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ONTARIO BUILDING CODE PART 9
MECHANICAL VENTILATION
PROPOSALS DEMONSTRATION

Ontario Building Code Part 9 Mechanical Ventilation Proposals Demonstration

Final Report

Prepared for:

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Executive Summary

This document is the final report on a field assessment of proposed revisions to Article 9.32 of the Ontario Building Code. In the fall of 1992, Buchan, Lawton, Parent Ltd. was commissioned by the Ontario New Home Warranty Program, on behalf of a group of Project Partners comprised of government agencies and industry groups[1], in order to undertake a field assessment of the residential construction industry's ability to install mechanical ventilation systems for houses to meet the requirements of the proposed Revisions. (The version of the proposed revisions to Article 9.32 used as the basis for construction of systems in the project was essentially the version in existence in the summer of 1992.) Many groups had expressed the concern that the proposals had to be tested before they could be advocated as suitable for inclusion in the Code.

The proposed revisions to the OBC were seeking to achieve several objectives:

- upgrade the minimum standard for residential mechanical ventilation systems in order to limit the need for make-up air inlets, electric tempering of incoming air and fan assistance to draw in outside air;
- minimize the potential for homeowner complaints as a result of fan noise, drafts, over-ventilation, under-ventilation, etc.;
- utilize commercially available and reliable technology;
- define systems which, while not inadequate, minimized the impact of incremental cost on builders and home buyers;
- provide a set of requirements which could be met consistently and reliably under Part 9 of the OBC (i.e. without a ventilation system designer necessarily involved.)

The wording of the text of the proposals contained some significant provisions which, among other things, provided for the following system features to be incorporated into mechanical ventilation systems under Part 9:

- direct connection of ventilation air inlets to the return air plenum of a forced air heating system and elimination of fan-forced make-up air systems in the intake ductwork;
- interconnection of controls for the forced air system and the ventilation system;
- introduction of untempered air into the return air plenum in non-electrically heated homes;
- provisions to ensure ventilation performance and noise levels created by fan-forced systems

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[1] Project Partners who provided funding and formed a project review group included Canada Mortgage and Housing Corporation, National Research Council of Canada, Ontario Home Builders' Association, Ontario Hydro, Ontario Ministry of Housing, Ontario Natural Gas Association and the Ontario New Home Warranty Program. Equipment and technical assistance to builders was provided by a consortium of ventilation equipment manufacturers comprised of Conservation Energy Systems, Nutech Energy Systems Inc. and Venmar Ventilation Inc.

- reduced ventilation flow requirements for houses (built to minimum code requirements) based on the concept of the Primary Exhaust Fan handling only the occupancy-based ventilation requirements.

The project provided some extremely useful feedback on the workability of some of the Code proposals. It attempted a "real world" demonstration of the proposed changes. Six prototypical systems were taken into the field with a view towards demonstrating the flexibility and practicality of a range of possible approaches to meeting the provisions of revised Article 9.32. The systems ranged in complexity from a central exhaust fan with untempered make-up air directly ducted to the forced air heating system ductwork, to a fully-ducted HRV system. As such, several alternate approaches were attempted with a view towards providing mechanisms for addressing the range of issues and concerns about the Code proposals which had been tabled with the Ontario Ministry of Housing at that point in time.

The scope of work for the project was restricted by the tight time-frame which was available for inputting to the OBC review process, as well as limited budgets and specific interests of the funding partners. The scope of the project provided for the following field work:

- construction of 7 house types – 6 ventilation/heating system combinations and 1 control house
- construction of at least 1 and not more than 2 examples of each house type
- documentation of the construction process specifically related to mechanical ventilation system installation,
- air tightness testing and identification of the depressurization potential of house systems,
- air exchange and ventilation air flow measurements
- interior air and duct air temperatures,
- limited air quality testing (time averaged measurements of formaldehyde and spot measurements of carbon dioxide)

Several key observations were identified as a result of the field work:

- significant difficulty was experienced by contractors attempting to achieve the interlocks (ie controls and wiring) for proper fan operation as set out in the OBC proposals;
- without proper interlocks it is difficult for some systems to operate in a balanced air flow mode;
- the requirements for "low sone" (i.e. quiet) fans generally resulted in better quality fans with a higher air flow ratings than required being installed; this may result in over-ventilation of the houses in the study, though it is noted that manufacturers are coming forward with lower capacity low sone fans as new markets are being identified;
- no indoor air quality problems were observed, though the testing was limited and the results may be a result of the over-ventilation tendencies described above;

- when tested via a fan depressurization (blower door) test, the houses in the project were generally very tight, though it should be recognized that these homes were not randomly selected and as a consequence may not be representative of the broad cross section of new homes in Ontario;
- as a consequence of the homes being airtight, large capacity exhaust fans could bring about significant depressurization leaving homes susceptible to soil gas problems and problems related to combustion spillage if spillage susceptible equipment is installed.
- introduction of untempered air into the heating system creates a potential for occupant comfort and equipment operation problems, leading to possible builder call backs and warranty issues.

Keying in on some of these observations, the Ontario Ministry of Housing organized an industry-government task group to review and suggest changes to the proposed revisions of the code. In the context of this project, action was recommended in the areas set out below:

- the OBC proposals generally incorporated complex wording which made for difficulties ensuring system requirements were properly understood and executed under OBC Part 9 conditions in the field; the wording needed to simplified;
- interconnection of controls for heating and ventilation systems raised concerns about certification and warranties on equipment, so, it appeared necessary to set out proper guidelines and limit the extent to which interconnection was needed;
- interconnection of ventilation and heating systems ductwork created the potential for cold temperatures in furnace ductwork and in some cases affected the balancing of HRV's, so it was suggested that direct connection of ventilation ductwork and heating system ductwork should only be done if approved and in a manner set out by the ventilation and heating system equipment manufacturers;
- introduction of untempered air into heating system ductwork appeared to require proper design and, as such, it appeared that such systems should not be handled in the context of Part 9 of the OBC;
- exhaust-only systems appeared to be able to create depressurization problems so it was suggested that exhaust-only systems be allowed only in houses where backdrafting and spillage was not an issue (e.g. houses with non-spillage susceptible heating and domestic hot water systems) or in situations where a qualified designer is involved (i.e. in Part 6 systems).

It should be recognized that, given the substantial progress which has been made since this project was originally undertaken, several new issues have arisen. The following points should be highlighted:

- The project, due in part to financial constraints, was very limited in scope with one or two examples of each system type being demonstrated; a more broad-based monitoring program should be undertaken in concert with implementation of the 1993 OBC.

- The results presented herein should not be construed as a verification of the merits of the requirements of the 1993 OBC, though they do provide rationale for some of the changes that have been made.
- Irrespective of the testing provided in this study, because the equipment installed in these homes was generally oversized, additional indoor air quality testing would be needed to verify that the Principal Exhaust Fan concept is adequate to meet the ventilation requirements of new homes.

Clearly, some important issues remain. For this reason, it is recommended that a monitoring program be set up to verify that a minimum of problems are encountered and that the revised requirements are adequate when the revised OBC is implemented in 1993, so that results can be ready for the next Code review cycle beginning in 1994.

RÉSUMÉ

Ce document constitue le rapport final d'une évaluation sur le terrain des révisions proposées à l'article 9.32 du Code du bâtiment de l'Ontario. À l'automne de 1992, le Régime de garantie des logements neufs de l'Ontario, au nom d'un groupe de partenaires composé d'agences gouvernementales et de sociétés industrielles[1], a retenu les services de la firme Buchan, Lawton, Parent Ltd. en vue d'évaluer sur le terrain la capacité de l'industrie de la construction d'équiper les habitations d'installations de ventilation respectant les exigences des révisions proposées. (La version des révisions proposées à l'article 9.32 sur laquelle se sont fondées les entreprises pour réaliser les installations à évaluer est essentiellement celle qui avait cours à l'été 1992.) De nombreux groupes avaient en effet manifesté le souhait que les propositions soient mises à l'essai avant d'être officiellement incluses dans le code.

Les révisions proposées au Code du bâtiment de l'Ontario visent plusieurs objectifs :

- rehausser la norme minimale touchant la ventilation des habitations afin de limiter le recours à des prises d'air de compensation, au préchauffage électrique de l'air admis et à un ventilateur pour introduire de l'air extérieur;
- réduire au minimum les possibilités de plaintes de la part des propriétairesoccupants, attribuables au bruit causé par les ventilateurs, aux courants d'air, à la ventilation excessive, à la ventilation insuffisante, etc.;
- utiliser de la technologie fiable et disponible dans le commerce;
- établir quelles installations diminuent l'impact du coût différentiel pour les constructeurs et les propriétairesoccupants même si elles sont adéquates;
- élaborer une série d'exigences intégrées à la partie 9 du CBO qui pourront être respectées sans exception et efficacement (c'est-à-dire sans nécessiter l'intervention d'un spécialiste de la ventilation).

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1. Les partenaires qui ont financé les travaux et formé le groupe d'évaluation du projet sont la Société canadienne d'hypothèques et de logement, le Conseil national de recherches du Canada, l'Ontario Home Builders' Association, Ontario Hydro, le ministère du Logement de l'Ontario, l'Ontario Natural Gas Association et le Régime de garantie des logements neufs de l'Ontario. L'équipement et l'assistance technique aux constructeurs ont été fournis par un consortium de fabricants d'équipement de ventilation comprenant les sociétés Conservation Energy Systems, Nutech Energy Systems Inc. et Venmar Ventilation Inc.

Le texte des propositions prévoit, entre autres mentions importantes, que les installations de ventilation de la partie 9 doivent posséder les caractéristiques suivantes :

- les conduits d'admission d'air doivent être directement raccordés au plénum de reprise dans le cas d'un générateur d'air chaud à air pulsé et les dispositifs mécaniques d'air de compensation doivent disparaître des conduits d'admission;
- les commandes de l'installation à air pulsé et de la ventilation doivent être reliées;
- le plénum de reprise d'air des maisons non chauffées à l'électricité doit recevoir de l'air non préchauffé;
- des mesures doivent être prises pour garantir la performance des installations à air pulsé et les niveaux de bruit qu'elles suscitent;
- le débit de ventilation requis pour les maisons qui respectent le code au minimum doit être réduit, suivant le concept que le ventilateur d'extraction primaire se charge seulement de la ventilation nécessaire aux occupants.

L'évaluation a permis d'obtenir des renseignements extrêmement utiles sur l'applicabilité de certains changements proposés au code en en faisant une démonstration réelle. Six installations prototypes ont été mises en service afin de démontrer la flexibilité et la faisabilité d'une série d'approches possibles pour satisfaire aux nouvelles exigences proposées à l'article 9.32. De complexité diverse, les installations allaient du ventilateur-extracteur central doté d'un apport d'air de compensation non préchauffé directement raccordé aux conduits d'un générateur de chaleur à air pulsé, à un VRC relié par conduits à toute la maison. C'est ainsi que plusieurs méthodes différentes ont été mises à l'essai afin de donner suite aux réserves et aux préoccupations que les changements proposés au code ont soulevées et qui ont été portées à la connaissance du ministère du Logement de l'Ontario.

Les travaux ont été limités par les courts délais impartis, dans le cadre du processus de révision du CBO, ainsi que par les ressources restreintes et les intérêts particuliers des partenaires responsables du financement. Les tâches suivantes ont donc été menées sur le terrain :

- construction de sept types de maison, six étant pourvues d'une installation mixte de ventilation et de chauffage et une servant de maison de référence;
- construction d'au moins un exemple (deux au plus) de chaque type de maison;
- documentation de la construction, particulièrement en ce qui a trait à l'installation de ventilation;

- essai d'étanchéité à l'air et détermination du potentiel de dépressurisation de chaque maison;
- mesure du renouvellement d'air et du débit de ventilation;
- mesure de la température de l'air intérieur et de l'air dans les conduits;
- essai limité de la qualité de l'air (taux moyen de formaldéhyde et mesure ponctuelle du dioxyde de carbone);

Le travail sur le terrain a permis de faire plusieurs observations clés :

- les entrepreneurs ont eu beaucoup de difficultés à réaliser l'interconnexion des commandes et des câbles proposée pour le nouveau code afin d'optimaliser le fonctionnement des ventilateurs;
- sans une interconnexion appropriée, il est difficile pour certaines installations d'arriver à équilibrer le débit d'air;
- l'exigence touchant le faible niveau de bruit des ventilateurs s'est en général traduite par la pose de ventilateurs de meilleure qualité et à plus fort débit d'air que ce qui est requis; cette situation peut entraîner une ventilation excessive des maisons évaluées, quoique les fabricants proposent des ventilateurs silencieux à plus faible capacité à mesure qu'ils en perçoivent la demande sur le marché;
- aucun problème de qualité de l'air intérieur n'a été observé, bien que les essais aient été limités et que les résultats obtenus puissent être le fait de l'excès de ventilation noté plus haut;
- à l'essai du ventilateur à débit contrôlé, les maisons évaluées se sont généralement avérées très étanches à l'air; cela dit, il faut noter que ces maisons n'ont pas été choisies au hasard et qu'elles ne sont peut-être pas représentatives du large éventail d'habitations neuves qu'on trouve en Ontario;
- compte tenu de l'étanchéité à l'air des maisons, les ventilateurs d'extraction à haute efficacité pourraient entraîner une forte dépressurisation et paver la voie à l'infiltration de gaz souterrains ou à des émanations des gaz de combustion dans le cas où de l'équipement sujet à ce genre d'ennui serait installé;
- l'admission d'air non préchauffé au sein de l'installation de chauffage soulève la question du confort des occupants et du fonctionnement de l'installation; il pourrait en résulter des plaintes auprès des entrepreneurs ainsi que des différends au sujet des garanties.

Se fondant sur certaines de ces observations, le ministère du Logement de l'Ontario a formé un groupe de travail réunissant des représentants de l'industrie et du gouvernement afin d'examiner les révisions proposées et de suggérer des modifications. C'est dans ce contexte que les mesures suivantes ont été recommandées :

- la formulation des changements proposés au CBO est généralement complexe et en rend la compréhension difficile; il est ardu de les exécuter sur le terrain tout en respectant les exigences du CBO; les changements devront être formulés plus simplement;
- l'interconnexion des commandes de chauffage et de ventilation a soulevé des préoccupations à propos de l'homologation et des garanties de l'équipement; il a donc semblé nécessaire d'établir des lignes de conduite appropriées et de limiter l'étendue de l'interconnexion requise;
- l'interconnexion des conduits des installations de ventilation et de chauffage a entraîné la possibilité que de l'air froid atteigne les conduits de chauffage et que, dans certains cas, l'équilibre du VRC soit menacé; c'est pourquoi on suggère que le raccordement direct des conduits de ventilation et de chauffage ne soit réalisé que s'il est autorisé par les fabricants de l'équipement concerné et selon la méthode que ceux-ci préconisent;
- l'admission d'air non préchauffé dans les conduits de chauffage a semblé nécessiter une conception appropriée et, de ce fait, il s'avère que de telles installations ne devraient pas être prises en considération dans le contexte de la partie 9 du CBO;
- les ventilateurs servant uniquement à l'extraction peuvent entraîner des problèmes de dépressurisation; on suggère donc qu'ils ne soient permis que dans les maisons qui ne posent pas de problèmes d'inversion de tirage ou d'émanation des gaz de combustion (p. ex. les maisons dont le générateur de chaleur et le chauffe-eau ne sont pas sujets aux émanations) ou alors dans les cas où l'on peut compter sur un concepteur qualifié (comme pour les installations mentionnées à la partie 6).

On remarquera que, compte tenu des progrès considérables qui ont été accomplis depuis le début de cette évaluation, plusieurs autres points d'interrogation ont été soulevés. Ainsi, les points qui suivent méritent d'être soulignés :

- L'évaluation, en partie à cause de contraintes financières, a été limitée à seulement un ou deux exemples de chacun des types d'installations. Un plus vaste programme de contrôle devrait être entrepris parallèlement à la mise en vigueur de l'édition de 1993 du CBO.

- Les résultats présentés dans le présent document ne doivent pas être considérés comme une vérification du bien-fondé des exigences du CBO de 1993, même s'ils justifient effectivement certains des changements qui ont été apportés.
- Outre les essais effectués lors de cette étude, il faudrait que d'autres mesures de la qualité de l'air intérieur soient prises afin de déterminer si le concept du ventilateur d'extraction primaire permet effectivement de répondre aux exigences de ventilation des habitations neuves, surtout que l'équipement installé dans les maisons à l'essai était généralement surdimensionné.

De toute évidence, des questions sont demeurées sans réponse. C'est pourquoi on recommande d'établir un programme qui permettra de maintenir les problèmes à un minimum et de faire en sorte que les nouvelles exigences sont adéquates lorsque l'édition révisée du CBO sera publiée en 1993, pour qu'ainsi les résultats soient prêts pour le prochain processus de révision en 1994.

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1. Introduction

This report presents findings of a demonstration project conducted by Buchan, Lawton, Parent Ltd. to test residential ventilation systems intended to meet the requirements of proposed changes to Article 9.32 of the Ontario Building Code. The demonstration and evaluation of these systems was commissioned in August 1992 by the Ontario New Home Warranty Program in conjunction with a group of industry partners including Ontario Ministry of Housing, Ontario Home Builders' Association, Ontario Hydro, Ontario Natural Gas Association, Canada Mortgage and Housing Corporation and the National Research Council.

The work involved testing new tract-built houses which were constructed incorporating the proposed revisions to OBC Mechanical Ventilation requirements and comparing these to houses built to present code requirements. Equipment and technical support to the builders constructing the new systems was provided by a consortium of HRV manufacturers and distributors, consisting of Conservation Energy Systems, Nutech Energy Systems Inc., and Venmar Ventilation Inc.

1.1 Background

Efforts to reduce energy consumption in Ontario's housing stock has led to implementation of measures to reduce air leakage through the building envelope by increasing air tightness. As first demonstrated by the R-2000 Program, this movement towards increased air tightness of houses has in increased awareness of indoor air quality problems and the need for adequate and effective ventilation.

With the implementation of requirements for continuous air barriers in the 1990 Ontario Building Code, steps were taken to increase ventilation requirements. The prescriptive requirements of Section 9.32 of the 1990 code have been received with skepticism by builders and home occupants alike and have proven to be of limited effectiveness. As a result, efforts have been directed at developing and implementing more comprehensive requirements for mechanical ventilation systems incorporating an effective degree of occupant control.

Currently, only the simple prescriptive ventilation system described in Part 9 of the 1990 OBC can be installed without the aid of a competent designer. Thus much of the effort has been directed at broadening and improving the alternatives available under Part 9.

In the summer of 1990, the Ontario New Home Warranty Program, in conjunction with industry partners, commissioned a study[2] of ventilation practices in the home building industry. The study, conducted by Habitechnica, consisted of items of work as set out below:

- surveying the industry for current practices, code interpretation, enforcement and perceptions
- technical analysis of the 1990 OBC requirements
- economic and energy analysis of ventilation system alternatives
- development of measures to address concerns and improve ventilation practices.

