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R-2000 HOME PROGRAM
DESIGN AND INSTALLATION GUIDELINES FOR VENTILATION SYSTEMS

COMMENTARY

The provision of adequate ventilation in residential occupancies can only be assured with positive, reliable mechanical ventilation systems. There is a need to provide both a minimum continuous ventilation rate and an additional capability to provide increased ventilation rates on an intermittent basis when required by occupants.

The continuous ventilation rate is required to control the level of carbon dioxide and other contaminants generated by occupants or by sources with no fixed and identifiable location by dilution through mixing of outdoor air with room air. There is also a need to remove some contaminants that are generated at fixed locations, such as kitchens and bathrooms. These should be exhausted at their source directly to the outdoors. Combustion products should also be vented at their source to minimize contaminant build-up within the living space. For example, combustion products from ranges shall be exhausted at source to the exterior using a range hood or central mechanical ventilation system. ASHRAE Standard 62-81, Ventilation for Acceptable Indoor Air Quality, and input from builders, researchers, manufacturers and regulatory agencies from across Canada were used to develop the R-2000 Home Program Design and Installation Guidelines for Ventilation Systems, which were subsequently accepted by the R-2000 Technical Advisory Committee.

The ventilation guidelines require a capability to provide a minimum supply of ventilation air, on a continuous basis, of 5 L/s (10 cfm) to each habitable room, bathroom and kitchen and 10 L/s (20 cfm) to basement areas and utility rooms.

There is a requirement for an additional minimum intermittent capacity of 25 L/s (50 cfm) to control excess humidity or contaminants. This shall be activated by means of a humidity controller and by either a manual override or a timer. Procedures for measuring installed airflow rates are specified in the guidelines.

There must also be a capability to exhaust contaminants and odours at their source at a minimum rate of 50 L/s (100 cfm) from a kitchen and 25 L/s (50 cfm) from each bathroom. This may be achieved by means of individual exhaust units or a central ventilation system.

The ventilation system must be designed and installed so that it does not contribute to a pressure difference across the building envelope of more than 10 pascals (Pa) or 0.04 inches W.G. with continuous ventilation and not more than 20 Pa (0.08 inches W.G.) with intermittent operation. Requirements for providing makeup or replacement air, if required, are specified. This requirement minimizes the entry of soil gases into the home and backdrafting of any woodburning appliances.

To avoid discomfort to occupants, when the temperature of the ventilation air is lower than that of the indoor air, it must be heated or adequately mixed with the indoor air before being discharged into the occupied zones. Forced warm air heating systems offer a means to heat, mix and distribute ventilation air to the rooms in a house, providing the heating system fan is operated continuously. In buildings with perimeter baseboard or panel heating systems, a means of distribution and introduction of tempered ventilation air must be provided, as well as a means to exhaust indoor stale air. This can be accomplished through a central system or through a combination of individual room units and/or a central system.

1. PURPOSE

1.1 These design and installation guidelines provide designers and installers with criteria for the selection, location and installation of ventilators, fans, heat recovery devices, ductwork, dampers and terminal fittings for R-2000 homes designed and built in accordance with the R-2000 Home Program Technical Requirements.

2. SCOPE

2.1 These guidelines apply to the design and installation of ventilation systems for individual dwelling units that shall provide:

(a) a continuous, minimum rate of ventilation air to all habitable rooms,
(b) a capability of providing an increased ventilation rate to habitable rooms on an intermittent basis when required,
(c) a capability to exhaust contaminants at their source when required.

2.2 These guidelines are applicable to residential occupancies as defined under Part 9 of the National Building Code of Canada.

2.3 These guidelines are in addition to the requirements of local or provincial codes or standards.

2.4 These guidelines are for the provision of ventilation to control general levels of carbon dioxide and other contaminants typically generated by occupants in a dwelling unit.

3. DEFINITIONS

3.1 **Air-to-Air Heat Exchanger:** a factory-assembled element in which heat is transferred between two air streams.

3.2 **Basement:** a storey or storeys of a building located below the first storey and not specifically intended to be occupied as a habitable room.

3.3 **Bathroom:** a room containing a bath and/or water closet (toilet).

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

3.5 **Exhaust Air:** air removed from a space and not reused within a dwelling unit.

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

3.7 **Heat Recovery Ventilator (HRV):** a factory-assembled unit which contains elements in which heat is transferred between two isolated air streams and a means to circulate air for ventilation.

