An Investigation of Design Criteria and Appropriate Technologies for Space Heating and Ventilation Systems for Northern Housing

Final Report

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Table of Contents

Abstract

A review of heating and ventilating systems used in Northern and remote housing was undertaken to determine the degree to which conventional and innovative approaches could meet the needs of Northern residents. A review of recent research and industry experience related to remote, cold climate heating and ventilating system was performed to identify the strengths and weaknesses of various approaches. A design specification detailing design guidelines for heating and ventilation systems is proposed. A system selection process was developed to guide designers and installers based on a number of performance criteria. Based on this information, three heating and ventilation systems are proposed for various locations in the North.

The study demonstrates the complexity of the design and installation of heating and ventilation systems in the North. It was found, in most instances, that information on system and component durability, cost information, occupant acceptance and long term performance was lacking. The lack of detailed cost information made it difficult to estimate the cost-effectiveness of various heating and ventilating systems alternatives. Innovative approaches to heating and ventilating systems are proposed that should improve the durability, energy efficiency and indoor air quality of Northern housing but performance monitoring will be required to confirm this. The study also identifies the need for occupant and community based operation and maintenance programs to support heating and ventilation systems. The study shows that the state-of-the-art of Northern heating and ventilation systems has not significantly improved in recent years. In view of changing regulatory requirements and the need to reduce the costs of housing associated with poor durability, energy inefficiencies and occupant health, the study concluded that more research is required to develop heating and ventilation systems that are appropriate for the North.

Key Words:

North, remote, heating systems, ventilating systems

Executive Summary

Historically, there have been a number of problems in Northern and remote housing related to heating and ventilation systems. Poor control of indoor conditions (temperature and humidity), high capital and operating costs, component reliability, the inability to operate under extreme indoor and outdoor conditions and occupant acceptance are among the most prevalent. Research work undertaken to mitigate these problems has been, to date, inconclusive. The Northern housing industry continues to face new challenges as its strives to improve the environmental and economic sustainability of housing in the North with ever shrinking budgets. Accordingly, heating and ventilating systems are often expected to perform to an ever conflicting list of criteria. Furthermore, changing regulatory requirements directed at preserving occupant health and safety while improving energy efficiency, if adopted, would force additional changes in the way heating and ventilating systems are designed and installed in Northern housing.

In the face of these challenges and changes, there is very little information available to define what constitutes appropriate heating and ventilation system for Northern applications. While a limited amount of research in this area has been undertaken in the context of improving specific technologies (e.g. oil burners), this work is not entirely useful in that no long-term monitoring has been performed to evaluate the performance of the system, or components proposed. In recent years, the Northern housing industry had adopted a trial and error approach to meeting the space heating and ventilation needs of Northern residents. However, there has been little information available regarding successes and failures. Additionally, while there have been many innovations in residential heating and ventilating systems over the past few years, few have penetrated the North housing markets.

In view of this situation, various members of the Northern housing industry have expressed concern that there is too little being done to support the research and development of appropriate heating and ventilation technologies for Northern and remote housing. In response, CMHC initiated this research project to document the state-of-the-art of Northern heating and ventilating systems through a review of available relevant research literature, interviews with members of the Northern housing industry and equipment suppliers. Based on this work, a list of design criteria was proposed to define appropriate equipment specifications. A guide for evaluating and selecting heating and ventilating system types was also proposed. Both the design criteria and guidelines are then used to select systems for three different community types in the Yukon and Northwest Territories.

The findings of the literature and regulatory review were telling. Not only is there a very limited volume of research specific to Northern housing, most of the research reviewed was concerned with mitigating specific moisture problems in existing housing. There were no research reports found that described the equipment and performance of innovative heating and ventilation systems. Passive ventilation systems - an approach often held up as having much promise in Northern and remote applications - were found to be prone to performance inconsistencies that generally outweighed their purported advantages. The advent of low power consumption, low noise ventilators

has reduced the relative advantages that passive ventilation held over mechanical alternatives.

The review of the new 1995 National Building Code of Canada and the proposed National Energy Code for Houses revealed that, if adopted, substantial changes would be required in the way heating and ventilation systems are designed and installed. While the changes the Codes would impose are onerous, the historical problems relating to building envelope durability, energy efficiency and indoor air quality warrant them. The implementation of the Code requirements will require careful equipment selection and system design and installation by the trades and then proper operation and maintenance by the residents.

Using the information obtained from the literature and regulations review, field surveys were designed and sent out housing agencies, system designers and contractors. The surveys indicated that there are currently a wide variety of systems and fuel types being used in the North and that there are considerable differences between the systems used in the public and private housing sectors. They identified the successes and failures of heating and ventilating systems currently and formerly used in the North and indicated the typical heating and ventilating system problems that are occurring.

Having identified the areas of concern, a process was developed to guide the selection of space heating and ventilation options intended for use in Northern housing constructed to the 1995 National Building Code. It is essential that space heating and ventilation options are considered coincidentally in order to ensure that the options are compatible and that the system most appropriate for the dwelling, the owner and the occupants is selected. Once the selection guidelines were completed, design recommendations were developed to direct the specification of a complete space heating and ventilating system that would address issues specific to Northern housing. A very special set of conditions apply to the North with regards to the space heating and ventilation. The number and complexity of these conditions increase as the location of residences becomes more remote. The design recommendations are intended to supplement local codes and standards and include a *Commentary* which is intended to provide the designer with a better understanding of the issue a particular recommendation is attempting to address. Barriers to the implementation of any of the recommendations are also included.

Using the system selection process and the design recommendations developed, a complete specification for three different heating and ventilation system options was developed that attempts to address all of the issues raised in this report. They provide a good indication of not only how complex the specification process is, but of how complete the specification must be because, ultimately, the success of a system will be determined by how well it is specified by the designer, installed by the contractor and operated by the homeowner. The three system options are:

- an outdoor air supply coupled with a fan coil space heating system using low diameter, high velocity ducting, and an oil-fired, direct-vent domestic hot water tank;
- an oil-fired, direct vent forced air furnace and domestic hot water tank, and a heat recovery ventilator with a dedicated ductwork system; and
- an oil-fired stove/space heater and an air exchanger ventilation air mixing box.

Many existing space heating and ventilating systems in the North are considered to be unacceptable. Homeowner complaints are most common with systems that are too noisy, too difficult to service and maintain, too expensive to purchase and operate, and/or generally ineffective because the HRV cores freeze, blowing snow blocks flues and fresh air intakes, heating equipment is oversized and adequate indoor air quality cannot be maintained. Any proposed space heating and ventilating system must ultimately be acceptable to the end user - the occupant. Along the way, however, appropriate organizations and contractors must buy into a proposed strategy and indicate their willingness and capability to properly install, repair and maintain the equipment involved. The key is to ensure not only that space heating and ventilating systems work effectively and efficiently, but that they are affordable to purchase, operate and maintain, and have a reasonable life expectancy. The three system options detailed in the report address these concerns.

This project has clearly indicated that there are a number of issues that impact significantly on the ultimate choice of a heating and ventilating system but which remain unresolved. Further research to address these issues will be required before it will be fully possible to design and specify systems that will work effectively and be accepted in the different communities throughout the North. Among the issues discussed in detail in the report that remain unresolved and require additional research are:

- the minimum temperature at which ventilation air can be delivered to the house and the temperatures at which preheating would be required
- the appropriate air volumes and temperatures required to discharge supply air into a room without causing comfort problems;
- the effect of the building envelope airtightness level on the specification of ventilation air flow rates and the type of equipment used;
- the real cost of coupling a ventilation system to a forced air system to provide air tempering and ventilation air distribution;
- the suitability of HRV's and ventilation mixing boxes that have not been certified for use where the design temperature is between -40 and -50°C; and
- the overall system efficiency, effectiveness and lifetime costs for a heating and ventilation system, including domestic hot water heating including a determination of the impact on systems of user attitudes and capabilities.

For all future research carried must address the fact that, ultimately, the success of a system will be determined by how well it is specified by the designer, installed by the contractor and operated by the homeowner.

Abrégé

On a passé en revue les systèmes de chauffage et de ventilation utilisés dans les habitations des régions nordiques et éloignées afin de déterminer dans quelle mesure les méthodes traditionnelles et les approches innovantes peuvent répondre aux besoins des populations qui y vivent. Une étude documentaire des récentes recherches effectuées sur les systèmes de chauffage et de ventilation destinés aux régions froides et éloignées et un survol de l'expérience de l'industrie dans ce domaine ont permis de relever les forces et les faiblesses des différentes méthodes. Par la suite, on a proposé des directives de conception pour les systèmes de chauffage et de ventilation. On a élaboré un processus de sélection des systèmes fondé sur un certain nombre de critères de performance afin de guider les concepteurs et les installateurs. À partir de cette information, trois systèmes de chauffage et de ventilation sont proposés pour diverses régions du Nord.

L'étude met en relief la complexité de la conception et de l'installation des systèmes de chauffage et de ventilation destinés aux régions nordiques. On a constaté, dans la plupart des cas, que les données sur la durabilité des systèmes et de leurs composants, et l'information sur le coût, l'acceptation par l'occupant et le rendement à longue échéance sont inexistantes. Il a été difficile, par manque de données détaillées sur le coût, d'estimer l'efficience des divers systèmes de chauffage et de ventilation de rechange. Des méthodes innovantes par rapport aux installations traditionnelles de chauffage et de ventilation sont proposées dans l'espoir d'améliorer la durabilité, l'efficacité énergétique et la qualité de l'air intérieur des habitations du Nord, mais il faudra procéder à un contrôle de la performance pour le vérifier. L'étude fait aussi ressortir la nécessité de mettre en oeuvre des programmes d'utilisation et d'entretien au sein même des communautés afin de soutenir ces systèmes de chauffage et de ventilation. L'étude montre que l'état des connaissances sur les systèmes de chauffage et de ventilation employés dans le Nord ne s'est pas beaucoup amélioré ces dernières années. Dans le contexte d'exigences réglementaires en évolution et de la nécessité de réduire les coûts du logement associés à une mauvaise durabilité, à l'inefficacité énergétique et à la santé des occupants, l'étude conclut que de plus amples recherches sont requises pour mettre au point des systèmes de chauffage et de ventilation appropriés pour le Nord.

Mots clés :

Nord, éloignées, systèmes de chauffage, systèmes de ventilation

Résumé

Dans le passé, les habitations des régions nordiques et éloignées ont éprouvé un certain nombre de problèmes de chauffage et de ventilation. La difficulté à maîtriser les conditions intérieures (température et humidité), les frais élevés liés à l'achat des systèmes et à leur fonctionnement, la fiabilité des composants, leur incapacité à fonctionner dans des conditions extrêmes à l'intérieur comme à l'extérieur et l'acceptation des occupants comptent parmi les plus fréquents. Les travaux de recherche entrepris dans l'espoir de résoudre ces problèmes ont été infructueux jusqu'ici. L'industrie de l'habitation en milieu nordique continue de faire face à de nouvelles difficultés dans ses efforts pour améliorer, malgré des budgets toujours plus serrés, la durabilité environnementale et économique du logement dans le Nord. C'est pourquoi on attend souvent du rendement des systèmes de chauffage et de ventilation qu'il respecte une liste de critères de plus en plus contradictoires. En outre, si elles étaient adoptées, les nouvelles exigences réglementaires destinées à préserver la santé et la sécurité des occupants tout en améliorant l'efficacité énergétique forceraient les fabricants à apporter des modifications additionnelles à la conception et à l'installation des systèmes de chauffage et de ventilation qu'ils fabriquent pour les régions nordiques.

Compte tenu de ces difficultés et de ces changements, on dispose de très peu d'information permettant de définir ce qui constitue un système de chauffage et de ventilation approprié pour des applications nordiques. Bien qu'un nombre limité de recherches aient été entreprises en vue d'améliorer des éléments particuliers (comme les brûleurs à mazout), ce travail n'est pas entièrement utile puisque aucun contrôle à long terme n'a été effectué pour évaluer la performance du système ou les composants proposés. Ces dernières années, l'industrie de l'habitation en région nordique avait décidé d'y aller par essai et erreur pour combler les besoins de chauffage et de ventilation des populations nordiques. Malheureusement, on dispose de très peu d'information sur les succès remportés ou les revers essuyés. De plus, malgré les nombreuses innovations qui ont marqué les systèmes de chauffage et de ventilation résidentiels ces dernières années, peu d'entre eux ont pu se tailler une place sur les marchés de l'habitation en milieu nordique.

Dans ce contexte, divers membres de l'industrie de l'habitation du Nord se sont dits inquiets de l'insuffisance des moyens employés pour soutenir la recherche et le développement portant sur les technologies appropriées en matière de chauffage et de ventilation en régions nordiques et éloignées. Pour donner suite à ces préoccupations, la SCHL a conçu ce projet de recherche qui a servi à documenter l'état des connaissances sur les systèmes de chauffage et de ventilation en milieu nordique par l'entremise d'un examen de la documentation de recherche pertinente et d'entrevues auprès des membres de l'industrie de l'habitation du Nord et des fournisseurs d'équipement. Par la suite, on a proposé une liste de critères de conception dans le but d'établir des spécifications appropriées pour l'équipement. On a aussi suggéré la rédaction d'un guide sur l'évaluation et le choix d'un système de chauffage et de ventilation. Les critères de conception et les directives devaient servir à choisir des systèmes pour trois différents types de communauté au Yukon et dans les Territoires du Nord-Ouest.

Les résultats de la recherche documentaire et de l'examen de la réglementation sont révélateurs. Non seulement il se fait très peu de recherche sur le logement du Nord, mais la plupart des

recherches étudiées portaient sur la réduction de problèmes d'humidité particuliers dans les habitations existantes. Les chercheurs n'ont pu trouver aucun rapport faisant état de l'équipement et de la performance de systèmes de chauffage et de ventilation novateurs. Les installations de ventilation passives, une approche qu'on dit souvent très prometteuse pour les régions nordiques et éloignées, se sont avérées peu constantes en matière de performance, au point que cette irrégularité pesait plus dans la balance que les avantages qui lui étaient attribués. L'arrivée des ventilateurs silencieux à faible consommation d'énergie a rendu la ventilation passive moins attrayante par rapport à la ventilation mécanique.

L'examen du nouveau Code national du bâtiment - Canada 1995 et du Code national de l'énergie pour les habitations proposé a révélé que, si ces codes étaient adoptés, des modifications substantielles devraient être apportées à la conception et à l'installation des systèmes de chauffage et de ventilation. Bien que les modifications que le Code imposerait soient pénibles, les problèmes passés liés à la durabilité de l'enveloppe du bâtiment, à l'efficacité énergétique et à la qualité de l'air intérieur les justifient. La mise en oeuvre des exigences du Code nécessitera un choix judicieux de l'équipement, une conception soignée des systèmes et une installation professionnelle de la part des corps de métier ainsi qu'une utilisation et un entretien appropriés de la part des occupants.

À partir de l'information obtenue lors de la recherche documentaire et de l'examen de la réglementation, on a conçu des sondages sur le terrain qu'on a envoyés à des agences de logement, à des concepteurs de systèmes et à des entrepreneurs. Les sondages ont indiqué qu'une grande variété de systèmes et de combustibles sont actuellement utilisés dans le Nord et qu'il existe des différences considérables entre les systèmes utilisés dans le secteur public et dans le secteur privé du logement. Les sondages ont aussi permis de relever les réussites et les échecs des systèmes de chauffage et de ventilation actuellement et anciennement utilisés dans le Nord et de soulever les problèmes les plus courants qu'éprouvent les systèmes de chauffage et de ventilation.

Une fois les problèmes relevés, on s'est attelé à la tâche de guider le choix d'un système de chauffage et de ventilation destiné aux habitations du Nord construit selon le Code national du bâtiment de 1995. Il est essentiel d'envisager simultanément les options de chauffage et de ventilation pour faire en sorte que les options choisies soient compatibles et que le système ainsi conçu convienne au logement, au propriétaire et à l'occupant. Quand les critères de sélection ont été arrêtés, on a élaboré des recommandations de conception pour orienter les spécifications relatives à un système complet de chauffage et de ventilation qui tiendrait compte des problèmes propres au logement du Nord. Une série de conditions très particulières doivent être prises en considération dans le Nord en matière de chauffage et de ventilation. Le nombre et la complexité de ces conditions est d'autant plus élevé que le logement se trouve dans une région éloignée. Les recommandations de conception visent à compléter les codes et les normes locaux et incluent un *commentaire* destiné à mieux faire comprendre au concepteur l'objectif visé par une recommandation particulière. On explique également les obstacles qui peuvent nuire à la mise en oeuvre de l'une ou l'autre des recommandations.

Grâce au processus de sélection du système et aux recommandations de conception élaborées, on a pu rédiger des spécifications complètes relatives à trois systèmes de chauffage et de ventilation différents qui tiennent compte de toutes les difficultés soulevées dans ce rapport. Ces spécifications montrent bien non seulement la complexité du processus de spécification, mais à quel point les spécifications doivent être complètes puisque, au bout du compte, l'efficacité d'un système dépendra de la qualité des spécifications formulées par le concepteur, de l'installation du système par l'entrepreneur et de l'usage qu'en fera l'occupant. Les trois systèmes élaborés sont les suivants :

- une bouche d'alimentation en air de l'extérieur raccordée à un système de chauffage à ventilo-convecteur muni de conduits de faible diamètre, mais à haut rendement, et d'un chauffe-eau domestique fonctionnant au mazout et doté d'un conduit mural d'évacuation;
- un chauffe-eau domestique et un générateur de chaleur à air pulsé fonctionnant au mazout avec conduit mural d'évacuation et ventilateur-récupérateur de chaleur pourvu de son propre réseau de conduits;
- une cuisinière-générateur de chaleur fonctionnant au mazout et un échangeur d'air à chambre de mélange d'air de ventilation.

Bon nombre des systèmes de chauffage et de ventilation actuellement utilisés dans le Nord sont considérés comme inacceptables. Les propriétaires-occupants déplorent surtout que les systèmes sont trop bruyants, trop difficiles à réparer et à entretenir, trop coûteux à l'achat et à l'utilisation ou généralement inefficaces parce que le noyau du ventilateur-récupérateur de chaleur gèle, que les rafales de neige bloquent les conduits d'évacuation et les bouches d'alimentation en air frais, que les appareils de chauffage sont surdimensionnés et qu'il est impossible de maintenir un air de bonne qualité à l'intérieur. Peu importe le système de chauffage et de ventilation proposé, il faudra, en définitive, qu'il soit acceptable pour l'utilisateur final, à savoir l'occupant. Tout au long du processus, cependant, les organisations concernées et les entrepreneurs doivent adhérer à la stratégie proposée et faire preuve de leur volonté et de leur capacité d'installer, de réparer et d'entretenir correctement l'équipement choisi. Il importe de s'assurer que les systèmes de chauffage et de ventilation fonctionnent bel et bien en toute efficacité, mais aussi qu'ils sont abordables lors de l'achat, de l'utilisation et de l'entretien et qu'ils offrent une vie utile raisonnable. Les trois systèmes dont il est question dans ce rapport répondent à ces exigences.

Cette étude a clairement indiqué qu'il existe un certain nombre de questions qui ont une influence considérable sur le choix ultime d'un système de chauffage et de ventilation, mais qui demeurent sans réponse. Ces questions devront être étudiées plus à fond avant que l'on puisse être pleinement en mesure de concevoir des systèmes capables de fonctionner efficacement et susceptibles d'obtenir l'assentiment des différentes communautés du Nord. Les questions suivantes ont été abordées en détail dans le rapport, mais elles soulèvent encore des interrogations et nécessitent de plus amples recherches :

- la température minimale à laquelle l'air de ventilation peut être diffusé dans la maison et les températures qui seraient requises pour le préchauffage;
- les volumes d'air et les températures appropriés nécessaires à la diffusion de l'air d'alimentation dans une pièce sans causer d'inconfort aux occupants;

- l'effet du niveau d'étanchéité à l'air de l'enveloppe d'un bâtiment sur les spécifications des débits de ventilation et sur le type d'équipement utilisé;
- le coût réel inhérent au couplage d'un système de ventilation à une installation à air pulsé dans le but de préchauffer l'air et de distribuer de l'air de ventilation;
- l'adéquation des VRC et des chambres de mélange de ventilation qui n'ont pas été homologués pour une utilisation à des températures oscillant entre -40 °C et -50 °C;
- le rendement général du système, l'efficacité et le coût global pour un système de chauffage et de ventilation, y compris le chauffage de l'eau domestique et la détermination de l'effet, sur les systèmes, de l'attitude et des capacités des utilisateurs.

