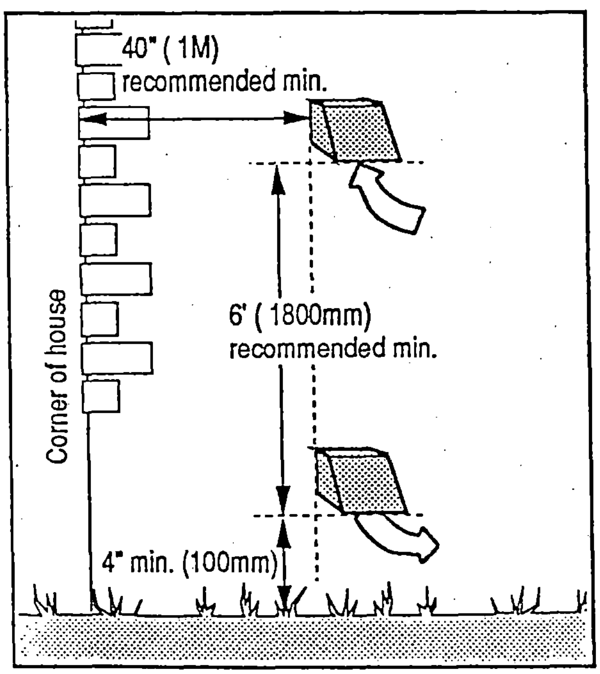
Student Reference Guide Section: ______

EXHAUST HOODS

- Openings should be protected by 1/4 inch screens
- Screens on hoods should be made of a corrosion-resistant material
- Hoods should be clearly labelled for accurate identification

SUPPLY AND EXHAUST PORT LOCATIONS





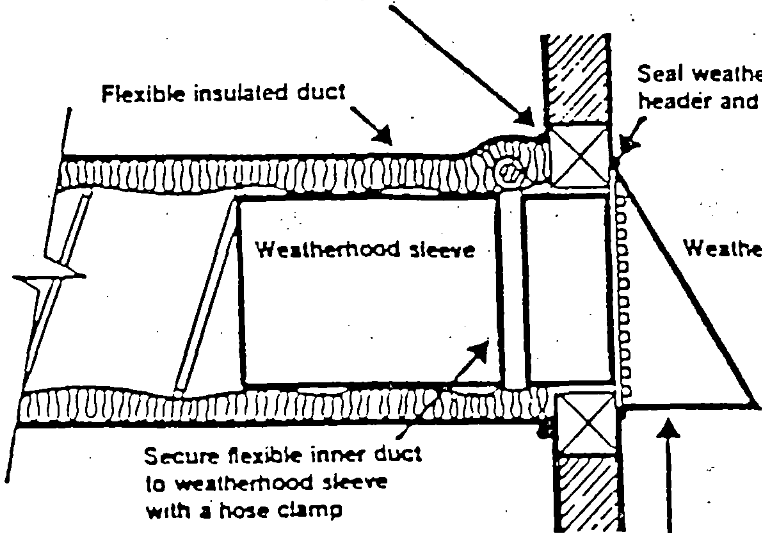
Avoid Placing Intakes Near:

- *exhausts*
- *dryer outlets*
- *driveways*
- *gas vents*
- *oil fill pipes*
- *garbage*
- *areas of snow accumulation*
- *other exhaust sources*