3.8 **Makeup Air:** supply air to replace exhaust air.

3.9 **Occupied Zone:** the region within a habitable room between 75 and 1800 mm (3 and 72 inches) above the floor and more than 300 mm (1 foot) from the walls or fixed air-conditioning equipment.

3.10 **Purchaser:** the person or persons having ownership or control of the home at a date no later than two weeks following the ventilation system start-up.

3.11 **Return Air:** air removed from a space to be recirculated or exhausted.

3.12 **Supply Air:** air taken directly from the external atmosphere.

3.13 **Utility Room:** a room used as a laundry or workshop or containing maintenance equipment and materials. A storage room, mechanical room or furnace room is not considered a utility room.

3.14 **Ventilation:** the process of supplying and/or removing air by natural or mechanical means to and from any space. Such air may or may not be conditioned.

3.15 **Ventilation Air:** supply air used for ventilation and therefore not previously circulated through the system.

4. GENERAL REQUIREMENTS

4.1 A ventilation system shall be installed to be capable of providing a continuous supply of ventilation air at a rate of 5 L/s (10 cfm) to each habitable room, bathroom and kitchen and 10 L/s (20 cfm) to basements and utility rooms.

4.2 Ventilation air to kitchens, bathrooms, basements and utility rooms can be supplied indirectly from other rooms in the dwelling unit providing these rooms exhaust air at the minimum continuous rate (Section 4.1).

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

4.4 A continuous supply of ventilation air is defined as being the average provided over a 24-hour period. The 'off' period of the ventilation system shall not exceed one hour at any one time. For heat recovery ventilators, the 'low temperature ventilation reduction factor', determined in accordance with CSA Preliminary Standard C439, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators, shall also be used to assess the average ventilation rate.

4.5 The ventilation system shall have the capability to provide additional ventilation air at a rate of at least 25 L/s (50 cfm) on an intermittent basis, activated by a control set to operate on increases of indoor relative humidity and one or more of the following located in a habitable room or bathroom:

(a) a manual override
(b) a timer.

4.6 There shall be a capability to exhaust air at rates of 50 L/s (100 cfm) from the kitchen and 25 L/s (50 cfm) from each bathroom. This may be provided by means of individual air exhaust units and/or by a central ventilation system on an intermittent or continuous basis. A central system to exhaust air from the kitchen and a number of bathrooms on an intermittent basis shall be capable of exhausting air from the kitchen and at least one bathroom simultaneously.

4.7 An unbalanced ventilation system, during continuous operation (Section 4.1), shall not contribute to increasing the air pressure difference across the building envelope by more than 10 pascals (0.04 inches W.G.).

4.8 A ventilation system, during continuous operation (Section 4.1) and in conjunction with the higher of the intermittent operation of the ventilation system (Section 4.5) or any other individual equipment or appliance exhausting air to the exterior, shall not contribute to increasing the air pressure difference across the building envelope by more than 20 pascals (0.08 inches W.G.).

4.9 Compliance with Sections 4.7 and 4.8 and the requirement for any makeup air shall be determined in accordance with Appendix A, Procedures to Determine Makeup Air Requirements and Measure Pressure Differences in R-2000 Homes.

4.10 The selection of supply and exhaust fans should be based on tests carried out in accordance with:

(a) ASHRAE Standard 51-75, Laboratory Methods of Testing Fans for Rating (AMCA Standard 210-74), or
(b) CSA Standard C260.2-1976, Residential Air Exhaust Equipment.

4.11 The ratings of heat recovery ventilators shall be based on tests carried out in accordance with CSA Preliminary Standard C439, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators.

4.12 Electrical components located in or on a cold air duct where condensation or moisture can occur shall be certified for exterior use.

4.13 Correct and comprehensive instructions and pertinent tables or graphs shall be supplied for all fans and ventilators for the purpose of:

(a) Informing the purchaser and the occupant about all aspects of operation, minor trouble-shooting, routine maintenance and seasonal operation. This information shall be provided as a separate manual.

(b) Providing the purchaser with an up-to-date parts list, with suppliers.

(c) Determining ventilation performance and the range of conditions at which the equipment is designed to operate.

(d) Trouble-shooting malfunctions.