The work undertaken in this study flowed into the development of proposed changes to the Part 9 Requirements of the OBC with respect to mechanical ventilation. A set of proposals were put forward by the Ontario Ministry of Housing for incorporation in the interim revisions to the OBC scheduled for implementation in 1993. These proposals were circulated for public comment as part of the Code review process undertaken by the Ministry. The original proposals are included here as Appendix "B".

The proposals were refined on the basis of initial feedback to the Ministry over the summer months of 1992 and this Demonstration Project was implemented to test and gather information on the operation and effectiveness of ventilation systems which comply with the prescriptive requirements of the proposals.

1.2 Objectives

The objectives of this project were to determine whether the proposed changes to article 9.32 of the OBC and the resulting mechanical ventilation systems:

- are suitable for inclusion in Part 9 utilizing prescriptive requirements (it was felt that Part 6 systems have been adequately demonstrated by the R-2000 Program,)
- provide an adequate supply of fresh air (to meet health and safety guide-lines and occupant needs)
- are reasonably efficient, in that they avoid tempering with electric resistance heat,
- are uncomplicated (as simple as possible while still being effective)
- are durable/reliable (do not require excessive maintenance)
- use commercially available and practical technologies (lead the industry without being out of reach) and are within the capabilities of the builder and industry
- do not create problems in terms of heating systems or occupant comfort

2 Study of Residential Mechanical Ventilation (1990), Habitechnica Inc.

It was also felt that this project would provide an opportunity to obtain valuable feedback from the builders involved with relation to perceptions, difficulties and costs they incurred in meeting the requirements.

1.3 Scope of Work

The project scope, as originally planned, consisted of undertaking installation of four ventilation systems derived from the previous research and complying with the proposed changes to the OBC. As well a control system complying with 1990 OBC requirements was to be undertaken. The houses incorporating these systems would then be tested to evaluate system performance and effectiveness. Feedback would be obtained from the builders participating in the project as to costs and difficulties for the various systems.

It was intended that four test houses and a control house would be built in each of the Greater Toronto and the Greater Ottawa areas. A series of tests was planned with the houses in unoccupied and occupied states.

A series of tests was also planned for each of the houses to provide data on building envelope parameters, air flows and exchange rates, and air quality. A detailed description of the project structure and the work undertaken is presented in Section 2 - Project Design and Methodology.

1.4 Organization of this Report

This report is arranged as follows:

- Section 2 outlines the design and methodology of each stage of the project.
- Section 3 (in addition to the data in the appendices) summarizes findings from the demonstration, presents test results and data and discusses the performance of each system based upon the findings.
- Section 4 outline the preliminary conclusions and recommendations coming from the work thus far.
- Appendix A provides detailed descriptions of each installation and presents test results and data obtained from testing.
- The other appendices provide relevant background material such as the wording of Code Proposals at the time the demonstration was taken to the field.

2. Project Design and Methodology

Because the project was envisaged as a demonstration, it was decided that the proposed systems would be evaluated in a real world context. Each system was installed as part of the construction of a new house. Based upon the previously referenced study and consultation with the Project Partners it was determined that four different ventilation system/heating system configurations and a control system complying with the 1990 OBC requirements would be installed and evaluated. One of each of the systems were to be located in each of the Toronto and Ottawa areas so as to evaluate the impact of varying climatic factors and installation practices on system performance.

The following division of project responsibilities was arrived at:

- Buchan, Lawton, Parent Ltd., in consultation with the Project Partners , was responsible for finalizing the scope of the demonstration, acting as a resource during construction, as well as documenting the construction process and assessing performance;

- the Project Partners were responsible for securing builders, providing incentives to participate, including the supply of equipment as arranged through the manufacturers of ventilation equipment.

A number of changes to the scope of the project work subsequently occurred:

- Delays in securing builder participants and in construction/sales timing resulted in inspections of the installations and testing being undertaken simultaneously in December and January. Less than half of the houses were occupied when tested, resulting in a reduction of air quality test data.

- Only one control house constructed to meet the 1990 code requirements was available - in Kingston.

- An additional system incorporating a packaged ventilator (System 5) was added for evaluation, this system was to be evaluated on a single house (located in Desboro, Ontario)

- At the request and funding of a consortium of HRV manufacturers an additional system known as a simplified HRV installation (System 6) was added for evaluation, this system was evaluated on a single house (in the Ottawa region).

- The builder demonstrating System 2 in the Ottawa area was unable to participate in the project, as a result the second System 2 house was deleted from the project.

The refinements to the scope of work at various stages of the project are discussed in detail later in this section.

2.1 Ventilation System Selection

It was the wish of the Project Partners that the following generic ventilation/heating system combinations be evaluated as part of the project:

Control System	Fresh air intake opening to basement with electric tempering. Independent bathroom and kitchen exhaust fan (i.e. the 1990 OBC Part 9 prescriptive system.)
System 1	Fresh air intake with motorized damper connected to return air plenum of natural gas furnace. Principal exhaust fan interlocked with motorized damper and furnace fan.
System 2	Fresh air intake with fan and motorized damper connected to supply air plenum of natural gas furnace. Principal exhaust fan interlocked with fresh air intake fan, motorized damper and furnace fan.
System 3	Heat Recovery Ventilator connected to return air plenum of electric furnace, and interlocked with furnace fan.
System 4	Heat Recovery Ventilator ducted directly to living space, electric resistance baseboard heating

The following systems were added in accordance with the deliberations as described previously. Funding was available for demonstration of these systems in one house only:

System 5	Recirculating Packaged Ventilator connected to return air plenum of electric furnace, and interlocked with furnace fan.
System 6	Heat Recovery Ventilator with fresh air intake and stale air exhaust ducted to return air plenum of furnace.

Generic diagrams describing key characteristics of each of the proposed systems are provided in Appendix D. The actual layout of mechanical systems (as installed) are presented along with detailed test results in Appendix A.

2.2 Builder and House Selection

The Ontario Home Builders Association (O.H.B.A.) and the Ontario New Home Warranty Program (O.N.H.W.P.) undertook to secure builder participants for the project. The selection of builders and houses was based upon generic house/system specification criteria (as presented in Appendix D) and the availability of houses with construction schedules matching the project schedule. The builders/houses who participated are identified in Section 3.

Each of the participating builders was provided with:

- copies of the proposed changes to the OBC Part 9 proposed revisions to Article 9.32 (as modified for this project,)
- a description and copy of a system diagram (see Appendix D), and
- a description of project objectives.

On the basis of this material each builder was asked to interpret the provisions of the OBC and install the specified system in compliance with the prescriptive requirements. Support was provided by Buchan, Lawton, Parent Ltd., as well as the HRV manufacturers, regarding technical questions and concerns.

2.3 Draft Code Proposals

The draft OBC Proposals, compiled by the ONHWP on the basis of the previous research (see Appendix B), formed the basis of the specifications for the systems in the demonstration. The modifications as requested by the Project Partners are presented in Appendix C.

The major changes which were made involved incorporating provisions to permit installation of the System 2, a system which involves introduction of ventilation air via a direct connection to the supply air plenum. This system was added to test the feasibility of introducing cool air in a manner which did not affect warranties on furnace components. A summary of changes made are as follows:

9.32.3.3(3) and (4)
Kitchen exhaust fans capacity was changed to be a minimum of 50 L/s (100 cfm) as per CSA F326 requirements and a maximum of 75 L/s (150 cfm) to prevent depressurization as stated in Article 9.32.4. Bathroom exhaust fans capacity was changed to be a minimum of 25 L/s (50 cfm) and a maximum of 75 L/s (150 cfm).

Table 9.32.3.A. Note (2)
Duct sizes increases required when equivalent length exceeds 15 m (50 ft.) due to greater duct lengths inherent in central exhaust systems.

9.32.3.3(12)
Changes were made to incorporate System 2 connection to supply air plenum of furnace

9.32.3.3(14)
The static pressure rating for the ventilating fan should be increased to 50 Pa (.0070 psi)to reflect the additional duct lengths and capacity required when utilizing a central exhaust system.

Table 9.32.3.B.
Duct sizes were increased to allow for greater friction losses due to possible long lengths and to reflect commonly available and used diameters, 100 mm (4"), 125 mm (5"), 150 mm (6") respectively.

Table 9.32.3.B.- Note 2
The minimum threshold for duct design per Part 6 were increased to 30 m (100 ft.) due to greater duct lengths inherent in central exhaust systems.

9.32.3.3(15)
The minimum sound level rating of the ventilating fan was increased from 2.0 Sones (50 dBA) to 2.5 Sones (65 dBA) due to the limited availability of fans rated at less than 2.0 Sones in the **current** Ontario market.

9.32.3.3(16), (17) and (19)
Changes were made to incorporate requirements for System 2 connection to supply air plenum of furnace.

9.32.3.3(25)
Insulation requirements provided for fresh air intake ducts.

It is important to note that as this demonstration project, has been underway, the original building code proposals have undergone numerous other changes as a result of public commentary and work undertaken by the joint NBC/OBC Task Force. Further to submission of the Preliminary Report on the Demonstration Project in January 1993, further changes have been made to reflect those findings and simplify the total requirements. As a result the draft proposals used for this demonstration project bear little resemblance to more recent drafts for the 1993 version of the OBC.

For the demonstration project, some preliminary testing and development work was undertaken to establish requirements for the application. The connection of a fresh air intake to the supply plenum of a forced air furnace requires that the positive pressure in the plenum be overcome so as not to exhaust air through the intake. As a result an intake fan is required for this application. The development work on this system consisted of determining the fan characteristics and the control strategies required to avoid backflow through the intake, backwashing of furnace filters, cold drafts and other undesirable effects. The following tests were undertaken to supplement the design process:

1. Survey of Furnace Plenum Pressures
   Five forced air furnace installations were tested to determine the range of actual furnace plenum pressures. Pressure in both the supply and returns were measured relative to the house interior space and the differential pressures between the supply and return plenums were measured .

2. Fan/Plenum Flow Test
   A test rig was set up at Buchan, Lawton, Parent Ltd.'s Ottawa facilities to evaluate the impact of duct resistance and increasing plenum pressure on the rate of flow of a typical small ventilation fan supplying air into the plenum. The test was conducted with a fan and three different duct configurations and with plenum pressures ranging from 10 to 100 Pa.

Because this testing is not directly relevant to the demonstration, data from the tests are presented in Appendix E

2.4 Documentation of the Construction Process

Because of the relatively limited scope of the demonstration, two site visits were planned for each house to document the construction process:

- a site visit immediately prior to the installation of the ventilation equipment to review system installation requirements
- a final site visit to review the as-built condition

Much of the work of getting feedback from the builders was carried out at these points in the process. Due to delays in securing participating builders and in construction of the houses, the two planned visits were in most cases combined, or the as built condition was verified at the same time as the testing was undertaken.

2.5 House Testing and Data Gathering

To evaluate the effectiveness and performance of the systems, testing was planned to provide data in three primary areas:

- Building parameters
- Air exchange and system flow characteristics
- Air quality

It was intended that the data gathered in these three areas would provide information not only on the function and effectiveness of the ventilation system but also upon its interaction with the building envelope, heating system, and occupants. The specific tests and methodology undertaken are further discussed in the following section.

2.5.1 Building Parameters and Occupant Comfort

Two tests were undertaken to provide specific information on the characteristics of the house and to provide a basis for comparison among systems and houses tested.

Fan Depressurization Test
A fan depressurization test was conducted to determine the air tightness of the houses and to indicate general characteristics of the house. This test provides a basis for comparison in determining the extent of air leakage/infiltration and thus the need for and contribution/effect of the mechanical ventilation system.

The test was undertaken in accordance with CAN/CGSB-149.10 M86 with a Minneapolis Blower Door to a depressurization level of 50 Pa. The capability of the ventilation system components, other fans and air exhausting appliances to depressurize the houses was also measured.

Air Temperatures
A series of air temperature measurements were taken to determine outdoor air temperatures, air intake temperatures, exhaust stream temperatures, and the effects of incoming air streams upon the heating systems (ie. within the duct systems) and occupant comfort. This information provides a basis to extrapolate the effects of the system upon heating/air handling systems and occupant comfort in worst case conditions.

2.5.2 Air Exchange and Flow Characteristics

The effectiveness of the ventilation system was gauged by two direct test measurements taken in the home:

Ventilation Duct Air Flows
Duct air flow measurements were taken to determine the component of ventilation rates provided by the mechanical ventilation systems. The intake and exhaust air flow rates were measured using "flow-cal" collars temporarily installed in the intake and exhaust air ductwork. Measurements were taken with a micromanometer.

Air Change Rates via Tracer Gas
A tracer gas test was used to determine effective air change rate with the ventilation systems in operation. The entire house was "seeded" with SF6 (Sulphur Hexafluoride) tracer gas and samples taken at two locations (bedrooms/second floor and living room/kitchen first floor) in each house over four twenty minute intervals. The samples were analysed in the laboratory and the air change rate calculated by ORTECH International, following procedures outlined in ASTM Standard E741-83, "Determining Air Leakage Rate by Tracer Dilution".

2.5.3 Air Quality

In addition to direct measurement of air change, the effectiveness of ventilation systems was gauged indirectly by contaminant measurements taken in the home. Specifically, the following pollutant concentration measurements were taken:

Formaldehyde
Seven day Formaldehyde samplers were placed in occupied homes to provide an indication of indoor air quality, sources of pollution and adequacy of ventilation. Due to the limited number of occupied units only two results were obtained.

Carbon Dioxide
Instantaneous carbon dioxide samples were also used as an indicator of indoor air quality and adequacy of ventilation in occupied homes.

3. Summary of Results

The houses in the study were constructed and ventilation systems installed in the fall and early winter of 1992. The following information was obtained.

3.1 Documentation of the Construction Process

During the construction phase of the project, several important findings were brought out.

Use of Flexible Duct work
Firstly, it appeared that installers have a preference for using flexible ducting to carry cool air. In such locations, the use of flexible duct, appears to be common practice because the ducts would have to be insulated and pre-insulated flexible duct is readily available for purchase. The flow resistance of flex duct will have a direct effect on the sizing requirements for the affected runs but some installers forgot to take this into account.

The installers had a tendency to size ductwork according to the requirements contained in the OBC table and overlooked corrections for using flex duct. (The tables which the installers were given assumed rigid ductwork with corrections for use of flexible duct.) For ease of use, consideration should be given for providing equivalent flexible duct sizes in the tables.

Controls and Operation
Secondly, a great deal of difficulty was experienced correctly installing the controls and wiring necessary to properly interlock fans, damper, and furnace operations to achieve balanced operation of System 1. The interconnection of the motorized damper, exhaust fan and furnace fan appears to present the greatest difficulty. Depending on the control strategy used by the furnace manufacturer, it appears that most ventilation installers will need to install a mixture of line voltage and 24 volt control wiring (with relays needed in some cases) to achieve the desired interlock.

Quite simply, the interlock was not easily achieved and it resulted in some confusion for several installers. Moreover, because of variations in the internal wiring contained in various furnaces, there is not a "universal fix" or wiring diagram which could be used in all cases. For a successful interlock to be accomplished, it would seem that, on the basis of the limited number of houses contained in this study, furnace manufacturers should produce a recommended wiring diagram for each model of furnace they make.

The HRV equipped systems appear to have an advantage in this area, as the HRV comes equipped with a pre-packaged control system which energizes the intake and exhaust fans in parallel so that they are relatively balanced. A level of support and experience is also present in the manufacturers of the equipment which is not available where individual components are being assembled for a ventilation system.

Excess Capacity of Ventilating Fans

Another important observation relates to the fact that the builders participating in the study in some cases installed fans which were of a significantly larger capacity than would have been required by the calculated ventilation capacity required in the proposed changes of the OBC (i.e. Table 9.32.3B.) If one reviews the data relating to air flows carried by ventilation fans in this study, one will note that a number of ventilating fans installed in the demonstration houses exceed the ventilating fan capacities prescribed in the proposed code changes. Heat recovery ventilator based systems also appeared to present similar difficulties in that they are typically rated for capacities exceeding those prescribed in the proposed revisions.

The reasons for this excess capacity relate to other selection criteria for fan equipment. Builders were required to install fans conforming to a low noise rating (i.e. 2.5 sones or less). A limited number of fans are available in the market which meet this threshold, as a result, some difficulty was experienced sourcing equipment which would provide low sone rating in the desired range of airflows. Typically, low sone fans are of better quality and manufactured to provide higher flows as well. Since the ventilation capacity was a minimum requirement, builders chose to use of fans of greater capacity than that required.

Text of Proposed Revisions

Finally, builders experienced considerable difficulty understanding the intent and scope of requirements of the proposed changes. The use of extensive cross referencing from one clause to another when relating to the components and their operation made it quite difficult to understand the material. In this respect, a picture is worth a thousand words; it appeared that the diagrams provided as part of the project documentation went a long way towards maximizing their understanding of the components and acceptable system.

An example of the problems encountered, as a result of the complicated wording, is provided by the System 1 house in Kingston, Ontario. Being unclear as to the intent of why the location of the air inlet to the return air plenum was important, the contractor wrongly connected the duct to the most convenient location, which in this house was at the end of the plenum (well beyond several branches.)

It appears that improvements to the wording of clauses, such as changes which would unify requirements for key components in an all-encompassing clause are needed to help builders understand the requirements and, thereby, to achieve compliance. The pictorial representation of the requirements simply cannot illustrate all conditions.

3.2 House Testing and Data Gathering

Preliminary data has been received pertaining to house testing as of the writing of this report.

3.2.1 Building Parameters and Occupant Comfort

Depressurization

Table 1 presents the results of the fan depressurization testing of the homes in the study. In addition to the results presented in terms of air tightness (i.e. Air Changes at 50 pa.), the Table indicates the unbalanced air flow which would cause a depressurization of 5 pa. across the building envelope. 5 pa. is widely considered to be the safe depressurization limit for homes containing "spillage susceptible" equipment. In other words, at flows beyond the range specified in the table, make-up air would be required to control house pressures.

Test results indicate a high level of air tightness, indicating that air sealing measures are being effectively implemented b the builders. As a result excessive depressurization is of concern in houses where spillage susceptible devices are present. The calculations presented in column 3 of Table 1 indicate the unbalanced flows required to depressurize each house to 5 Pa. All of these houses would be depressurized beyond this limit, by flows of less than 150 cfm (75 L/s) and a number of the houses would be depressurized by flows of less than 50 cfm (25 L/s), a level at which many common bathroom fans are rated.

In terms of the testing of the depressurization potential of installed systems, none of the systems appear to cause excessive depressurization of the houses under normal operation. Based on the fact that the sample houses were quite air tight, it can only be assumed that the exhaust fans in the houses were moving far less air than indicated by the manufacturers' ratings. The HRV unit in the System 4 house tested in Jackson's Point caused depressurization in the range of 4 Pa, in the defrost mode. All other houses tested had little or no depressurization attributable to operation of the air exhausting appliances (please refer to Appendix A for detailed test results).