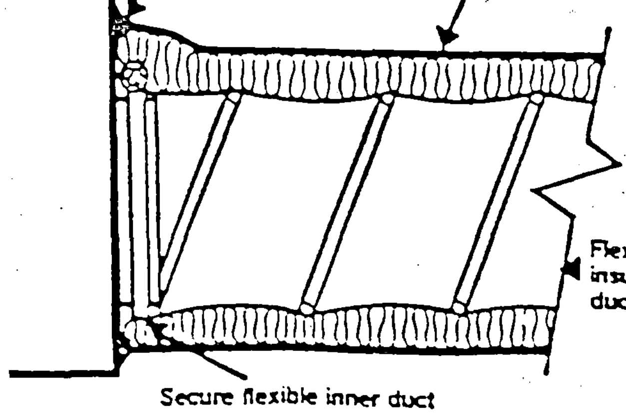
Student Reference Guide Section: ______

SEALING OF WEATHERHOODS

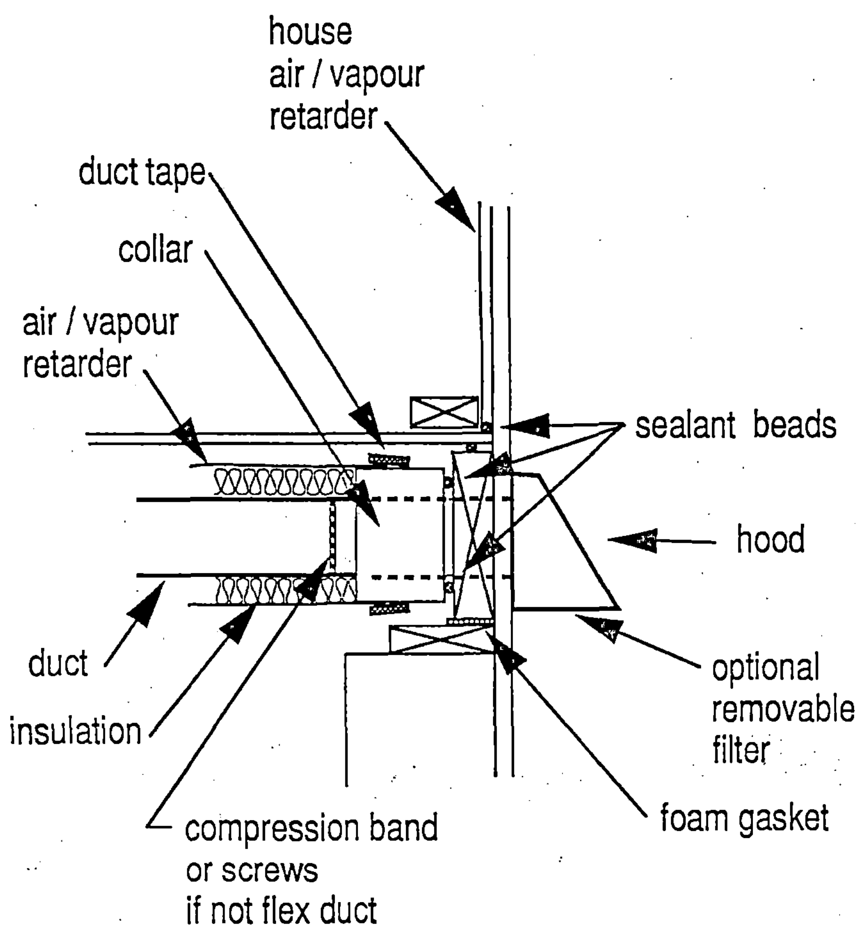
A. WEATHERHOOD INSTALLATION



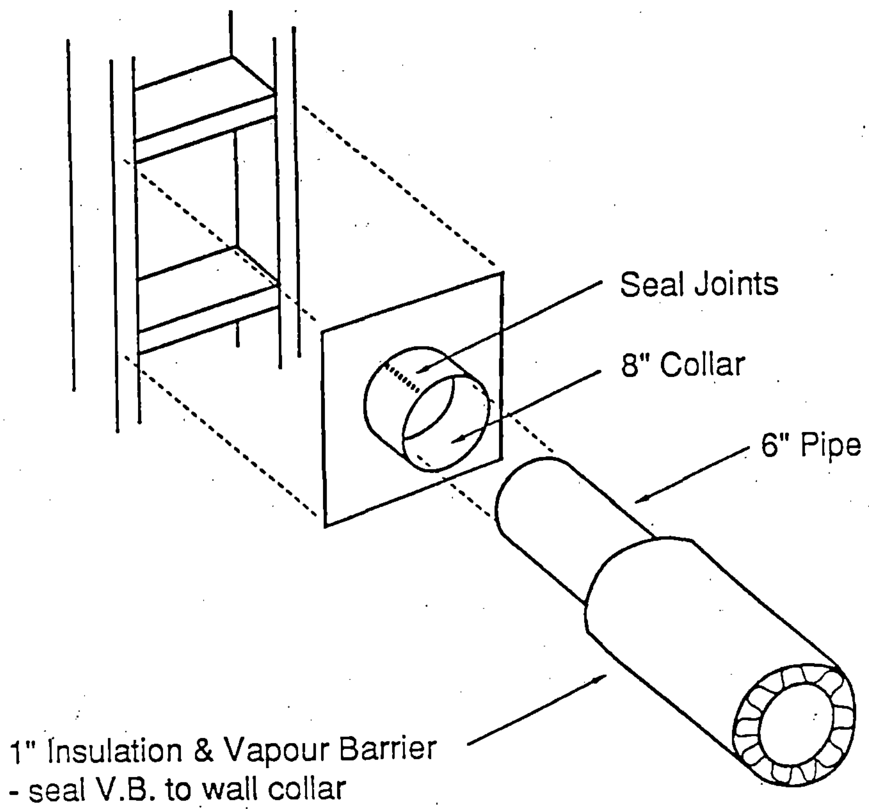
B. SEALING THE INSULATED DUCTING TO THE UNIT



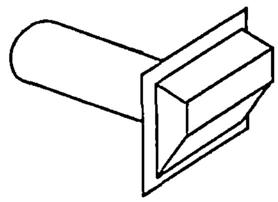
PROPER COLLAR-TO-WALL ASSEMBLY



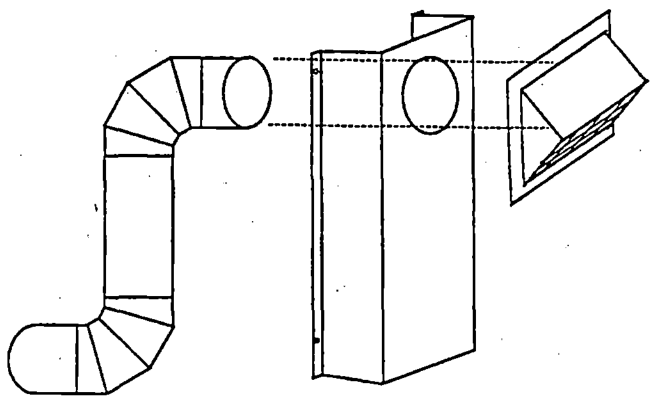
ALTERNATE METHOD FOR FABRICATING COLLAR



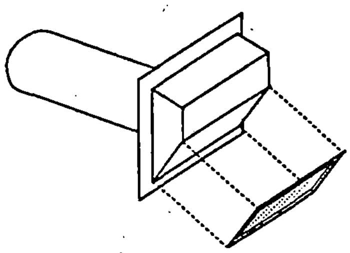
OPTIONS FOR TERMINATING OUTLETS AND INLETS