Pour toutes les recherches futures, il faudra tenir compte du fait que, au bout du compte, le succès d'un système sera déterminé par la qualité de sa conception, la qualité de son installation et la qualité de l'utilisation qui en est faite.

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1. Background

It has not been unusual for equipment, systems and building components designed and suitable for houses in southerly climates to be used in the North. If this technology is carefully specified and/or slightly modified, it may be suitable. To facilitate the adoption of more appropriate design and construction methods for Northern housing, the Technical Policy and Research Division of Canada Mortgage and Housing (CMHC) is undertaking a series of projects directed at the development of a rational approach to building homes in the North. Massive thermal insulation levels, use of local resources for construction and energy, low energy systems, and passive solar design are among the concepts to be studied. This project represents the first step in this undertaking and will evaluate space heating and ventilating systems.

In the late 1980's, CMHC initiated a series of studies to evaluate heating and ventilating problems in Northern housing. It was found that the heating and ventilating systems being installed were somewhat problematic due to conditions imposed by the extreme cold, building size, occupant lifestyle, remoteness of location, and the cost of energy and power. Ventilation system failure due to ice and snow filled vents and frozen components were common. The incidence of deactivation of ventilation systems by occupants due to noise, energy consumption, and comfort problems (drafts) was also found to be high. Heating systems were usually oversized due to a lack of oil-fired equipment with a suitable firing rate. The complexity and unreliability of higher efficiency equipment (especially oil furnaces & boilers) discouraged their use.

In addition to these studies, CMHC initiated several demonstration projects to develop, install and test innovative heating and ventilating systems. None of these projects were completely successful. Commercially available, energy efficient, reliable components suitable for the North were found to be lacking largely because the market was to small to drive private sector research and development efforts. Occupants routinely interfered with the equipment in an effort to improve comfort conditions, and to reduce energy consumption and noise.

Since completion of these initial projects five years ago, Northern housing agencies have adopted various heating and ventilating strategies based upon trial and error, and experience. Unfortunately, little information was gathered on system performance and occupant acceptance so that the appropriateness of the solutions developed is not fully known. Furthermore, in recent years there have been advances in the efficiency and reliability of some heating and ventilating equipment and installation procedures that may present opportunities to better meet the unique needs of Northern housing. This project was initiated to document the Northern experience with traditional heating and ventilating systems, review new and emerging technology, to suggest ways to improve systems and to direct future research efforts. As the design and construction of Northern housing evolves to better reflect the environment in which it is located, the design criteria for heating and ventilating systems must also evolve.

2. Objectives

The objectives of this project were:

- to conduct a review of space heating and ventilating systems in the North identifying existing conditions and successes and failures with current systems;
- to identify available new and emerging technologies that are appropriate for space heating and ventilating systems in the North;
- to develop a performance based specification for space heating and ventilation equipment and systems for Northern housing;
- to suggest systems that could be installed today which would improve on existing approaches; and
- to make recommendations for future research.

3. Review of Existing Conditions

3.1. Literature Review

Since the advent of the first energy crisis of the 1970's, much work has been undertaken to improve the energy efficiency, durability and indoor environment of houses. The performance of housing has substantially improved and continues to evolve towards a sustainable form. Unfortunately, relatively little of this work has been performed in the context of Northern and remote housing where extremes of climate, remoteness, lifestyles, infrastructure limitations and costs impose markedly different loads and conditions on the design, construction and operation of houses.

Since the 1980's, there have been scattered research projects to deal with the most significant problems affecting Northern housing: moisture, heating and ventilating systems, and building envelope design. Most of the projects undertaken dealt with the characterization of the problems and the development of solutions. However, the ability, or desire, of the occupants to adopt the changes that such solutions would inevitably impose on their lifestyles, habits, and operating costs was not sufficiently explored. Furthermore, while many solutions were proposed, few were developed and even fewer were adequately monitored to assess their strengths and weaknesses. Consequently, information on successful, innovative approaches to heating, ventilating and building envelope systems in the North is very limited.

The following sections detail the results of the literature review. While there was an emphasis on the review of studies pertaining explicitly to Northern issues, relevant studies undertaken in the South are also discussed. The publications reviewed are listed in Appendix A. The key points of the review, and supporting references, follow.

3.1.1 Space Heating Systems

Much of the literature reviewed discusses space heating systems within the context of integration with ventilation and domestic hot water systems. For instance, many of the low cost, simple ventilation strategies proposed involve the ducting of outdoor air to the return air plenum of forced air heating systems. Similarly, opportunities to integrate the space and domestic hot water heating systems are also explored in a number of publications. Nevertheless, some of the literature reviewed contained several relevant observations and conclusions regarding the design, installation, operation and maintenance of space heating systems.

Forced Air Heating Systems

Recent work undertaken by the former Alberta Municipal Affairs (56) and the Saskatchewan Municipal Government (6) noted that a lack of basic furnace maintenance (e.g.; cleaning of filters) had a deleterious affect on the performance of space heating systems. The reduction of airflow was noted to cause problems such as burner cycling and poor heat distribution. Condensation related problems were noted in several of the cold rooms in the houses reported of the Alberta study. The observations recorded in this research work demonstrated the relationships between occupant understanding of the operation and maintenance needs of their space heating equipment and indoor air quality and building durability. Implicit in these observations is that either fail-proof equipment, or, more realistically, occupant training and education will be required to ensure that space heating equipment performs properly over time. Alternatively, more formal, community based maintenance plans would be required to support conventional, less than perfect, heating (and ventilating) equipment.

Existing strategies for the distribution of air by forced air systems were sometimes found to be problematic. The supply of warm air to crawl spaces was suspected to result in the transfer of moisture laden air from the crawl space to the house (the venting of clothes dryers to crawl spaces was noted to have the same consequences) (6, 56). The moisture related problems discussed in these studies emphasize the importance of separating crawl spaces, particularly those with known moisture problems, from the habitable spaces of houses. This would tend to imply that forced air heating systems should not be located within such crawl spaces. Accordingly, ductwork systems would have to be located at the ceiling level either exposed, in box-outs or dropped ceilings.

It has been reported that the continuous operation of forced air heating systems resulted in complaints due to noise (56). Noise associated with forced air systems tends to be more of an issue in smaller houses due to the proximity of noise generating equipment and air supply diffusers to the occupied space. The lack of space for mechanical services tends to encourage ductwork design and installation practises that result in increased air flow noise due to abrupt transitions, short fittings and truncated duct dimensions.

Occupant concerns about the energy costs associated with continuous operation of forced air heating system was also reported (6). Recent research by CMHC (21) revealed that continuously operating furnace fans could cost as much as $1.00 per day (@$0.08/kWh) to operate. Given the costs of electricity in remote areas of the

Northwest Territories and the Yukon ($0.20 - 0.30/kwh), the consequences of operating furnace fans continuously as part of a ventilation strategy become very apparent. Currently, CMHC is working with the HVAC industry to set voluntary timelines for the improvement of the energy efficiency of motor fan sets for all ventilation and space heating equipment (57). Two furnace manufacturers (Lennox and Carrier) already offer high efficiency motors in some models. While the electrical consumption is less than conventional motors, the lack of long-term operating experience and the use of "high tech" components can be disconcerting to the Northern housing industry. Furthermore, existing high efficiency motor sets are not easily retrofitted into existing equipment, therefore, their application is likely limited to new installations.

Research of methods to improve the performance of forced air heating ductwork systems is underway. CMHC is engaged in the performance monitoring of a small diameter ductwork system in one of two demonstration projects in Dawson City. The Institute for Research in Construction is performing similar tests (on a small diameter system) in a laboratory setting. A relatively new approach, small diameter ductwork systems distribute heated, high velocity air through 50 mm flexible ductwork from a central high pressure ductwork system. The system offers the advantages of reduced space requirements, factory engineered designs and ease of installation. Shipping costs may be lower than conventional sheet metal ducts due to the use of lightweight flexible ducting for branch ducts. The electricity consumed by the fan-motor set is of concern due to the power required to overcome the high static system pressure. The field and laboratory monitoring will determine whether or not this is significant.

CMHC is also studying methods to improve the performance of conventional forced air ductwork systems. An "optimized" ductwork system is to be evaluated in the second demonstration house in Dawson City. The system utilizes simplified ducting that delivers warm air through interior, high wall grilles on the ground floor and interior, low wall grilles on the second storey. This approach capitalizes on the extremely airtight and well insulated building envelope in that reduced wall heat losses negate the need to blanket exterior walls with warm air delivered through a perimeter ductwork system. The optimized design reduces the amount of material and labour embodied in the ductwork system and should also reduce furnace fan power requirements due to the shorter, simplified duct branches. It is important to note that air delivered by the systems must be no less than 13°C if delivered through high wall grilles and no less than 17°C if delivered through conventional floor diffusers to prevent comfort problems (58).

The use of forced air heating systems to draw in and deliver ventilation air via fresh air ducts connected to the return air plenums has been thoroughly studied - in Southern Canada. Field and laboratory research work by CMHC (23, 24, 59) studied mixing devices, mixed air temperature and the potential for furnace heat exchanger condensation and occupant discomfort with such systems. The HRAI Residential Air System Design Manual (60) prescribes the design and installation requirements for fresh air ducts connected to return air plenums and provides a procedure to calculate the mixed air temperature (which must be greater than or equal to 17°C). By all accounts, this approach can be successful if careful design and installation practises are used however the limitations are unknown. Research on the use of forced air systems to deliver ventilation within the context of Northern housing is not available although it is known that this approach has been adopted in the Northwest Territories. The issue of heat exchanger condensation not relevant to furnaces equipped with electric or hydronic heating coils although occupant comfort, coil freeze-up, and component durability can be of concern (65).

There were no references found to the merits of the various energy sources available for furnaces in the North. High seasonal efficiencies are possible with natural gas and propane furnaces but the limited availability of natural gas limits market penetration. Oil-fired furnaces have become increasing popular in the far North (over the more conventional hydronic baseboards) due to reduced capital costs. Experience is limited with high efficiency side-wall venting units as they have only come on to the market in the past few years.

Experience with integrated, or "combo" space and domestic hot water heating systems is limited. Combos use a domestic hot water tank (electric, oil or gas) to provide hot water for domestic consumption and to supply hot water to a fan-coil unit for space heating. Work performed by Howell-Mayhew Engineering (8) in 1988 indicated that there did not seem to be any operational problems with domestic hot water tanks being used to supply hot water for both space and domestic water needs. Combo systems are seen to represent a promising approach to heating systems in the North due to reduced space requirements, the reduction of the number of penetrations required in the building envelope for combustion air and venting, the economies associated with reduced capital, installation and shipping costs. At this time, not enough is known about the performance of these systems to comment on the impact on operating costs. Work is ongoing to assess the annual operating efficiencies of combo systems. CMHC will be monitoring the performance of a combo system in one of the Dawson City demonstration homes during the winter of 1996-97.

<u>Wood-fired Space Heating Systems</u>

Experience with wood-fired space heating systems is documented in (2), (3), (4), (5), (6) and (56). Wood-fired space heating systems are popular options below the treeline, in rural areas where alternative energy sources are more expensive or not available at all. The performance of these systems is documented from the perspective of integration with ventilation systems and the quality of the indoor environment. The most notable observation regarding the performance of wood-fired space heating systems is the lack of consistency of indoor temperatures both from room to room and over time.

Most wood-fired space heaters are located in the main living space of the house. Not surprisingly, the air temperatures in rooms adjacent to, or remote from, this central area were often noted to be substantially lower. Notwithstanding the issue of occupant comfort, this temperature differential was noted to be problematic due to moisture condensation on exterior walls, windows in the colder rooms which caused mould and mildew growth and damaged surface finishes. Mould and moisture damaged surfaces were found in the bedrooms of such houses, particularly where furniture and bedding was pushed up against exterior walls. The same type of problems were also noted to occur throughout the house if the firing rate of the wood stove was reduced or stopped altogether during extended owner absences from the house.

The Alberta Study (56) documented the installation of a limited supply/recirculation forced air system in a house with moisture and other IAQ-related problems. The system delivered a mixture of indoor and fresh (cold) outdoor air to a location under the space heater, thereby tempering of the outdoor air and recirculating indoor air. The system resulted in a better burn in the fire box (according to the occupant) and a more even temperature distribution throughout the house. Open architectural plans were also found to result in more even temperatures than plans that included long corridors between the location of the space heater and the other rooms of the house (56).

Hydronic Heating (Convective, radiant) Systems

Hydronic convective baseboard systems, coupled to an oil-fired boiler were a popular heating option in the north-eastern Arctic. The relatively high capital cost of such systems has diminished their market presence in new housing in favour of forced air space heating systems. CMHC was involved in an evaluation of high efficiency boiler systems in the late 1980's (8). However, this study was inconclusive due to a lack of field monitoring.

A novel, simple, low-cost and energy efficient hydronic heating system was recently installed in 20 houses in Couchiching, Ontario. Convectors were installed within the floor cavities to provide radiant heat to the houses. Ventilation air was delivered to the floor cavities where it is tempered by the convectors before being delivered to the rooms of the houses through openings in the floor (61). Unfortunately, there is no monitoring information available on this project.

3.1.2 Ventilation Systems

Passive Ventilation Systems

There has been a substantial amount of research directed at developing passive ventilation systems for Northern housing. The attractions are obvious: simplicity of design and installation, low capital and operating cost, no moving parts, minimal requirements of occupants and potentially sufficient ventilation during the winter months when it is most needed. A number of systems have been developed ranging from simple vertical vents from outdoors to the interior spaces to more sophisticated vapour permeable wall vents (2),(3), (6). The results of the efforts to date have been conclusive in that the problems associated with passive ventilation strategies generally outweigh their advantages. Uncontrollable flow rates, the presence of full time ventilation (whether it is needed or not), the absence of driving forces during substantial parts of the year, the lack of fresh air distribution, the potential for cold drafts, insect, snow and rain penetration are but a few of the problems that have yet to be overcome.

Dumont (6) and Lee (56) in developing simple, affordable and effective proposal for ventilation systems in Northern and rural housing did not consider passive strategies, perhaps for these very reasons. The development of quiet, durable, low energy fans has minimized many of the drawbacks of mechanical ventilation systems while offering many advantages over passive approaches.

Exhaust-Only Ventilation Systems

The Institute for Research in Construction (IRC) and CMHC have studied the effectiveness of exhaust-only (supply air by passive intakes or infiltration) ventilation systems in houses (62), (63). The studies have shown that exhaust fans located in kitchen, bathroom or central areas are not able to ventilate all rooms of a house. The overall house air change rate may be acceptable but the air change in areas such as bedrooms and other living areas not directly connected to the exhaust fans was found to be insufficient. These findings, and others, support the recent changes to the 1995 National Building Code that require ventilation air distribution to all rooms of residential dwellings.

IRC (62), and studies conducted on behalf the Alberta Municipal Affairs (2, 3) evaluated ventilation systems consisting of exhaust fans in bathroom, kitchens or other central areas and passive air inlets located in some or all of the other rooms. While better air distribution was achieved, particularly where passive vents were provided in all rooms, problems with the systems included variable ventilation rates due to the influence of stack and wind effects, cold drafts, insect and snow penetration, and occupant dissatisfaction with the noise and operation of exhaust fans.

Ventilation systems that use both supply and exhaust air fans to deliver and remove air from a house are becoming more common. Packaged air exchangers and heat recovery ventilators represent the most common system types. CMHC has tested HRV ventilation systems that deliver air directly to each room of a house while exhausting air from kitchen and bathroom areas (sometime referred to as direct duct ventilation systems). Such direct duct ventilation systems were found to be effective and acceptable to the occupants as long as they are properly designed and installed. Comfort and noise are the most significant issues with such systems (7). A cost study performed by Natural Resources Canada (64) found that direct duct ventilation systems that operate independently of the forced air heating systems could be very cost effective as the energy consumption of the furnace fan-motor set could be avoided. The implications of this study on Northern housing are due to a number of factors. Certainly, the high cost of electricity would tend to support the adoption of any ventilation strategy which does not depend upon continuous furnace fan operation for ventilation air distribution. However, the fact that, in the North, furnace fans may be operating for a good part of the year anyway may negate some of the apparent advantages of direct duct ventilation systems. It is recognized that this issue requires further evaluation within the context of Northern and remote housing. The Dawson City Demonstration project will attempt to identify the relative advantages of ventilation systems that are integrated with forced air heating systems versus direct duct ventilation systems over the 1996-97 heating season.

Lee reported on the installation of a balanced supply and exhaust air ventilation system in a house (56). An approach independent from the furnace circulation fan was selected to avoid furnace heat exchanger condensation problems and draft, noise and cost issues related to continuous operation of the furnace fan. After an initial monitoring period, this approach was found to be effective at controlling humidity levels in the house. The system was also found to be affordable at the given electrical rates. The fan operation and electric pre-heat was estimated to cost $0.45/day (@

$0.06/kWh). It should be noted that the study did not explore the effectiveness of the system in maintaining adequate IAQ in all rooms.

Ventilation Systems Coupled to Forced Air Heating Systems

In houses with forced air heating systems, it has become common practise to integrate the ventilation system with the forced air system ductwork. This eliminates the need to duct the space heating and ventilation systems separately to each room thereby saving material and labour costs.

The connection of a fresh air duct from outdoors to the return air plenum of a forced air system represents one of the most simple and affordable means of integrating the ventilation and space heating functions. However, while the new 1995 National Building Code allows this approach, a number of conditions have been imposed that will affect affordability, complexity of the installation and simplicity of operation (see Section 3.2, Regulatory Review). The most significant change is that the supply air fan (i.e.; the furnace fan) must be interlocked with an exhaust fan of equal capacity to ensure a balanced air flow into, and out of, the house.

CMHC and the Ontario New Home Warranty Program reported on the effectiveness of fresh air duct/furnace return ventilation systems (59) and (31). While the approach was generally found to be effective, it was not without problems relating to poor installation practises, highly variable ventilation performance, and occupant dissatisfaction due to noise, and perceptions of energy waste. The poor quality of conventional bathroom and kitchen exhaust fans, and improper sizing and installation of the fresh air ducts were most often the cause of the problems noted.

Lee (56) commented that in a rural, Northern test house where a fresh air duct was retrofitted to the furnace return and an exhaust fan was added in the kitchen, the system greatly reduced the incidence of condensation and moisture related problems. It was observed that greater moisture control and ventilation performance could have been achieved if the furnace fan had been set up to operate continuously. However, Lee acknowledged that noise, cost and draft associated with continuous operation could potentially outweigh the advantages.

Packaged ventilator systems such as air exchanger and heat recovery ventilators are also often integrated with the forced air heating system. The ventilator draws air in from outdoors and delivers it to the return air duct of the forced air system. The forced air system then distributes the fresh air to all rooms of the house. The ventilator also exhausts air from the house thereby providing balanced ventilation. CMHC explored the effectiveness of using the furnace to distribute ventilation air supplied by an HRV (7). The primary conclusion of this work was that the furnace fan had to operate if adequate ventilation of all areas was to be achieved. Despite the fact that the HRV supply fan was available to deliver air into the furnace ductwork system, if the furnace fan was not operating, the ventilation air would not be distributed throughout the house. This was found to be the case regardless of how the HRV exhaust ducting was installed. This finding is significant as the costs of operating the three fans (two in the HRV, one in the furnace) can be considerable, particularly in the North. Unies (64) found that the costs of operating all three fans was expensive enough to justify the installation of a dedicated ventilation supply ductwork system in parallel with the space heating system ductwork to each room so that the operation of the furnace fan would not be required. As mentioned earlier, furnace heating run times, fuel cost economics would have to be analyzed in Northern housing to determine if this conclusion still holds.