Table 1 - FAN DEPRESSURIZATION TEST RESULTS

System/House	Air Change Rate (ACH) @ 50 Pa	Flow Required to Cause 5 Pa Depressurizaton (cfm)	House Volume cu. ft.	Max. Depress. Caused by House Exhaust Systems	Test Conditions (See Note)
Control House - Kingston	Not Available		18,630		
System 1 - Kitchener	1.46	84	26,691		
System 1 - Kingston	1.51	63	14,727	2 Pa	1
System 2 - Mississauga	2.12	93	22,716	1 Pa	2
System 3 - Desboro	0.77	36	14,421		
System 3 - Ottawa	1.42	26	14,408	4 Pa	4
System 4 - Jacksons Point	2.42	57	9,845	5 Pa	3
System 4 - Carleton Place	1.77	35	13,102	0	5
System 5 - Desboro	0.67	37	14,350		
System 6 - Ottawa	2.32	105	30,795		

NOTES: Test Conditions

1. 2 Bathroom exhaust fans (Manufacturer's Rating - 75 cfm)
2. Kitchen Hood + 3 Bathroom fans (Manuf. Rating - 170 cfm and 50 cfm)
3. HRV in defrost mode + clothes dryer.
4. HRV in defrost mode.
5. HRV has electric defrost.

(Exhaust fans appear to be performing below manufacturers' ratings).

Air Temperatures
Table 2 summarizes test data relating to house and ventilation air temperatures. The table not only attempts to summarize data obtained during test conditions, but also, the temperature in the home in the depths of winter. Temperature difference measurements were proportionately extrapolated to estimate temperatures at the mid-winter January extreme of -25°C. (-25°C is equivalent to the 2.5% design temperature for January in Ottawa).

To some extent each house represents a unique case which can be best understood in terms of the geometry of locations of ducts, intakes and branches on the system. For this reason, the detailed temperature measurement data at various points on each system is also presented on the system configuration diagrams in Appendix A.

In terms of concerns identified in this series of measurements, System 2 (connection of fresh air intake to the supply plenum), in Mississauga, presents the most clear cut example of temperature distribution problems caused by inadequate mixing of ventilation air. Findings indicate that, because the intake air is not passed through the furnace fan, it is not well dispersed in the supply plenum. The supply air system branches in a "T" connection soon after the connection point for fresh air. This results in a cold area near the fresh air intake and which continues along the adjacent side of the plenum. The stream of air on the affected branch of plenum duct was found to be from 10°C to 15°C colder than other areas of the plenum.

The duct air temperature problem is not the only problem with System 2. The installation/configuration in this house is such that the two plenum branches form the main heating supply ducts for opposite ends of the house. As a result one end of the house is significantly colder than that served by the opposite branch (to the front of the house). The temperature difference was measured at approximately 12°C and was confirmed not only within the branch ducts but also at the floor registers at either end of the house.

In most other cases, adequate mixing occurred within the ductwork. Naturally, systems which incorporate a heat recovery ventilator will tend to have warmer intake air temperatures and warmer mixed air temperatures. But other non-heat recovery ventilation systems are worth considering. For example, air temperatures in the System 1 houses were checked to determine if adequate mixing within the return plenum was taking place and the resultant temperatures at the entrance to the furnace. Based upon the results in the two houses examined, it appears that the air streams are well mixed prior to entering the furnace heat exchanger, due to the increased turbulence caused by the directional change air movement in the plenum as it passes from horizontal to vertical. In both of the houses tested, air temperatures entering the furnace were 18°C and 21°C (at outdoor temperatures of -5°C and 4°C respectively.)

Although the System in Kingston was originally installed incorrectly, it provides another indication of the interaction of air temperature and relative volumes of intake and recirculation air which are mixing. As the volume of recirculating air increases - which is graphically illustrated by inflow from each return inlet as air passes down the plenum - the ever increasing ratio of warm house air to cold outside air increases and the overall mixed air temperature in the plenum increases. In this case, the temperature of air in the ductwork at the furnace was almost equivalent to the house air temperature.

Table 2 - AIR TEMPERATURE TEST RESULTS / FORCED AIR HEATING SYSTEMS

System/House	Outside Air Temperature (C)	House/R.A. Temp	Air Temp. Inside @ Test Condition		Estimated Air Temp. @ - 25 C	
			Minimum Temp. in R.A. Plenum	Mixed Air Temperature	Est. Min. Temp. in R.A. Plenum	Est. Mixed Air Temperature
System 1 - Kitchener	-5	21	-1	18	-17.92	15.69
System 1 - Kingston	4	22	17	21	8.94	19.39
System 2 - Mississauga	1	64	29	45	14.56	37.16
System 3 - Desboro**	-3	23	20	20	17.46	17.46
System 3 - Ottawa**	-13	26	20	22	17.63	20.77
System 5 - Desboro	N/A	N/A	N/A	N/A	N/A	N/A
System 6 - Ottawa**	-11	22	20	21	19.15	20.58

* Connection to supply plenum of furnace
** HRV Connection to Return Plenum

3.2.2 Air Exchange and Flow Characteristics

Another measure of effectiveness of the ventilation systems was the air exchange characteristics of the systems.

Flows and Air Change Rates

Table 3 provides a summary of the ventilation flow rates and tracer gas measurements of effective ventilation rates. The preliminary data from the tracer gas testing indicates that all of the houses equipped with mechanical ventilation systems were provided with effective rates of ventilation well above that of the control house. The reasons for this are twofold: firstly, the way fresh air is distributed by the forced air heating system is according to heating requirements (larger open areas of the house, such as the living areas, effectively get more ventilation air), secondly, as previously mentioned, the fans which were installed often had a capacity significantly greater than the required minimums indicated in the proposed code changes.

Effectively, in the two points measured in each house, air change rates were well in excess of the 0.3 to 0.5 AC/h range. The rate of air change in the control house, although meeting this threshold, was well below that in the other demonstration houses.

The actual rates of air change measured far exceed those which would be estimated based upon a simple sum of the prescribed ventilating fan capacity and the estimated natural infiltration rate. It appears that the effective rate of ventilation in the house is affected by the ventilation system, as well as by the forced air heating system distributing air throughout the house. For example, in the System 1 house examined in Kitchener, the rate of air exchange is significantly higher in the kitchen location than the bedroom location. It is important to note features of the kitchen area of this house which may affect the amount of ventilation it receives:

- kitchen is open to family room, breakfast area, entry and stairs to basement and second floor.
- a large number of windows in the kitchen/breakfast area results in a large number of heating floor registers, supplying the area with larger quantities of fresh air, the greater number of windows may also contribute to increased envelope air leakage in this area.
- the ground floor kitchen area is closer to the furnace, resulting in delivery of greater air volumes (i.e. shorter duct length resulting in higher rates of air flow).

The bedroom, by contrast, although in closer proximity to the exhaust fan, is an enclosed space with a single heating floor register beneath a single window, and at a greater distance from the distribution source. (Note: tracer gas testing was conducted with all interior doors in open positions to provide an indication of whole house air change rates).

The System 4 house, with electric baseboard heating, tested in Jackson's Point, by contrast, shows the closest correlation between estimated natural infiltration, installed ventilating capacity and tracer gas test results.

Ventilation Capacity vs. House Volume

The sample of houses tested illustrates the divergence between calculating the required ventilating capacity based upon the number of bedrooms versus a whole house air exchange rate. The results indicate that the total capacity of the prescribed ventilating systems to house volume range from 0.15 AC/h to 0.37 AC/h, with the majority between 0.19 and 0.25 AC/h. It should be noted that the house with the greatest prescribed rate of ventilation does not have a basement, which therefore decreases the volume of the house.

Table 3 Air Flows and Air Change Rates

System	**Prescribed Ventilating Fan Capacity** (Based on No. of bedrooms)	**Tracer Gas Test[1] - Air Change Rate** Average	**Tracer Gas Test[1] - Air Change Rate** Kitchen/Living Room (First Floor)	**Tracer Gas Test[1] - Air Change Rate** Bedroom(s) (Second Floor)	**Ventilation Flow & Air Change Rate[2]** (As Measured)
Control House	0.19 AC/h 60 cfm	0.31 AC/h 95 cfm	0.23 AC/h 71 cfm	0.38 AC/h 118 cfm	N/A
System 1 Kitchener	0.17 AC/h 75 cfm	0.52 AC/h 233 cfm	0.68 AC/h 162 cfm	0.36 AC/h 105 cfm	0.16 AC/h 70 cfm
System 1 Kingston	0.24 AC/h 60 cfm	0.61 AC/h 149 cfm	0.65 AC/h 159 cfm	0.56 AC/h 137 cfm	0.35 AC/h 86 cfm
System 2 Mississauga	0.20 AC/h 75 cfm	0.83 AC/h 314 cfm	0.94 AC/h 355 cfm	0.72 AC/h 273 cfm	0.36 AC/h 135 cfm
System 3 Desboro	0.25 AC/h 60 cfm	1.28 AC/h 307 cfm	1.19 AC/h 286 cfm	1.38 AC/h 331 cfm	0.52 AC/h 125 cfm
System 3 Ottawa	0.19 AC/h 45 cfm	0.70 AC/h 168 cfm	0.82 AC/h 197 cfm	0.59 AC/h 141 cfm	0.47 AC/h 114 cfm
System 4 Jackson's Pt.	0.37 AC/h 60 cfm	0.63 AC/h 103 cfm	0.75 AC/h 123 cfm	0.51 AC/h 83 cfm	0.44 AC/h 72 cfm
System 4 Carleton Place	0.27 AC/h 60 cfm	0.72 AC/h 157 cfm	0.60 AC/h 131 cfm	0.84 AC/h 183 cfm	0.50 AC/h 110 cfm
System 5 Desboro	0.25 AC/h 60 cfm	N/A	N/A	N/A	N/A
System 6 Ottawa	0.15 AC/h 75 cfm	0.86 AC/h 441 cfm	0.75 AC/h 384 cfm	0.97 AC/h 498 cfm	0.18 AC/h 92 cfm

Notes:

1 Tests undertaken with interior with doors open.
Samples were analysed in the laboratory and the air change rate calculated by ORTECH International, per ASTM Standard E741-83.

2 Greater of measured exhaust or intake air streams. Measured using "flow-cal"duct collar.

- Air change rates or flows determined from house volumes as contained in Table 1 and in Appendix A.

3.3.3 Air Quality

The air quality portions of the data collection are the most limited aspects of the project at this point. No contaminant problems have been found, but only limited testing has been undertaken. Less than half of the houses were occupied at their most recent site visit; therefore no air quality testing was undertaken because the data would not represent realistic performance. In an unoccupied house, the absence of occupants limits pollutant generation on the one hand and limits ventilation on the other because there is no one available to operate the system in a normal manner.

Further, because the ventilation capacities the builders chose to install were well above what was needed as a minimum flow rate, the data would not represent a suitable assessment of the proposed ventilation rates.

Table 4 - AIR QUALITY TEST RESULTS

System/House	Number of Occupants	Carbon Dioxide CO_2	Formaldehyde ppm
System 1 - Kitchener	4	425 ppm	
System 3 - Ottawa	2	625 ppm	
System 4 - Carleton Place	N/A	N/A	0.06 ppm
System 4 - Jackson's Point	2	650 ppm	0.02 ppm
System 6 - Ottawa	4	517 ppm	
Maximum Acceptable Levels [1]		3500 ppm [1,2]	0.10 ppm [1]

Notes:

1 Maximum Acceptable Levels per: "Exposure Guidelines for Residential Indoor Air Quality", Health and Welfare Canada, 1989.

2 Maximum acceptable level for long term exposure. 1000 ppm is recommended by A.S.R.A.E. as an indicator of adequate ventilation rates.

4. Conclusions and Recommendations

Based upon the data obtained, it appears that all of the systems demonstrated, provide adequate rates of ventilation to provide control of contaminants.

The tracer gas testing indicates that all of the houses equipped with mechanical ventilation systems are provided with effective rates of ventilation exceeding 0.3 AC/h based on house volume. (0.3 AC/h was the air change rate threshold set by the 1990 OBC) and are more effective than the 1990 OBC prescriptive system. The rate of air change in the control house, although meeting this threshold, is well below the rate in those houses with the proposed mechanical ventilation systems. It is important to note, however, that in almost all of the systems tested the air flow capacities of the systems installed, were well in excess of the air flows required by the room count approach of the draft code changes (see Appendix C).

Notwithstanding the acceptable level of performance of the demonstrated systems, a number of issues were highlighted which indicates that these systems are too complex to be executed under prescriptive Part 9 requirements. This indicates that balanced exhaust fan systems would best be handled by a competent designer under Part 6 provisions of the OBC. A number of construction and performance related issues encountered (as explained below) suggest directions for simplification and changes to the Part 9 requirements.

Construction and Implementation Issues

Text of Code
Most builders experienced some difficulty in understanding the intent and requirements of the proposed revisions to the OBC. The use of extensive cross referencing from one clause to another, relating system components to their operation, makes understanding the material difficult. Simplifying the language of this section would go a long way to helping builders understand the requirements and achieving compliance.

Controls Interconnection with Heating Appliances
The evidence that clarity of the text is a problem shows up in examples, such as System 1, where a great deal of difficulty was experienced in correctly installing the controls and wiring necessary to achieve balanced operation. The interconnection of the motorized damper, exhaust fan and furnace fan appears to present the greatest difficulty. (This can be partly attributed to the range of furnace equipment available on the market and the differences in their internal controls.) Clearly, the interlock requirements are going to be a weak spot in the design of prescriptive systems.

Equipment Availability and Selection
A number of ventilating fans (or HRV's) installed in the demonstration houses exceed the ventilating fan capacity prescribed in the proposed code changes. This over capacity can, in part, be attributed to the limited availability of and difficulty in finding fans with the required capacities which perform to the

prescribed low sone rating (2.5 Sones or less.) From the builder's perspective, installing a quiet fan which is larger than required, ensures that adequate rates of ventilation are provided. However from the research perspective, this does present difficulty in assessing or predicting the effectiveness of systems when equipment becomes available to more closely meet the prescribed capacities.

The requirement that the Principal Exhaust Fan conform to a low sone rating may be redundant in some cases, most notably when the system is combined with forced air heating systems, because fan noise is far exceeded by noise levels caused by furnace fan operation. The requirement that the furnace fan, ventilating fan and motorized damper (or HRV) be interlocked ensures that the noise levels generated by the furnace fan will exceed that produced by the ventilating fan. Consideration could be given to easing the low sone requirement in situations where the ventilating fan is to be located in a basement, dedicated mechanical room or where the fan is a through-wall type with exterior motor housing, (i.e. if the fan is not located within the living space and thus will not be heard by the occupants.)

Other common tendencies amongst installers was the tendency to use flexible duct, a common practice especially for the areas requiring insulated duct, due to the availability of pre-insulated flexible duct. The equipment sizing tables in the OBC proposals are presently sized for rigid ductwork; consideration should be given for providing equivalent flexible duct sizes in the tables.

The requirement that the outside air supply duct, connected to return plenum, conform to Part 6 requirements for supply ducts, appears to be redundant where the balance of the return plenum is not required to conform to this requirement.

Performance Issues

A number of performance issues were identified which would indicate the limitations of a prescriptive approach to ventilation requirements. This would suggest that design of an appropriate system under Part 6 of the OBC would be more effective in overcoming problems brought about by variations with house sizes and design characteristics.

Air Tightness/Depressurization

With the equipment installed in the homes, none of the systems appeared to cause excessive depressurization of the houses under normal operation. However, because many houses were unoccupied when tested, some exhaust devices such as dryers had not yet been installed.

Although none of the houses tested was shown to experience a problem with excessive (beyond 5 Pa) depressurization, the results indicate that high levels of air tightness is being achieved by the builders through sealing of the envelope. (The HRV unit in the System 4 house tested in Jackson's Point caused some significant depressurization, but this occurred only when the device was operating in the defrost mode.) Calculations based upon results of the fan depressurization tests indicate that all of the houses are capable of being depressurized in excess of 5 Pa by unbalanced exhaust flows (caused by dryers, kitchen and bath fans) of less than 100 cfm. This is well below the threshold of 75 L/s (150 cfm), established in the OBC proposals (and the 90 L/s (180 cfm) limit proposed by some authorities), as the point at which exhaust devices will require make-up air.

Sizing of Ventilation Capacity
The ventilation requirements for the set of houses in the Demonstration Project illustrate the divergence between the occupancy/bedroom count approach to determining ventilating capacity and a whole house approach. If the ventilation systems installed in these houses were closer matched to the prescribed requirements and no additional ventilating capacity was added (i.e. bathroom and kitchen exhaust fans), it may be that inadequate ventilation could result because of the low ventilation rate in relation to house volumes. In almost all cases the prescribed rate of ventilation based upon bedroom count is well below the 0.3 air changes/hour rate which is required by the 1990 OBC on the basis of house volume. The proposed calculation method will, therfore, significantly reduce the capacity of the mechanical ventilation system which is required.

Distribution of Ventilation Air
The actual rates of air change measured, far exceed those which would be estimated based upon a simple sum of the ventilation flows and the estimated natural infiltration rate. It appears that the effective rate of ventilation in a specific area of the house is affected by air movement and distribution created by the forced air heating system as well as the air change rate provided by the ventilation system.

Comfort and Air Temperature Problems
The evidence gathered suggests that great care is going to be required in the installation of any system which provides supply of ventilation air to areas of the house with minimal tempering. Some of the problems which were identified in various houses in this regard relate to comfort and possible adverse effects to heating equipment, these include:

- drafty areas as a result of cool air introduced into plenum or living space,
- concerns about uneven distribution of ventilation air,
- poor heat distribution resulting from cold air streams in supply plenum,
- concerns about temperatures to which furnaces (i.e. heat exchangers) would be subjected in extremely cold outdoor conditions.

It is important to note that subsequent changes to the proposed Section 9.32 have resulted in the draft proposals used here bearing little resemblance to the final version of the 1993 OBC. However, the findings provide useful information for Part 6 designers bringing untempered air into heating system plenums. In addition this research provided a number of general themes and directions for further development of residential mechanical ventilation systems as well as for the evolution of the building code requirements.

The experience of this project suggests that the prescriptive requirements of Part 9 of the OBC should be kept as simple and easy to follow as possible using pre-designed/engineered technology. More complex interlocked and balanced (supply/exhaust) systems should be handled under Part 6 provisions of the code and designed by competent professionals.

Simple exhaust only systems appear to be feasible for inclusion as Part 9 systems, provided they are implemented only in situations where make-up air is not required (i.e. no spillage susceptible appliances) and where forced air heating systems are in place to distribute fresh air which enters via air leakage.