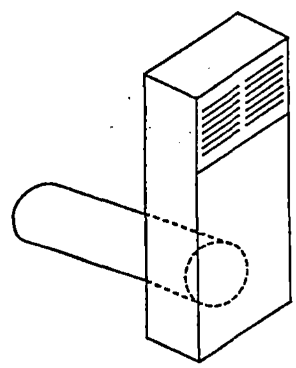
Plain Hood



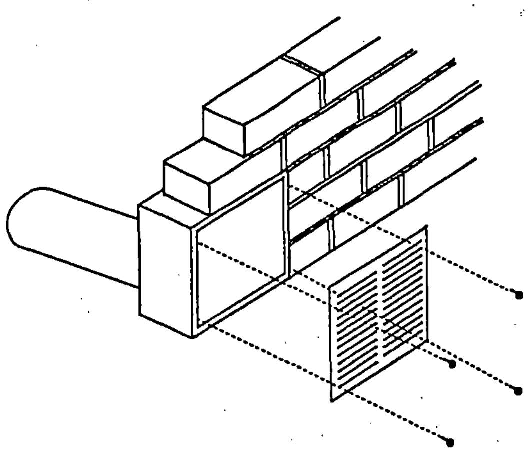
Covered-Pipe Riser



Hood With Filter



Stack-Duct Riser



Brick-Box With Grille

INSULATION AND SEALING

- Ducts carrying outside air are to be sealed, insulated, and protected by an airtight barrier

- Duct surface temperatures must not fall below 14°C in order to prevent condensation

- Duct insulation levels are dictated by local design temperatures in CSA F326; however NBC, Part 6, calls for RSI 2.1 (R12) for all insulated duct runs