4.14 The principles and procedures described in the following references are suitable as a basis for the design of air distribution, supply and exhaust systems:

- HRAI Residential System Design Manual for Air Heating/Cooling Systems.
- ASHRAE 1984 Systems Handbook, Air Distribution Design for Small Heating and Cooling Systems, Chapter 11.
- CSA Standard 260.1-1975, Installation Code for Residential Mechanical Exhaust Systems, Appendix C.

4.15 Construction of ducts and fittings shall conform to CSA Standard B228.1-1968, Pipes, Ducts and Fittings for Residential Type Air Conditioning Systems, except that the metal thickness shall be a minimum of 0.33 mm (30 gauge) for galvanized steel or 0.41 mm (18 gauge) for aluminum, as required for heating and air conditioning in Section 6, Table 6.2.4.A. of the 1985 edition of the National Building Code of Canada.

4.16 All flexible ducts shall meet the requirements of ULC Standard 181 for Class 1 ducts.

4.17 Labels shall be supplied to identify components of the system which require cleaning and/or maintenance.

5.0 VENTILATION SYSTEM INSTALLATION

5.1 Ventilation systems and equipment shall be installed by a registered HRAI installer.

5.2 Mechanical exhaust systems shall be installed in accordance with CSA Standard C260.1-1975, Installation Code for Residential Mechanical Exhaust Systems.

5.3 Heat recovery ventilators shall be installed in accordance with CSA Preliminary Standard C444, Installation Guidelines for Heat Recovery Ventilators, except that supply air intakes shall be located at least 450 mm (18 inches) above finished grade.

5.4 Ventilation air shall be introduced into each room in such a way as to avoid discomfort in the occupied zone.

5.5 Central air recirculation systems such as forced air heating systems can be used to distribute ventilation air to rooms provided the recirculation fan is operated continuously.

5.6 A means of adjusting the continuous ventilation airflow shall be provided. Controls and dampers shall be readily accessible.

5.7 Contaminants from sources within the space should be collected as close as practicable to the source and exhausted from the space. For example, clothes dryers shall be vented to the exterior of the dwelling.

5.8 Any mechanical equipment shall be installed to minimize noise to occupants by installing vibration isolation components according to manufacturers' instructions. Flexible connections at the equipment shall be used to minimize vibration transmission to the duct system, and noise transmission to the building. Where possible, locations under or near rooms such as bedrooms should be avoided.

5.9 The system shall be installed to provide access for cleaning and servicing outside supply air intake and exhaust air outlet connections, filters, fans and heat exhanger cores without moving the equipment or requiring the use of special tools.

5.10 Supply air intakes shall be at least 450 mm (18 in.) above finished grade and located to take into account snow levels. Exhaust air outlets shall be at least 200 mm (8 in.) above finished grade and located so that exhaust air does not create a nuisance or contaminate supply air. Supply air intakes and exhaust air outlets shall be separated a minimum of 2 metres (6 feet).

5.11 Supply air intakes shall be located so that contamination from automotive exhaust and other sources is minimal.

5.12 Supply air intakes shall be clearly labelled to identify them as ventilation air intakes.

5.13 Bird screens for intake and exhaust ducts shall have a mesh of not less than 6 mm (1/4 in.). Insect screens, where installed, shall be accessible and removable for cleaning.

5.14 Cold air ducts in conditioned spaces shall have a minimum of RSI 0.4 (R-2) insulation with vapour barrier to avoid condensation on the duct.

6.0 SYSTEM PERFORMANCE AND COMPLIANCE

6.1 Airflow Measuring Stations shall be installed to measure the continuous ventilation airflow capability of the ventilation system. Airflow Measuring Stations shall be installed on the warm side of any HRV (Appendix B, Procedures for Measuring Airflow Rates).

6.2 Airflow rates shall be determined using measuring instruments with an accuracy of $\pm$10% (Appendix B).

6.3 The ventilation rate shall be measured in the normal continuous ventilation mode with all recirculation systems in operation.

6.4 The measured continuous ventilation rate shall be in accordance with Section 4.1. If the required continuous ventilation rate is greater than 0.45 air changes per hour (ach), based on total house volume including any basement volume, the installer is permitted to reduce the continuous ventilation rate to the equivalent of 0.45 ach.