Research Literature Review Summary

Based upon the research performed to date, the following statements concerning heating and ventilation systems would appear to be true:

1. Ventilation systems must either directly supply or exhaust every room to be effective.
2. Passive ventilation techniques developed to date have not been successful.
3. Ventilation systems connected to forced air heating systems require continuous operation of the furnace fan to provide effective ventilation.
4. Continuous furnace fan operation is expensive.
5. Space heating systems must be capable of evenly distributing heat throughout a dwelling to prevent comfort and condensation/moisture related problems.
6. Occupant training and education is required to ensure proper operation and maintenance practises for heating and ventilation equipment.
7. Regardless of the heating and ventilation system selected, a local support infrastructure of skilled and semi-skilled trades will be required for maintenance.

3.2. Regulatory Review

The publication of the 1995 National Building Code and the development of the proposed National Energy Code for Houses will, if adopted, change the way heating and ventilating systems are designed and installed in the North.

3.2.1 1995 National Building Code

3.2.1.1 Ventilation Provisions

The 1995 NBC contains a number of new sections that govern the design, installation and commissioning of ventilation systems for houses. A number of these sections contain provisions that are directly relevant to Northern and remote housing:

Non-Heating Season vs. Heating Season Ventilation Requirements

Non-heating season ventilation can be achieved through either natural ventilation via unobstructed areas (e.g. windows) or mechanical ventilation, or both. Heating season ventilation can be achieved via mechanical ventilation systems in any residential building supplied with electricity. This provision would require that cottages and other seasonal use residential buildings with electric services be supplied with mechanical ventilation even if they are only used in the non-heating season months. This provision would have an immediate impact on houses as well as any other seasonal dwelling.

Requirements for Mechanical Ventilation Systems

Where mechanical ventilation is required, the system must meet the requirements of CAN/CSA F326 "Residential Mechanical Ventilation Systems" or either of the two prescriptive approaches detailed in the Code. The three methods have the following in common:

- the capacity of ventilation systems is to be calculated on a room by room basis
- ventilation air is to be distributed to all habitable rooms in a house
- the exchange of ventilation air in a dwelling must be achieved through mechanical supply and exhaust - air infiltration through the building envelope is no longer an acceptable method of balancing mechanical exhaust.
- the ventilation air must be tempered to adequate temperatures.
- the supply air fan must be interlocked with the exhaust air fan to ensure balanced operation.

These are significant changes to the way ventilation systems have been traditionally designed and installed in most areas of the North and the rest of Canada. While higher capital and operating costs for owners are implicit in these requirements, the arguments (e.g. durability and occupant health) for their implementation are substantive given historical problems in Northern and remote housing. The challenge for housing agencies, designers and installers will be development of low-cost, simple and effective ventilation systems that will meet the Code requirements.

System Design and Installation Practices

The Code calls for ventilation systems to be designed and installed in accordance with good practice guidelines described in a number of reference guidelines and standards. The implications of this requirement are obvious: training and education will be required for local trades in Northern and remote communities to ensure that the systems provided meet the intent of the Code.

Total Ventilation System Capacity

The Code requires that the capacity, or size, of the ventilation system be based on the number of habitable rooms in a house. This requirement is of significance when small houses are designed with a large number of rooms. Ventilation rates can then exceed the old ventilation requirements that were based on the heated volume of the house only. In Northern and remote communities where energy costs are high, this change may be significant in some designs.

Ventilation System Design

Whether the ventilation system is designed to meet the performance based requirements of CSA F326 or the more prescriptive approaches detailed in the Code, the number of changes to conventional design and installation practices are substantial. A "systems" approach to the ventilation system in itself and the overall house in general must be taken. No longer can the ventilation trades install equipment in isolation of the potential impact on the performance of combustion appliances, space heating equipment and occupant comfort. A structured approach to the ventilation system and careful consideration of how it works with other house systems is required.

To aid designers and installers, CMHC has produced a prescriptive guide that provides equipment lists and installation details for six ventilation systems that could be used to meet the Code requirements (65).

3.2.1.2 Space Heating Systems

The 1995 NBC contains requirements for space heating systems for residential buildings intended for heating season use. The Code now contains design, fabrication and installation practice requirements as given by a number of industry publications. Minimum indoor air temperatures are prescribed as are duct and convective-radiant space heating system design and installation requirements.

The implications of the detailed Code requirements on Northern and remote housing are significant. For instance, houses relying on centrally located, wood-fired space heating systems may have difficulty meeting the intent of the Code given past problems with inadequate heat distribution. The standards to which systems must be installed will require skilled trades people whose availability in some communities may be non-existent.

Another specific Code change that is worth mentioning is that which allows high, side-wall or ceiling grilles to be used in an air distribution system intended to convey both space heating and ventilation air. This is of significance to Northern housing where the installation of ducts in unheated areas such as crawl spaces or attic spaces is not desirable. The new code requirements will allow the ducting to be run in the ceiling of the first floor to deliver air from the ceiling or high side wall locations. This provision should allow for the design and installation of simplified ductwork systems that is less expensive to purchase, and install and that makes better use of limited space.

3.2.2 The Proposed National Energy Code for Houses (NECH)

Although the NECH has not been adopted by any province or territory, if adopted, it contains a number of requirements that would impact on the design and installation of heating and ventilation systems across Canada. There are provisions that are particularly relevant to the North due to implications on capital and operating costs, energy consumption and system complexity.

For instance, ducts, other than exhaust, installed outside of the building envelope must be sealed and insulated to the same level of the exterior walls. In some areas of the Yukon and the Northwest Territories, R26 to R 38 would be required depending upon region and space heating fuel type.

Make-up air and combustion air ducts would require automatic, motorized dampers. Increased capital costs would be incurred and the system would be more complex due to the wiring interconnections required to operate the dampers. More equipment also usually implies more maintenance which may be difficult to arrange in some remote communities. Depending upon the damper wiring, automatic motorized dampers can consume up to 7 - 10 watts continuously while closed as they are usually wired so that they fail open in the event of a power failure. Designers and installers will have to be conscious of this potential when selecting equipment.

Electric resistance heaters (e.g. baseboards) must be controlled by individual, remote thermostats (except in vestibules, and bathrooms where the heater is supplemental). A thermostat located on the unit itself will no longer be adequate. Unit mount thermostats do not regulate room temperature particularly well and they are not readily available for adjustment. By providing a central wall mount thermostat, it is hoped that better heating performance will be achieved with less power consumption. The accessible control may also encourage occupants to setback temperature in unoccupied rooms.

Furnaces must be controlled by programmable set-back thermostats. While this provision would increase the cost of furnace thermostatic control, the thermostats offer the advantage of automatic setback. While this may reduce space heating energy consumption, the implementation of this measure should be approached with caution as the setback of the furnace may cause increased night-time condensation on windows. Durability and health-related problems may occur without diligent clean-ups of moisture deposited upon the windows.

As a part of the prescriptive approach to complying with the energy code, heat recovery is required for ventilation systems. Heat recovery is not necessarily required for a given house if it can be shown that alternative approaches can match the energy consumption performance of the house with heat recovery. Notwithstanding the apparent choice this offers, the mention of heat recovery ventilation as a requirement of the Code is problematic to Northern Housing agencies. Concerns regarding the reliability, durability, economics and occupant acceptance has, to date, discouraged the penetration of HRV systems in the North and in remote housing. Additionally, the availability of HRV's appropriate for Northern housing is of concern as there are currently no packaged residential HRV's rated for the design temperatures of most Northern communities.

SUMMARY

Given the historical moisture, durability and comfort related problems in Northern housing, the changes to the ventilation requirements of the 1995 National Building Code are appropriate. Research and field evaluations performed to date have shown that ventilation systems must be able to exchange, distribute, circulate and condition outdoor air in order to prevent the aforementioned problems from occurring. The new Code requirements now ensure that the necessary equipment is provided and installed to an acceptable standard.

However, the problems that the new requirements would impose on Northern housing are many. There have been many documented problems with air intakes and exhausts blocking due to hoar frost and/or driving snow. The ability of fresh air fans, air tempering devices and side-wall venting systems to operate in the wide range of climatic conditions of the North is unknown. The ability of occupants to use and maintain the ventilation systems also has yet to be determined.

While the concepts behind the Code requirements are relatively straightforward, implementing them successfully in practise in Northern and rural housing will be more difficult.

3.3. Community and Housing Archetypes

Once the *Literature and Regulatory Review* was completed , the next step was to identify the different types of communities that exist across the North, and the different housing archetypes within these communities. Depending upon the size and "remoteness" of a community, existing housing consists of some combination of conventional, renovated and advanced housing archetypes, each of which requires different heating and ventilating strategies. For this project, the decision was made to focus on housing built in accordance with the 1995 National Building Code. Identifying communities and housing archetypes was necessary in order to more clearly define the scope of work for this project, which is new Northern housing, and to put this class of housing into perspective with regards to the overall housing situation in the North. It was anticipated that, after addressing new housing issues, approaches suitable to retrofitting the existing housing stock would also emerge.

With the assistance of the Yukon Housing Corporation (YHC) and the Northwest Territories Housing Corporation (NWTHC), it was determined that, for space heating and ventilating, there are at least three major classifications of Northern communities:

<u>Type 1 Northern: Example - Whitehorse or Yellowknife</u>

- Fuel and electricity reasonably priced (Oil: $0.40/L; Electricity: $0.15/kWh)
- Trained personnel available to service higher technology systems
- Higher income population
- Willingness to make long term investment in housing
- Greater understanding by occupants and contractors of issues and technology surrounding higher technology heating and ventilating strategies

<u>Type 2 Northern: Example - Ross River, Yukon or Cambridge Bay, NWT</u>

- Fuel and electricity more expensive (Oil: $0.55/L; Electricity: $0.30/kWh)
- Operating and maintenance potentially a major concern due to lack of trained service personnel for any higher technology system
- Modest income population
- Lifestyle and culture a greater consideration (occupancy loading of space, use of space, willingness to undertake routine maintenance, etc.)
- Less desire to make large investment in higher technology housing form
- Steep learning curve with respect to higher technology systems

<u>Type 3 Northern: Example - Old Crow, Yukon</u>

- Fuel and electricity costs a major concern (Oil: $0.70/L; Electricity: $0.40/kWh)
- Operating and maintenance a major concern
- Lower income population
- Lifestyle and culture a major consideration
- Money and desire not present to support higher technology systems
- Steepest learning curve with respect to higher technology systems

Each type of community is comprised of both private and public housing. The houses are a combination of conventional, renovated and advanced housing archetypes. The public housing is somewhat unique in that the heating and ventilating systems have been designed by professionals and maintenance of these systems is carried out by regional housing corporations.

The YHC maintains approximately 650 residential units in 15 different communities throughout the Yukon. These units consist of single and multiple family dwellings and apartment blocks and represent about 6 percent of all housing. The NWTHC maintains an inventory of approximately 6500 residential units. With the recent loss of Federal subsidies for this type of housing, neither corporation is increasing their inventories due to high operation and maintenance costs. They are now involved in home ownership programs, owner-built programs, and home repair programs.

Housing units maintained by YHC and NWTHC are often characterized by smaller floor plans, high occupancy patterns and a lifestyle that places a high demand on the ventilation system. Ventilation strategies intended to meet these high demands, have often been found to be inappropriate or too expensive to operate because of problems associated with HRV cores freezing, excessive ventilation rates, drafts, significant fan electrical costs and occupant interference with the unit. It should be noted that, in Alaska, where the climate is not as severe as some parts of the Canadian North, there has been a good success rate with two brands of Canadian heat recovery ventilators when the unit is installed properly and maintenance is carried out on a regular basis by maintenance personnel trained by the housing authorities.

3.4. Field Survey Protocol

Using the information obtained from the literature and regulation review, and from the investigation into housing and community archetypes, three different surveys were designed and sent out to three different groups. Approximately 40 surveys were sent out with the following responses received from each group:

- Housing Agencies - 7 responses;
- Experts and System Designers - 4 responses; and
- Installation and Service Contractors - 4 responses.

The survey was used to gather information on:

- housing archetypes and typical indoor environment conditions;
- the heating and ventilating systems currently installed in each community archetype;
- the successes and failures that have been experienced with each system;
- improvements that could be made to heating and ventilating systems; and
- fuel, equipment, installation, operation and maintenance costs.

A copy of the three different survey forms and a list of the individuals that initially received the surveys are included in Appendix A.

3.5. Field Survey Results

A summary of the basic survey findings gathered for each community type from each of the three groups is included in Appendix B. The survey showed that there is a great difference between the type of communities, infrastructure and housing found in the Northern regions of the provinces and the territories. This required some re-focusing of the project and the decision was made to concentrate on space heating and ventilating systems for communities located in the territories. The systems recommended for this region would also be suitable for many applications in remote northern regions of the provinces.

It is important to recognize that technology and codes are evolving towards more advanced forms of housing. For example, the 1995 National Building Code now has a requirement for mechanical ventilation and the proposed 1995 National Energy Code will specify systems based on different degree-day regions. The National Energy Code is calling for the use of HRV's in all northern housing and there is considerable concern about this among Northern housing authorities because of the problems with HRV's in the past and the fact that there are no HRV's currently certified for use at the design temperatures found in the North.

The surveys indicated that there are currently a wide variety of systems and fuel types being used in the North and that there are considerable differences between the systems used in the public and private housing sectors. The public housing agencies have played a far greater role in providing housing stock in the North than elsewhere.

- In the Yukon, 80 percent of the housing is heated with forced air systems with the remainder split between hydronic and electric baseboard heating. About 70 percent of the forced air systems are oil-fired with the remainder using mainly propane or a wood/fuel combination system.
- In the NWT, approximately one-half of the NWTHC housing inventory is currently being heated by a hydronic system, whereas, forced air systems dominate new housing. Although the majority of the heating is provided with oil-fired systems, there are some unique exceptions. Norman Wells, for example, is a community serviced by natural gas while Yellowknife and Hay River use propane as their main fuel source.
- In Alaska, the use of efficient oil-fired Japanese stoves as space heaters, or a new, fast reacting 87% efficient oil-fired boiler in combination with HRV's designed for Northern conditions have been utilised. Further investigation revealed that the Japanese stoves were originally designed for kerosine use and required considerably more maintenance when used with fuel oil. It was also discovered that the populated areas of Alaska have a more moderate climate due to the moderating effect of the sea, making the use of HRV's more practical.

The survey was used to identify the successes and failures of heating and ventilating systems currently and formerly used in the North. They indicated that the following heating and ventilating system problems have been common in the far north.

- ***Heating System Design & Installation Problems:***
  - Installers and service technicians are not always knowledgeable - especially with hydronic systems.

* The minimum oil furnace/boiler heating capacity is 70,000 Btuh but heat losses may be only 40,000 Btuh.
* Initial capital cost is high.
* Locating ductwork is difficult because of the lack of basements and or failure of the architect to take the duct system into account.
* The electronic components of propane furnaces located in crawls spaces are frequently damaged by flooding of the space.
* Equipment prices are extremely high because of high freight and labour costs.
* Forced air systems, when properly designed and installed, can work well in the north, but the electrical cost of blower operation is a significant expense because of the high cost of electricity.

- ***Ventilating Design & Installation Problems***:
  * Few installers can balance systems or understand Code requirements.
  * Some houses require higher ventilation rates than mandated by Building Code because humidity levels are very high.
  * The operating noise level is too high.
  * Space limitations are a serious concern.
  * HRVs have not performed well in the past and are now usually not used.
  * Occupants sometimes are not able to operate and maintain equipment appropriately.
  * Equipment prices are extremely high because of high freight and labour costs.
  * National Building Code ventilation requirements may not be suitable for very cold and windy conditions found in the North.

In summary, the surveys indicated that:

- The ideal fuel in remote areas is fuel oil because it is relatively easy to transport, it has a high energy content for its weight and volume, residents are familiar with the fuel and the technology surrounding it, and it is relatively safe to handle, store and transport.
- Space heating technology that is efficient and uses little, or no, electrical energy would be ideal. Such systems could include: oil-fired furnaces or boilers with high efficiency motors to distribute heated air or water throughout the house; and space heaters or wood stoves that use no electricity in combination with a ventilation system that is electrically efficient and that would distribute both outdoor and indoor air.
- A method of heat recovery from ventilation air that is suitable for operation in extreme Northern conditions is required.
- A method of providing adequate ventilation using a minimum amount of electrical energy is required.

4. Development of Design Recommendations

Using the information gathered by conducting the literature review and field survey in Task 1, a process was developed for selecting space heating and ventilating systems. The process is intended to assist a system designer in choosing space heating and ventilation options that would best suit the type of community, house and occupants for which the system is intended. This selection process is presented in Section 4.2.

Once the selection guidelines were completed, design recommendations were developed to direct the specification of a complete space heating and ventilating system that would address issues specific to Northern housing. These design recommendations are presented in Section 4.3.

4.1. Issues Specific to Northern Housing

A very special set of conditions apply to the North with regards to the space heating and ventilation of residences. The number and complexity of these conditions increase as the location of residences becomes more remote. In developing a set of design recommendations, there were a number of considerations:

- It was necessary to determine the costs that would be tolerated with respect to space heating and ventilating systems. Consideration had to be given to equipment, installation, system operation and maintenance costs. For example, in a remote community such as Old Crow, Yukon, where the average income is very low, high initial equipment costs and high operation costs will not be acceptable. If operating costs of the ventilation system are too high, for example, the occupant will turn the system off.
- Design recommendations had to address the extreme conditions which occur in the North. For example, an existing problem relates to relative humidity spikes due to cooking, swabbing floors and/or high occupancy. It is important that occupants have the ability to control these spikes without over ventilating their home at other times.
- Design recommendations had to be sensitive to the “house as a system” so that the system designed would be compatible with the other houses systems, especially the building envelope. Consideration, for example, had to be given to providing for makeup and combustion air and to addressing concerns such as backdrafting.
- The installation and operation of the system required special consideration since, due to extreme conditions in the North, the effectiveness of a particular system will be closely tied to how well it is installed and the ability and willingness of the occupant to operate the system as intended. How well a system is installed is dependent upon the ease of installation and the commissioning that is carried out, while the willingness of the occupant to operate the system is linked to the complexity and cost of operating and maintaining the system.

4.2. Selecting a Space Heating and Ventilating System

The following set of questions is intended to guide the selection of space heating and ventilation options intended for use in Northern housing constructed to the 1995 NBC (National Building Code). It is essential that space heating and ventilation options are considered coincidentally in order to ensure that the options are compatible and that the system most appropriate for the dwelling, the owner and the occupants is selected.

The information presented in Tables 1 and 2 details the space heating and ventilation options that have the potential for operating effectively in the North. The advantages and disadvantages of each option are presented so that the system designer will realize, understand and address the issues associated with choosing a specific option.

1. What special needs do the owner/occupants have which will affect the system selection? Special needs which may eliminate the use of some systems should be considered at the outset of the design process.
   - Consideration should be given to questions such as:
     - ⇒ How many occupants will be living in the house?
     - ⇒ Do any of the occupants have special health problems such as asthma?
     - ⇒ Are there lifestyle activities which may generate high levels of humidity?
     - ⇒ Is the occupant a senior who may desire higher indoor temperatures?
     - ⇒ Is even temperature distribution to all rooms important?