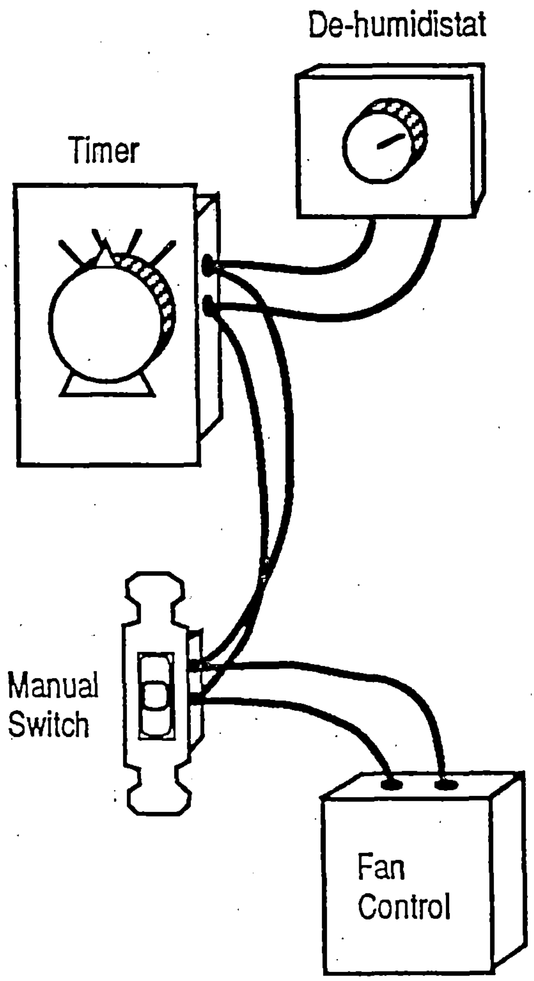
- Insulated ducting required on:
  - cold ducts indoors
  - warm ducts outdoors

CONTROLS

- NBC Part 9 systems require fans to be controlled by a humidistat or a manual switch

- NBC Part 6 systems require a manual switch be provided to control the system. In addition, all ventilation system controls must:
  - be clearly marked and accessible
  - allow adjustment of air flows to less than the required minimum ventilation capacity
  - be such that a switch can override other controls and switch on the ventilation system

VENTILATION CONTROL OPTIONS



FILTERS

- Not required by NBC except for grease filters on range hoods and kitchen exhausts that are not accessible for cleaning
- Filters should be easily accessible for cleaning and maintenance without need of special tools
- Filters should be installed in accordance with manufacturer's instructions
- It is good practice to place a filter on any supply or exhaust duct to protect equipment and minimize maintanence problems

LABELLING

- NBC does not require labelling, but indicates it is good practice

- CSA F326 specifies that the following must be labelled:
  - intake hoods
  - filters, cleaning and maintenance ports
  - controls
  - equipment

- Additional good practice labelling:
  - damper settings
  - ducts serving remote locations
  - wiring
  - air flow directions
  - exhaust hoods

MODULE 4

LEARNING OBJECTIVES

- To become familiar with the steps in design review
- To be able to uncover obvious errors in a design
- To be able to deal with revisions to the design as determined by site conditions

STEPS IN THE INSTALLER'S DESIGN REVIEW

- review design for obvious errors
- deal with special site conditions not foreseen by designer
- make field substitutions for equipment and system components, where field conditions dictate, in a way that will not degrade the performance of the resulting system

THE INSTALLER SHOULD BE CAPABLE OF CHECKING:

- Overall sizing of the ventilation system
- Whether kitchen and bathroom exhausts are specified
- Adequacy of provisions for ventilation air distribution
- Likelihood of need for make-up air
- Likelihood of need for relief air
- Adequacy of provisions for preheating make-up or supply air
- Location of air inlets
- Location of exhausts
- The need for combustion air

The installer's design review is best done after visiting the actual installation site.

OVERALL SYSTEM SIZING

VENTILATION REQUIREMENTS PER FLOOR

Area of Floor		Living Areas (8 ft ceiling)		Basement Level (7 ft ceiling)		Heated Crawl Space (4 ft headroom)	
ft²	*m²*	*cfm*	*(L/s)*	*cfm*	*(L/s)*	*cfm*	*(L/s)*
500	46	20	(10)	18	(9)	10	(5)
600	56	24	(12)	21	(11)	12	(6)
700	65	28	(14)	25	(13)	14	(7)
800	74	32	(16)	28	(14)	16	(8)
900	84	36	(18)	32	(16)	18	(9)
1,000	93	40	(20)	35	(18)	20	(10)
1,100	102	44	(22)	39	(20)	22	(11)
1,200	111	48	(24)	42	(21)	24	(12)