6.5 Where a measurement of pressure differential across the building envelope is required to ensure compliance with the maximum allowable indoor to outdoor pressure difference (Sections 4.7 and 4.8), it shall be performed in accordance with Appendix A, Procedures to Determine Makeup Air Requirements and Measure Pressure Differences in R-2000 Homes.

7.0 SYSTEM START-UP

7.1 The ventilation system, including all control wiring and power wiring connections, shall be thoroughly checked out at start-up and recorded on the R-2000 Ventilation Equipment Installation Report.

7.2 An appropriate label shall be affixed to all elements of the unit which require caution, cleaning and/or maintenance.

7.3 The installer shall ensure that the system operation is explained to the initial purchaser. The purchaser shall be advised about the separate requirements for the supply of outside air for combustion equipment, including fireplaces.

7.4 The purchaser shall be given the manufacturer's information on operation, controls and maintenance.

7.5 The R-2000 Ventilation Equipment Installation Report shall be completed and copies distributed to the purchaser, manufacturer and the CHBA R-2000 program authorities.

APPENDIX A

PROCEDURES TO DETERMINE MAKEUP AIR REQUIREMENTS AND MEASURE PRESSURE DIFFERENCES IN R-2000 HOMES

A.1 This procedure applies to those houses with ventilation systems or other air exhaust equipment which do not have balanced airflows, such as bathroom exhaust fans, kitchen range hoods, clothes dryers and heat recovery ventilators (HRV) with unbalanced airflows during the defrost mode of operation.

A.2 The R-2000 program specifies that ventilation equipment and other individual appliances which exhaust air to the outside shall not contribute to increasing the air pressure differences across the building envelope by more than 10 pascals (Pa) or 0.04 inches W.G. if operated continuously and, in conjunction with the higher of the intermittent operation of the ventilation system or any other individual equipment or appliance that exhausts air to the exterior, shall not contribute to increasing the air pressure difference across the building envelope by more than 20 Pa (0.08 inches W.G.).

A.3 To comply with this requirement it is necessary to determine the Leakage Area (LA) required to limit pressure differences across the building envelope to 10 Pa or 20 Pa and compare this with the Equivalent Leakage Area (ELA) of the building which is calculated during the Fan Depressurization Test (CGSB Standard CAN2-149.10-M86). This test is conducted to determine whether the house complies with the R-2000 requirement for airtightness. The ELA divided by the surface area of the building envelope equals the Normalized Leakage Area (NLA).

When the ELA of the building is lower than the required LA, makeup air will be needed to increase the ELA of the building to be at least equal to the required LA, and thereby reduce the pressure difference across the building envelope to an acceptable level. Alternatively, the amount of unbalanced airflow may be reduced.

Figure A-1 provides the required LA needed to limit the pressure difference across the building envelope to 10 or 20 Pa for any unbalanced airflow. Table A-1 provides information on the additional ELA provided by the installation of different sizes of makeup air inlet ducts, and Table A-2 can be used to determine typical airflows and appropriate default values for various air-exhausting appliances.

Figure A-1 and Tables A-1 and A-2 are provided with the R-2000 Ventilation Equipment Installation Report.

A.4 The steps required to determine compliance with the program requirements for maximum pressure differences across the building envelope are as follows:

1. **Continuous Ventilation:** For ventilation systems where the measured supply and exhaust airflows are not equal, determine the unbalanced airflow "Q" and use Figure A-1 to determine the required leakage area (LA-10) using the "10 pascal" reference line.

2. **Intermittent Operation:** Determine the maximum intermittent unbalanced airflow of either:

   a) the ventilation system. Include any unbalanced airflow of a heat recovery ventilator during the defrost mode which is considered intermittent operation;

   b) any other single individual appliance or equipment that exhausts air to the exterior. Where actual airflows are not known, use Table A-2 to determine appropriate default values.

   Add any unbalanced airflow due to continuous operation of the ventilation system to determine total unbalanced airflow "Q" (intermittent plus unbalanced continuous) and use Figure A-1 to determine the required leakage area (LA-20) using the "20 pascal" reference line.

3. Compare the required LA-10 and LA-20 with the ELA of the dwelling unit determined by the Fan Depressurization Test. When the ELA is higher than the LA-10 or LA-20, no makeup air is needed.