2. What available fuel/energy sources would be most suited to the owner/occupants needs?

   DO NOT CONSIDER COST AT THIS POINT.
   - Consideration should be given to points such as the following:
     - ⇒ Electricity is simple, efficient and requires no venting, makeup or combustion air, but may have to be produced by a diesel generator which will be expensive.
     - ⇒ A propane tank may require electrical heating if located outdoors.
     - ⇒ A wood-fired system may require a backup system to prevent water line freezing.
     - ⇒ Wood is not a practical choice above the tree line or where occupants do not wish to invest the time and energy required to gather wood and maintain a chimney.

3. Based on suitable fuel/energy sources, what space heating systems would be best suited to the owner/occupants needs?

   DO NOT CONSIDER COST AT THIS POINT.
   - Use *Table 1: Space Heating Systems for Northern Housing* to select options compatible with the suitable fuel/energy types.
   - Consideration should be given to points such as:
     - ⇒ The *Disadvantages/Problems* associated with each space heating system (*Table 1)* will have to be addressed so that overall system operation is not adversely affected.

⇒ The space heating system should fit into the interior space available and be accessible for servicing and maintenance. Homes in many communities have no basement and/or are small, leaving a minimum amount of room for the space heating and ventilation system.
⇒ It may be possible to integrate the domestic hot water heating system with the space heating system.

4. What ventilation options could be combined with the space heating options to provide a space heating and ventilation system best suited to the owner/occupants needs?

   DO NOT CONSIDER COST AT THIS POINT.

   - Use *Table 2: Ventilation Systems for Northern Housing* to select ventilation options which are compatible with the selected space heating systems.
   - Consideration should be given to points such as:
     ⇒ The *Disadvantages/Problems* associated with each ventilation system (*Table 2)* will have to be addressed so that overall system operation is not adversely affected.
     ⇒ The ventilation system should fit into the interior space available and be accessible for servicing and maintenance.

5. Can the owner/occupant afford to install, maintain and operate the space heating and ventilation system options selected?

   - The installed cost should be the price for a space heating and ventilation system that meets the 1995 NBC, the design recommendations presented in Section 4.3 and addresses the *Disadvantages/Problems* associated with each space heating system (*Table 1)* and ventilation system (*Table 2)*.
   - In addition to considering the installed cost, it is equally important to consider the cost of operating and maintaining the space heating and ventilation system. For example, electric baseboard heaters offer one of the lowest cost space heating systems and require little maintenance but, if operating costs are high, any capital cost savings will be quickly eroded.
   - Consideration should be given to points such as:
     ⇒ The complexity of installation and high shipping costs can have a significant impact on the final cost.
     ⇒ System components should have a proven record of reliability.
     ⇒ Where the owner/occupant has the financial resources, emphasis should be put on selecting the most efficient system to operate recognising the bounds of other considerations such as servicing and maintenance.
     ⇒ A system with the most efficient and least number of fans and with a design and control system to optimise its use is most likely going to be the least expensive to operate. However, if the system is too expensive to operate, it will be turned off. Ease of operation should not be sacrificed for efficiency.

6. Are skilled technicians available locally to service and maintain the space heating and ventilation system options selected?

   - Newer equipment can be very sophisticated and require specially trained technicians to service the units. DO NOT CHOOSE any system that cannot be serviced and maintained by local personnel.

   - Consideration should be given to points such as:
     ⇒ In addition to trained service personnel, replacement parts should be locally available.
     ⇒ If a sophisticated system has proven to be reliable, it may be worthwhile to consider it despite its complexity.

7. What system can be operated, as intended, by the occupants?

   - It is essential that the system complexity, or simplicity, be matched to the ability of the occupants to operate and maintain the space heating and ventilation system selected. The occupants of houses in some communities may be able to understand and operate a system that would be too complex for another.

   - Ideally, the occupants should have an opportunity to review the system selected and asked what barriers they see to its operation and maintenance.

   - Consideration should be given to points such as:
     ⇒ Simplicity is essential for the long term success of a space heating and ventilation system.
     ⇒ Occupant education on system operation and maintenance is essential if the system is to operate efficiently and effectively, and operation and maintenance costs are to be minimized.
     ⇒ If maintenance teams/programs are available in the community to assist the occupants, it may be possible to ease the system selection restrictions.
     ⇒ Traditional thinking and practices can nullify the best intentions of a well designed space heating and ventilation system. For example, popular in remote communities is the concept of opening a window or door in winter to provide adequate ventilation. Once open, the window freezes and the hardware is subsequently damaged trying to close it.

TABLE 1: Space Heating Systems for Northern Housing

SPACE HEATING SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC FORCED AIR SYSTEM	• heat delivery to each room can be easily balanced • heat delivery can be ducted under windows to reduce condensation • provides possible distribution system for ventilation air • facilitates the tempering and humidifying of ventilation air • lower equipment and installation cost than hydronic system • more controllable and reacts more quickly than hydronic system	• if no basement, ducting must be boxed in and passed to floor level via interior walls • "no basement ducting" can result in added pressure drop and duct leakage making it difficult to achieve design flows • potential for backdrafting increases substantially in tighter houses with spillage susceptible equipment • noise may be a problem for systems designed to run continuously to distribute ventilation air	• route ductwork through a false floor which can be an expensive option • architectural design must consider mechanical design • use low resistance ductwork components • select non-spillage susceptible equipment , or install a properly designed make-up system • select a furnace air handling unit with a sone rating of less than 2
FA1: Forced air with oil-fired furnace	• same as generic system plus; • equipment, trained installers and service technicians readily available • low maintenance and service costs • direct vent models available which do not backdraft • if direct vent model used with direct vent or electric DHW heater, makeup air is not required and potential for backdrafting is eliminated	• same as generic system plus; • high efficiency condensing models not available • smaller output furnaces not available for energy efficient houses which result in less efficient operation and higher heating costs	• same as generic system
FA2: Forced air with gas-fired furnace	• same as FA1 plus; • high efficiency models available which, when used with the appropriate water heater, eliminate need for makeup and combustion air	• same as generic system plus; • skilled service technicians and replacement parts may not be available for high efficiency models	• same as generic system
FA3: Forced air with propane-fired furnace	• same as FA2	• same as FA2 plus; • fuel tank must be heated in very cold temperatures otherwise fuel will not vaporize	• same as FA2
FA4: Forced air with: - combination wood/oil-fired; - combination wood/ electric; - or wood-fired furnace	• same as generic system	• same as generic system plus; • higher maintenance requirements due to chimney cleaning • creosote build-up can result in chimney fires	

TABLE 1: Space Heating Systems for Northern Housing

HEATING SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC FAN COIL FORCED AIR SYSTEM	• same as generic forced air plus; • one heating appliance can be used to supply both space and domestic hot water heating thus reducing capital, operating and maintenance costs • depending upon heating needs, a DHW heater can to supply both space and domestic hot water needs • can be used in combination with high velocity, low diameter ducting to eliminate complex ducting	• same as generic forced air plus; • may be more expensive to purchase and install initially • fewer trained installers and service technicians available • circulation pump and presence of more controls may result in higher maintenance costs • any preheat system must have protection against freezing requires a pressurized water system	
GENERIC HYDRONIC SYSTEM	• a major advantage is flexibility in design and construction especially in houses without a basement • electric operating costs may be lower than forced air systems • piping through the house is relatively easy eliminating complex ductwork • piping can be run through floor reducing cold floor complaints • eliminates noise associated with forced air system • the system can be used to provide preheating for all ventilation/ makeup air strategies • DHW can be integrated into system increasing efficiency and reducing operation and maintenance costs	• more expensive to purchase and install and maintain • requires skilled trades to install • skilled service technicians and replacement parts may not be readily available • boiler and more controls may result in higher maintenance costs • requires a pressurized water system • sizing of distribution system critical since balancing capabilities limited • proper placement of thermostat critical for optimum performance • ventilation air must be distributed by dedicated ducting system • any preheat system must have protection against freezing	
HS1: Hydronic using oil-fired or gas-fired boiler or domestic hot water heater	• same as generic system plus; • high efficiency models are available • if direct vent boiler used with direct vent or electric DHW heater, makeup air is not required and potential for backdrafting is eliminated	• same as generic system plus; • replacement part availability becomes a greater problem with high efficiency models • potential for backdrafting of naturally aspirated models increases in tighter houses	
HS2: Hydronic using propane-fired boiler	• same as HS1	• same as HS1 plus; • fuel tank must be heated in very cold temperatures	

TABLE 1: Space Heating Systems for Northern Housing

HEATING SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC SPACE HEATER	• technology mature • trained technicians and installers readily available • lowest equipment and installation costs • low maintenance and service costs	• takes up valuable living space • provision must be made to distribute heat and ventilation air to other rooms of house	• select a ventilation system that circulates house air
SH1: Fuel-fired	• same as generic system	• same as generic system	
SH2: Wood-fired	• same as generic system	• same as generic system plus; • if not equipped with airtight doors, a CO sensor with an audible alarm is required (1995 NBC) • higher maintenance requirements due to chimney cleaning • creosote build-up can cause chimney fires • occupant may be responsible for task of supplying wood • generally requires a backup heating system such as electric baseboard to protect water pipes from freezing if occupant is away	
SH3: Electric baseboard	• same as generic system plus; • can be used as a backup system for SH2	• same as generic system	

TABLE 2: Ventilation Systems for Northern Housing

VENTILATION SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC MECHANICAL SUPPLY AND EXHAUST COMPONENT SYSTEM **NOTE: System comprises a supply and exhaust component from the options below. Self-contained units are detailed on the next page.**	• skilled installer not necessary • relatively low equipment and installation costs if simple, readily available components used • low maintenance	• no heat recovery from exhaust air • supply and exhaust components, including the furnace fan, must be interlocked to operate simultaneously (1995 NBC) • outdoor air should be heated to at least 12°C before being introduced to occupied areas (1995 NBC) • ventilation air not delivered through the forced air heating system shall be delivered through high wall or ceiling grilles (1995 NBC) • conventional equipment may not be designed for cold weather operation and may be too noisy	• install preheat system • select controls which interlock supply and exhaust fan operation • install preheat system • select equipment designed for cold weather and quiet operation
MS1: Outdoor air supply duct or central supply fan direct connected to the return air plenum of a forced air system	• same as generic system plus; • simplified ductwork • no capital cost for supply fan if outdoor air supply duct used instead of central supply	• same as generic system plus; • using furnace fan as supply fan may result in higher operating costs • difficult to carry out any system balancing • CSA-F326 requires the minimum air temperature entering the fuel-fired furnace to be ≥15.5°C which limits the supply air volume unless preheating is provided • if furnace fan run continuously to distribute fresh air, distribution temperature during very cold weather may be unacceptable	• same as generic system plus; • install high efficiency furnace blower motor • install preheat system • install preheat system
MS2: Central supply fan not coupled to forced air system	• same as generic system plus; • potential lower operating costs when furnace fan not be used distribute ventilation air	• same as generic system plus; • second system of ductwork required to distribute ventilation air	• same as generic system
ME1: Central exhaust fan	• same as generic system plus; • higher mechanical reliability due to a single central exhaust fan • lower operating costs with one fan	• same as generic system	• same as generic system
ME2: Point of use fans	• same as generic system	• same as generic system	• same as generic system

TABLE 2: Ventilation Systems for Northern Housing

VENTILATION SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC MECHANICAL SUPPLY AND EXHAUST SYSTEM **NOTE: These are self-contained units incorporating both supply and exhaust.**	• provides consistent air flows • air flows can be easily balanced • can incorporate simple or elaborate components and/or controls • may be used in conjunction with forced air system to distribute supply air • fan noise is not a problem if continuous operation is required	• requires properly trained installers • higher equipment & installation cost • higher maintenance & service cost • service technicians & replacement parts may not be readily available • if not forced air system, ductwork is required to distribute supply air • distribution temperature during very cold weather may be unacceptable	• install preheat system
MSE1: Air exchanger system	• same as generic system plus; • lower operating and maintenance costs for units using only one fan • provides partial preheating by mixing supply air with indoor air • will serve to recirculate indoor air in houses without forced air systems	• same as generic system plus; • no heat recovery from exhaust air to reduce space heating costs	
MSE2: Heat recovery ventilator (HRV)	• same as generic system plus; • provides exhaust air heat recovery which reduces space heating costs • provides partial preheating of fresh air supply	• same as generic system plus; • typically most expensive to purchase, install and maintain • higher operation cost from two fans • locating large units may be difficult • models with exhaust-only defrost cause negative indoor pressure increasing backdrafting potential • HRV's are only tested & certified to -25°C and at lower temperatures is critical that installation procedures designed to address extreme conditions be strictly adhered to	
MSE3: MSE2 with supply air ducted into return air plenum and distributed by forced air system	• same as MSE2 plus; • some HRV controllers also control furnace fan operation allowing occupant to reduce operation costs	• same as MSE2 plus; • higher operation costs since furnace fan run continuously to distribute supply air throughout house	
MSE4: MSE2 with dedicated ducting to distribute supply air	• same as MSE2 plus; • reduced operating cost since HRV, and not furnace fan, distributes air	• same as MSE2 plus; • houses with forced air systems need second ductwork system for HRV	
MSE5: MSE2 with simplified principal exhaust ductwork	• same as MSE2 plus; • general exhaust drawn directly from furnace return air duct	• same as MSE2 plus; • supplemental exhaust required in each bathroom and kitchen	

TABLE 2: Ventilation Systems for Northern Housing

NOTE: THE FOLLOWING SYSTEMS APPEAR IN THE LITERATURE BUT DO NOT MEET CODE REQUIREMENTS AND DESIGN RECOMMENDATIONS AND, THEREFORE, ARE NOT CONSIDERED OR DISCUSSED FURTHER IN THIS REPORT.

VENTILATION SYSTEM	*ADVANTAGES*	*DISADVANTAGES/ PROBLEMS*	*SOLUTIONS*
GENERIC PASSIVE SUPPLY SYSTEM	• skilled installer not necessary • low equipment and installation costs • simple ductwork • no servicing and low maintenance • no operating costs • no occupant participation involved • quiet operation	• supply air needs to be preheated in colder weather • snow and rain penetration into ductwork can be a problem • frost accumulation may block duct • supply air may not be delivered where needed	
P1: Fresh air intake via insulated ducts drawing air from breezeway under house and discharging through high sidewall grills	• same as generic system plus; • minimizes problems of rain and snow penetrations	• same as generic system; plus; • air flow dependant upon stack and wind effects • quality of supply air cannot be guaranteed due to natural and other pollutant sources in breezeway	
P2: Distributed inlets	• same as generic system plus; • simple system, minimal ductwork • minimizes problems of rain and snow penetrations	• requires negative house pressure to induce flow • practical preheat system not known	
GENERIC PASSIVE EXHAUST SYSTEM	• skilled installer not necessary • low equipment and installation costs • simple ductwork • no servicing, low maintenance • no operating cost • quiet operation • no occupant participation involved • can exhaust air room-by-room	• air flow dependent upon stack and wind effects • snow and rain penetration into ductwork can be a problem • duct susceptible to condensation and icing and potential for moisture problems in warmer weather • no heat recovery • potential for negative house pressure resulting in backdrafting and infiltration of cold air through unregulated openings	

4.3. Space Heating and Ventilation System Design Recommendations

The following design recommendations address issues specific to the specification of a space heating and ventilation system intended for Northern housing. They are intended to supplement local codes and standards that apply to the design and installation of residential heating and ventilation systems. The *Commentary* is intended to provide the designer with a better understanding of the issue a particular point is attempting to address. Barriers to the implementation of any of the recommendations are also stated.

DESIGN RECOMMENDATIONS FOR ALL SPACE HEATING SYSTEMS

1. **Sizing the Heating System:** The capacity of the heating system should be determined in accordance with CSA F280, *Determining the Required Capacity of Residential Space Heating and Cooling Appliances.*

   Commentary

   CSA F280 has been specifically referenced here for the sizing of heating systems to ensure that some of the prescriptive components that restrict equipment oversizing become part of the design criteria.

   Barrier to Implementation

   If the design heat loss is low, it may not be possible to find oil-fired equipment that is not oversized beyond what CSA F280 allows. Several manufacturers are investigating oil space heating technologies that do not use a powered burner and that provide a variable outlet and much lower firing rates.

2. **Burner Efficiency:** Oil-fired appliances with an AFUE between 82% and 84% should be selected to ensure maximum efficiency without the possibility of flue condensation occurring. Where trained service personnel are available, gas-fired appliances with an AFUE of greater than 90% are recommended. Propane-fired appliances should have a minimum AFUE of 90%.

   Commentary

   Due of the high cost of fuel in the North, equipment with the highest possible efficiency should be installed, if replacement parts and servicing are available locally. In some instances, it is wise to limit the appliance efficiency. For example, by selecting an oil-fired appliance with an AFUE no greater that 84%, it is less likely that the installer would adjust the unit to operate at a higher efficiency and increase the risk of flue gas condensation and corrosion.

3. **System Electrical Efficiency (SEE):** Select the space heating system with the highest electrical efficiency. This efficiency, which accounts for the electrical consumption of all appliance components, can be calculated as follows:

$$SEE = \frac{(EFt / El) * AF}{El}$$ [1]

   where,

   EFt = total electrical and fossil fuel energy output (Watts)

[1] Taken from the study, *Electrical Efficiency of Gas Furnaces*, conducted by Doug Geddes for Ontario Hydro, 1992.

EI = total electrical energy input (Watts)
AF = airflow against an external static pressure of 125 Pascals (Litres/sec)

Commentary

Due to high electricity as well as fuel costs in the North, it is important not to rely solely on burner efficiencies when selecting a space heating appliance. Depending upon the system selected, the overall electrical consumption could include a blower motor, fuel pump, fan coil motor, circulation pump, and/or controls, all of which should be considered. For many heating appliances, the Eft and EI are in the GAMA directory which is published by the American Gas Appliance Manufacturer's Association, or can be extracted from the information provided. The AF is provided by the manufacturer.

In addition to selecting a burner and system electrical efficiency, it is also possible to specify separately, electrically efficiency components which are not offered as standard equipment. For example, high efficiency blower motors are now available. Although currently in its infancy, this technology is evolving rapidly. There are currently two types of high efficiency blower motors available which can significantly reduce furnace electrical consumption. The most efficient is the electronically commutated motor (ECM) which is offered with a limited number of furnaces models and can reduce furnace electrical consumption by 75 to 85%. This motor, however, uses sophisticated electronics for motor control and should only be used in communities where replacement parts and trained service personnel are locally available.

The second type of high efficiency motor, although not as efficient as the ECM, does not require a complex circuit board but can only be retrofitted into furnaces with belt drive blowers and not those with direct drive. It is less expensive that the ECM motor and, because of high electricity rates, has a short payback period if the furnace is run continuously to distribute ventilation air.

Barrier to Implementation

A furnace and all of its components are approved as a complete package. If a specific blower motor, such as a high efficiency motor, was installed in a furnace that was not approved for use with that motor, the manufacturer may void the furnace warranty. There are currently only a few high efficiency gas-fired furnaces approved for use with an ECM motor. A greater demand for high efficiency motors through the marketplace or government regulation will encourage the approval of more models for use with these motors.

4. **Control System:** The system should have automatic thermostat control that provides a temperature swing of between 1 and 5C degrees, and a manual switch to activate the continuous operation of the furnace blower in forced air systems. The thermostat should be installed in a central location approximately 1.5 meters high and not be exposed to cold drafts or, radiant or convective heat sources.

Commentary

Smaller temperature swings are more important in the North where outdoor temperature extremes are greater and fuel prices are higher. Large temperature swings usually result in the thermostat being set higher to provide comfort at the low end of the swing. This increases energy consumption. The smaller swing

will conserve energy and increase comfort levels, especially when the ventilation air supply to the house is at its lowest temperature. A temperature swing that is too small will result in shorter run times and less efficient combustion.
The thermostat location is particularly important in remote Northern communities where houses are fairly small and properly locating the thermostat may require a little thought and planning to ensure efficient operation of the heating system. This requirement also applies to electric baseboard systems as baseboard mounted thermostats can be unreliable and misused.