Appendix A

Detailed System Description and Test Results

1. Control House

System Description:	Six inch fresh air intake duct/opening to basement with in line electric resistance heater for tempering, separate four inch combustion air supply duct to gas fired furnace and water heater. Point exhaust fans: kitchen range hood and bathroom exhaust fan.
Location:	Kingston
Builder:	Dacon Corporation,
House Description:	1 Storey, 3 Bedroom, Full Basement
Heating Source:	Forced Air Gas Heating
Status/Comments:	• Inspection conducted Oct. 26, 1992, with system installed. Testing conducted Dec. 16, 1992 • The house was vacant, purchase/occupancy status unknown.

Test Results

Building Parameters

Fan Depressurization	Not Available
House Volume	18,630 ft^3
Depressurization	
Bathroon Fan Operation	0
Kitchen Range Hood Operation	0

Intake Air Temperature — Tempering to 20° C by electric resistance heater

Air Exchange and Flow Characteristics

Duct Air Flow Measurements	
Intake Air Flow	Not Measurable
Exhaust Air Flow	Not Measurable
Tracer Gas Tests	
Calculated Air Change Rate - Bedroom	0.38 AC/h = 118 cfm
Calculated Air Change Rate - Kitchen	0.23 AC/h = 71 cfm
Calculated Average Air Changes for House	0.31 AC/h = 95 cfm

Air Quality

House not occupied no testing.

2. System 1

2.1 System 1 - Kitchener

<u>System Description:</u>	Six inch fresh air intake duct with motorized damper connected to Return Air Plenum. Bathroom fan in 2nd floor bath has been upgraded and designated as the Principal exhaust fan. Principal exhaust fan is interlocked with motorized damper and furnace fan. Point exhaust fans: kitchen range hood and two additional bathroom exhaust fans.
Location:	Kitchener
Builder:	Ian Cooke Homes,
House Description:	2 Storey, 4 Bedroom, Full Basement
Heating Source:	Forced Air Gas Heating, high efficiency sealed combustion.
Status/Comments:	Operation of interlock/controls was to be corrected. Ventilation fan was activated when furnace fan operated whether or not ventilation is requested by occupants. When ventilation fan is activated by manual switch furnace fan and motorized damper are correctly activated.

Test Results

Building Parameters

<u>Fan Depressurization</u>

Air Flow @ 50 Pa	658 cfm / 1.46 AC/h
Equivalent Leakage Area	46.06 in^2
Estimated Natural Infiltration Rate	45.8 cfm / 2,748 cfm
House Volume	26,961 ft^3

Estimated Air Changes by Natural Infiltration: $2748 \div 26961 = 0.10$ AC/h

<u>Depressurization</u>

Bathroon Fan Operation	N/A
Kitchen Range Hood Operation	N/A

<u>Air Temperatures</u> — See Figure

Outdoor/Intake Temp.	-5 °C
Intake @ return plenum connection.	-1 °C
House/Return temp,.	21 °C
Return plenum at entry to furnace.	18 °C

Air Exchange and Flow Characteristics

Duct Air Flow Measurements

Intake Air Flow	51 cfm = 0.11 AC/h
Estimated Exhaust Air Flow	75 cfm = .017 AC/h

(exhaust flow estimate based upon fan rating of 80 cfm @ 50Pa coupled to approximately 4 ft. of flexible duct and exhaust hood)

Tracer Gas Tests

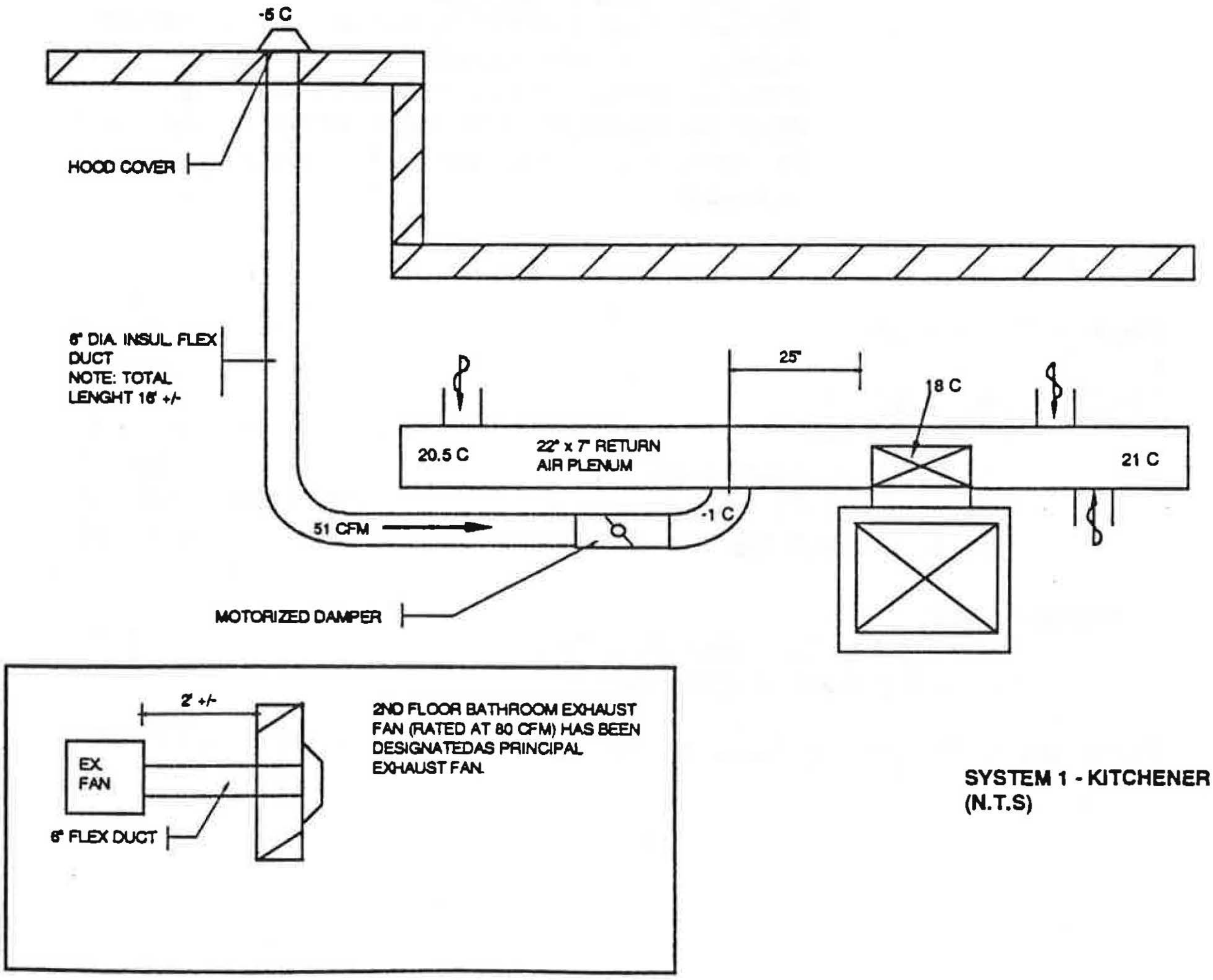
Calculated Air Changes - Bedroom	0.36 AC/h = 162 cfm
Calculated Air Changes - Kitchen	0.68 AC/h = 305 cfm
Calculated Average Air Changes for House	0.52 AC/h = 233 cfm

Air Quality

Formaldehyde — N/A

Carbon Dioxide — 425 ppm

FIGURE - System 1 Kitchener - Installation Layout and Test Results



2.2 System 1 - Kingston

<u>System Description:</u>	Six inch fresh air intake duct with motorized damper connected to Return Air Plenum. Principal exhaust fan in basement with intake at 2nd floor corridor. Principal exhaust fan is interlocked with motorized damper and furnace fan. Point exhaust fans: two bathroom exhaust fans. (Recirculating kitchen range hood)
Location:	Kingston
Builder:	Dacon Corporation,
House Description:	2 Storey, 3 Bedroom, Full Basement
Heating Source:	Forced Air Gas Heating
Status/Comments:	• Inspection conducted Oct. 26, 1992, system not installed at that time. • Fresh air intake duct originally incorrectly connected at end of return plenum i.e. upstream of all return branches. This has since been changed with <u>no change in flows measured.</u> • Operation of interlock/controls has been corrected. Ventilation fan was activated when furnace fan operates whether or not ventilation was requested. When ventilation fan was activated by manual switch furnace fan and motorized damper were correctly activated.

Test Results

Building Parameters

<u>Fan Depressurization</u>

Air Flow @ 50 Pa	372 cfm/1.51 AC/h
Equivalent Leakage Area	31.66 in^2
Estimated Natural Infiltration Rate	25.9 cfm / 1,554 cfh
House Area/Volume	14,727 ft^3

<u>Depressurization</u>

Bathroon Fan Operation (2 @ 75 cfm)	2 Pa
Ventilation System Operation	0 Pa

Estimated Air Changes by Natural Infiltration $1554 \div 14727 = 0.11$ AC/h

Air Temperatures

	See Figure
Outdoor/Intake Temp.	5 °C
Intake @ return plenum connection.	6 °C
House temp,.	22 °C
Return plenum temp.	Varies
Return plenum at entry to furnace.	22 °C

Air Exchange and Flow Characteristics

Duct Air Flow Measurements

Intake Air Flow	51 cfm = 0.21 AC/h
Exhaust Air Flow	86 cfm = 0.35 AC/h

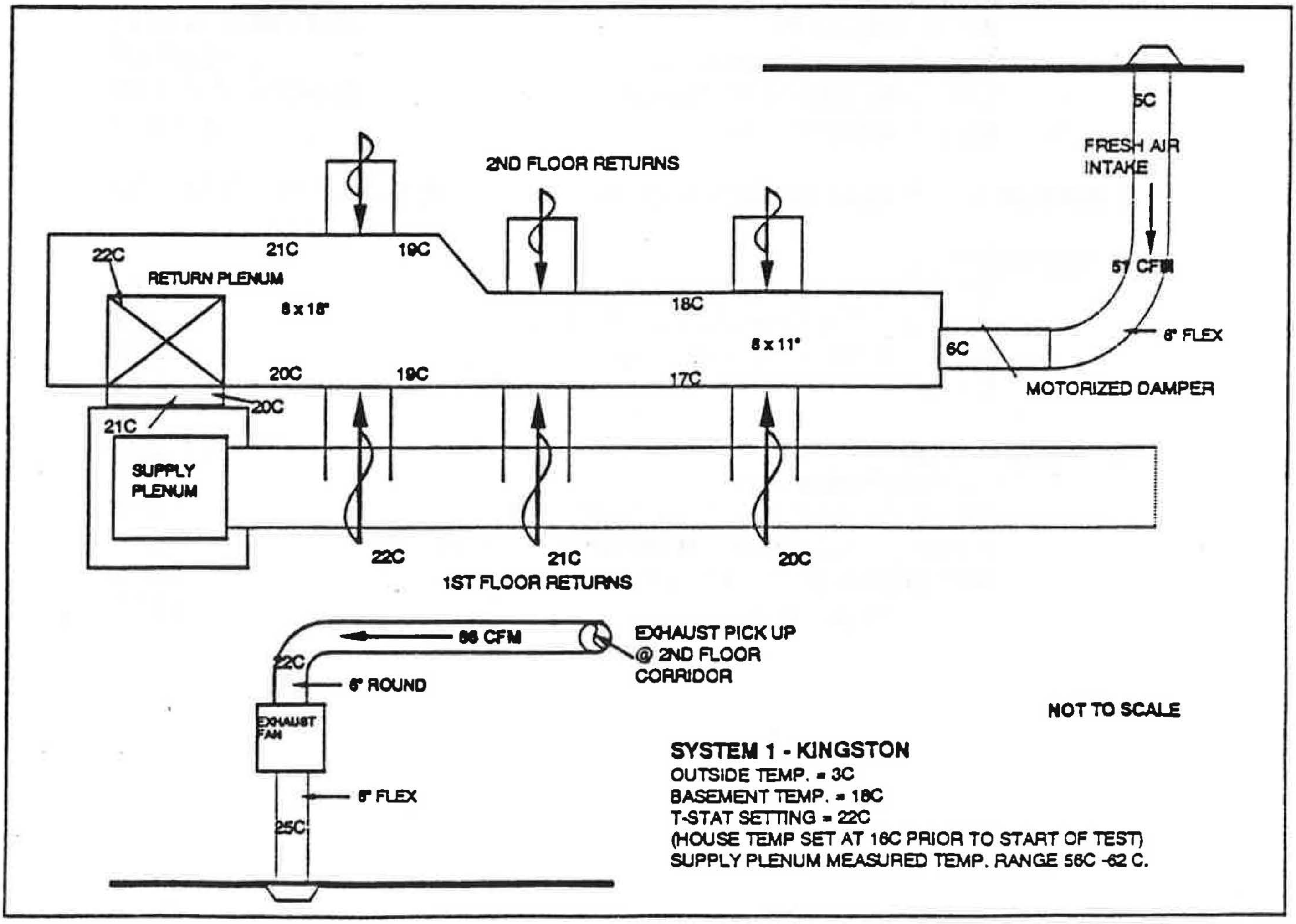
Tracer Gas Tests

Calculated Air Changes - Bedroom	0.56 AC/h = 137 cfm
Calculated Air Changes - Living/Dining	0.65 AC/h = 159 cfm
Calculated Average Air Changes for House	0.61 AC/h = 149 cfm

Air Quality

House not occupied

FIGURE - System 1 Kingston - Installation Layout and Test Results



3. System 2 - Mississauga

<u>System Description:</u>	Fresh air intake with fan and motorized damper connected to <u>supply air plenum</u> of furnace. Principal exhaust fan in basement with inlet at 1st floor. Principal exhaust fan interlocked with fresh air intake fan, motorized damper and furnace fan. Point exhaust fans: kitchen range hood and three bathroom exhaust fans.
Location:	Mississauga
Builder:	The Daniels Group Inc.,
House Description:	2 Storey, 4 Bedroom, Full Basement
Heating Source:	Forced Air Gas Heating
Status/Comments:	

Test Results

Building Parameters

<u>Fan Depressurization</u>

Air Flow @ 50 Pa	804 cfm/2.12 AC/h
Equivalent Leakage Area	52.45 in^2
Estimated Natural Infiltration Rate	46.6 cfm / 2,796 cfh
House Area/Volume	22,716 ft^3

Estimated Air Changes by Natural Infiltration: $2796 \div 22716 = 0.12$ AC/h

<u>Depressurization</u>

Ventilation System Operation	0 Pa
Bathroon Fan Operation (3 @ 50 cfm)	0 Pa
Kitchen Hood (1 @ 170 cfm)	1 Pa
Dryer	0 Pa

<u>Air Temperatures</u> — See Figure

Outdoor/Intake Temp.	-2 °C
Intake @ Supply plenum connection.	4 °C
Supply plenum temp. at intake connection	29° C
Supply plenum at exit from furnace.	64 °C
House temp. setting	22 °C

Air Exchange and Flow Characteristics

Duct Air Flow Measurements

Intake Air Flow	135 cfm* = 0.36 AC/h
Exhaust Air Flow	132 cfm = 0.35 AC/h

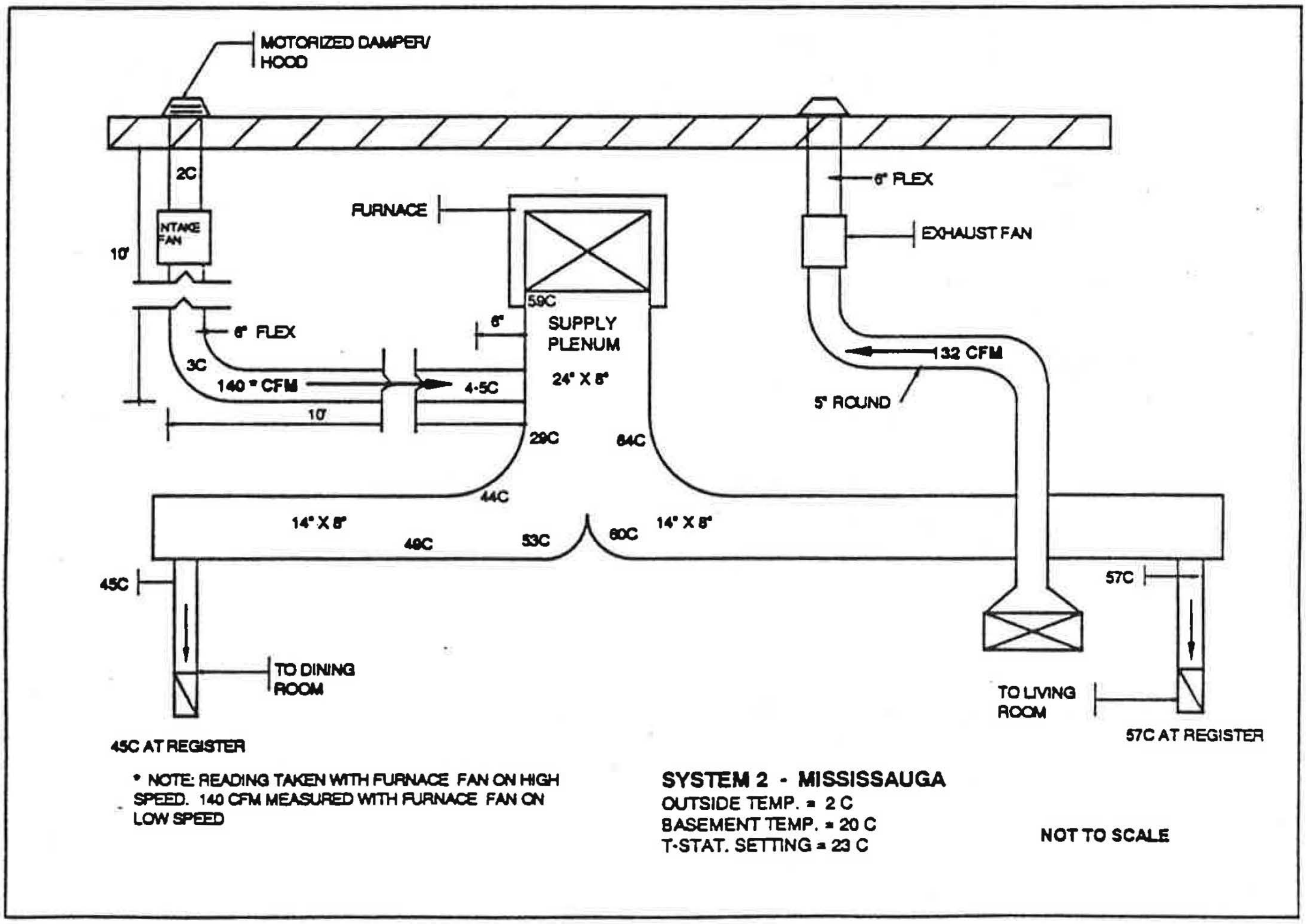
(* furnace fan on high speed 140 cfm = .037 AC/h measured with furnace fan on low)