4. When the ELA is lower than the LA-10 or LA-20, makeup air is required. Table A-1 is used to determine the size of a makeup air duct which would increase the ELA of the building to be at least equal to the required LA at 10 Pa or 20 Pa. This table is based on an effective duct length of 25 metres (75 feet) and includes the effect of an outside hood, elbows and other connections.

5. When powered equipment, such as a fan, is used to provide makeup air, determine the difference between the required LA-10 or LA-20 and the measured ELA. Use Figure A-1 to determine the unbalanced airflow "Q" that would correspond to the additional LA at either the 10 Pa or 20 Pa reference line, whichever is applicable. A makeup air fan would then have to be installed to provide this amount of makeup air.

Figure A-1

TABLE A-1

EQUIVALENT LEAKAGE AREA (ELA) PROVIDED BY
INLET DUCTS OF VARIOUS DIAMETERS

DUCT DIAMETER mm	(in.)	ELA PROVIDED (m2)
75	(3)	0.0024
100	(4)	0.0052
125	(5)	0.0092
150	(6)	0.0156
175	(7)	0.0240
200	(8)	0.0340

TABLE A-2

AIRFLOWS OF VARIOUS AIR EXHAUST DEVICES

Exhaust Devices	Range of Airflows L/s	(cfm)	Default Value L/s	(cfm)
Bathroom Fans	20 - 50	(40 - 100)	25	(50)
Standard Range Fan	50 - 100	(100 - 200)	65	(130)
Grille-Top Range Fan	60 - 150	(120 - 300)	110	(220)
Clothes Dryer	40 - 55	(80 - 110)	50	(100)
Central Vacuums (exterior exhaust)	45 - 65	(90 - 130)	50	(100)

A.5 To assist builders at the design stage, the HOT-2000 computer program will estimate the ELA of the building envelope based on 60% of the R-2000 requirement for airtightness or an NLA of 0.45 cm2/m2. HOT-2000 will also estimate the unbalanced airflow which will cause a 10 Pa and 20 Pa pressure difference across the building envelope. The actual ELA from the fan depressurization test must still be used to confirm compliance.

Alternatively, when a builder wants assurance of compliance with program requirements at the design stage, Table A-3 provides information on the size of duct required to limit pressure differences caused by various unbalanced continuous or intermittent airflows. This table assumes the ELA of the building would be minimal. If this option is used, a fan depressurization test is not required to confirm compliance.

TABLE A-3

REQUIRED SIZE OF MAKEUP AIR INLET DUCTS WHERE THE EQUIVALENT LEAKAGE AREA OF THE BUILDING ENVELOPE IS NOT KNOWN

Unbalanced Airflow		Required Makeup Air Inlet
Continuous L/s (cfm)	Intermittent L/s (cfm)	Duct Diameter mm (in.)
10 (20)	20 (40)	75 (3)
20 (40)	30 (60)	100 (4)
30 (60)	50 (100)	125 (5)
50 (100)	80 (160)	150 (6)
75 (150)	125 (250)	175 (7)
100 (200)	170 (340)	200 (8)

A.6 The following is an example of the procedure applied to a ventilation system with unbalanced airflow during intermittent operation and a makeup air inlet duct installed to provide additional LA to keep the pressure difference across the building envelope within acceptable levels.

Intermittent unbalanced ventilation airflow = 85 L/s (170 cfm)
Required LA at 20 Pa (LA-20) from Figure A-1 = 0.020 m2.
Measured ELA from fan depressurization test = 0.015 m2
Difference to be provided by makeup air inlet = 0.005 m2
Size of makeup air inlet (Table A-1) = 100 mm (4 in.)

A.7 The following is an example of the procedure applied to a ventilation system where a fan is installed to reduce the unbalanced airflow to an acceptable level.

Intermittent unbalanced ventilation airflow = 85 L/s (170 cfm)
Required LA at 20 Pa (LA-20) from Figure A-1 = 0.020 m2
Measured ELA from fan depressurization test = 0.015 m2
Difference to be provided by makeup air fan = 0.005 m2
Airflow for makeup air fan (Figure A-1) = 23 L/s (46 cfm)

A.8 The following measurement technique is an alternative method that can be used to determine whether a house conforms to the program requirement for maximum pressure differences across the building envelope and the need for makeup air.

This method may be used when it is unclear whether the requirements for makeup air have been met and it is desirable to measure the pressure difference across the building envelope before modifying the ventilation system.