Student Reference Guide Section: _______

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^3 or m^3

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 ________ L/s

Exhaust Air

Hi ________ Continuous ________ L/s

Manufacturer:________________

Model:________________

(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

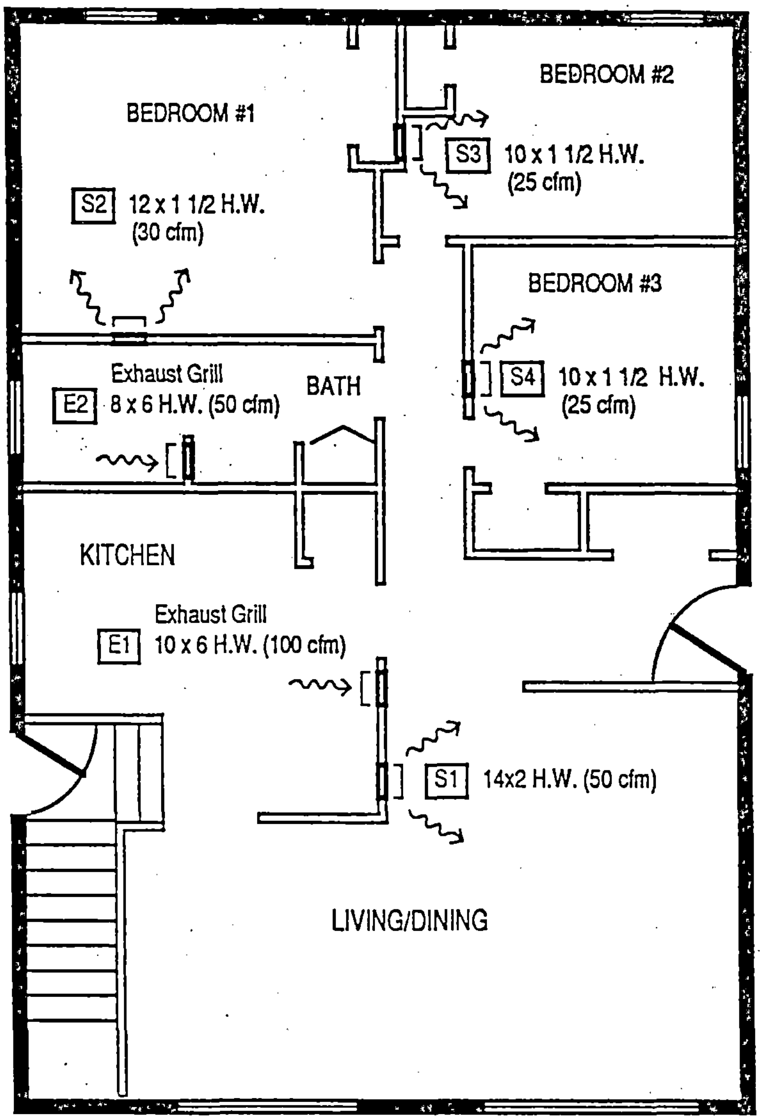
I hereby certify that this ventilation system has been installed in accordance with R-2000 Home Program Design and Installation Guidelines for Residential Ventilation Systems.

Name____________________

Signature____________________

Date____________________

DESIGN REVIEW PROBLEM 1



Equipment	
Furnace:	Induced draft, gas
DHW:	Induced draft, gas
HRV Flow Ratings:	160 @ 0.1 in. W.G. 140 @ 0.3 in. W.G. 132 @ 0.4 in. W.G. 117 @ 0.6 in. W.G.

MODULE 5

LEARNING OBJECTIVES

- To understand the need for a start up procedure
- To become familiar with the items in a system which should be visually tested at start up
- To understand how to perform tests on the system which may be required
- To become aware of the documentation requirements outlined in the codes and standards

STEPS IN A VISUAL REVIEW OF THE SYSTEM

Ventilator and Fan Mounting

- Is all equipment mounted securely?
- Are supports properly fastened to the joists?
- Are vibration isolators in place, as specified by the manufacturer?
- Is all excess material trimmed and smoothed from mounting brackets and hardware?