Tracer Gas Tests

Calculated Air Changes - Bedroom	0.72 AC/h = 273 cfm
Calculated Air Changes - Living/Dining	0.94 AC/h = 355 cfm
Calculated Average Air Changes for House	0.83 AC/h = 314 cfm

Air Quality N/A

FIGURE - System 2 Mississauga - Installation Layout and Test Results



4. System 3

4.1 System 3 - Desboro

System Description:	Heat Recovery Ventilator connected to return air plenum of furnace, and interlocked with furnace fan.
	HRV exhaust intakes located at kitchen, bathroom and basement/laundry area. Recirculating kitchen range hood installed.
Location:	Desboro
Builder:	Barry's Construction,
House Description:	1 Storey, 3 Bedroom, Full Basement
Heating Source:	Forced Air, Propane Heating

Test Results

Building Parameters

Fan Depressurization

Air Flow @ 50 Pa	186 cfm/0.77 AC/h
Equivalent Leakage Area	17.30 in^2
Estimated Natural Infiltration Rate	11.5 cfm / 690 cfh
House Area/Volume	14,421 ft^3

Estimated Air Changes by Natural Infiltration — 690 ÷ 14421 = 0.05 AC/h

Depressurization — N/A

Air Temperatures — See Figure

Outdoor/Intake Temp.	-3 °C
HRV fresh air supply	15 °C
Return plenum from house	23° C
Return plenum at fresh air intake connection	20° C
Return plenum at entrance to furnace.	20 °C
House temp. setting	23 °C
Exhaust from HRV to exterior	12° C

Air Exchange and Flow Characteristics

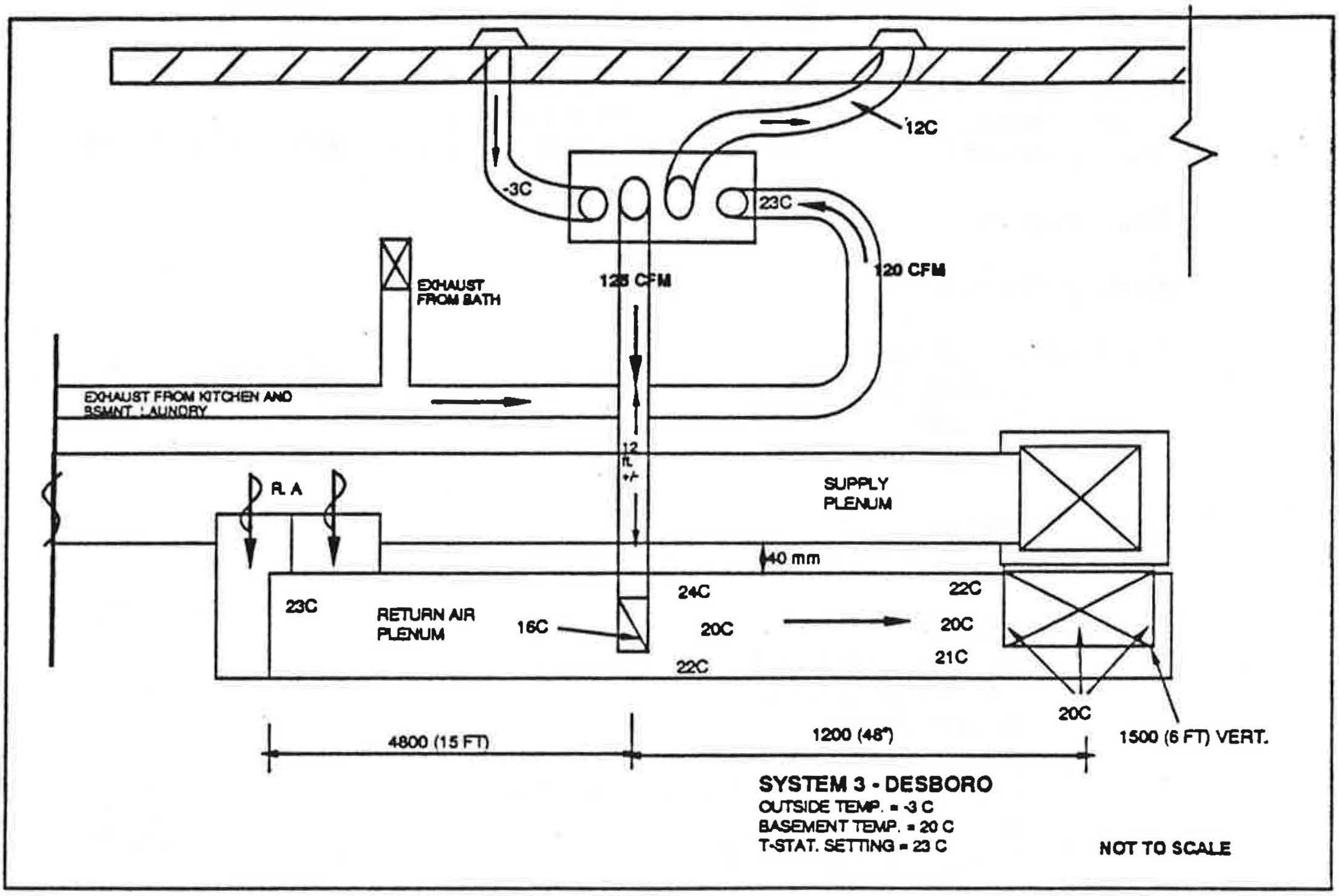
Duct Air Flow Measurements

Intake Air Flow	125 cfm = 0.52 AC/h
Exhaust Air Flow	120 cfm = 0.49 AC/h

Tracer Gas Tests

Calculated Air Changes - Bedroom	1.38 AC/h = 331 cfm
Calculated Air Changes - Kitchen/Dining	1.19 AC/h = 286 cfm
Calculated Average Air Changes for House	1.28 AC/h = 307 cfm

FIGURE - System 3 Desboro - Installation Layout and Test Results



4.2 System 3 - Ottawa

System Description:	Heat Recovery Ventilator connected to return air plenum of furnace, and interlocked with furnace fan.
	HRV exhaust intakes located at kitchen, bathroom and basement/laundry area. Recirculating kitchen range hood installed.
Location:	Ottawa
Builder:	G&M Custom Contracting,
House Description:	1 Storey, 2 Bedroom, Full Basement
Heating Source:	Forced Air Electric Heating
Status Comments:	HRV fresh air supply soft connection to return plenum

Test Results

Building Parameters

Fan Depressurization

Air Flow @ 50 Pa	186 cfm/1.42 AC/h
Equivalent Leakage Area	30.24 in^2
House Volume	14,408 ft^3

Depressurization

HRV in defrost mode.	4 Pa

Air Temperatures — See Figure

Outdoor/Intake Temp.	-13 °C
HRV fresh air supply	16 °C
Return plenum	26° C
Return plenum at fresh air intake connection	20° C
Return plenum at entrance to furnace.	22 °C
House temp. setting	26 °C
Exhaust Stream to HRV	24° C

Air Exchange and Flow Characteristics

Duct Air Flow Measurements

Intake Air Flow	105 cfm = 0.43 AC/h
Exhaust Air Flow	114 cfm = 0.47 AC/h

Tracer Gas Tests

Calculated Air Changes - Bedroom	0.59 AC/h = 141 cfm
Calculated Air Changes - Kitchen/Dining	0.82 AC/h = 197 cfm
Calculated Average Air Changes for House	0.70 AC/h = 168 cfm

Air Quality

Carbon Dioxide — 624 ppm

5. System 4

5.1 System 4 - Jackson's Point

<u>System Description:</u>	Heat Recovery Ventilator ducted directly to living space, electric resistance baseboard heating.
	HRV exhaust intakes located at kitchen, bathroom and powder room. Recirculating kitchen range hood installed.
Location:	Jackson's Point
Builder:	Ron Gosse Construction,
House Description:	2 Storey, 3 Bedroom, No Basement
Heating Source:	Electric Resistance Baseboard .Heating

Test Results

Building Parameters

<u>Fan Depressurization</u>

Air Flow @ 50 Pa	398 cfm/2.42 AC/h
Equivalent Leakage Area	30.10 in^2
Estimated Natural Infiltration Rate	22.1 cfm / 1,326 cfh
House Area/Volume	9,845 ft^3

Estimated Air Changes by Natural Infiltration — 1326 ÷ 9845 = 0.13 AC/h

<u>Depressurization</u>

HRV Defrost Cycle	4 Pa
Dryer	4 Pa
Bathroom Fan (1@ 50 cfm)	0 Pa
Combined Dryer and HRV Defrost	5 Pa

<u>Air Temperatures</u> — N/A

Air Exchange and Flow Characteristics

<u>Duct Air Flow Measurements</u>

Intake Air Flow	72 cfm = 0.44 AC/h
Exhaust Air Flow	72 cfm = 0.44 AC/h

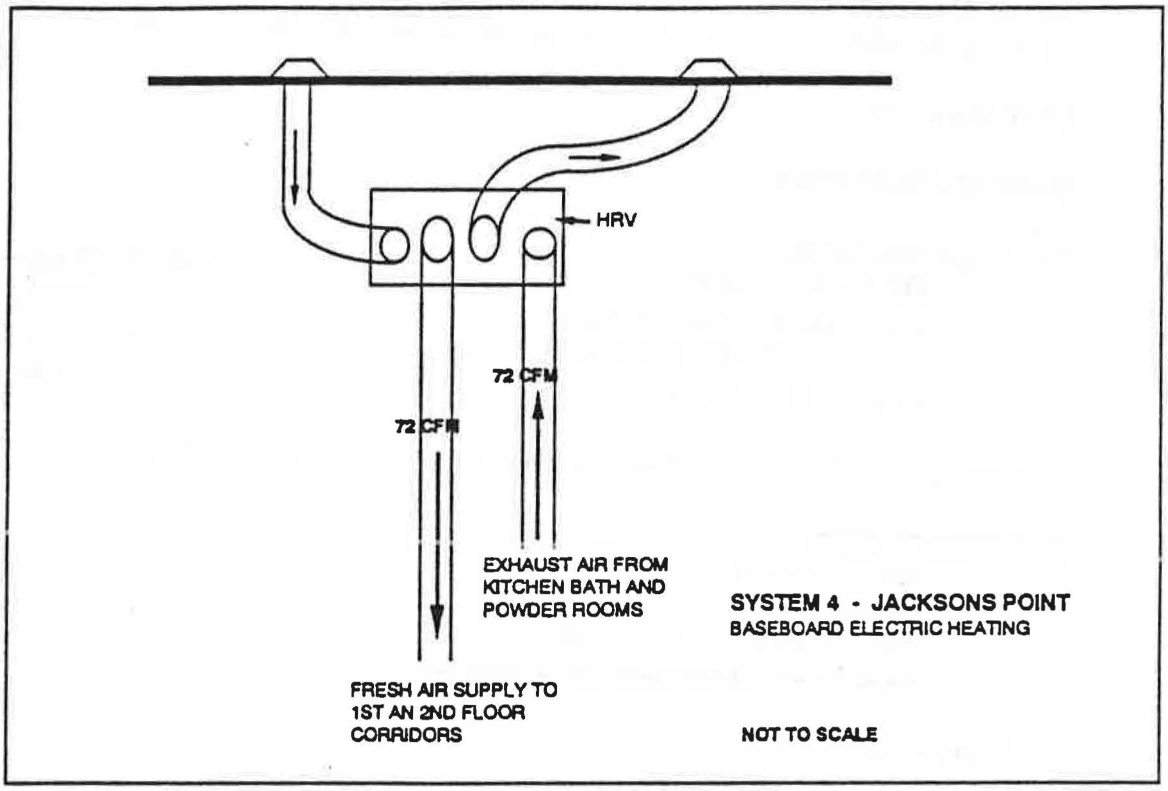
<u>Tracer Gas Tests</u>

Calculated Air Changes - Bedroom	0.51 AC/h = 83 cfm
Calculated Air Changes - Living/Dining	<u>0.75 AC/h = 123 cfm</u>
Calculated Average Air Changes for House	0.63 AC/h = 103 cfm
Estimated Air Flow per Tracer Gas Test	6202 AC/h/103 cfm

Air Quality

Formaldehyde	0.02 ppm
Carbon Dioxide	650 ppm

FIGURE - System 4 Jackson's Point - Installation Layout and Test Results



5.2 System 4 - Ottawa

System Description:	Heat Recovery Ventilator ducted directly to living space, electric resistance baseboard heating.
Location:	Carleton Place
Builder:	Wilford Construction ,
House Description:	1 Storey, 3 Bedroom, Crawl Space,
Heating Source:	Electric Resistance Baseboard Heating.
Status Comments:	House is a prefabricated type. Currently used as a model home

Test Results

Building Parameters

Fan Depressurization	
Air Flow @ 50 Pa	386 cfm/1.77 AC/h
Equivalent Leakage Area	37.2 in^2
House Area/Volume	13,101 ft^3
Depressurization	N/A
Air Temperatures	See Figure
Outdoor/Intake Temp.	4 °C
HRV fresh air supply	18 °C
House setting/Exhaust Stream to HRV	22 °C
Exhaust to outside	11 °C

Air Exchange and Flow Characteristics

Duct Air Flow Measurements	
Intake Air Flow	108 cfm
Exhaust Air Flow	110 cfm
Tracer Gas Tests	
Calculated Air Changes - Bedroom	0.84 AC/h = 183 cfm
Calculated Air Changes - Kitchen	0.60 AC/h = 131 cfm
Calculated Average Air Changes for House	0.72 AC/h = 157 cfm

Air Quality

Formaldehyde	
T.V Room	0.05 ppm
Living Room	0.07 ppm

6. System 5 - Desboro

System Description:	Recirculating Packaged Ventilator connected to return air plenum of furnace, and interlocked with furnace fan. Exhaust intakes located at kitchen, bathroom and basement/laundry area. Recirculating kitchen range hood installed.
Location:	Desboro
Builder:	Barry's Construction,
House Description:	1 Storey split level, 3 Bedroom, Half Basement and Crawl Space
Heating Source:	Forced Air Propane Heating
Status/Comments:	Access to occupied unit not available.

Test Results

Building Parameters

Fan Depressurization

Air Flow @ 50 Pa	162 cfm/0.67 AC/h
Estimated Equivalent Leakage Area	16.81 in^2
Estimated Natural Infiltration Rate	11.4 cfm / 684 cfh
House Area/Volume	14,350 ft^3

Estimated Air Changes by Natural Infiltration	684 ÷ 14350 = 0.05 AC/h
Depressurization	N/A
Air Temperatures	N/A

Air Exchange and Flow Characteristics

Duct Air Flow Measurements

Intake Air Flow	N/A
Exhaust Air Flow	N/A

Tracer Gas Tests	N/A

Air Quality

Formaldehyde	N/A
Carbon Dioxide	N/A

7 System 6 - Ottawa

System Description:	Simplified H.R.V. Heat Recovery Ventilator with both fresh air intake and stale air exhaust ducted to return air plenum of furnace.
Location:	Ottawa
Builder:	Valformon Construction,
House Description:	2 Storey split level, 4 Bedroom, Full Basement
Heating Source:	Forced Air Gas Heating
Status/Comments:	House approximately 2 years old.

Test Results

Building Parameters

Fan Depressurization	
Air Flow @ 50 Pa	2.23 AC/h
Equivalent Leakage Area	113.2 in^2
House Area/Volume	30,795 ft^3
Depressurization	N/A

Air Exchange and Flow Characteristics

Duct Air Flow Measurements	
Intake Air Flow	84 cfm = 0.16 AC/h
Exhaust Air Flow	92 cfm = 0.18 AC/h

Tracer Gas Tests	
Calculated Air Changes - Bedroom	0.97 AC/h = 498 cfm
Calculated Air Changes - Kitchen	0.75 AC/h = 384 cfm
Calculated Average Air Changes for House	0.86 AC/h = 441 cfm

Air Quality

Carbon Dioxide	517 ppm

Appendix B

Proposed OBC Changes

PROPOSED REVISION SHEET

Change No: 9.22-01	Date: February, 1992	Page 1 of 1
Reference: 9.22.1.4.	Ontario Building Code, Ontario Reg. 413/90	

EXISTING REQUIREMENT

9.22.1.4. Combustion Air

(3) The supply duct shall have
(a) a diameter of at least 100 mm (4 in) or an equivalent area,
(b) an exterior intake for entry of air from the outdoors, and
(c) an interior outlet for providing air for the fire chamber.

PROPOSED CHANGE

Delete Sentence (3) and substitute:

9.22.1.4. Combustion Air

(3) The supply duct shall have
(a) a diameter of at least 150 mm (6 in) or an equivalent area,
(b) an exterior intake for entry of air from the outdoors, and
(c) an interior outlet for providing air for the fire chamber.

REASON

A larger than currently required combustion air supply is necessary to compensate for the reduced envelope air leakage and combustion spillage.

PROPOSED REVISION SHEET

Change No: 9.32-01	Date: February, 1992	Page 1 of 1
Reference: 9.32.1.1.	Ontario Building Code, Ontario Reg. 413/90	

EXISTING REQUIREMENT

9.32.1.1. Application

(1) This Section applies to the ventilation of rooms and spaces in residential occupancies by natural ventilation and to self-contained mechanical ventilation systems serving only one dwelling unit.

(2) Mechanical ventilation systems serving more than one dwelling unit shall conform to Part 6.

(3) Ventilation of rooms and spaces in other than residential occupancies shall conform to Part 6.

(4) A storage garage for more than five cars shall be ventilated in accordance with Part 6.

PROPOSED CHANGE

Add new Sentence (5)

(5) Where a dwelling unit contains a basement with one or more storeys above the basement, and the basement contains a separate dwelling unit the requirements of this Section shall apply to each dwelling unit.

REASON

As there will be individual living quarters in each dwelling unit there should be a separate ventilation systems for each.

PROPOSED REVISION SHEET

Change No: 9.32-02	Date: February, 1992	Page 1 of 8
Reference: 9.32.3.	Ontario Building Code, Ontario Reg. 413/90	

EXISTING REQUIREMENT

9.32.3. Mechanical Ventilation

9.32.3.1. Required Mechanical Ventilation for Dwelling Units

(1) Every dwelling unit shall be provided with a mechanical ventilation system having a capacity to exhaust inside air or to introduce outside air at the rate of not less than 0.3 air change per hour, averaged over any 24-hour period.

(2) The rate of air change in Sentence (1) shall be based on the total interior volume of all storeys including the basement, but excluding any attached or built-in garage or unheated crawl space.

9.32.3.2. Mechanical Ventilation of Rooms and Spaces. Where a habitable room or space in a dwelling unit is not provided with natural ventilation described in Article 9.32.1.2., mechanical ventilation shall be provided to exhaust inside air or to introduce outside air to that room or space at the rate of one-half air change per hour if the room or space is mechanically cooled in summer, and one air change per hour if it is not.

9.32.3.3. Design and Installation Requirements

(1) Except as provided in Sentence (2), mechanical ventilation shall conform to the requirements in Part 6.