The test must be performed with an instrument capable of measuring pressure differences in the 0-60 Pa (0.0 - 0.25 inches W.G.) range, with a sensitivity of 1 Pa (0.004 inches W.G.). The Dwyer Durablock Manometer, Model 115 is an example of a suitable instrument.

The test procedure is as follows:

- Test under calm wind conditions, 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.

- Makeup 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 house and connect to the 'high side' of the differential measuring device, which should be located inside the building at or near grade (Figure A-2).

- Switch off ventilation equipment and any other appliances that exhaust air to the exterior and record the pressure difference (P) measured on the instrument.

- Switch on all equipment used for continuous ventilation and record the pressure difference (Pc). To comply with program requirements 'Pc-P' must be less than 10 Pa (0.04 inches W.G.).

- Switch on the individual equipment or single appliance that creates the highest intermittent air exhaust and record the pressure difference (Pi). To comply with program requirements 'Pi-P' must be less than 20 Pa (0.08 inches W.G.). For an HRV with fan shut off and/or unbalanced airflow during the defrost mode of operation, operate the HRV in defrost mode or block air intake during the test.

- Unseal any openings that had been sealed for the test and complete the R-2000 Ventilation Equipment Installation Report.

FIGURE A-2

Location of Pressure Taps for Measurement of Pressure Difference Across the Building Envelope

APPENDIX B

PROCEDURES FOR MEASURING AIRFLOW RATES

B.1 To ensure compliance with the R-2000 ventilation requirements, airflows must be measured. For 1986 and 1987, Airflow Measuring Stations are available from the regional offices of Energy, Mines and Resources Canada. Measuring stations provide high and low pressure outputs which can be connected to a differential pressure measuring instrument. A calibration chart can then be used to convert the pressure reading to airflow. Alternative methods of measuring airflows must be submitted to CHBA for prior approval.

B.2 The Airflow Measuring Stations shall be installed as follows:

1. Airflow Measuring Stations shall be located in the duct such that all the supply and exhaust air is measured. All joints between the measuring stations and the exterior should be sealed. Airflow Measuring Stations shall be installed on the warm side of any HRV.

2. Airflow Measuring Stations can be installed immediately before or after a 90 degree elbow and 300 mm (12 inches) from any damper. In a straight section of duct, the measuring stations should be installed at least 760 mm (30 inches) downstream from any fan and at least 760 mm upstream from any "axial" fan (Figure B-1 Locations of Airflow Measuring Stations).

3. Airflow Measuring Stations must be oriented for flow in the direction indicated by the arrow on the outside of the station sleeve.

4. Prior to measuring flows, air should be blown through the high and low pressure outputs of the measuring station to clear any accumulated dirt.

5. Flow measurements should be taken with a differential pressure measuring instrument with an accuracy of 1 Pa (0.004 inches W.G.) within a measuring range of 0.0 to 60 Pa (0.0 to 0.25 inches W.G.), such as a Dwyer Duralock Manometer, Model 115.

6. The ventilation system shall be measured in its normal continuous ventilation mode with any recirculation system operating. An HRV should not be in defrost mode.

7. Any adjustments to the ventilation system shall be completed before final measurements are made.

8. The calibration chart affixed to the sleeve shall be used to convert the pressure differential to airflow. The result shall be recorded on the R-2000 Ventilation Equipment Installation Report.

Figure B-1

diagrams

APPENDIX C

EXAMPLES OF VENTILATION SYSTEMS FOR DWELLING UNITS

C.1 There are three basic ventilation requirements to be met:

- A continuous requirement for the house which is the total of 5 L/s (10 cfm) for all habitable rooms, kitchens and bathrooms and 10 L/s (20 cfm) for a basement and/or utility room.

- An additional intermittent requirement of 25 L/s (50 cfm) controlled by a humidistat and manual switch or timer.

- The capability to exhaust contaminants and odours at their source at a rate of 50 L/s (100 cfm) for kitchens and 25 L/s (50 cfm) for each bathroom. This capability can be provided with separate manually operated exhaust units and/or part of the continuous or intermittent requirements for the house ventilation system.