Ducts

- Are ducts properly supported?
- Is all flexible duct firmly attached to its connectors?
- Are all splices and terminations in flex ducting done according to the supplier's recommendations?
- Are all duct joints taped or sealed?
- Are all cold ducts in heated spaces and warm ducts in cold spaces insulated?
- Are all joints or tears in the vapour barriers on the insulated ducts patched and sealed?
- Are all ducts sealed to the house vapour barrier wherever they pass through it?
- Is all flex ductwork supported to ensure it does not sag?
- Is all flex duct liner properly stretched to provide the smoothest air flow surface possible?
- Are all ducts connected to appropriate ventilator or HRV ports?

Outside Duct Termination

- Are ducts sealed to vapour barrier at outside wall?
- Are inlets and outlets properly located?
- Do outside duct terminations have bird screens and hoods?
- Are outdoor air intakes labelled as air intakes?

Grilles and Diffusers

- Are all dampers open?
- Are all ducts connected to grilles or diffusers?
- If ventilation air supply is indirectly connected to a forced warm air system, is the ventilation air supply outlet or breather tee within one foot of the return air pick up?
- Are the grilles and diffusers properly secured?

Wiring and Controls

- Has all wiring been properly secured?
- Are all electrical connections enclosed?
- Are all occupant controls installed in accessible locations and properly labelled?

Drains (HRV)

- Are drains equipped with traps and filled with water?

Filters

- Are all system filters in place and clean?

SPECIFIC TESTS THAT SHOULD BE UNDERTAKEN

Testing of Basic Operation

Air Flow Measurement and Balancing

House Pressure Test

Combustion Safety Checklist

Step 1:
Choose a calm, cool day
This represents the most hazardous condition. Winds should be less than 10 km/h (6 mph). Outdoor temperatures should be lower than indoor temperatures, but well above freezing.

Step 2:
Inspect chimney and flue connector
Examine the following for proper installation and maintenance: chimney cap, masonry, metal lining, spark screens, ash cleanout, and flue connector. Check the flue for blockage, and for soot and creosote accumulations greater than 6 mm (¼").

Step 3:
Prepare house for testing
Turn down thermostats on furnace and hot water heater to prevent their operation during test. Allow chimneys to cool (metal — 15 min; masonry — 30 min). Remove filters, grills and screens from all exhaust devices, including bathroom fans, range hood, clothes dryer and central vacuum system. Prepare fireplace or wood stove for a rapid, hot fire (but don't light yet); close metal or glass doors; close all dampers. Close exterior doors and windows. Close interior doors to rooms which do not contain exhaust devices (bedrooms, for example). Practice checking for an upward chimney draft by holding a flame (from a butane lighter or a candle) or a smoke pencil along the upper lip of the dilution air inlet of the furnace or next to the draft hood of the hot water heater. The flame will lean into the opening when the flue is exhausting; it will flutter during backdrafting.

Step 4:
Operate exhaust fans and check draft
Turn on all exhaust devices to their highest setting. Set heat recovery ventilators on defrost mode, and operate at high speed. Check draft at furnace and hot water heater.

Step 5:
Operate furnace blower and recheck draft
Turn on furnace blower to high speed (if the blower cannot be operated manually, proceed to the next step). Recheck draft.

Step 6:
Operate fireplace and check all chimneys
Open doors on fireplace or wood stove. Open chimney damper and any air supply inlets or fans to fireplace. Temporarily open a nearby window prior to lighting a fire. Light a fast fire with newspaper and kindling. When the fire is blazing, check for spillage by holding a flame along the top edge of the fireplace opening. Shut the window and recheck. Return to the furnace and hot water heater and recheck their draft.

Step 7:
Operate furnace and check for spillage
With exhaust devices and fireplace operating, start the furnace by turning up the thermostat. Once the furnace is fully operational, hold flame along dilution air inlet. Spillage for more than 15 seconds indicates failure. Also check flue connector joints, thimble, and water heater draft hood for spillage.

Warning: Continue only if no spillage has occurred in Step 7.

Step 8:
Operate gas hot water heater and recheck
Operate hot water heater by turning up its thermostat and turning on a hot water tap. Check for spillage at draft hood and along flue connector.

Step 9:
Check fireplace for spillage as fire dies down
With all systems (exhaust fans, furnace, hot water heater) still running, periodically check upper edge of fireplace opening or cracks around fireplace doors for spillage as fire dies down. If spillage occurs while fire is still burning, open a nearby window until spillage disappears.

Step 10:
Return house to normal operating conditions
Reset thermostats. Turn off exhaust devices. Open or close doors and windows as appropriate.