(2) Mechanical ventilation required in Articles 9.32.3.1. and 9.32.3.2., and consisting of one or more exhaust fans without an air circulating ductwork system, need not conform with Part 6, provided

(a) each exhaust fan conforms to CSA C22.2 No.113, "Fans and Ventilators",

(b) except as permitted in Sentences (3) and (4), air intake openings for make-up air are installed and are of a size to prevent excessive depressurization in the dwelling unit when all exhaust fans of the system are operating, and

(c) the exhaust fans are controlled either manually by a switch or automatically by a humidistat.

(3) The mechanical ventilation capacity of the system described in Sentence (1) shall be assumed to be the sum of the capacities of the individual fans, as rated at a differential static pressure of at least 25 Pa (0.0035 psi).

(4) The air intake openings described in Clause (2)(b) are not required if spillage susceptible fuel-fired heating appliances which are required to be vented are not installed in the dwelling unit.

Change No: 9.32-02	Date: February, 1992	Page 2 of 8
Reference: 9.32.3.	Ontario Building Code, Ontario Reg. 413/90	

(5) The air intake openings described in Clause (2)(b) are not required if it can be shown by test that air leakage is sufficient to prevent excessive depressurization in the dwelling unit when all exhaust fans of the system are operating.

(6) Special purpose air exhausting equipment such as central vacuum cleaning systems, downdraft cook tops and clothes dryers shall not be included in the calculation of the capacity of the system described in Sentence (2).

9.32.3.4. Combustion and Dilution Air. 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 serve both functions simultaneously without creating excessive depressurization in the dwelling unit.

9.32.3.5. Exhaust Ducts

(1) Exhaust ducts shall discharge directly to the outdoors.

(2) Where the exhaust duct passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture condensation in the duct.

9.32.3.6. Accessibility

(1) Ventilation equipment shall be accessible for inspection, maintenance repair and cleaning.

(2) Kitchen exhaust ducts shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

9.32.3.7. Protection from Weather and Insects

(1) Outdoor air intake and exhaust outlets shall be shielded from weather and insects.

(2) Screening shall be of rust-proof material.

9.32.3.8. Requirements for Ducts. Ventilating ducts shall conform to the requirements of Part 6 for supply ducts, except exhaust ducts that serve only a bathroom or water-closet room may be of combustible material provided the duct is reasonably air-tight and constructed of a material impervious to water.

Change No: 9.32-02	Date: February, 1992	Page 3 of 8
Reference: 9.32.3.	Ontario Building Code, Ontario Reg. 413/90	

PROPOSED CHANGE

Delete Subsection 9.32.3. and substitute:

9.32.3. Mechanical Ventilation

9.32.3.1. Required Mechanical Ventilation for Dwelling Units

(1) Every dwelling unit shall be provided with a mechanical ventilation system having a capacity to continuously supply outside air and exhaust inside air at a rate corresponding to 15 L/s (30 cfm) for the main bedroom, and 7.5 L/s (15 cfm) for each additional bedroom.

(2) Where a habitable room or space is not provided with natural ventilation described in Article 9.32.1.2, mechanical ventilation shall be provided to exhaust inside air or to introduce outside air to that room or space at the rate of one-half air change per hour if the room is mechanically cooled in summer, and one air change per hour if it is not.

9.32.3.2. Design and Installation Requirements

(1) Except as provided in Article 9.32.3.3, a mechanical ventilation system shall conform to the requirements of Part 6.

9.32.3.3. Mechanical Ventilation Systems Installed to Conform With Part 9

(1) Except when electric resistance is used to provide space heating or domestic hot water heating, mechanical ventilation required in Sentences 9.34.3.1.(1) and (2) installed in conformance with this Article need not conform with Part 6.

(2) The supply air volume required by Sentence 9.32.3.1.(1) shall be distributed by ductwork to each storey and the basement of the dwelling unit and the exhaust air volume required in Sentence 9.34.3.1.(1) shall be extracted from any storey except the basement.

(3) Where a kitchen is provided with mechanical ventilation the exhaust fan shall have a capacity of not more than 50 L/s (100 cfm).

(4) Where a bathroom is provided with mechanical ventilation the exhaust fan shall have a capacity of not more than 25 L/s (50 cfm).

(5) Except as provided in Sentences (12) to (23), supply and exhaust air capability described in Sentences 9.32.3.1(1) and (2) shall be provided by a mechanical ventilation system consisting of outside supply air fans and inside air exhaust fans which are controlled to provide balanced flow rates.

(6) Exhaust capability for kitchens described in Sentence (3) and bathrooms described in Sentence (4) may be provided by separate exhaust fans.

(7) Except for a kitchen or a bathroom, the supply of outside air to rooms with installed exhaust capability provided by the mechanical ventilation system is not required.

(8) The installation of a mechanical ventilation system described in Sentence (5) having heat recovery capability shall conform to CAN/CSA-C444-M87, "Installation Requirements for Heat Recovery Ventilators.

(9) Mechanical ventilation systems shall conform to CSA C22.2 No. 113, "Fans and Ventilators.

(10) The minimum size of supply and exhaust ducts serving a mechanical ventilation system shall conform to Table 9.32.3.A., except when designed according to the requirements of Part 6.

Table 9.32.3.A.
Forming Part of Sentence 9.32.3.4.(10)

Minimum Mechanical Ventilation System Duct Sizes	
Function	Duct Size mm (in)
Main Trunks	200 (8)
Inside Supply Air	100 (4)
Inside Exhaust Air	125 (5)
Kitchen Exhaust Air	150 (6)
Outside Supply and Exhaust Air	150 (6)
Column 1	2

Notes to Table 9.32.3.A.
(1) Where flex duct is used add 25 mm (1") to the duct diameter.
(2) Where the equivalent length of the duct exceeds 15 m (50 ft), add 25 mm (1") to the duct diameter.

(11) All supply and exhaust ducts serving the mechanical ventilation system shall be provided with dampers, louvres or grilles which permit the adjustment of the air flow rate.

(12) In dwellings equipped with forced warm air heating systems
(a) supply air described in Sentences 9.32.3.1.(1) and (2) may be introduced from the outdoors to the return air plenum of the forced air system with a supply duct sized as shown in Table 9.32.3.B., and
(b) the heating system capacity shall be designed to include the heating requirement of the ventilation load.

(13) Exhaust air described in Sentences 9.32.3.1.(1) and (2) may be provided by a ventilating fan with a point of exhaust centrally located on any storey except the basement, at the capacity shown in Table 9.32.3.B.

(14) The ventilating fan described in Sentence (13) shall be rated to provide the flow capacity at a differential static pressure of 25 Pa (0.0035 psi).

(15) The ventilating fan described in Sentence (13) shall have a rating of not more than 2 sones (50 dBA).

(16) A motorized damper shall be installed in the outside air supply duct described in Sentence (12).

(17) The outside air supply duct described in Sentence (12) shall not be connected less than 2.4 m (8 ft) upstream of the furnace heat exchanger, and shall not be connected upstream of any return branch connection of the return

(18) Electric resistance shall not be used for tempering of the outside supply air described in Sentences 9.32.3.1.(1) and (2).

Table 9.32.3.B.
Forming Part of Sentences 9.32.3.3.(12), (13) and (25)

Ventilating Fan Capacity and Duct Size		
No. of Bedrooms	Fan Capacity L/s (cfm)	Duct Size mm (inches)
1	15 (30)	75 (3)
2	22.5 (45)	100 (4)
3	30 (60)	100 (4)
4	37.5 (75)	125 (5)
5 or more	Part 6 design	
Column 1	2	3

Notes to Table 9.32.3.B.
(1) Where flex duct is used add 25 mm (1") to the duct diameter.
(2) Where the equivalent length of the duct exceeds 15 m (50 ft), it shall be designed in accordance with Part 6.

(19) The ventilating fan described in Sentence (13) shall be controlled by a clearly marked manual switch or dehumidistat.

(20) The operation of the ventilating fan described in Sentence (13) shall automatically move the motorized damper described in Sentence (16) to the fully open position and shall remain there as long as the fan is operating.

(21) The motorized damper described in Sentence (16) shall be controllable by a manual switch and provided with controls so that its activation automatically engages the furnace fan.

(22) The motorized damper described in Sentence (16) shall be equipped with a means of indicating that it is closed or open.

(23) Where exhaust capability described in Sentences (3) and (4) is provided by a single fan or individual fans which exhaust air to the outdoors, these shall be rated to provide the flow capacity at a differential static pressure of 25 Pa (0.0035 psi).

(24) A kitchen exhaust fan other than the range hood may serve as the ventilating fan described in Sentence (13).

(25) An exhaust fan used to ventilate a room containing a water closet shall not be used as the ventilating fan described in Sentence (13).

(26) Each exhaust fan, including the ventilating fan, shall conform to CSA C22.2 No. 113, "Fans and Ventilators.

(27) The minimum size of exhaust ducts serving the ventilating fan shall be sized as shown in Table 9.32.3.B.

9.32.3.4. Combustion and Dilution Air. 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 serve both functions simultaneously without creating excessive depressurization in the dwelling unit.

9.32.3.5. Exhaust Ducts

(1) Exhaust ducts shall discharge directly to the outdoors.

(2) Where the exhaust duct passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture or condensation in the duct.

9.32.3.6. Accessibility

(1) Ventilation equipment shall be accessible for inspection, maintenance, repair and cleaning.

(2) Kitchen exhaust ducts shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

9.32.3.8. Protection from Weather and Insects

(1) Outdoor air intake and exhaust outlets shall be shielded from weather and insects.

(2) Screening for air intake and exhaust outlets shall be of rust-proof material.

PROPOSED REVISION SHEET

Change No: 9.32-02	Date: February, 1992	Page 8 of 8
Reference: 9.32.3.	Ontario Building Code, Ontario Reg. 413/90	

9.32.3.9. Requirements for Ducts Ventilating ducts shall conform to the requirements of Part 6 for supply ducts, except exhaust ducts that serve only a bathroom, laundry room or water-closet room may be of combustible material provided the duct is reasonably air-tight and constructed of a material impervious to water.

PROPOSED REVISION SHEET

Change No: 9.32-03	Date: February, 1992	Page 1 of 2
Reference: 9.32.4.	Ontario Building Code, Ontario Reg. 413/90	

EXISTING REQUIREMENT

None.

PROPOSED CHANGE

Add new Subsection 9.32.4.

9.32.4. Depressurization Limits

9.32.4.1. Make-up Air

(1) Except as permitted in Sentence (2), each air exhausting device in a dwelling unit, which is rated to provide a net exhaust capacity of more than 75 L/s (150 cfm), shall be provided with make-up air from the outdoors to replace the exhausted flow of air.

(2) A central vacuum system need not be provided with make-up air from the outdoors.

(3) Except as provided in Sentence (4), the make-up air inlet shall be sized as shown in Table 9·32.4.A, and shall provide the required flow of air described in Sentence (1) at a differential pressure of 10 Pa, and shall be located in the same room as the air exhausting device.

(4) Make-up air described in Sentence (1) may be provided to the air exhausting device from the outdoors by fans, interlocked to the device and installed to deliver make-up air to the same room in which the device is located.

(5) In addition to the ventilation rates required in Article 9.32.3.1., where no provision is made for a dedicated supply of make-up air for a fuel fired appliance and the appliance relies on air supplied from within the dwelling unit for its operation, provisions for additional make-up air shall be made when determining the area of the make-up air duct in accordance with Sentences 9.32.3.3.(10) and (12).

PROPOSED REVISION SHEET

Change No: 9.32-03	Date: February, 1992	
Reference: 9.32.4.	Ontario Building Code, Ontario Reg. 413/90	

Table 9.32.4.A.
Forming Part of Sentence 9.32.4.1(3)

Minimum Make-Up Air Intake Opening Size Necessary to Avoid Excessive Depressurization	
Air Exhausting Device Flow Rate L/s (cfm)	Round Duct Size mm (in)
60 (120)	125 (5)
80 (160)	150 (6)
120 (240)	175 (7)
165 (330)	200 (8)
Greater than 165 (330)	Part 6
Column 1	2

Notes to Table 9.32.4.A
(1) Where flex duct is used add 25 mm (1") to the duct diameter.
(2) Where the equivalent length of the duct exceeds 6 m (20 ft), it shall be designed in accordance with Part 6.

Appendix C

Modified Proposals for Demonstration Project

PROPOSED REVISIONS TO PART 9 REQUIREMENTS FOR FIREPLACES (For Ventilation Demonstration Project)

SECTION 9.22. FIREPLACES

9.22.1. General
No Changes

9.22.1.1. Application
No Changes

9.22.1.2. Masonry and Concrete
No Changes

9.22.1.3. Footings
No Changes

9.22.1.4. Combustion Air
(1) Except as permitted in Article 9.22.1.6, every fireplace, including a factory-built fireplace, shall have a supply of combustion air from outdoors in accordance with Sentences (2) to (12).

(2) The combustion air shall be supplied by a noncombustible and corrosion-resistant supply duct.

(3) The supply duct shall have
- (a) a diameter of at least 150 mm (6") or an equivalent area,
- (b) an exterior intake for entry of air from the outdoors, and
- (c) an interior outlet to the fire chamber.

(4) The supply duct shall contain a tight fitting damper that shall be located close to the interior outlet and be operable from the room containing the fireplace.

(5) The operating mechanism shall clearly indicate the actual position of the damper.

(6) The interior outlet shall
- (a) be constructed of noncombustible material,
- (b) be placed inside the fire chamber, and
- (c) be designed to prevent embers from entering the supply duct.

(7) The exterior intake shall be protected against the entry of rain and direct wind and have an insect screen of corrosion-resistant material.

(8) Where the exterior intake is located at or below the level of the fire chamber hearth, the supply duct shall be installed with a minimum clearance from combustible material of 50 mm (2 in) for a distance of 1 m (3 ft 3 in) measured from the interior outlet.

(9) Where the exterior intake is located above the level of the fire chamber hearth, the supply duct shall be installed with a minimum clearance from combustible material of,

(a) 50 mm (2 in) for a distance of 1 m (3 ft 3 in) measured from the interior outlet, and

(b) 25 mm (1 in) for the remainder of the supply duct to the exterior intake.

(10) The exterior intake shall be located to avoid being blocked by snow or fallen leaves.

(11) Where the supply duct is exposed to a heated space, the duct shall be insulated to provide a thermal resistance of not less than RSI 1.4 (R 8).

9.22.1.5. Combustion Air for Factory-Built Fireplaces

No Changes

9.22.1.6. Combustion Air for Steel Fireplace Liners

No Changes

REVISIONS TO PART 9 REQUIREMENTS FOR MECHANICAL VENTILATION (For Ventilation Demonstration Project)

SECTION 9.32 MECHANICAL VENTILATION

9.32.1 General

(no revisions proposed)

9.32.2 Natural Ventilation

(no revisions proposed)

9.32.3 Mechanical Ventilation

9.32.3.1 Required Mechanical Ventilation for Dwelling Units

(1) Except as provided in Article 9.32.3.3, every dwelling unit shall be provided with a mechanical ventilation system which conforms to the requirements of Part 6.

9.32.3.2 Mechanical Ventilation of Rooms and Spaces

(1) Where a habitable room or space is not provided with natural ventilation described in Article 9.32.1.2, mechanical ventilation shall be provided to exhaust inside air or to introduce outside air to that room or space at the rate of one-half air change per hour if the room is mechanically cooled in summer, and one air change per hour if it is not.

9.32.3.3 Design and Installation Requirements

(1) Every dwelling unit shall be provided with a mechanical ventilation system having a capacity to continuously supply outside air and exhaust inside air at a rate corresponding to 15 L/s (30 cfm) for the main bedroom, and 7.5 L/s (15 cfm) for each additional bedroom.

(2) The supply air volume required in Sentence (1) shall be distributed by ductwork to each storey and the basement of the dwelling, and the exhaust air volume required in Sentence (1) shall be extracted from any storey of the dwelling except the basement.

(3) Where a kitchen is equipped with mechanical ventilation it shall have an exhaust capacity of not less than 50 L/s (100 cfm) and not more than 75 L/s (150 cfm).

(4) Where a bathroom is equipped with mechanical ventilation it shall have an exhaust capacity of not less than 25 L/s (50 cfm) and not more than 75 L/s (150 cfm).

Dwellings Equipped with Any Type of Heating System

(5) Except as provided in Sentences (12) to (25), supply and exhaust air capability described in Sentences (1) to (4) shall be provided by a mechanical ventilation system consisting of fans which are controlled to supply outside air and exhaust inside air at balanced flow rates.

(6) Exhaust capability for kitchens described in Sentence (3) and bathrooms described in Sentence (4) may be provided by separate exhaust fans.

(7) The supply of outside air to rooms with installed exhaust capability provided by the mechanical ventilation system is not required.

(8) The installation of a mechanical ventilation system described in Sentence (5) having heat recovery capability shall conform to CAN/CSA-C444-M87 "Installation Requirements for Heat Recovery Ventilators".

(9) Mechanical ventilation systems shall conform to CSA C22.2 No. 113, "Fans and Ventilators".

(10) The minimum size of the mechanical ventilation system's supply and exhaust ducts serving the dwelling shall conform to Table 9.32.3.A, except when designed according to the requirements of Part 6.

Table 9.32.3.A.
*forming Part of Sentence 9.32.3.3 (10)

Minimum Mechanical Ventilation Svstem Duct Sizes	
Type of Duct	Duct Size*1 mm (inches)
Main Trunks	200 (8)
Inside Supplv Air	100 (4)
Inside Exhaust Air	125 (5)
Kitchen Exhaust Air	150 (6)
Outside Supplv and Exhaust Air	150 (6)
column 1	2

notes to table
(1) Where flex duct is used add 25 mm (1") to the duct diameter.
(2) Where the equivalent length of the duct exceeds 15 m (50 feet), add 25 mm (1") to the duct diameter.

(11) All supply and exhaust ducts serving the mechanical ventilation system shall be provided with dampers, louvres or grilles which permit the adjustment of the air flow rate.

Dwellings Equipped with Forced Warm Air Heating Systems

(12) In dwellings equipped with forced warm air heating systems, supply air described in Sentences (1) and (2) may be introduced with a supply duct sized as shown in Table 9.32.3.B. and connected from the exterior to
- a) the return air plenum of the forced air furnace, or
- b) the supply air plenum of the forced air furnace.

(13) Exhaust air described in Sentence (1) may be provided by a ventilating fan with a point of exhaust centrally located on any storey except the basement, at the air volume capacity shown in Table 9.32.3.B.

(14) The ventilating fan described in Sentence (13) shall be rated to provide the flow capacity at a differential static pressure of 50 Pa (0.0070 psi).

(15) The ventilating fan described in Sentence (13) shall be rated at or less than 2.5 sones (65 dBA).