C.2 The following is an example of the ventilation requirements for a typical house:

	Continuous		Exhaust Capability	
	L/s	(cfm)	L/s	(cfm)
Kitchen	5	(10)	50	(100)
Dining Room	5	(10)		
Living room	5	(10)		
Bathroom #1	5	(10)	25	(50)
Bathroom #2	5	(10)	25	(50)
Master Bedroom	5	(10)		
Bedroom #2	5	(10)		
Bedroom #3	5	(10)		
Basement	10	(20)		
Sub-Total	50	(100)		
Intermittent Capacity	25	(50)		
Total System Capacity	75	(150)		

The continuous ventilation air for kitchens, bathrooms, basement and utility rooms can be provided indirectly by increasing the amount of ventilation air to other rooms provided that these rooms exhaust air continuously at the required rate, such as with a heat recovery ventilator.

The exhaust capability for the kitchen and bathrooms can be met with a central system such as a heat recovery ventilator exhausting air from the kitchen and bathrooms or by providing separate manually operated exhaust equipment in the kitchen and bathrooms.

C.3 The following is a possible distribution arrangement for the typical house (C.2) using a central ventilation system such as a heat recovery ventilator and one additional bathroom fan.

	Central System				Additional Exhaust	
	Supply		Exhaust			
	L/s	(cfm)	L/s	(cfm)	L/s	(cfm)
Kitchen			50	(100)		
Dining Room	10	(20)				
Living room	15	(30)				
Bathroom #1			25	(50)		
Bathroom #2	10	(20)			25	(50)
Master Bedroom	10	(20)				
Bedroom #2	10	(20)				
Bedroom #3	10	(20)				
Basement	10	(20)				
Total	75	(150)	75	(150)		

The ventilation system would be set at 50 L/s to provide continuous ventilation (low-speed). Where this rate is greater than 0.45 ach, the installer is permitted to reduce the continuous ventilation rate setting to the equivalent of 0.45 ach. The maximum capacity at 75 L/s would be activated by a humidity controller or by a manual switch or timer. The bathroom fan would be activated by a manual switch or timer.

C.4 The need for any makeup air to conform with requirements for the maximum pressure differences across the building envelope during continuous and intermittent operation can be determined from the procedures outlined in Appendix A, Procedures to Determine Makeup Air Requirements and Measure Pressure Differences in R-2000 Homes. Makeup air should be introduced in a way that does not cause discomfort to occupants. For example, a barometric damper could be installed in a makeup air duct to open only when excessive pressure differences occur. The R-2000 Home Program Technical Requirements also provide information concerning makeup air for combustion appliances.

C.5 Forced warm air heating systems provide a means to mix and distribute ventilation air to all rooms for both continuous and intermittent operation, providing the furnace circulation fan operates continuously. A central recirculating fan and ductwork could also provide a comparable distribution system in a house with a perimeter heating system. The additional exhaust requirements could be met by a central ventilation system and/or individual exhaust units.

C.6 Air recirculation systems should normally be capable of mixing and distributing ventilation air in rooms without discomfort to the occupants if the supply air temperature is no more than 12 degrees C below room air temperature.

For distribution systems which supply ventilation air to individual rooms without mixing it with recirculating air, smaller specialized outlets or diffusers such as those used for air conditioning may be required to ensure adequate distribution within the room, and air may have to be tempered to avoid discomfort in the occupied zone.

The following established methods of distributing ventilation air may be considered:

1) Ceiling registers or high side-wall registers with horizontal discharge located on interior walls.

2) Floor registers and baseboard or low side-wall outlets with vertical, non-spreading characteristics located on outside or inside walls.

3) Floor registers and baseboard or low side-wall outlets with vertical, spreading discharge located on outside walls.

Ceiling and high side-wall outlets or diffusers are likely to be the best arrangement for any ventilation system that supplies air at lower than room temperatures, since lower air temperatures and higher velocities are not as easily detected by the occupants and a larger 'unoccupied' zone is available for mixing with warm room air. Alternatively, floor registers or low side-wall registers with vertical, non-spreading discharge characteristics could be considered.

C.7 The following is an example of total ventilation through a central ventilation system, such as a heat recovery ventilator and an air recirculation system.

- Ventilation air is supplied to the return air intake of an air recirculation system such as a furnace. The recirculation system fan operates continuously to distribute ventilation air to rooms.
- Indoor air is exhausted from the kitchen and bathrooms through the HRV to the outside to meet all the continuous ventilation and additional exhaust air requirements.
- The HRV fans are operated on 'low speed' for minimum continuous ventilation rate and on 'high speed' for higher capacity, intermittent operation that is activated by a humidity controller and a manual switch or timer.
- Makeup air would not generally be required.