5. **Provisions for Combustion Air:**

a) Combustion air for electrically controlled, vented combustion appliances should be regulated by an electronic damper which will shut off the combustion air duct when combustion appliances served by the damper are not operating.

Commentary

As with the makeup air supply (see ventilation design recommendations), if the combustion air duct is allowed to spill cold air into the house, it will be blocked by the homeowner. As building envelopes become increasingly tighter, adequate combustion air becomes more important to ensure sufficient air for complete combustion and to assist in reducing any potential for backdrafting.

b) Combustion air kits for oil-fired appliances which supply combustion air directly to the burner should only be used if the manufacturer has demonstrated that they have been field tested successfully on units operating in extreme Northern conditions.

Barriers to Implementation

Combustion air kits currently available have not been tested by the manufacturer for extreme Northern conditions.

6. **Exterior sidewall vents and weatherhoods:** All heating appliance sidewall vents and weatherhoods associated with makeup and combustion air ducts should be located above anticipated snow levels and protected from snow and rain entry. In addition, weatherhoods should be covered with a corrosion resistant mesh no finer than 6 mm and be easily accessible for cleaning.

Commentary

Sidewall venting terminations can be problematic in the North because of wind driven snow and high winds which adversely affect system performance. Further research is required in order to determine the best weatherhood design and location for the extreme conditions in many locations in the North.

DESIGN RECOMMENDATIONS FOR FORCED AIR HEATING SYSTEMS

1. **Furnace Life:** The furnace should have a minimum expected life of 20 years.

Commentary

The manufacturer's heat exchanger warranty period is deemed to be indicative of the expected furnace life. Long furnace life is important because of the high cost of furnace replacement in the North.

2. **Location of Ductwork and Supply Outlets**: Ductwork should be located within the heated volume of the building. Special consideration should be given to the placement of heating supply outlets that are also used to provide ventilation air. See the ventilation system design recommendations for more detailed information.

   Commentary

   Attempts to properly insulate and vapour barrier ductwork located in an attic or unheated crawlspace are generally not successful. Ducts located outside the heated volume typically lose heat and air which leads to higher energy consumption and building durability problems. Provision for ductwork in houses without basements must be considered at the design phase of the building envelope in order that ductwork can be properly provided for and located.

3. **Sound Levels:** The furnace air handling system sound rating, with the burner not firing, should be less than 2.0 sones, when not enclosed in the occupied space, and 2.5 sones if enclosed, as in a utility room or closet.

   Commentary

   In many Northern communities, houses have no basements or mechanical rooms and the furnace may be an integral part of the living space. The noise emitted becomes a problem especially if the furnace blower is run continuously to circulate ventilation air, or because it is sized properly and runs continuously at design conditions (design conditions in the North may last a lot longer than the few hours typical in the South). As a result, furnaces should be required to meet the same noise limitations as ventilation fans.

   Barrier to Implementation

   There are currently no noise related code requirements for heating systems and furnace manufacturers do not provide sound ratings. The manufacturers should be encouraged to provide sound ratings as part of their normal specifications.

HYDRONIC SPACE HEATING SYSTEMS

1. **Equipment Life:** A boiler should have a minimum expected life of 25 years. A domestic hot water heater used as a space heating appliance, should have a minimum life of 15 years and be approved for this application.

   Commentary

   The manufacturer's heat exchanger warranty period is deemed to be indicative of the expected life and is important due to high replacement costs in the North.

2. **Pressurized Water Supply:** Hydronic systems should only be used where they can be connected to a pressurized water supply for automatic replenishment.

   Commentary

   Many Northern communities do not have central water distribution. Experience has shown that hydronic systems will begin to circulate air bubbles that can cause the circulating pump to cavitate after a short period of time unless the system is connected to a pressurized water system that can automatically replenish the system when air is bled from radiators.

3. **Antifreeze Protection and Backflow Prevention:** All hydronic baseboard systems should have antifreeze protection and all non-potable water systems with an automatic fill valve should have a back-flow prevention valve to ensure that the antifreeze solution does not enter the domestic water supply.

   Commentary

   It is recommended that hydronic systems have a 35% denatured ethanol glycol antifreeze/water solution which prevents freezing of the system down to -18°C should the electric power or the heating plant fail. This type of antifreeze solution is not as toxic as other solutions. In a relatively well insulated house with the ventilation system off, it is unlikely that the house temperature will drop to -18°C before power is restored.

4. **Combination Systems:** Systems which provide both hydronic forced air space heating and domestic hot water heating should be designed according to the *Combination 'COMBO' Forced Air Space and Domestic Hot Water Heating Systems: Guidelines* provided by BC Gas Utility Ltd. (Appendix C) or an equivalent document. In addition, these systems should meet all the design recommendations for the forced air system discussed previously.

   Commentary

   Combination system technology and design guidelines have now advanced to the point where these systems provide an attractive space and domestic hot water heating option for the North. A potable water fan coil system used in combination with a domestic hot water heater provides all of the heating requirements with one appliance and eliminates the use of expensive electricity for hot water heating.

5. **Freeze Protection**: Hydronic coils used to preheat incoming supply air should have freeze protection to prevent major coil damage if freezing occurs.

   Commentary

   In a non-potable water system, the antifreeze may provide burst protection. In a potable water system, it will be necessary to trickle hot water to the coil to prevent freezing. With either system, provision should be made for automatically shutting down the ventilation system in the event of a heating plant failure.

DESIGN RECOMMENDATIONS FOR SPACE HEATER SYSTEMS

1. **Sizing the Heating System:** The system should be capable of maintaining *at least* 22°C in each habitable room at the outside design temperature.

   Commentary

   The code requirements are often misunderstood to mean that the system should be capable of maintaining an even 22°C temperature throughout the house. This is not the case and may not even be possible where a space heater is the sole heating appliance. In this case, the room in which the space heater is located may have to be somewhat higher in order to attain 22°C in other rooms.

2. **Supplemental Heating:** With a solid fuel-fired space heater and piped domestic water, supplemental heating should be installed and meet the following criteria:

a) The supplemental heating system should be able to automatically maintain at least 0°C in all habitable rooms.

Commentary

This is to ensure that the supplemental system has the capability of keeping water pipes from freezing when the occupants are away for prolonged periods (a common occurance for native Canadians in remote communities).

b) The combined space and supplemental heating system should be capable of maintaining 22°C in all habitable rooms when the space heater is operating.

Commentary

In some jurisdictions, building officials have interpreted the building code to require that the supplemental heating system be sized to meet the entire design heat load. This is not the case.

c) The supplemental heating system should have automatic thermostat control. The thermostat should be capable of being set as low as, but not below, 2°C and be installed in a central location approximately 1.5 m high, where it will not be exposed to cold drafts or, radiant or convective heat sources.

Commentary

Many space heating thermostats cannot be set lower than 10°C. This, however, wastes too much energy if the occupants intend to be away for an extended period. A thermostat capable of being set below 2°C may inadvertently be set too low, causing plumbing pipes, canned foods, drinks, etc to freeze and burst.

DESIGN RECOMMENDATIONS FOR VENTILATION SYSTEMS

1. **Design and Installation:** The ventilation system should be designed and installed in accordance with Section 9, 1995 NBC or the Canadian Standards Association CAN/CSA-F326, *Residential Mechanical Ventilation Systems,* October 1993.

Commentary

Due to the wide range of indoor (e.g. humidity and occupancy) and outdoor (e.g. wind and temperature) conditions experienced by the different types of Northern communities, it is strongly recommended that the ventilation system be designed and installed to these standards. They will help to ensure that the system has the capability of handling a wide range of conditions and that the homeowner has the control capability required to adjust the operation of the system to deal with the extreme indoor and outdoor conditions that may be encountered.

2. **Air Flow Rates:** The ventilation system air flow rates for houses built to conventional levels of envelope airtightness (approximately 3 air changes per hour (ACH) @ 50 Pascals) can be determined using Section 9 of the 1995 NBC.

However, if a house is built to an R2000 airtightness level (1.5 ACH) or less, then the CSA F326 standard should be used to determine supply air requirements and ensure that the ventilation system capacity is sufficient to meet the home's needs.

3. **Equipment Life:** Any ventilation fan intended to operate continuously should be designed for such operation and should have an expected life of at least ten years.

   Commentary

   Most bathroom fans and kitchen rangehoods are designed for intermittent operation only and will fail quickly if run continuously as part of the whole house ventilation system. Manufacturer's literature should state that a fan is designed for continuous operation. The manufacturer's warranty period may be deemed indicative of expected fan life.

   Barrier to Implementation

   Manufacturers do not typically provide anticipated equipment life spans.

4. **Equipment Efficiency:** Ventilation exhaust and supply fans intended for continuous operation should have an electrical power consumption not exceeding 1.2 Watts per Litre per second (W/L/s) of air flow capacity for houses not incorporating a forced air heating system. For houses with a forced air heating system, the combined heating and ventilating power consumption should not exceed 0.75 W/L/s of combined air flow.

   Commentary

   These requirements have been taken from the *Advanced Houses Technical Requirements* and are indicative of the direction the industry is moving. With the introduction of high efficiency motors, it is expected that these requirements will be reduced significantly in the future.

5. **Certified HRV**: An HRV should only be used where the outdoor design temperature is equal to or greater than the minimum temperature for which the HRV has been tested and certified.

   Commentary

   Outdoor design temperatures in the North are as low as -51°C. HRV's are currently only tested and certified down to -25°C. However, a study recently completed in the Yukon concluded that, if properly installed and maintained, HRV's will function as they are intended. The study centered in Whitehorse where the outdoor design temperature is -41°C.

   In addition, it is known that the combination of high house humidity and very cold outdoor temperatures can cause the HRV core to freeze. Unfortunately, testing has not been carried out to determine the combination and duration of humidity and temperature that will render the HRV ineffective. It is important to note that the colder the outdoor temperatures, the more critical is the installation, maintenance and operation of the unit. Where experienced installers are not available, or where the occupants do not understand how, or are not prepared, to operate and maintain an HRV properly, other alternatives should be considered.

Barrier to Implementation

HRV's are currently only tested and certified down to -25°C. They should be tested in accordance with CSA C439 at a temperature and relative humidity level indicative of the areas where the units are intended for operation.

6. **Noise Levels:** The ventilation system should have a noise level of less than 2.0 sones at the minimum required continuous ventilation rate.

   Commentary

   The level of 2.0 sones has been established by the 1995 NBC as the maximum acceptable level for a continuously operating ventilation fan so as not to encourage the occupants to shut the system off. This is particularly important for remote Northern housing where the fan components of a ventilation system may be located in close proximity to the living area.

   Barrier to Implementation

   Where the furnace blower is used to distribute ventilation air, it may not be possible to find a furnace that meets this requirement.

7. **Heating / Ventilation System Return Air Mixed Air Temperature:** When a forced air system is used to distribute ventilation air, CSA F326 recommends that the return air mixed air temperature across a furnace heat exchanger not be less than 15.5°C.

   Commentary

   Due to extremely cold temperatures in many areas of the North, it may be necessary to temper ventilation air being introduced into the return air plenum. This will depend upon the furnace size and the ventilation air requirement.

8. **Discharge Air Temperature to Living Areas:**

   a) If a forced air heating system is used to circulate ventilation air, the discharge air temperature from floor diffusers should not be less than 20°C.

   Commentary

   HRAI investigated the use of conventional floor registers to deliver ventilation air into a habitable space when the furnace blower only is operating and the furnace is not providing heat. It was determined that, with the pressure and velocity available from residential systems, air cooler than room temperature could not be discharged without causing cold drafts and poor room air mixing.

   b) If the ventilation air discharge temperature from a forced air heating system supply outlet is below 20°C, the air should be delivered through outlets located in the ceiling or in a wall within 150 mm of the ceiling with grilles that are designed to promote diffusion across the ceiling.

   Commentary

   Supply outlets direct cool ventilation air along the ceiling allowing it to warm up before it drops into the habitable space, thereby improving comfort. Although a high wall location is not the most desirable for a heating system supply outlet, the heating system will spend much more time off than on throughout the total heating season. This means that most of the time, the heating/ventilation system is, in fact, operating like an air conditioner, delivering cool air. When the thermostat calls for heat, warm air will be discharged at ceiling level and cool gradually until it starts to fall or hits an opposing wall. When the heating cycle is complete, cool air is again being discharged. It quickly drives the warm air lower in the room causing it to mix with the ambient air. The 1990 NBC recognized this and allowed for this design configuration as does the new 1995 NBC.

c) If ventilation air is not delivered with the forced air heating system, Section 9 of the 1995 NBC requires that the air be tempered to at least 12°C before being delivered to living spaces. The air is to be delivered through ceiling or high wall outlets as described in b).

9. **Tempering of Ventilation Air Supply**: When it is necessary to temper the ventilation air being delivered to the return air plenum or directly to the living spaces, Section 9 of the 1995 NBC states that it shall be tempered by passing it over an electric duct heater or a hydronic heating coil.

Commentary

Providing preheating with an electric heater may be an expensive option. Air tempering can also be achieved through the use of an HRV or an air exchange device without heat recovery. At very cold temperatures, however, these devices are not capable of tempering the air to at least 12°C. As a result, the air from these devices would require additional preheating or have to be introduced into the return air plenum of a forced air system and mixed with return house air. Additional electricity costs to run the forced air system blower motor to distribute the ventilation air may not be acceptable, or affordable, to the homeowner.

10. **Ductwork**: All ductwork should be located inside the heated volume of the building and be sealed using aluminium duct tape or a sealing compound designed for that purpose. Duct tape is not acceptable since the adhesive has a short life.

11. **Exterior Intake and Exhaust Hoods and Locations:**

a) Where possible, and where the area under the house is not enclosed, it is recommended that the exhaust outlet and fresh air intake be located through the floor into this space and be installed such that:

- an airtight seal is provided at the points where the duct exits both the house and underside of the floor assembly;
- the ducts are at least 1800 mm apart in order to prevent cross contamination;
- the supply duct is easily accessible for cleaning;
- both supply and exhaust pipes are provided with insulation and a vapour barrier. For non-heat recovery systems, the exhaust duct need only be insulated to a point 600 mm from the floor where frost will occur when the ventilation system is not operating.
- both the intake and exhaust openings should be covered with a corrosion resistant, hinged mesh no finer than 6 mm.

Commentary

Sidewall intakes or outlets are often problematic in the North because of wind driven snow and exposure to high winds that adversely affect ventilation system performance. Locating the supply and exhaust termination points under the house can often solve this problem. Note that, if the ground beneath the house is very wet, or if there are potential sources of air contamination, this location should not be used for the intake. To facilitate installation and air tightness, the intake and outlet ducts can be made from ABS pipe. ABS pipe is used because it is readily available, corrosion resistant, low cost, and is rigid for ease of penetrating the building envelope and for mounting a hood and/or mesh. The insulation and vapour barrier is most easily provided by sliding a length of insulated flex duct over the ABS pipe. Consideration may have to be given to the formation of condensation from exhaust air stream.

b) Where the ventilation intake configuration described in (a) is not possible or practical, the inlet and outlet should be:

- through the same wall and above anticipated snow levels;
- protected from snow and rain entry and easily accessible for cleaning; and
- covered with a corrosion resistant mesh no finer than 6 mm.

Commentary

If a through-the-wall intake is used, the intake should have a face intake area at least 4 times the area of the intake pipe. This is to ensure that the air velocity at the face will be low enough to not draw in large amounts of snow or other undesirable material that may clog the inlet mesh. Further research is required in order to determine the best intake design so as to prevent fine snow and other particles from entering under high wind conditions.

12. **Intermittent Point Exhausts:** Regardless of the ventilation system installed, the kitchen should have a rangehood with a sound rating less than 3.5 sones capable of exhausting a minimum of 50 L/s directly to the outdoors. Any bathroom (or honey bucket room) not served by a central exhaust fan, should have an exhaust fan that exhausts 25 L/s directly to the outdoors. A point exhaust fan intended only for intermittent use should have a minimum efficiency of 1.7 Watts per Litre per second of airflow capacity. The device should have an expected lifespan of at least 10 years when used less than 3 hours per day.

Commentary

The kitchen fan will assist in reducing humidity spikes that may not be adequately controlled by the ventilation system. Although there is no mandated Canadian energy performance standard for residential fans at this time, the most efficient fans available should be selected.

Barrier to Implementation

Manufacturers do not normally provide efficiency data expressed in this manner or the expected life of their fans. A manufacturer's warranty could be deemed to be indicative of the expected life of the fan.

13. **Provisions for Makeup Air:** The 1995 NBC requires that makeup air be provided for devices that exhaust more than 75 L/s if non-solid fuel burning appliances are vented through a chimney, or if soil gas is a problem. Makeup air should be tempered to at least 12°C or delivered to a normally unoccupied area. In addition, carbon dioxide detector/alarms are to be installed in rooms with solid-fuel appliances that do not have doors which substantially close off the firebox.

    Commentary

    Every effort should be made to ensure exhaust devices large enough to require makeup air are not installed in Northern housing. If a makeup air duct is required, it should be supplied with an electronic damper wired to the exhaust device. Otherwise, because of the extremely cold temperatures, experience has shown that this line will be blocked by the homeowner and the potential for backdrafting will increase significantly.

    The alternative to a makeup air duct and electronic damper is to install non-spillage susceptible space, domestic hot water, and supplemental heating appliances and so that backdrafting is no longer an issue.

5. Space Heating and Ventilation System Development

Using the system selection process and the design recommendations developed, a list of prescriptive space heating and ventilation options suitable for a representative house in a representative Type 1, 2 and 3 community were determined. In order to complete this task, it was necessary to describe the representative houses and communities and to go through the selection process presented in Section 4.3 to develop the list of prescriptive options presented in Section 5.2.

5.1. Issues Specific to Northern Housing

Many existing space heating and ventilating systems in the North are considered to be unacceptable. Homeowner complaints are most common with systems that are too noisy, too difficult to service and maintain, too expensive to purchase and operate, and/or generally ineffective because the HRV cores freeze, blowing snow blocks flues and fresh air intakes, heating equipment is oversized and adequate indoor air quality cannot be maintained.

Any proposed space heating and ventilating system must ultimately be acceptable to the end user - the occupant. Along the way, however, appropriate organizations and contractors must buy into a proposed strategy and indicate their willingness and capability to properly install, repair and maintain the equipment involved. The key is to ensure not only that space heating and ventilating systems work effectively and efficiently, but that they are affordable to purchase, operate and maintain, and have a reasonable life expectancy.

5.2. Space Heating and Ventilating System Sample Selection Process

Using the seven step selection process developed in Section 4.2, space heating and ventilating options were selected for a representative house in a representative Type 1, 2 and 3 community. The results of the selection process are presented in Table 3. In completing the selection process, the following tasks were carried out:

- Floor plans and elevations for typical newly constructed houses in the different types of communities were obtained from the YHC and NWTHC (see Appendix D for sample plan) and a representative house was chosen for each community type.
- Degree-day climates were chosen for each community based on the weather data locations available in the HOT2000 computer simulation program and what was deemed representative for each type of community (Appendix D).
- Fuel and electricity cost data from Northern suppliers was used to determine typical energy costs for each community type (Appendix D). Natural gas is generally not used in the North and was not considered. Wood cannot be modelled accurately in HOT2000 and also was not considered as an option for this sample exercise.
- A design evaluation was carried out on the representative house in each community and the data input into the HOT2000 simulation program. A computer output showing the components used for each house is included in Appendix E. The following points should be noted with respect to the modelling of the house:
    - Basically, the building envelope comprised the ceiling @ R-40, the walls @ R-20, exposed floors @ R-50 and double glazed windows.
    - A present day level of airtightness was chosen and the program assigned an air change rate of 3.57 ACH @ 50 Pascals.
    - Ventilation rates determined by the program using CSA F326 were reduced by 50% to 30 L/s in the Type 1 house, and by 30% to 28 L/s in the Type 2 and 3 houses. These air flow rates were more representative of 1995 NBC house which requires a minimum principal exhaust capacity of only 50% of the *Total Ventilation Capacity.*
    - The house was modelled with no occupants to eliminate these internal gains, and with no domestic hot water heating which was not being considered in this project.
- Numerous computer simulations were then carried out with different fuel and equipment options for each community (Appendix F) and space heating, and furnace fan and pump, energy costs were determined. To compare various systems options, it was sufficient to use present day costs and look at simplified lifetime costs. Future projects may want to look at detailed lifetime costing on the recommended systems.
- The HOT2000 cost information was combined with equipment and installation costs, and operating and maintenance costs, as reported in the surveys to determine lifetime costs for the potential space heating (Table F1, Appendix F) and ventilation (Table F2, Appendix F) options that had been selected. The results of the lifecycle costing were used to narrow down the list of potential options.
- Finally, the remaining options were considered based on the service personnel and replacement part availability, and on the suitability of each option for the homeowners.