Table 9.32.3.B.
*forming Part of Sentences 9.32.3.3 (12), (13), (16) and (24)

Ventilating Fan Capacity and Duct Size		
No. of Bedrooms	Fan Capacity L/s (cfm)	Duct Size*1 mm (inches)
1	15 (30)	100 (4")
2	22.5 (45)	125 (5")
3	30 (60)	125 (5")
4	37.5 (75)	150 (6")
5 or more	Part 6 design	
column 1	2	3

Notes to table
(1) Where flex duct is used add 25 mm (1") to the duct diameter
(2) Where the equivalent length of the duct exceeds 30 m (100 feet), it shall be designed in accordance with Part 6.

(16) A motorized damper shall be installed in the outside air supply duct described in Sentence (12) Where the outside air supply duct is connected to the supply air plenum the supply air duct shall also be provided with a fan

a) sized to provide the air volume capacity shown in Column 2 of Table 9.32.3.B.

b) rated to provide the required flow at a differential static pressure greater than the pressure induced in the supply plenum of the furnace, as specified by the manufacturer of the furnace equipment but in no case shall the fan be rated at a pressure of less than 50 Pa (0.0070 psi)..

(17) The outside air supply duct described in Sentence (12) shall be connected:

a) not less than 2.4 m (8 feet) upstream of the furnace heat exchanger, and shall not be connected upstream of any return branch connection of the return air plenum, when connected to the return air plenum of the forced air furnace, or

b) downstream of the furnace heat exchanger, and shall not less than 1 m (3 feet) upstream of any supply branch connection of the supply air plenum, when connected to the supply air plenum of the forced air furnace,

(18) The ventilating fan described in Sentence (13) shall be controlled by a clearly marked switch which automatically engages the motorized damper described in Sentence (16) to the fully open position when it is turned to the on position.

(19) The motorized damper described in Sentence (16) shall be controlled by a switch and provided with controls so that its activation automatically engages both the furnace fan and the outside air supply duct fan described in sentence (12)

(20) The motorized damper described in Sentence (16) shall be equipped with a means of indicating that it is closed or open.

(21) Where exhaust capability described in Sentences (3) and (4) is provided by a single fan or individual fans which exhaust air to the outdoors, these shall be rated to provide the flow capacity at a differential static pressure of 25 Pa (0.0035 psi).

(22) A kitchen exhaust fan other than the range hood may serve as the ventilating fan described in Sentence (13).

(23) Each exhaust fan, including the ventilating fan, shall conform to CSA C22.2 No. 113, "Fans and Ventilators".

(24) The minimum size of exhaust ducts serving the ventilating fan shall be sized as shown in Table 9.32.3.B.

(25) The outside air supply duct described in sentence (12) shall be insulated to prevent moisture or condensation in the duct and shall conform to the requirements of Part 6 for supply ducts.

9.32.3.4 Combustion and Dilution Air

(1) Every fuel fired appliance located within a dwelling unit shall be provided with a supply of outside air for combustion, except where this requirement is excluded by standards or codes applicable to the specific equipment used.

(2) Systems designed to provide combustion and/or dilution air for fuel burning appliances shall not be used to supply make-up air for exhaust appliances or ventilation supply air as described in Article 9.32.3.3 Sentences (1) and (2).

9.32.3.5 Exhaust Ducts

(1) Exhaust ducts shall discharge directly to the outdoors.

(2) Where the exhaust duct passes through or is adjacent to unheated space, the duct shall be insulated to prevent moisture or condensation in the duct.

9.32.3.6 Accessibility

(1) Ventilation equipment shall be accessible for inspection, maintenance, repair and cleaning.

(2) Kitchen fan exhaust duct shall be designed and installed so that the entire duct can be cleaned where the duct is not equipped with a filter at the intake end.

9.32.3.7 Protection from Weather and Insects

(1) Outdoor air intake and exhaust outlets shall be shielded from weather and insects.

(2) Screening for air intake and exhaust outlets shall be of rust-proof material.

9.32.3.8 Requirements for Ducts

Ventilating duct shall conform to the requirements of Part 6 for supply ducts, except exhaust ducts that serve only a bathroom, laundry room or water-closet room may be of combustible material provided the duct is reasonably air-tight and constructed of a material impervious to water.

9.32.4. Depressurization Limits

9.32.4.1. Make-up Air

(1) Except as permitted in Sentence (2), each air exhausting device in a dwelling unit, which is rated to provide a net exhaust capacity of more than 75 L/s (150 cfm), shall be provided with make-up air from the outdoors to replace the exhausted air flow.

(2) A central vaccum system need not be provided with make-up air from the outdoors.

(3) Except as provided in Sentence (4), the make-up air inlet shall be sized as shown in Table 9.32.4.A, and shall provide the required flow of air described in sentence (1) at a differential pressure of 10 Pa, and shall be located in the same room as the air exhausting device.

(4) Make-up air described in Sentence (1) may be provided to the air exhausting device from the outdoors by fans

a) installed to deliver make-up air to the same room in which the exhausting device is located,
b) interlocked to the device, and
c) sized to provide the required flow of air described in sentence (1) at a differential pressure of not more than 5 Pa.

Table 9.32.4.A.
*forming Part of Sentence 9.32.4.1 (3)

Minimum Make-up Air Intake Opening Size, Necessary to Avoid Excessive Depressurization	
Air Exhausting Device Flow Rate L/s (cfm)	Round Duct Size*1 mm (inches)
75 (150)	150 (6)
120 (240)	175 (7)
165 (330)	200 (8)
Greater than 165 (330)	Part 6 Design
column 1	2

notes to table
(1) Where flex duct is used add 25 mm (1") to the duct diameter.
(2) Where the equivalent length of the duct exceeds 15 m (50 feet), it shall be designed in accordance with Part 6.

Appendix D

House Selection Criteria and System Diagrams

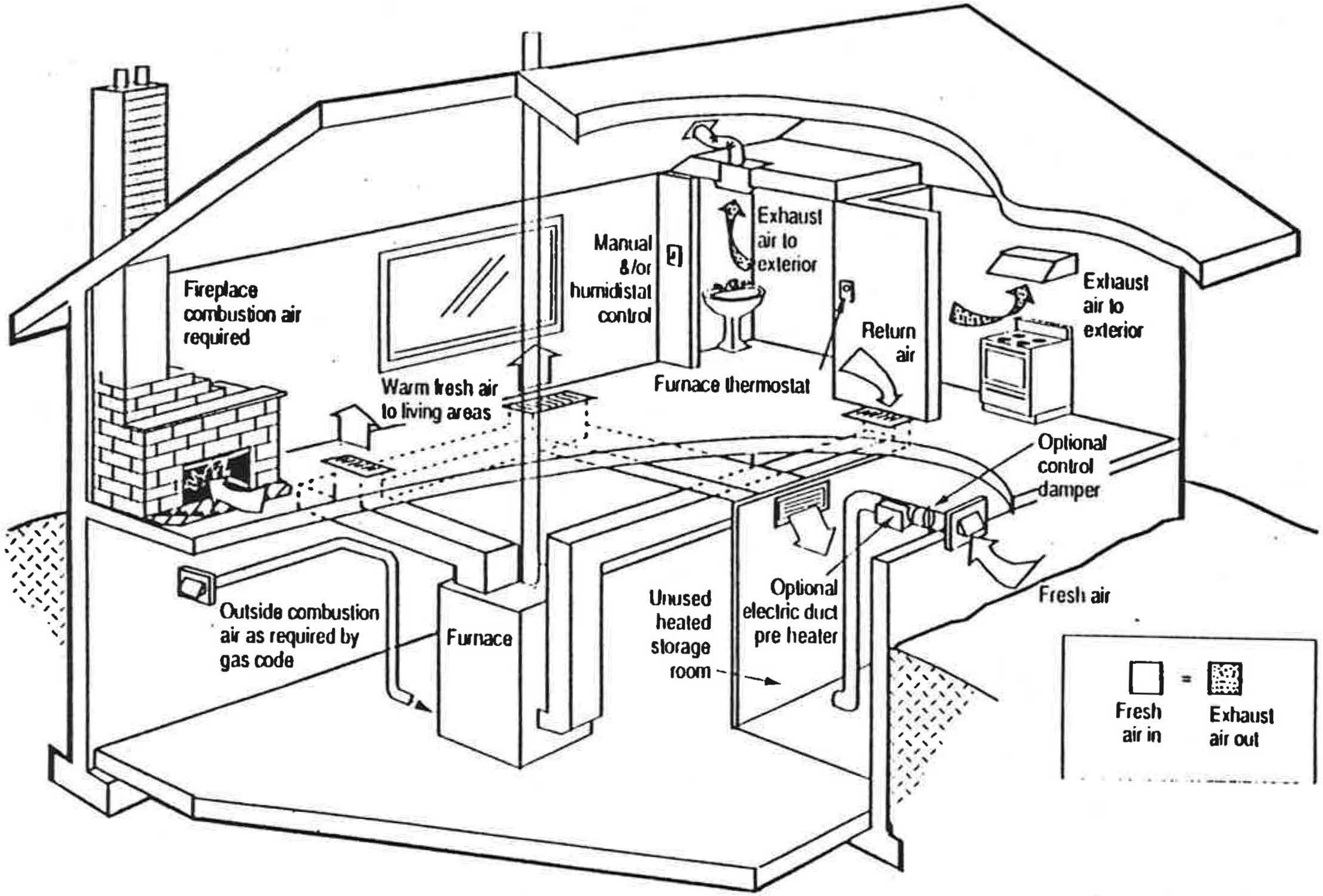
House System Type 1:
Description:
Hard duct connection to the Return Air Plenum (non fan-driven) with:
- Forced Air Gas Heating (non condensing type)
- 2 speed fan on the furnace
- Gas DHW
- Combustion air as required by the Gas Code
- having a fireplace with combustion air and glass doors
- other exhaust systems to be present to include a bathroom fan ducted to the exterior, a range hood ducted to the exterior, central vacuum in the garage, clothes dryer ducted to the exterior.

House System Type 2:
Description:
Hard duct connection to the Supply Air Plenum (fan-driven) with:
- Forced Air Gas Heating (non condensing type)
- 2 speed fan on the furnace
- Gas DHW
- Combustion air as required by the Gas Code
- having a fireplace with combustion air and glass doors
- other exhaust systems to be present to include a bathroom fan ducted to the exterior, a range hood ducted to the exterior, central vacuum in the garage, clothes dryer ducted to the exterior.

House System Type 3:
Description:
Hard duct connection of a basic Heat Recovery Ventilator to the Return Air Plenum with:
- Forced Air Electric Heating
- 2 speed fan on the furnace
- Electric DHW
- having a fireplace with combustion air and glass doors
- other exhaust systems to be present to include a bathroom fan ducted to the exterior, a range hood ducted to the exterior, central vacuum in the garage, clothes dryer ducted to the exterior.

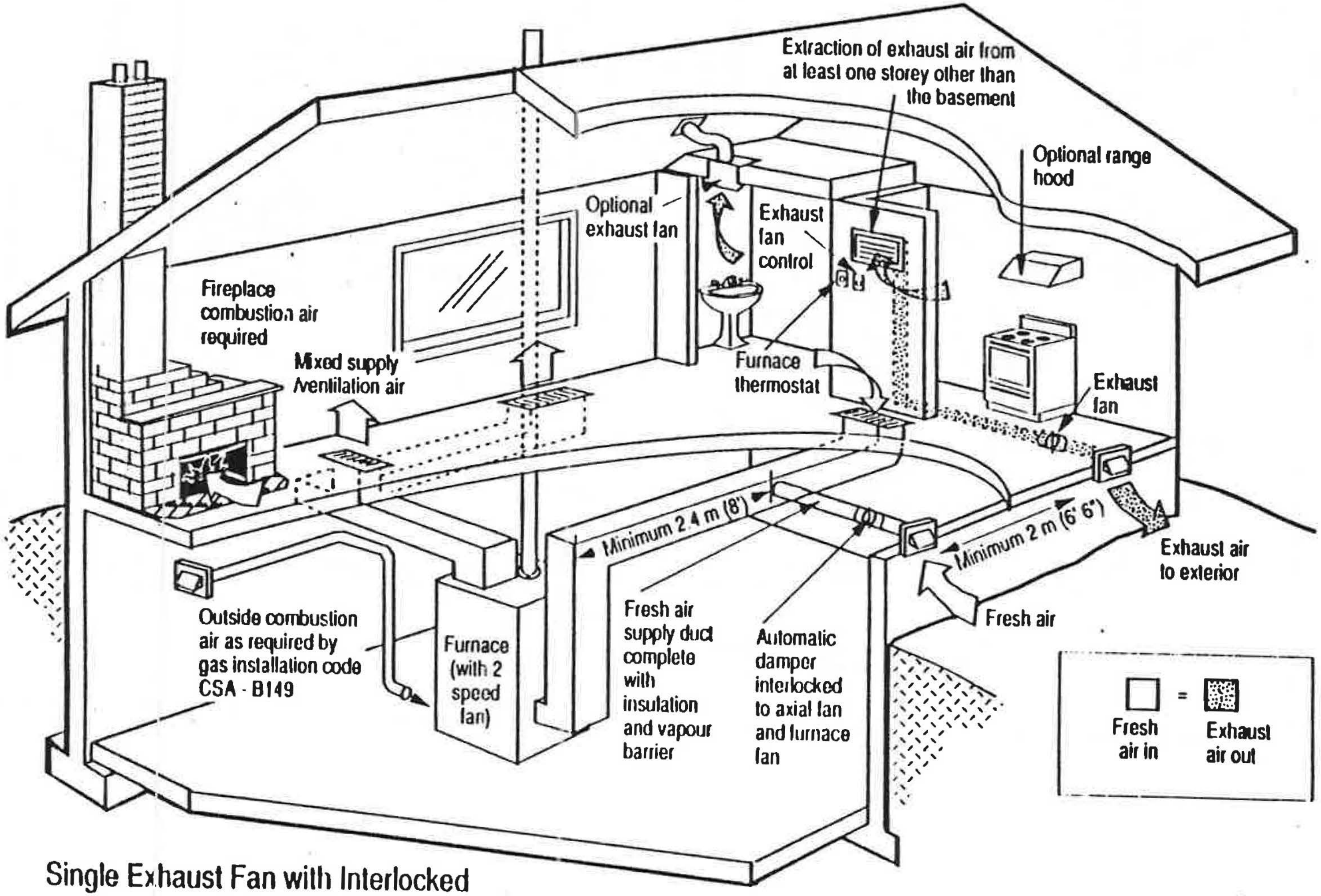
House System Type 4:
Description:
Heat Recovery Ventilator integrated with Baseboard Heating:
- Baseboard Electric Heating
- ducting to all rooms of the house
- Electric DHW
- having a fireplace with combustion air and glass doors
- other exhaust systems to be present to include a bathroom fan ducted to the exterior, a range hood ducted to the exterior, central vacuum in the garage, clothes dryer ducted to the exterior.

Two control houses (one in the GTA and one in the Greater Ottawa area) would be built to present code requirements for comparison to realistically assess the impact of the proposed changes.



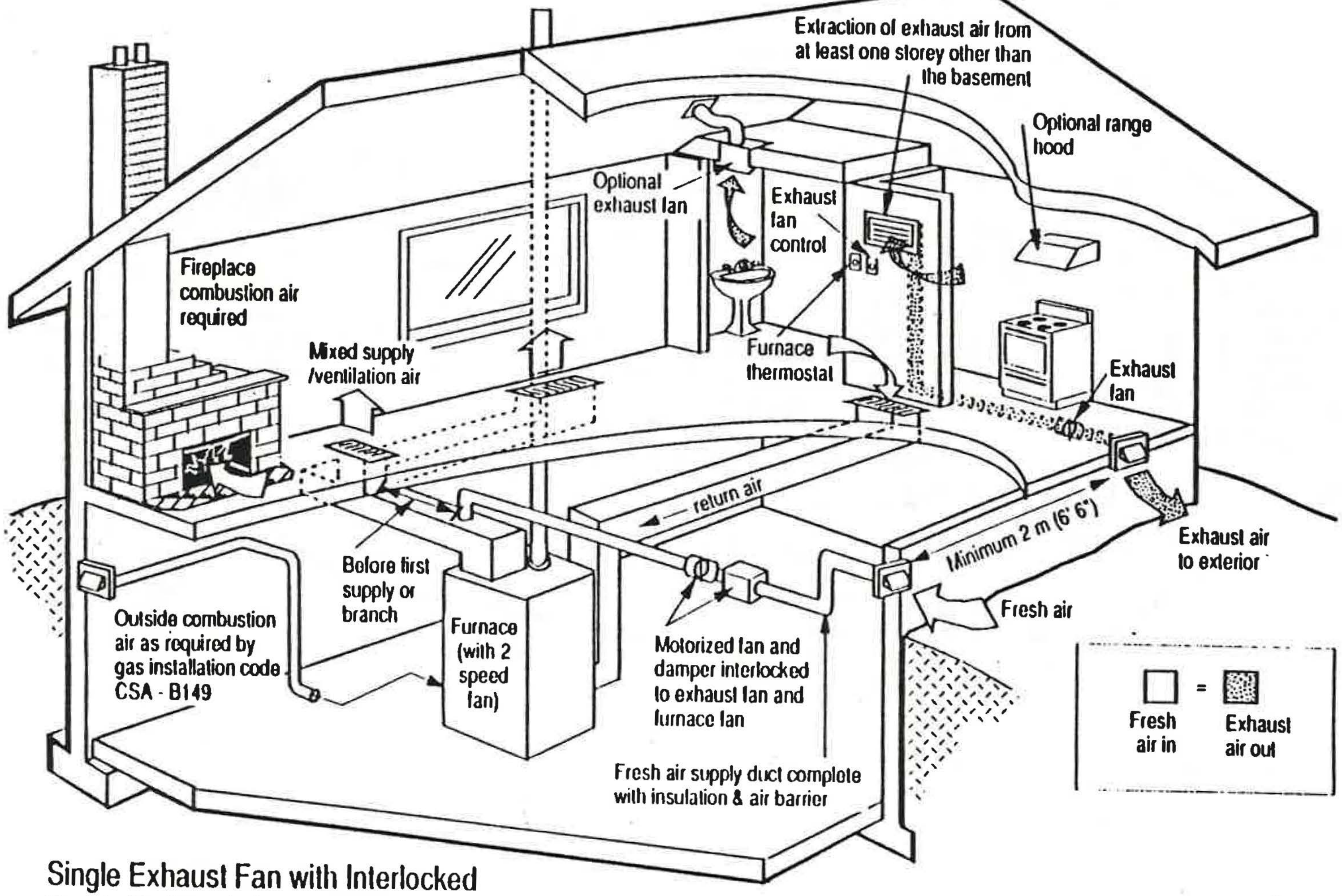
Point Exhaust ventilation system: Forced Air