C.8 The following is an example of continuous ventilation provided by a central air recirculation system and a heat recovery ventilator. Additional exhaust capacity is provided by individual exhaust units from the kitchen and/or bathrooms.

- Continuous ventilation is provided by exhausting indoor air from one or more rooms and/or a basement or from the return air trunk of a furnace to the HRV and supplying ventilation air to a return air intake of a central recirculation system such as a furnace. The recirculation system fan operates continuously to distribute ventilation air to rooms.
- Additional exhaust capacity is achieved by individual exhaust fans in the kitchen and/or bathrooms or through a central fan by ducts from the kitchen and/or bathrooms. At least 25 L/s of exhaust can be activated by a humidity controller.
- Makeup air, if required to meet the requirement for maximum pressure differences across the building envelope, can be supplied through a single intake from the exterior or through individual room supply air inlets and/or leakage openings.

C.9 The following is an example of a central ventilation system, such as a heat recovery ventilator, with perimeter heating and no central recirculation system.

- Ventilation air is supplied from the HRV through ducts to individual rooms. Indoor air is exhausted from kitchen and bathrooms through the HRV to the exterior.
- HRV fans are operated on 'low speed' for continuous ventilation and on 'high speed' by a humidity controller and a manual switch or timer to meet requirements for intermittent and exhaust air capacity.
- Generally no additional makeup air is required.

C.10 The following is an example of continuous ventilation provided by a central ventilation system, such as a heat recovery ventilator, with additional capacity provided by exhaust units from the kitchen and/or bathrooms.

- Ventilation air is supplied through ducts to individual rooms. Indoor air is exhausted from one or more rooms such as bathrooms, a kitchen and/or a basement through the HRV to the exterior.
- Additional exhaust capacity from bathrooms and/or the kitchen is achieved through individual exhaust fans or a central fan ducted to the outside. At least 25 L/s of airflow can be activated by a humidity controller.
- Makeup air, if required, can be supplied through a central intake or individual room air inlets.

C.11 The following is an example of a central exhaust system, such as a heat pump heat recovery ventilator, with ventilation air provided to rooms directly or by a recirculation system.

- Ventilation air at a flow rate at least equal to the minimum continuous ventilation rate is supplied to individual rooms either directly through a central fan and duct system (with an air-tempering duct heater in cold zones) or by a recirculation system.
- Indoor air is exhausted at a rate at least equal to the minimum continuous ventilation rate through the heat pump HRV to recover heat for space heating and/or domestic water heating.
- Additional ventilation capacity is provided by 'high speed' operation of the heat pump HRV or direct exhaust through individual fans from bathrooms and/or kitchen. At least 25 L/s must be activated by a humidity controller.
- Any additional makeup air can be provided through individual room supply air inlets and/or leakage openings or 'high speed' operation of the outside supply air fan.

C.12 The reference standards are:

- CSA Preliminary Standard C444-M1985, Installation Guidelines for Heat Recovery Ventilators.
- CSA Preliminary Standard C439, Standard Methods of Test for Rating the Performance of Heat Recovery Ventilators.
- CSA Standard C260.1-1975, Installation Code For Residential Mechanical Exhaust Systems.
- CSA Standard C260.2-1976, Residential Air Exhaust Equipment.
- HRAI Residential System Design Manual for Air Heating and Cooling Systems.

C.13 The following additional references/standards are related to the design of air distribution systems and room air supply inlets:

- ANSI/ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy.
- ASHRAE 1984 SYSTEMS HANDBOOK, Chapter 11, Air Distribution Design for Small Heating and Cooling Systems.
- ASHRAE 1983 EQUIPMENT HANDBOOK, Chapter 2, Air Diffusing Equipment.
- ASHRAE 1981 FUNDAMENTALS HANDBOOK, Chapter 32, Space Air Diffusion.
- Canadian Building Digest 102, Thermal Environment and Human Comfort.
- Canadian Building Digest 106, The Basic Air-Conditioning Problem.
- NBS Technical Note 710-6, Building Research Translation, Ventilation Air Inlets for Dwellings.
- NBS Technical Note 710-3, Building Research Translation, New Regulations on Ventilation of Dwellings, Fixed Heating Facilities and Flues.