The recommended space heating and ventilation systems based on the sample selection process are presented in Table 3. Two different sets of options were proposed due to a number of unresolved issues that are discussed in the next section.

TABLE 3: SPACE HEATING AND VENTILATING SYSTEM SAMPLE SELECTION PROCESS

SELECTION CRITERIA	*TYPE 1 COMMUNITY*	*TYPE 2 COMMUNITY*	*TYPE 3 COMMUNITY*
Representative Characteristics For Each Type of Community	• 139 m^2 (1500 ft^2) house with basement • Outdoor design temperature: -44°C • 8500 degree days (DD); latitude - 62°	• 111 m^2 (1200 ft^2) house; no basement • Outdoor design temperature: -44°C • 10,000 DD; above the treeline; latitude - 66°	• 93 m^2 (1000 ft^2) house; no basement • Outdoor design temperature: -44°C • 12,000 DD: above the treeline; latitude - 70°
1. Special Needs & Lifestyle Assumptions	• 4 occupants; higher income family • Even temperature in rooms very important • Understand issues and technology • Culture not a major consideration	• 6 occupants; modest income family • High humidity levels; even temp. preferred • Less understanding of issues and technology • Culture a greater consideration	• 6 occupants; lower income family • High humidity levels • Least understanding of issues and technology • Culture a major consideration
2. Available fuel/energy	• Oil @ $.40/L; Propane @ $.50/L • Grid electricity @ $.15 kWh.	• Oil @ $.55/L • Grid electricity @ $.30 kWh.	• Oil @ $.70/L • Diesel generated electricity @ $.40 kWh.
COMMENTS	• Natural gas is generally not used in the North and has not been considered	• Propane is generally not used in Type 2 communities and has not been considered	• Propane is generally not used in Type 3 communities and has not been considered
3. Possible heating systems based on Table 1, Section 4.2 with lifetime costs not a consideration	• Forced air furnace - oil , propane or electric • Fan coil system - oil or propane • Hydronic system - oil or propane • Baseboard - electric	• Forced air furnace - oil or electric • Fan coil system - oil • Hydronic system - oil • Space heater - oil • Baseboard - electric	• Forced air furnace - oil or electric • Fan coil system - oil • Hydronic system - oil • Space heater - oil • Baseboard - electric
COMMENTS	• Space heater rejected because in larger house is difficulty in maintaining even temperatures throughout the house	• Based on the available fuels, no systems were rejected at this point.	• Based on the available fuels, no systems were rejected at this point.
4. Possible ventilation systems based on Table 2, Section 4.2 with lifetime costs not a consideration	• Outdoor air supply coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan not coupled with forced air and interlocked with central exhaust fan - PREHEAT MAY BE REQUIRED • Air exchanger system, no heat recovery - PREHEAT MAY BE REQUIRED • HRV coupled with forced air • HRV not coupled with forced air - PREHEAT MAY BE REQUIRED	• Outdoor air supply coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan not coupled with forced air and interlocked with central exhaust fan - PREHEAT MAY BE REQUIRED • Air exchanger system, no heat recovery - PREHEAT MAY BE REQUIRED	• Outdoor air supply coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan coupled with forced air and interlocked with central exhaust fan • Auxiliary supply fan not coupled with forced air and interlocked with central exhaust fan - PREHEAT MAY BE REQUIRED • Air exchanger system, no heat recovery - PREHEAT MAY BE REQUIRED
COMMENTS	• At this point, point of use fans as the principal exhaust fans were rejected for all communities due to the complexity that would be encountered in providing system interlock controls and in providing system balancing.		
	• No other systems were rejected at this point	• HRV's for Type 2 and 3 communities were rejected at this point because it has not been demonstrated that , even if installed and operated properly, they will function in extremely cold, high humidity environments without the core freezing and other operational problems	

SELECTION CRITERIA	TYPE 1 COMMUNITY	TYPE 2 COMMUNITY	TYPE 3 COMMUNITY
5a. Possible heating systems considering the annual lifetime cost (ALC) (Table F2, Appendix F	• Forced air furnace - oil (ALC = $2992) • Fan coil system - oil (ALC = $3223)	• Forced air furnace - oil (ALC = $3921) • Fan coil system - oil (ALC = $4225) • Space heater - oil	• Forced air furnace - oil (ALC = $6053) • Space heater - oil
COMMENTS: Lifetime costs include equipment, installation, operating and maintenance costs	• Heating systems using propane or electricity were eliminated • The radiant/convective hydronic system was eliminated due to an installed cost 2 - 3 times higher than the remaining systems. The annual lifetime cost was also greater (ALC = $3289)	• The radiant hydronic system was eliminated due to a high installation cost and a higher annual lifetime cost (ALC = $4308). • The fan coil system remained because of its unique ability to provide the preheating required by some of the ventilation options. • Compared to other options, space heater is cost effective; the ALC was not calculated.	• The hydronic system and the fan coil systems were eliminated due to the high installed cost and the need for a pressurized water system. • Compared to other options, space heater is cost effective; the ALC was not calculated.
5b. Possible ventilation systems considering the annual lifetime cost (ALC) Table F3, Appendix F	• Outdoor air supply coupled with fan coil forced air system and interlocked with central exhaust fan (ALC = $548) • HRV not coupled with forced air - PREHEAT MAY BE REQUIRED (ALC = $301)	• Outdoor air supply coupled with fan coil forced air system and interlocked with central exhaust fan (ALC = $1072) • Air exchanger system, no heat recovery - PREHEAT MAY BE REQUIRED (ALC=$544)	• Air exchanger system, no heat recovery - PREHEAT MAY BE REQUIRED (ALC = $654)
COMMENTS: Lifetime costs include equipment, installation, operating and maintenance costs	• The system with a separate central supply and exhaust system was rejected for all communities due to the higher electrical cost of running 2 fans and preheating the supply air. • All other systems (except fan coil) coupled to forced air were rejected because of the high cost of operating the blower motor to distribute ventilation air. High efficiency blower motors were not considered because of their complexity and/or lack of availability in approved furnaces.		
	• The fan coil option for Type 1 & 2 was not rejected due to some unique advantages it offers with respect to preheating and DHW heating which may be required (see Section 5.3)		• Only the air exchanger option remains
6. Possible systems considering local availability of skilled service technicians and replacement parts	• None of the remaining heating or ventilation systems were rejected due to this consideration	• The fan coil system may be rejected in some Type 2 communities due to this consideration	• None of the remaining heating or ventilation systems were rejected due to this consideration
7. Possible systems considering what the occupants are capable of, and willing to, operate	• None of the remaining heating or ventilation systems were rejected due to this consideration	• The fan coil system may be rejected in some Type 2 communities due to this consideration	• None of the remaining heating or ventilation systems were rejected due to this consideration

RECOMMENDED HEATING AND VENTILATION SYSTEMS BASED ON SAMPLE SELECTION PROCESS			
A. If preheating is ***not*** needed and ***no*** consideration is given to DHW heating	• Forced air furnace - oil • HRV not coupled with forced air	• Forced air furnace - oil • Air exchanger system not coupled with forced air	• Space heater - oil • Air exchanger system
B. If preheating is needed and consideration is also being given to DHW heating	• Potable water fan coil forced air system using an oil-fired DHW heater to supply both space and DHW water heating requirements • HRV coupled with fan coil system	• Outdoor air supply coupled with potable water fan coil forced air system interlocked with central exhaust fan and using an oil-fired DHW heater to supply both space and DHW heating requirements	• Forced air furnace - oil • Air exchanger system coupled with forced air

5.3. Unresolved Issues Affecting System Selection

A number of issues that impact significantly on the ultimate choice of a heating and ventilating system remained unresolved. These issues include:

- the minimum temperature at which ventilation air can be delivered to the house and the necessity for preheating;
- the effect of building envelope airtightness level on the specification of ventilation air flow rates and the type of equipment used;
- the real lifecycle cost of coupling a ventilation system to a forced air system to provide air tempering and ventilation air distribution;
- the complexity of specifying a system that will address the wide range of extreme conditions that are specific to Northern populations and communities; and
- the limited information available on overall system efficiency, effectiveness and lifetime costs for a heating and ventilation system fully specified according to Section 4.3 and including domestic hot water heating.

5.3.1. Discharge Air Temperatures and Preheating

Standards are consistent in that ventilation systems should be designed and installed so that ventilation air is introduced into a living area with no discomfort to the occupants. Although no specific discharge temperature is specified in Section 6 of the 1995 NBC, a system designed using Section 9 of the 1995 NBC, which is the code's prescriptive section, requires that outdoor air be tempered with an electric duct heater or a hydronic heating coil to at least 12°C before being introduced into a living space. The CSA F326 standard recommends that unless air diffusers are especially designed and located, supply air temperatures in winter should not be less than 17°C with floor diffusers and not less that 13°C with high side-wall or ceiling diffusers. The design recommendation in Section 4.3 for the floor diffuser air discharge temperature is not less than 20°C. In specifying any temperature, however, the problem that exists is that sufficient information is not available to guide the designer in specifying and locating the required diffusers such that the discharge air will not cause occupant discomfort.

Calculations of potential ventilation air discharge temperatures for a number of ventilation options for the representative houses investigated in Section 5.2 were carried out and are presented in Table F3, Appendix F. The table indicates that, except for ventilation systems that use a forced air system to distribute ventilation air, the discharge air temperature at an outdoor temperature of -40°C could be as low -3°C and possibly no higher than 7°C when the indoor temperature is 22°C. Mixed temperatures for the forced air option ranged from 9°C with 500 cfm of forced air and the full supply air requirement recommended by CSA F326, to 17°C with 800 cfm of forced air. Most of the calculated values are well below recommended values and suggest that, no matter what ventilation option is chosen, special attention has to be given to selecting and locating diffusers and to deciding whether or not to provide additional preheating.

The question that persists is: Down to what temperature can low discharge air temperatures be handled by specially designed and located diffusers and at what temperature will additional preheating be required? A literature search through past and current ventilation research projects revealed that this issue has not been adequately addressed and that clear guidelines are not available. It has been suggested that if it is possible to supply cooling air 14 to 17C degrees below room temperature and heating air 28 to 39C degrees above room temperature then, with proper outlet locations and grilles, it should be possible to supply ventilation air that is up to 21C degrees below room temperature.

This makes it very difficult for a system designer to make informed choices that will ensure that a system selected to operate in extreme Northern conditions will perform to the satisfaction of the homeowner. From Table 3, Section 5.2, it can be seen that the heating and ventilating system chosen can change significantly if preheating is required. For example, in looking at the system recommendations at the bottom of Table 3 for a Type 1 community, if preheating is not required, the recommended system would be a forced air, oil-fired furnace and an HRV not coupled to the forced air system. No consideration had to be given to DHW heating. However, if preheating is required, then the recommended system would be a forced air, fan coil system which would provide the requirements for preheating in addition to both space and domestic hot water heating. The HRV was still chosen but is now coupled to the fan coil system.

Future research must address this issue because without proper guidelines with respect to selecting and locating diffusers and determining the temperature at which additional preheating is required, discharge air temperatures creating occupant discomfort will result in ventilation systems being turned off.

5.3.2. Ventilation Requirements and Building Envelope Airtightness

The 1995 NBC does not address the affect of envelope airtightness on reducing the availability of outdoor air through infiltration. The R2000 Program, however, which allows a maximum envelope air change rate of 1.5 ACH @ 50 Pascals, requires that the ventilation systems for these houses be designed in accordance with CSA F326, a standard which specifies outdoor air supply flow rates and requires that balanced supply and exhaust flow rates be provided by a mechanical ventilation system.

In addition, if a house is built to an R2000 level of airtightness and is to meet the ventilation requirements of CSA F326, then the use of an air exchanger unit will be limited to the size of representative house modelled for the Type 2 and 3 communities because of the limited supply capacity of the units currently available. For example, the largest FRESHVENT model can provide a maximum of 40 L/s of outdoor air which is equal to the total CSA F236 supply air requirement for these relatively small houses. Once again, future research must address the building envelope airtightness / ventilation air issue and provide system designers with guidelines that will allow them to make informed choices and ensure that a system selected to operate in extreme Northern conditions will perform to the satisfaction of the homeowner.

5.3.3. Coupling Ventilation Systems with Forced Air Heating Systems

One of the best methods of tempering outdoor air that would usually preclude the use of a preheating device, is to mix the ventilation air with house air using the forced air heating system. For the sample selection process (Section 5.2), however, any system relying on the forced air system to distribute fresh air was rejected because of the high electrical costs in Northern communities. In making this decision, however, there were two considerations which remained unresolved:

- For what portion of the ventilation season is the forced air system required to operate strictly to supply ventilation air? Although using forced air systems to distribute ventilation air was rejected, if a furnace can be properly sized, it may be running the majority of the time during the heating / ventilation season and the actual cost of using the forced air system to distribute ventilation air may be significantly less that calculated values. This assumes, of course, that the ventilation system will not be operated during the months when occupants will be opening windows for natural ventilation. Proper furnace sizing may well be a key factor but this area has not been addressed and the information is not available.
- If high efficiency motor technology were readily available, coupling the ventilation and the forced air heating system would be far more attractive. Currently, however, the technology is limited and no oil-fired appliances have been approved for use with the motors that are available. Manufacturers have indicated that a new furnace retrofitted with a high efficiency motor not approved for that unit may have its warranty voided. They have also indicated, however, that given the demand, they would go through the process of having models approved.

5.3.4. Overall System Efficiency, Effectiveness and Lifetime Costs

A field evaluation of the entire heating and ventilation system, including the space heating unit, the DHW heater, the ventilation system and all components such as appliance controls, and makeup and combustion air controls is the only method of determining the actual effectiveness and efficiency of a particular system. The scope of this project did not allow for the indepth analysis required to provide all of the information required to specify complete systems that will address the design recommendations presented in Section 4.3 and the unresolved issues presented in this section. This is part of the continuing work that should be carried out in the future.

6. Promising State-of-the-Art Systems

Once a space heating and ventilation option has been chosen, a complete heating and ventilating system should then be specified according the design recommendations presented in Section 4.3. This section presents examples of a complete specification for three different system options that attempts to address all of the issues raised in this report. These specifications, however, are based on the limited information that was available and do not considered overall system efficiencies or detailed lifetime costing. They provide a good indication of not only how complex the specification process is, but of how complete the specification must be because, ultimately, the success of a system will be determined by how well it is specified by the designer, installed by the contractor and operated by the homeowner.

Example 1 and 2 are systems that were installed in two demonstration house in Dawson City, Yukon in the summer of 1996 and which will be monitored during the 1996 - 1997 heating season. The specific pieces of equipment indicated were the best products available at the time this project was conducted, but technology is changing and other products are being developed and becoming available which will also be appropriate in addressing the requirements and concerns for systems in the North.

Example 1: Outdoor Air Supply Coupled with a Fan Coil Space Heating and Domestic Hot Water System

A. SPACE AND DOMESTIC HOT WATER HEATING STRATEGY

Equipment Specifications

1. Combination space and domestic hot water direct vent, oil-fired heater

⇒ Make and Model = John Woods - Direct Vent JWF307V
⇒ Capacity = 32 U.S. Gal.
⇒ Input = 90,000 Btu/h
⇒ Recovery Efficiency = 76%
⇒ Output = 68,400 Btu/h
⇒ Burner = Beckett only available

Commentary

* The was sized determined using an elevation for Dawson City of 370 meters.
* The building envelope will have a continuous air barrier and the builder is aiming to achieve an airtightness of less than one air change per hour (ACH) when the house is depressurized to 50 Pascals (Pa) in accordance with the CGSB-149.10 standard, *Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method.* The R2000 Program standard is 1.5 ACH at 50 Pa. With a tight building envelope, the potential for backdrafting is increased significantly.

* By installing a direct vent model, the potential for backdrafting induced by exhaust appliances, such as the clothes dryer and kitchen exhaust fan, is eliminated. As a result, the house will not be subject to a 5 Pa depressurization limit in accordance with CSA F326, *Residential Mechanical Ventilation Systems,* and a makeup air will not have to be supplied to meet the reference exhaust flow-rate condition (Clause 6.3.1).

  If a naturally aspirated model was installed, a makeup air duct would have to be installed to meet the exhaust flow-rate condition. To prevent cold air from flooding into the house and the homeowner from permanently blocking this duct, an electronic damper, tied in to appliances exhausting more than 75 L/s, would also have been installed.

* Although backdrafting and depressurization requirements may also be satisfied with a power-vented model, this type of unit was not specified because it would result in a more complicated installation, higher operating costs and potential servicing problems in a smaller center such as Dawson City.

2. Combustion air inlet and electronic damper

- The combustion air inlet shall be a round duct 4 inches in diameter and no longer than 6 metre equivalent length (CAN/CSA B149 - Table 7.2.2B). This duct will be insulated and located in accordance with local codes. (Note: Although the requirement is for only a 75 mm diameter tube, the electronic damper does not come in a unit that small.
- An electronic combustion air damper will also be installed.

  ⇒ Make and Model = ACA PAC: HOM-0411-SF1

<u>Commentary</u>

* The combustion air damper control will prevent cold air from entering the house when it is not required. When the heating unit stops, the damper closes. Pressure and wind induced airflow through the combustion air line will be eliminated preventing comfort problems and the possibility of the homeowner permanently blocking this outdoor air supply.

3. Fancoil Unit

⇒ Make and Model = Energy Saving Products, Model HV-50 DHW
⇒ Output = 50 MBH @ 180°C A.W.T.
⇒ The unit comes with:
- ◊ Taco 006B 3/4" circulator, 115/1/60, 0.62 Amps.
- ◊ Danfoss RA2000 1/2" non-electric zone valve c/w RA 2002 thermostat operator
- ◊ Honeywell V8043 3/4" zone valve
- ◊ 3/4" check valve
- ◊ outdoor temperature sensor for pump activation at approximately -20°C
- ◊ low ambient cut-off to shut down the fancoil and close the outdoor air damper in the ventilation duct in the event of a water heater failure

Commentary

* All components in the fancoils manufactured by Energy Savings Projects are non-ferrous in construction and approved for use with potable water. The units are complete with an activation timer which circulates water for 5 minutes every 24 hour period to ensure that the potable water in the system does not stagnate during long periods of non-heating.
* Water will be circulated through a hot water coil which is four row Cu / Al construction at a temperature of 150°C. A tempering valve is provided with the unit to reduce the domestic hot water temperature to a suitable level.
* The fancoil motor is a 1/3 HP, 115 V, 3.9 Amp., General Electric *Energy $aver* model operating at 1625 RPM and having a full draw power consumption of 380 Watts. Low speed operation draws 220 Watts.
* The low ambient cut-off feature will shut down the fancoil fan in the event of low temperatures across the fancoil due to a water heater failure. This feature will eliminate the possibility of the core freezing.

B. VENTILATION STRATEGY

Equipment Specifications

1. **Fresh Air Duct c/w Electronic Damper**
   - An electronic in-line air damper will be installed.