Part 9 Control System



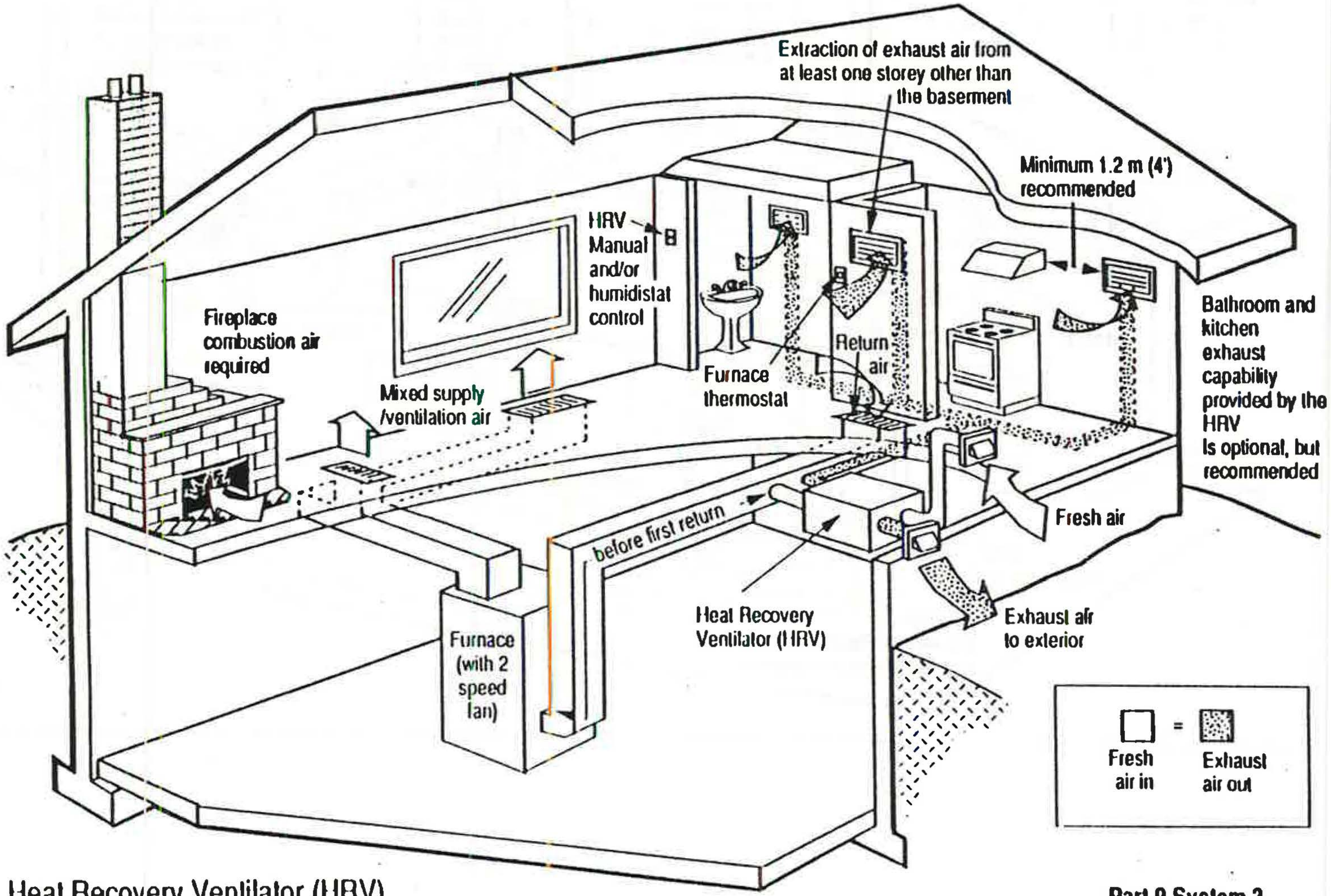
Single Exhaust Fan with Interlocked
Fresh Air Supply in dwelling with Forced Warm Air
Heating System connected to return plenum of furnace

Part 9 System 1



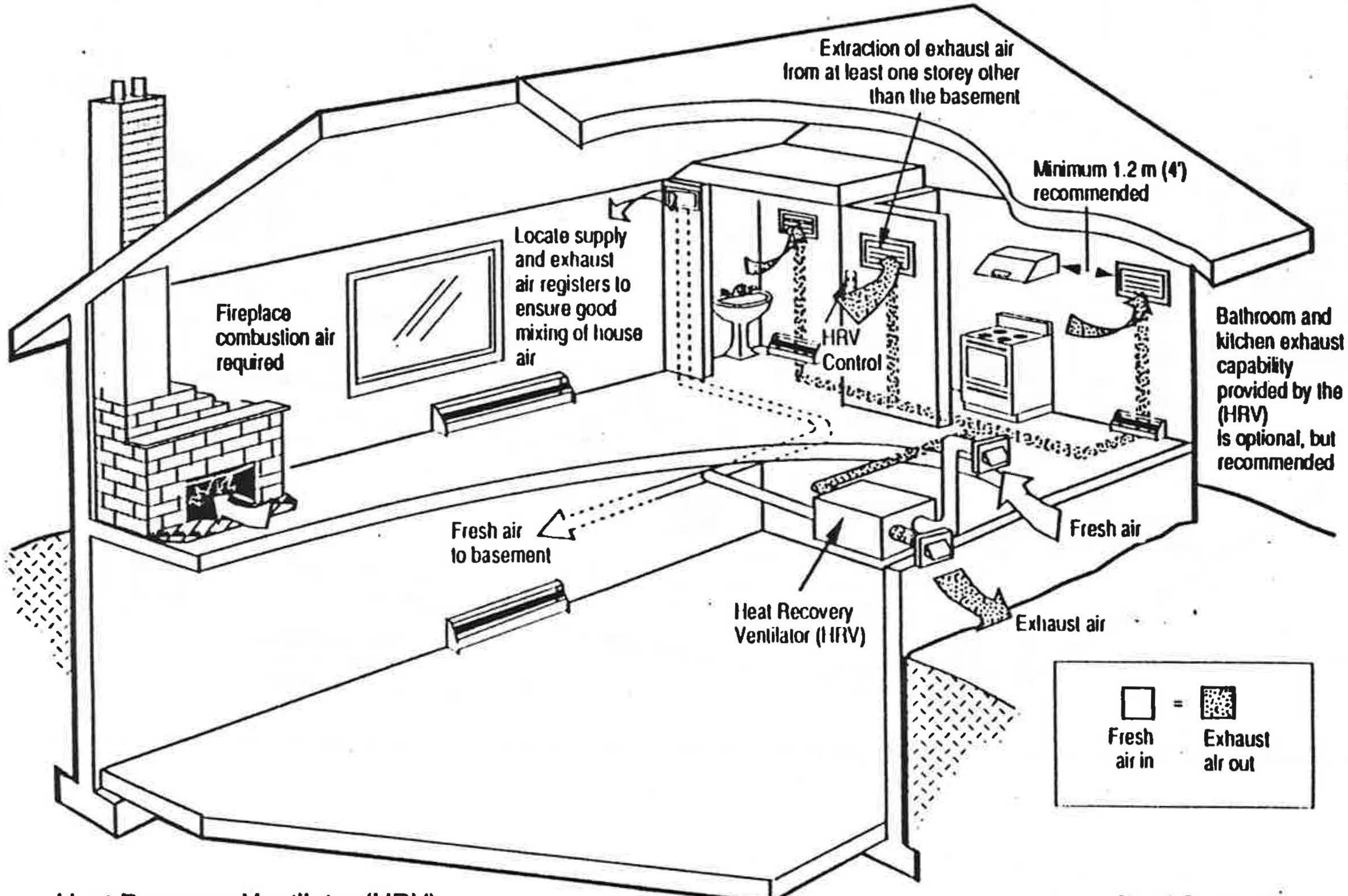
Single Exhaust Fan with Interlocked
Fresh Air Supply in dwelling with Forced Warm Air
Heating System connected to supply plenum of furnace

Part 9 System 2



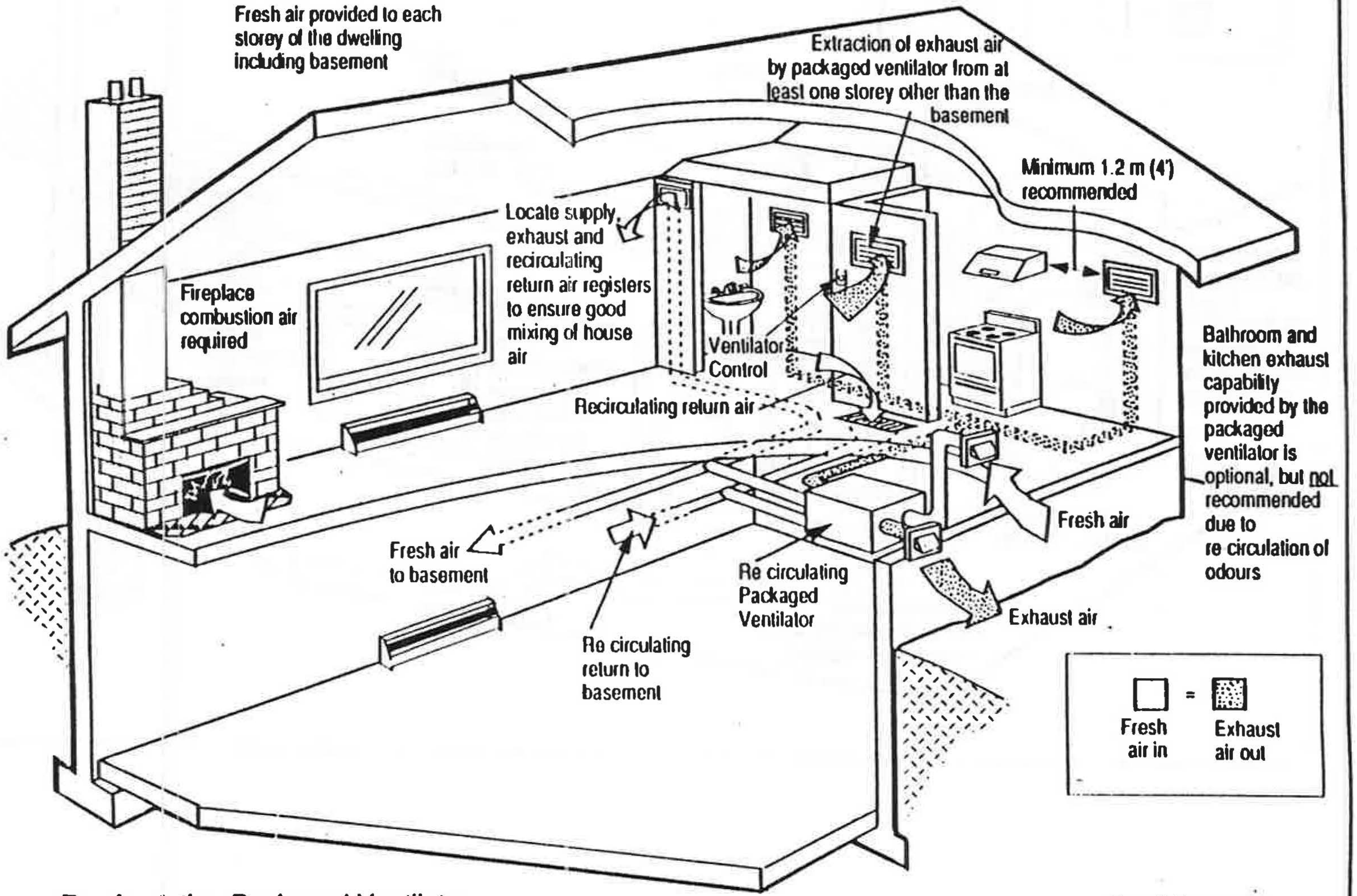
Heat Recovery Ventilator (HRV)
in Dwelling with Forced Warm Air Heating System

Part 9 System 3



Heat Recovery Ventilator (HRV)
in Dwelling with Baseboard/Hydronic Heating System

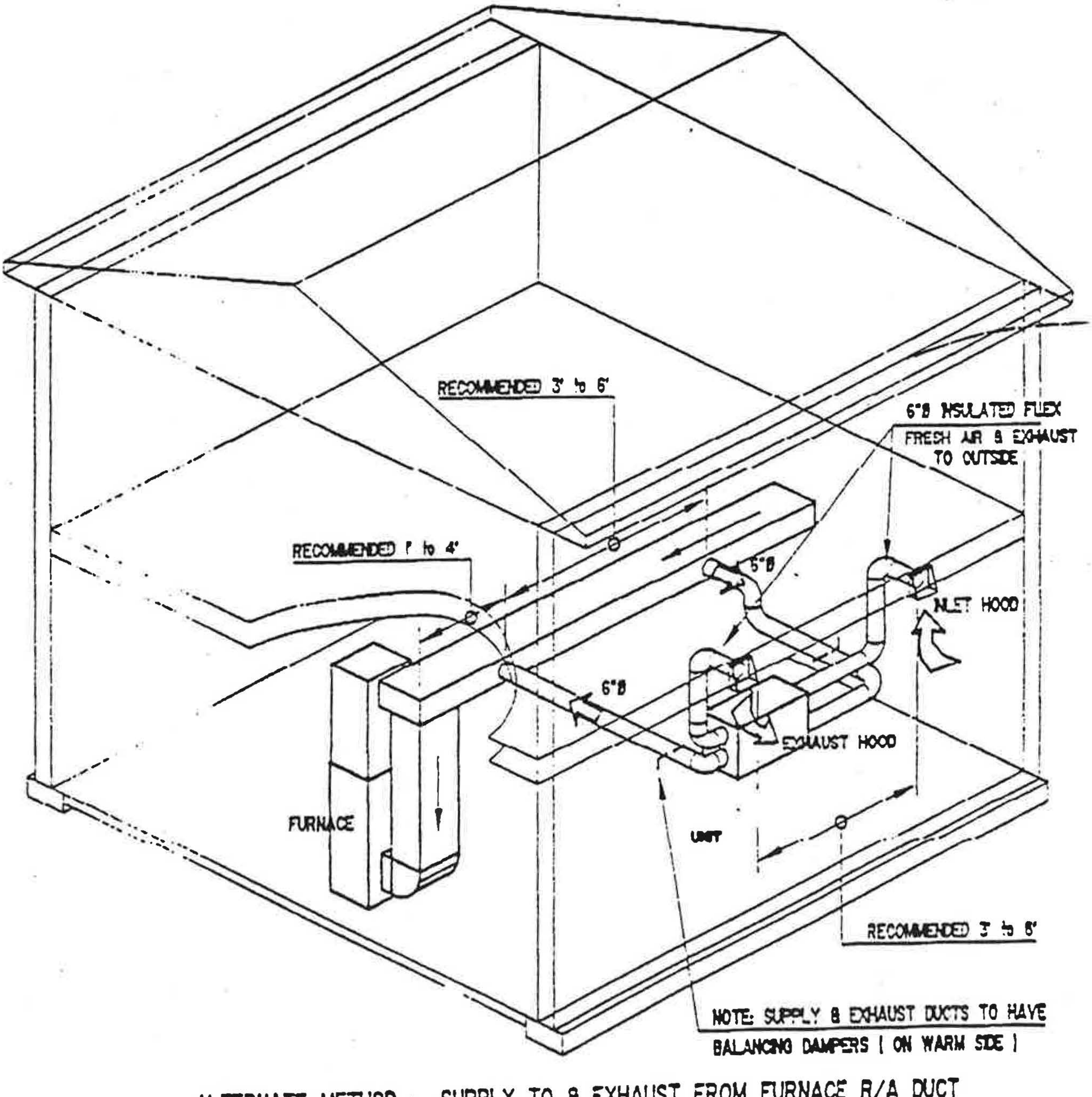
Part 9 System 4



Re-circulating Packaged Ventilator
in Dwelling with Baseboard/Hydronic Heating System

Part 9 System 5

SYSTEM 6

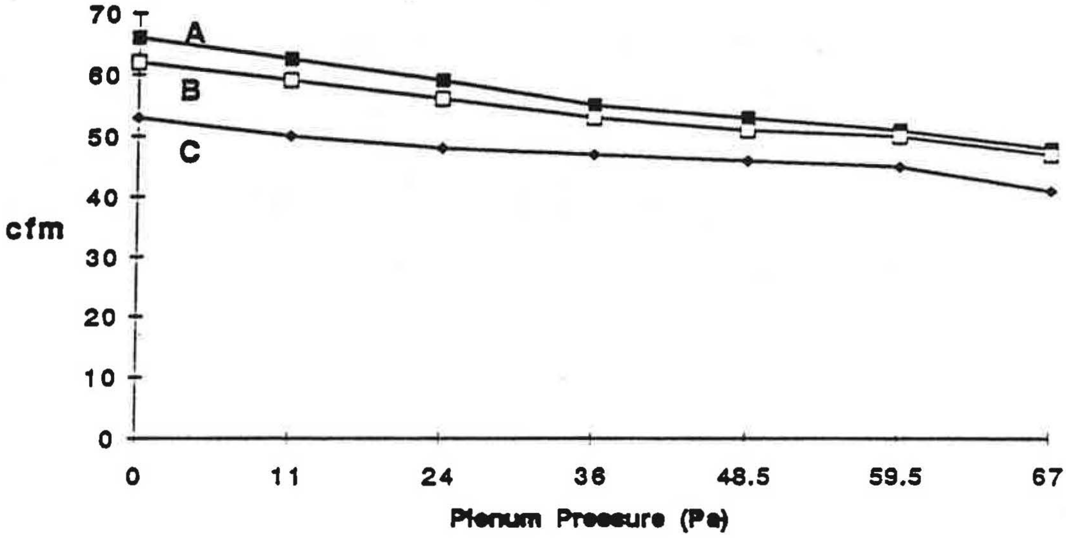


ALTERNATE METHOD : SUPPLY TO & EXHAUST FROM FURNACE R/A DUCT

CENTRAL EXHAUST VENTILATION
FORCED AIR HEATING SYSTEM

Appendix E

Test Results re: System 2 Development



CONFIGURATIONS TESTED

A 8 feet of straight duct, Flow meter, 2 Elbows, Fan

B 8' feet of straight duct, Flow meter, 2 Elbows, Fan & Hood

C 8' feet of straight duct, Flow meter, 2 Elbows, Fan & Hood, 8 feet of Flexible duct

	House 1A		House 1B		House 2		House 3		House 4	
	2 Ret. blocked		4 Returns							
	In/H2O	Pa	In/H2O	Pa	In/H2O	Pa	In/H2O	Pa	In/H2O	Pa
Supply to Interior of House	0.025	6	0.038	9.1	0.067	16.1	0.09	21.6	0.146	35
Return to Interior of House	0.076	18.2	0.08	19.2	0.038	9.1	0.08	19.2	0.142	34
Total	0.101	24.2	0.118	28.3	0.105	25.2	0.17	40.8	0.288	69
Supply to Return -Measured	0.102	24.5	0.107	25.7	0.11	26.4	0.17	40.8	0.283	68