     ⇒ Make and Model = ACA PAC: VAC-6010-0P0

2. **Exhaust Fan Unit**

⇒ Make and Model	=	Energy Saving Products, Model JH-15
⇒ Capacity	=	94 L/s, variable speed
⇒ Controls	=	10 Amp. rheostat for variable speed control
	=	Honeywell humidistat, Model H46C1000

2. **Kitchen Exhaust (specified model or equivalent)**

⇒ Make and Model	=	Venmar H030950
⇒ Exhaust Capacity	=	250 cfm
⇒ Motor watts	=	115 W
⇒ Noise	=	5.0 sones
⇒ Speed Control	=	3-speed

Field Installation Instructions

- The unit shall by installed by an HRAI certified installer in accordance with the CSA-F326 standard and the manufacturer's installation instructions.

  ◊ Provide a fresh air supply weatherhood similar to the one designed for use with an HRV. These low restriction hoods are supplied with extra length sleeves and vapour seal collars to ensure a proper and secure seal of the insulated flexible duct. The supply hood is also equipped with a velcro mounted screen which can be opened during the winter months to prevent the formation of hoar frost on the screen which will block off the fresh air supply to the house.

◊ Supply and exhaust weatherhoods must be installed a minimum of 1.8 m apart and **located on the same wall.**

◊ A single piece of insulated flex duct must be installed for the fresh air from the outside. The supply side duct is under a negative pressure and any leakage points draw warm, moist house air against the cold duct resulting condensation and icing.

◊ A balancing damper must also be provided in the fresh air line from the outside. It is recommended that the damper be installed in a short length of smooth ducting and attached directly to the return air plenum. The one piece, insulated flex duct can then be attached and sealed directly to this sleeve.

◊ Supply air is delivered through the small diameter, high velocity ducting used by the fancoil system for space heating. No additional supply ducting will be required.

◊ The exhaust system will meet the following specifications:

  * the discharge air plenum will be an 200 mm round, or equivalent rectangular duct size;
  * bathroom exhaust ducts will be 75 mm in diameter;
  * the kitchen exhaust duct will be 100 mm in diameter; and
  * the exhaust pickups shall be round grilles designed specifically for use with round ducting. These grilles are commonly used with an HRV installation and elbows with a square throat are available for use in a 38 x 89 mm wall.

◊ Exhaust pickups shall be installed in each bathroom and in the kitchen. All pickups shall be located far enough into the room so as to adequately pull exhaust air from the entire room. The kitchen exhaust pickup must be located at least 1.2 metres horizontally from the stove to prevent grease contamination.

◊ The exhaust pickups must be as far away as possible from any supply inlet in order to prevent the supply air from being drawn into the exhaust pickup before being distributed throughout the room.

◊ Additional exhaust air from the kitchen will be provided by a range hood which exhausts to the outside. The ductwork shall be installed down through the wall cavity and out through the floor truss area. The unit must have at least three speed settings or a variable speed control. **The unit selected must have a noise rating no greater than 6 sones.** A recirculating rangehood is not acceptable.

- All seams, connections and elbow joints on the warm side supply and exhaust ducts must be sealed. **Duct tape is not acceptable** because the adhesive dries over time, aluminium backed tape is a more acceptable alternative, and a latex sealer as used on commercial applications is highly recommended.
- The ventilation supply and exhaust air must be balanced in the same manner that an HRV would be balanced. Once the unit has been balanced, the control must be

clearly labelled to indicate the speed at which the CSA F326 ventilation requirement is being met.

- The following three heating and ventilation system controls shall be installed in an approved location and operate in the following manner:
  - ◊ Variable Speed Control: This control will vary the balanced ventilation flow of supply and exhaust air. The control should be clearly labelled to indicate the speed at which the CSA F326 ventilation requirement is being met. This control will have a full range of operation from off to full capacity.
  - ◊ Dehumidistat: This control operates the ventilation system at full capacity when the indoor relative humidity is above the setting selected. This will occur even if the variable speed control has been turned to the off position.
  - ◊ In addition, the system shall be wired so that the bathroom switches control the full capacity operation of the exhaust system. When the bathroom light is on, the ventilation system will be operating at full capacity. Additional exhaust in the kitchen will be provided by the kitchen exhaust fan. Specifying a unit that operates quietly and has a number of different speed settings will ensure that the homeowner will use it.

Example 2: Oil-fired Forced Air Furnace and DHW Heater Heat Recovery Ventilator Not Coupled to Furnace

A. SPACE AND DOMESTIC HOT WATER HEATING STRATEGY

Equipment Specifications

1. **High efficiency, direct vent, oil-fired forced air furnace**
   - ⇒ Make and Model = Clare Bros. - OHB3F
   - ⇒ Input = 76,800 Btu/h
   - ⇒ Energy Efficiency = 86%
   - ⇒ Output = 66,000 Btu/h
   - ⇒ Burner = Beckett or Riello available

2. **Domestic hot water direct vent, oil-fired heater**
   - ⇒ Make and Model = John Woods - Direct Vent JWF307V
   - ⇒ Capacity = 32 U.S. Gal.
   - ⇒ Input = 90,000 Btu/h
   - ⇒ Recovery Efficiency = 76%
   - ⇒ Output = 68,400 Btu/h
   - ⇒ Burner = Beckett only available

3. **Combustion air inlet and electronic damper**
   - The combustion air inlet will be a round duct 4 inches in diameter and no longer than 20 feet in length (CAN/CSA B149 - Table 7.2.2B). This duct will be insulated and located in accordance with local codes.
   - An electronic combustion air damper will also be installed.
     - ⇒ Make and Model = ACA PAC: HOM-0411-SF1

Commentary

* The building envelope will have a continuous air barrier and the builder is aiming to achieve an airtightness of less than one air change per hour (ACH) when the house is depressurized to 50 Pascals (Pa) in accordance with the CGSB-149.10 standard, *Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method.* The R2000 Program standard is 1.5 ACH at 50 Pa. With a tight building envelope, the potential for backdrafting is increased significantly.

* By installing a direct vent model, the potential for backdrafting induced by exhaust appliances, such as the clothes dryer and kitchen exhaust fan, is eliminated. As a result, the house will not be subject to a 5 Pa depressurization limit in accordance with CSA F326, *Residential Mechanical Ventilation Systems,* and a makeup air will not have to be supplied to meet the reference exhaust flow-rate condition (Clause 6.3.1).

If a naturally aspirated model was installed, a makeup air duct would have to be installed to meet the exhaust flow-rate condition. To prevent cold air from flooding into the house and the homeowner from permanently blocking this duct, an electronic damper, tied in to appliances exhausting more than 75 L/s, would also have been installed.

* Although backdrafting and depressurization requirements may also be satisfied with a power-vented model, this type of unit was not specified because it would result in a more complicated installation, higher operating costs and potential servicing problems in a smaller center such as Dawson City.

B. VENTILATION STRATEGY

Equipment Specifications

1. **Heat Recovery Ventilator (HRV)**

⇒ Make and Model = Flair 5585 Compact High Efficiency
⇒ Capacity = 55 L/s to 92 L/s
⇒ Sensible Efficiency = 84% @ 0°C to 72% @ -25°C
⇒ Defrost = Adjusts defrost cycle for temperatures below -31°C
⇒ Wall Control Unit = Standard model which includes a dehumidistat, an automatic and intermittent mode, and a maintenance indicator

2. **Kitchen Exhaust (specified model or equivalent)**

⇒ Make and Model = Venmar H030950
⇒ Exhaust Capacity = 250 cfm
⇒ Noise = 5.0 sones
⇒ Speed Control = 3-speed

Field Installation Instructions

- The unit shall by installed by an HRAI certified installer (or one approved by YHC) in accordance with the CSA-F326 standard and the manufacturer's installation instructions.

◊ Supply and exhaust weatherhoods specifically designed for use with an HRV must be used. These low restriction hoods are supplied with extra length sleeves and vapour seal collars to ensure a proper and secure seal of the insulated flexible duct. The supply hood is also equipped with a velcro mounted screen which can be opened during the winter months to prevent the formation of hoar frost on the screen which will block off the fresh air supply to the house.

◊ Supply and exhaust weatherhoods must be installed a minimum of 1.8 metres apart and located on the same wall.

◊ A single piece of insulated flex duct must be installed for both the fresh air from the outside and the exhaust air to the outside. The supply side duct is under a negative pressure and any leakage points draw warm, moist house air against the cold duct resulting condensation and icing. The exhaust duct is positively pressurized and duct leakage back into the house will significantly reduce the overall efficiency of the HRV.

◊ The HRV should be installed in a location in the mechanical room that will ensure the shortest possible duct lengths for both the fresh air from the outside and the exhaust air to the outside. If duct lengths exceed 3 metres, double insulated flex duct must be installed. Long duct lengths can reduce the overall HRV efficiency by as much as 40%.

◊ The HRV must have a dedicated distribution system. Fresh air shall not be circulated through the forced air heating system. The cost of continuous furnace fan operation, in addition to the operation of the HRV, will be too expensive.

◊ Exhaust pickups shall be installed in each bathroom and in the kitchen. All pickups shall be located far enough into the room so as to adequately pull exhaust air from the entire room. The kitchen exhaust pickup must be located at least 1.2 metres horizontally from the stove to prevent grease contamination

◊ Additional exhaust air from the kitchen will be provided by a range hood which exhausts to the outside. The ductwork shall be installed down through the wall cavity and out through the floor truss area. The unit must have at least three speed settings or a variable speed control. **The unit selected must have a noise rating no greater than 6 sones.** A recirculating rangehood is not acceptable.

◊ Fresh air must be distributed to all rooms of the house. **Those rooms from which air is being exhausted do not require a separate supply diffuser.** Doors to rooms with an exhaust pickup must be sufficiently undercut (25 mm) to allow adequate fresh air to be pulled into the room and circulated to the exhaust pickup. Otherwise, a separate supply diffuser must be provided.

◊ High sidewall diffusers will be used to distribute fresh air. The location of the diffusers must be chosen so as to prevent any discomfort to the homeowners. A supply air diffuser located over a bed, for example, is not acceptable.

- All seams, connections and elbow joints on the warm side supply and exhaust ducts must be sealed. **Duct tape is not acceptable** because the adhesive dries over time, aluminium backed tape is a more acceptable alternative, and a latex sealer, as used in commercial applications, is highly recommended.
- The HRV must be balanced according the manufacturer's instructions. Once the unit has been balanced, the HRV control must be clearly and permanently labelled to indicate the speed at which the CSA F326 ventilation requirement is being met.

Commentary

* The HRV selected is HVI certified and designed for cold weather operation. At temperatures below -31°C, the defrost cycle automatically switches from 6 minutes defrosting / 35 minutes operating, to 6 minutes defrosting / 20 minutes operating.

* If it is found that the core freezes in the most severe weather, it is recommended that the balancing of the unit be adjusted so that the exhaust

flow rate is higher than the supply flow rate. This will assist in preventing the build-up of ice in the core. The ensuing negative pressure will not create a backdrafting concern since the oil-fired appliance is not susceptible to backdrafting.

* The choice of a wall control is important in order to provide the homeowner with the options necessary to maximize indoor ventilation while minimizing electricity use. The *Standard Wall Control Unit* provides the following options:

  ◊ The dehumidistat will operate the unit at its maximum capacity when the indoor relative humidity levels are above the setting selected by the homeowner.

  ◊ When the *Automatic Mode* is selected, the unit operates at the *Minimum Ventilation Capacity* as determined by the HRAI certified installer using CSA F326.

  ◊ When the *Intermittent Mode* is selected, the HRV stops when the indoor relative humidity is lower than the setting selected by the homeowner. This mode ensures minimum air exchange when the house is unoccupied to minimize costs.

* External switches for the HRV in the bathrooms and kitchen are not being installed because a sudden draw of high moisture air into the heat recovery unit during severe winter conditions may result in core freezing. It is better to allow the moisture to circulate throughout the house and to have the dehumidistat determine the point at which humidity levels need to be reduced.

  As a result, the selection of a kitchen range hood becomes more important. Additional intermittent exhaust will most often be required in the kitchen. Specifying a unit that operates quietly and has a number of different speed settings will ensure that the homeowner will use it.

Example 3: Oil-fired Stove / Space Heater and Air Exchanger Ventilation Air Mixing Box

A. SPACE AND DOMESTIC HOT WATER HEATING STRATEGY

Equipment Specifications

1. **High efficiency, oil-fired stove**

⇒ Make and Model	=	EFEL (there are other UL approved units to chose from)
⇒ Output	=	Adjustable from 13,000 to 40,000 Btu/h
⇒ Energy Efficiency	=	82%
⇒ Electricity Required	=	None, if oil tank is located higher than stove, or a very small pump to pump oil from tank to stove reservoir
⇒ Combustion air	=	Taken from internal space
⇒ Venting	=	Through a 100 to 125 mm vertical vent

2. **Air Exchanger ventilation air mixing box**

⇒ Make: electrical	=	Nutech (this unit appears to use the least amount of energy for its ventilation capacity)
⇒ Model	=	FRESHVENT 1001DXPRO
⇒ Capacity	=	42 L/s ventilation air & 85 L/s of recirculating air Total = 127 L/s.
⇒ Electricity use	=	125 Watts
⇒ Filter	=	Included, access through door

System Design and Operation

- This system must be installed in a house with a combined ventilation and envelope heat loss of less than 40,000 Btuh and is best suited, but not restricted to, a fairly open internal design.
- The stove should be situated in a central location in the room most often occupied during waking hours. The ideal location for the oil tank would be indoors at a level slightly higher than the stove to provide a gravity feed. This eliminates the need for the small pump to pump the oil to the stove's reservoir and keeps the oil warm so that it flows and burns better.
- These stoves are very attractive with a glass door similar to that of a wood burning stove and can even be used for heating water or keeping food warm. They usually become the focal point of the room. They can run indefinitely with gravity-fed oil when installed with the oil tank mounted higher than the stove, or for a few hours if the electricity goes off when the pump is required.
- The problem of distributing the warm air to distant rooms is taken care of by the ventilation system's air mixing box. The mixing box indoor return air inlet should be located above the stove where it will pick-up the warm air and mix it with the

ventilation air to temper it. The tempered air would then be distributed throughout the house.

- The ventilation system is a balanced system that uses warm house air to temper the cold outdoor air. A Freshvent mixing box is used to bring in the minimum continuous 30 L/s required for a three bedroom home of the type commonly found in the remote areas of the North. A damper is required on the inlet and exhaust ducts to reduce the equipment's undampered ventilation capacity of 42 L/s to 30 L/s. This cold outdoor air is mixed with 85 L/s of warm indoor air picked-up above the space heater and distributed to all occupied rooms (as required by the 1995 NBC) through high inside wall supply outlets located within 200 mm of the ceiling. These outlets should have grilles that spread the airflow horizontally but not vertically. The spread should be such that noticeable air movement has stopped before the plume of air has reached the opposite wall.

- The ducts for this system could be located in small chases located where the wall and ceiling meet in rooms or a hallway. If attractively painted, it may be possible to leave the small duct system completely exposed. This would make an already reasonable installed cost even lower.

- All inside doors to rooms where ventilation air is supplied should be undercut by an amount such that the space under the door equals, or exceeds, the free area of the supply grille. This will allow stale air to migrate back to the system's return air grille and result in stale air moving towards the oil stove where, coincidentally, some will be used for combustion and the balance will be rise by natural convection (caused by the heat of the stove) to the ventilation system inlet grille at the ceiling.

- In houses with no basements, which is typical in remote areas, the outdoor intake and outlet of the ventilation system should be located through the floor and be spaced at least 2 metres apart to avoid cross contamination. They should be covered with a 6 mm rodent mesh. No insect screen should be used at this point as it may clog with dust and lint on the exhaust side and with insects, spider webs and plant seeds on the intake side. The filter located in the unit should filter out most insects. However, if small insects, such as black flies, make it through the mesh, a piece of window screen could be installed in front of the filter.

- The main advantage of this system is that the total electrical consumption for heating and cooling is 125 Watts compared to several hundred Watts for other space heating and ventilation options. The oil efficiency is equal to that of most oil furnaces so that oil efficiency is not traded for electrical savings. A similar system using a wood stove to provide heat rather than an oil stove / space heater has been tested in Alaska with considerable success.

7. Recommendations for Future Research

This project has clearly indicated that there are a number of issues that impact significantly on the ultimate choice of a heating and ventilating system but which remain unresolved. Further research to address these issues will be required before it will be fully possible to design and specify systems that will work effectively and be accepted in the different communities throughout the North. These issues are discussed in detail in Section 5.3 and future research and field monitoring is suggested that would determine:

- the minimum temperature at which ventilation air can be delivered to the house and the temperatures at which preheating would be required;
- the effect of the building envelope airtightness level on the specification of ventilation air flow rates and the type of equipment used;
- the real cost of coupling a ventilation system to a forced air system to provide air tempering and ventilation air distribution;
- the field documentation and guidelines required for designers and contractors to direct the complex process of specifying a system which will address the wide range of extreme conditions specific to Northern conditions, populations and communities;
- the overall system efficiency, effectiveness and lifetime costs for a heating and ventilation system, including domestic hot water heating, that has been as rigorously specified as the examples in Section 6. This research would include a determination of the impact on systems of user attitudes and capabilities.

In addition to the field monitoring, the following types of research projects carried out in a test chamber, or preferably a house, are required in order to determine how to most effectively use current technology:

- The appropriate air volumes and temperatures required to discharge supply air into a room without causing comfort problems could be determined in a test facility having the capability of introducing supply air volumes over a range of 5 L/s to 30 L/s at temperatures ranging from -50°C to 40°C. Various high wall and ceiling grille configurations could be tested and compared with a traditional forced air floor perimeter system. The discharge temperature from the high outlets could also be cycled through a high to low temperature range to simulate a combined heating/ventilating system. By cycling the heating system at different frequencies, different outdoor design temperatures could be simulated. The goal of such research would be to generate guidelines for designers and contractors that relate room heat loss, temperature, air flow and air flow temperature and occupant comfort.
- The combination of an oil-fired stove and a ventilation mixing box (Section 6: Example 3) offers great promise for houses with a fairly open concept design and an envelope and ventilation heat loss of less than 40,000 Btuh. This combined system should be installed in houses of different designs in locations where the outside design temperature ranges from - 30°C to -50°C. Different ventilation flow rates should be tested to determine the system's ability to provide comfort at higher ventilation rates than the minimum required by the Code.

- Research should be conducted to test different types of, and locations for, ventilation, makeup and combustion air inlets which have been designed to have low velocity intake rates to keep out insects while preventing frosting, and wind driven snow and dust problems. The best location for sidewall vented combustion appliance terminals should also be determined.
- The suitability of HRV's and ventilation mixing boxes that have not been certified for use where the design temperature is between -40 and -50°C should be tested and monitored under such conditions. Testing should determine the combination of indoor relative humidity and outdoor temperature that will render the HRV ineffective.
- Most oil burners can be directly connected to a combustion air intake. However, these combustion air kits have not been tested under the extreme conditions of the North. Testing should be carried out to determined if the air/oil mixture settings that are correct for 10°C are also suitable for -50°C. The ability of the heating appliance to deal with condensation and cold burner components should also be determined.

Research should continue to be directed at evaluating and adapting new technologies for use in northern housing. For example, the most significant advances in heating systems will come from new technologies for burning fuel oil at high efficiencies with low capacity, low maintenance, non-electric burners. Adaptation of the European oil-fired stove technology for use in forced air furnaces equipped with high efficiency blower motors would have a significant impact on space heating costs in the North. This technology would provide a full range of firing rates, allowing the system output to match the design heat load. With the heating plant properly sized, it would be running almost continuously during the coldest periods of heating season and could then be used to temper and distribute ventilation air without incurring additional electrical costs. Such technology could also be used to heat hot water for a fan coil or hydronic system and for domestic requirements.

With respect to ventilation equipment, the most urgent need is for the development of highly efficient HRV's that will operate at temperatures as low as -50°C. Currently, there is not one HRV available that has been independently tested and approved to operate at any temperature below -25°C. Unfortunately, the northern market is so small that manufacturers have not been able to justify the designing, certifying and manufacturing of HRV's specifically for cold Northern climates.

For all future research projects it will be very important to remember that, ultimately, the success of a system will be determined by how well it is specified by the designer, installed by the contractor and operated by the homeowner.

APPENDIX A

1. List of Resource Publications
2. Sample Survey Forms
3. List of Contacts

Resource Publications

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39. Energy Mines and Resources Canada, Indoor Air Quality Monitoring of the Flair Homes Energy Demo, 1990.

40. Energy Mines and Resources Canada, Utilization Patterns of Residential Mechanical Ventilation

41. Systems, Flair Homes Energy Demo, 1990.

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43. Energy Mines and Resources Canada, Controlled Ventilation in Housing.

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45. Public Works Canada, Integrated Mechanical Systems: Recent Developments and Potential Housing Applications.

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62. Canadian Electrical Association, "Ventilation Systems for New and Existing Houses with Electric Baseboard Heating, 1996

63. CMHC, Research Division, "Performance of Simplified Ventilation Systems", 1995

64. Natural Resources Canada, Energy Efficiency Division, Energy Impact of Ventilation Air Distribution, 1995

65. CMHC, Technical Policy and Research Division, Complying with Residential Ventilation Requirements of the 1995 National Building Code 1996

An Investigation of Design Criteria and Appropriate Technologies for Heating and Ventilation Systems for Remote Housing

EXPERTS AND SYSTEM DESIGNERS SURVEY

NOTE: If you have any questions regarding completing this survey, please contact:
Wil Mayhew Phone: (403) 484-0476 FAX: (403) 484-3956

Company Name: ____________________ Person Surveyed: ____________________

Company's areas of expertise: ____

How long have your company been involved with Northern and remote housing and/or heating and ventilation? __________

How many employees in your company? __________ How many are specifying heating/ ventilation systems: __________

Where have you obtained your knowledge regarding Northern and remote housing and/or heating and ventilation:

____

____

Table 1: Houses that are CURRENTLY being built in the North and the manner in which they are typically operated vary depending upon the type of community. For this survey, three different types of communities have been identified.

	TYPE 1 COMMUNITY - Fuel reasonably priced - Trained contractors available - Higher income population - Understand issues and technology - Culture not a major consideration		TYPE 2 COMMUNITY - Fuel reasonably priced/expensive - Servicing a potential concern - Modest income population - Less idea of issues & technology - Culture a greater consideration		TYPE 3 COMMUNITY - Fuel expensive - Servicing a definite concern - Lower income population - Least idea of issues & technology - Culture a major consideration	
PROVIDE EXAMPLES OF EACH COMMUNITY TYPE THAT YOU SERVE						
HOUSE DESCRIPTION - No. of Storeys - Typical Floor Area - Typical Volume - Foundation Type						
INSULATION	TYPE	R-VALUE	TYPE	R-VALUE	TYPE	R-VALUE
- Ceiling						
- Wall						
- Exposed Floor						
WINDOWS - # of Glazings - Type of Frame - Other Features						
ENVELOPE AIRTIGHTNESS - Degree of airtightness - Type of Air Barrier	(Circle One) Loose Relatively Airtight Airtight		(Circle One) Loose Relatively Airtight Airtight		(Circle One) Loose Relatively Airtight Airtight	
TYPICAL TEMPERATURES	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
- Living Area						
- Bedrooms						
TYPICAL HUMIDITY LEVELS - Winter humidity levels - Major humidity sources	(Circle One) High (>40%) Moderate (20-40%) Low (<20%)		(Circle One) High (>40%) Moderate (20-40%) Low (<20%)		(Circle One) High (>40%) Moderate (20-40%) Low (<20%)	
HOUSING STARTS Indicate number of starts	New Housing	Retrofits	New Housing	Retrofits	New Housing	Retrofits

Table 2: Questions regarding the heating and ventilation systems currently being designed? (Please be as detailed as possible and use additional sheets if required.)

QUESTIONS	TYPE 1 COMMUNITY	TYPE 2 COMMUNITY	TYPE 3 COMMUNITY
How many systems does your company design/ specify each year? Who are your clients?	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________
What are the applicable building codes in the areas that you service?			
What percentage of systems are installed in full accordance with the applicable building code?			
What restrictions do you most commonly face when designing and delivering HEATING systems? (such as code requirements, equipment limitations, installer and homeowner limitations, etc.)			
What restrictions do you most commonly face when designing and delivering VENTILATION systems? (such as code requirements, equipment limitations, installer and homeowner limitations, etc.)			
Who is responsible for maintaining and servicing the heating and ventilation system?			

Table 2: Questions regarding the heating and ventilation systems currently being installed? (Please be as explicit as possible and use additional sheets if required.)

QUESTIONS	TYPE 1 COMMUNITY	TYPE 2 COMMUNITY	TYPE 3 COMMUNITY
Which of these services do you provide? (Circle)	Design Installation Servicing	Design Installation Servicing	Design Installation Servicing
How many systems does your company design/ specify each year? Who are your clients?	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________
Who else designs/specifies systems that your company installs?			
How many systems does your company INSTALL each year?	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________	New Housing ________ Retrofit ________
What are the 3 most frequent service calls?	1) 2) 3)	1) 2) 3)	1) 2) 3)
What codes regulate the installations in the areas that your company services?			
Are any of these codes inappropriate in your work? If "Yes", which code and what changes would you like to see?	Yes No	Yes No	Yes No
Who is responsible for inspecting the systems?			
What restrictions does your company most commonly encounter when designing/specifying and installing HEATING systems? (such as code requirements, equipment availability and limitations, occupant limitations, etc.)			
What restrictions does your company most commonly encounter when designing/specifying and installing VENTILATION systems? (such as code requirements, equipment availability and limitations, occupant limitations, etc.)			

Table 3: Information on heating systems CURRENTLY installed in TYPE 1 COMMUNITIES? (Please be as detailed as possible and use additional sheets if required.)

Criteria for Type 1 Community - Fuel reasonably priced - Understand issues and technology - Trained contractors available - Culture not a major consideration - Higher income population	TYPICAL TYPE 1 COMMUNITY HEATING SYSTEMS Describe the three heating systems identified in the left hand column. Include manufacturers and details regarding the control and operation features such as continuous fan operation, etc.	
1) Heating System Typically Designed/Specified Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS
2) Heating System Typically Installed (If different from designed heating system in 1) above, please comment on the changes and why they occur?) Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS
3) Most Suitable Heating System (Ignore code requirements, but consider effectiveness, reliability, fuel and equipment costs, servicing, maintenance and operation, and lifestyle) Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS

IMPROVEMENTS TO HEATING AND VENTILATION EQUIPMENT

1) In your opinion, what design changes or improvements could be made to heating and ventilating equipment to make it simpler to operate by occupants in the North?

____

____

____

____

____

2) What design changes or improvements would make heating and ventilating equipment easier to maintain?

____

____

____

____

____

3) What design changes or improvements would make heating and ventilating equipment easier to service?

____

____

____

____

____

4) What design changes or improvements would make heating and ventilating equipment more reliable?

____

____

____

____

____

5) What design changes or improvements would make heating and ventilating equipment less expensive?

____

____

____

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6) Additional Comments:

____

____

____

____

____

Table 4: Information on heating systems CURRENTLY installed in TYPE 2 COMMUNITIES? (Please be as detailed as possible and use additional sheets if required.)

Criteria for Type 2 Community - Fuel reasonably priced/expensive - Less idea of issues & technology - Servicing a potential concern - Culture a greater consideration - Modest income population	TYPICAL TYPE 2 COMMUNITY HEATING SYSTEMS Describe the three heating systems identified in the left hand column. Include manufacturers and details regarding the control and operation features such as continuous fan operation, etc.	
1) Heating System Typically Designed/Specified Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS
2) Heating System Typically Installed (If different from designed heating system in 1) above, please comment on the changes and why they occur?) Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS
3) Most Suitable Heating System (Ignore code requirements, but consider effectiveness, reliability, fuel and equipment costs, servicing, maintenance and operation, and lifestyle) Equipment Cost: $ ________ Installation Cost: $ ________	ADVANTAGES AND DISADVANTAGES	PROBLEMS AND POTENTIAL SOLUTIONS

Individuals Receiving Surveys from Howell-Mayhew Engineering

	Title	First	Last	Company	Address1	Address2	City	Prov	Postal	Workphone	Faxphone
H	Mr.	Dan	Boyd	Yukon Housing Corporation	410A Jarvis St.	PO Box 2703-Y1	Whitehorse	Yukon	Y1A 2C6	(403) 667-5759	(403) 667-3664
D	Mr.	Rob	Mason	Northern Cadworks	29 Tamarac Drive		Whitehorse	Yukon	Y1A 3W4	(403) 668-2238	(403) 668-2368
D	Mr.	Mike	Mason	Yukon College		P.O. Box 2799	Whitehorse	Yukon	Y1A 5K4	(403) 668-8766	(403) 668-8890
H	Mr.	Larry	Willson	CMHC Whitehorse	402, 3106 - 3rd Ave.		Whitehorse	Yukon	Y1A 5G1	(403) 633-7530	(403) 633-7542
D	Mr.	Juergen	Korn	Northern Research Institute	Yukon College	P.O. Box 2799	Whitehorse	Yukon	Y1A 5K4	(403) 668-8879	(403) 668-8734
C	Mr.	Mike	Youso	Arctech Associates		P.O. Box 4863	Whitehorse	Yukon	Y1A 4N6	(403) 667-6182	(403) 667-6182
H	Mr.	Richard	Bushley	NWT Construction Assoc.	201 Bowling Green Bldg.		Yellowknife	NWT	X1A 3S7	(403) 873-3949	(403) 873-8366
H	Mr.	Barton	Bourssa	CMHC Yellowknife		P.O. Box 2460	Yellowknife	NWT	X1A 2P8	(403) 873-2637	(403) 873-3922
H	Mr.	Marshall	Wilson	NWT Housing Corporation		P.O. Box 2100	Yellowknife	NWT	X1A 2P6	(403) 873-7861	(403) 920-8024
D	Mr.	William	Talalayevsky	NWT Housing Corporation		P.O. Box 2100	Yellowknife	NWT	X1A 2P6	(403) 873-7861	(403) 920-8024
D	Mr.	Ross	Abdurahman	Ferguson, Semik and Clark		P.O. Box 1777	Yellowknife	NWT	X1A 2P4	(403) 920-2882	(403) 920-4319
C	Mr.	John	Allen	Mallard Constructing	43 Pelly Road		Whitehorse	Yukon	Y1A 4L9	(403) 667-7017 res. 633-2177	(403) 667-7179
C	Mr.	Randy	Mulder	MALCO		P.O. Box 130	Coppermine	NWT	X0E 0E0	(403) 982-3001	(403) 982-3021
C	Mr.	Joe	Chorostkowski	J & R Mechanical		P.O. Box 1541	Yellowknife	NWT	X1A 2P2	(403) 920-2495	(403) 873-6904
C	Mr.	Steve	Duncan	Duncans Ltd.	106 Copper Road		Whitehorse	Yukon	Y1A 2Z6	(403) 667-6613	(403) 668-4502
D	Mr.	Wayne	Wilkinson	Wilkinson Consulting		P.O. Box 774	Fort Simpson	NWT	X0E 0N0	(403) 695-3760	(403) 695-2665

Individuals Receiving Surveys from CMHC

Title	First	Last	Company	City	Prov	Workphone	Faxphone	Comments
Mr.	Stan	Koller	CMHC	Prince George	BC	(604) 561-5481		- senior technical officer
Mr.	Wayne	Willkenson		Fort Simpson	NWT	(403) 695-3533	(403) 695-2665	- project manager for native band
Mr.	Regan	Jacques	G.C. North	Iqualuit	NWT	(819) 979-1992	(819) 979-0507	
Mr.	George	D'Aoust	Jomanik - Can	Iqualuit	NWT	(819) 979-6624	(819) 979-5967	
Mr.	Renault	Sage	Narwhal Plumbing and Heating	Iqualuit	NWT	(819) 979-6350	(819) 979-6622	- does lots of maintenance
Mr.	Kevin	Divbold	Whiponic - Welpater	Norman Wells	NWT	(403) 920-2495	(403) 873-6904	- Mechanical, electrical firm
Mr.	Scott	Hunt	Clarke Builders	Yellowknife	NWT	(403) 667-5759	(403) 667-3664	- also works in Russia
Mr.	Eric	Sputck	Hovat Construction	Yellowknife	NWT	(403) 920-4141	(403) 873-6880	- all over NWT
Mr.	Joe	Leonardis	JSL Mechanical	Yellowknife	NWT	(403) 920-2495	(403) 873-6904	
Mr.	Bob	Maddigan	Maddigan Consulting	Yellowknife	NWT	(403) 920-7227	(403) 920-7927	
Mr.	John	Lemieux	Maple Leaf Plumbing & Heating	Yellowknife	NWT	(403) 873-9578		- lower end housing in Yellowknife
Mr.	Dave	Spirig	Nitey North Constr.	Yellowknife	NWT	(403) 873-8583	(403) 873-2334	- commercial; Housing Corp; hot company
Mr.	Dan	Adams	Park, Sanders, Adam & Visko, Architects	Yellowknife	NWT	(403) 920-2609	(403) 920-4261	- residential, commercial, everything
Mr.	Gino	Pin	Pin, Mathews, Arch	Yellowknife	NWT	(403) 920-2728		- won all sorts of awards for design, does not like HRVs
Mr.	Neil	Slade	Slades Mechanical	Yellowknife	NWT	(403) 873-8569	(403) 873-6957	
Mr.	Randy	Taylor	YTG employee	Carmack	Yukon	(403) 863-5247		- does a lot of operation and maintenance
Mr.	Pat	Hogan		Dawson City	Yukon	(403) 993-5803		- inspector
Mr.			Crawford Heating and Plumbing	Watson Lake	Yukon	(403)536-2338		
Mr.	Ken	Hight		Whitehorse	Yukon	(403) 667-6401		- inspector
Mr.	Bill	Mason	Budget Plumbing	Whitehorse	Yukon	(403) 633-5646		-installs hydronic systems
Mr.	Bert	Wolffe	Fred's Plumbing & Heating	Whitehorse	Yukon	(403) 667-6441		-equipment supplier, no installations
Mr.	Terry	Griffith	Griffith Heating & Sheet Metal	Whitehorse	Yukon	(403) 667-2214		
Mr.	Joel	Hackney	Horizon Construction	Whitehorse	Yukon	(403) 633-2960		
Mr.	John	Thompson	Northwest Heating	Whitehorse	Yukon	(403) 667-6039		-installs both forced air and hydronic
Mr.	Keith	Butler	YTG Protective Services	Whitehorse	Yukon	(403) 667-5828		- inspector
Mr.	Marvin	Brooks	YTG Protective Services	Whitehorse	Yukon	(403) 667-5824		- inspector

APPENDIX B

Summary of Survey Results

TYPE 1 COMMUNITY

RESPONDENTS: 7 Housing Agencies

GENERAL

House Type: 1-2 storeys; 1000 - 3000 ft²; PWF, concrete, crawlspace, piles; R40 ceiling, R20 - 30 walls, R20 - 40 floors; double - triple glazing, Low E/argon, wood/vinyl; Tyvek/poly, relatively airtight to airtight

Indoor Temps: Living Area: Day 20-24°C Night 15-24°C * Higher end temps for seniors
Bedrooms: Day 18-24°C Night 15-24°C

Humidity Levels: Moderate to high from cooking, cleaning, laundry, bathroom, crawlspace, occupancy

Housing Starts: NWTHC - 100 new, 70 retrofit
YHC - 150 new, 50 retrofit
AHC (Alaska) - 1000 new

SYSTEM INSTALLATION, OPERATION, SERVICE AND MAINTENANCE

Heating: Installed as per code: YHC - 90%
NWTHC - 100%
AHC (Alaska) - 100%
Maintained by: YHC - occupant/housing corp
NWTHC - occupant/housing corp
AHC (Alaska) - occupants

Typical fuel Yukon - 80% fuel oil, 20 % propane
NWT - 90% fuel oil, 5% propane, 5% natural gas
AHC (Alaska) - 100% natural gas

Ventilation: Installed as per code: YHC - 90%
NWTHC - 100%

Maintained by: YHC - occupant/housing corp
NWTHC - occupant/housing corp
AHC (Alaska) - occupants

Annual costs YHC: Mechanical repairs - $100
Maintenance - $200
Operation - $1200 - $1500

Future role: YHC - moderate through leadership, training, standards, design and home ownership programs
CMHC Yukon - very little
NWTHC - currently active in future advisory
CMHC NWT - none, provide only mortgage insurance
AHC (Alaska) - responsible to insure AHC (Alaska) Building Energy Efficiency standards are complied with

TYPE 1 COMMUNITY

HEATING SYSTEMS CURRENTLY INSTALLED

Forced air, oil-fired

1. Installation	NWTHC:	No problems; equipment supplied by NWTHC or contractor, design by NWTHC, startup by contractor; equipment cost $6000, install cost $6000
	CMHC NWT:	No problems
	YHC:	Installations are 50% high and 50% mid-efficient units; 75% oil-fired, 25% propane-fired Equipment cost $4000, install cost $2500 Start up commissioning not done; need education, training, enforcement;
	CMHC Yukon:	Standard installation, Olsen and Rudd most popular; Combined equipment/install cost $6000 - $8000
2. Servicing	NWTHC:	No problems; community housing assoc. has maintenance staff to service and deal with problems on site; they keep spare parts in warehouse; $500/year/ house for repairs
	CMHC NWT:	No problems
	YHC:	No problems
	CMHC Yukon:	Easy servicing, lots of service companies Mid-efficient units are low maintenance but lack of skilled personnel to service
3. Maintenance	NWTHC:	Maintenance schedule carried out by trained staff; upgrading provided for staff Repairs cost $500 / house / year PROBLEM: Occupant does not inform maintenance staff about problem SOLUTION: Tenant education
	CMHC NWT:	Filter changed by occupant; annual servicing costs $150;
	YHC:	Little maintenance required by occupant by typically not carried out Annual servicing required by serviceperson; cost $100
	CMHC Yukon:	No problems; replace air filters and service burners
4. Operation	NWTHC:	No problems - equipment serviced, tenants educated, maintenance staff available systems accepted; cost $1200/yr
	CMHC NWT:	Most units without continuous fan but is becoming more popular;
	YHC:	Continuous fan operation not common but there is a need; cost $800 - $1200/yr
	CMHC Yukon:	No problems; furnaces have 2 speed fans; cost $1000/yr for 1100 ft² house

Forced air, propane-fired

1. Installation	CMHC Yukon:	Standard installation; combined equipment/install cost $6000 - $8000
2. Servicing	CMHC Yukon:	Easy servicing, lots of service companies Mid-efficient units are low maintenance but lack of skilled personnel to service
3. Maintenance	CMHC Yukon:	No problems; replace air filters and service burners.
4. Operation	CMHC Yukon:	Propane cost higher, lower BTU's per litre; Yukon Electric studies show cost higher than oil or electricity. Propane is a colder heat; introduces lots of moisture into house.

Wood-fired space heater or forced air system

1. Installation	YHC:	No problems; equipment cost $2500, install cost $1000 Radiant space heaters - 85%, forced air - 15% A lot of people are moving away from wood heating
2. Servicing	YHC:	No problems
3. Maintenance	YHC:	Requires weekly or monthly cleaning by occupant and are usually maintained
4. Operation	YHC:	No problems; cost $700 - $1000

TYPE 1 COMMUNITY

Forced air, natural gas-fired, 80% AFUE

1. Installation	AHC (Alaska)	PROBLEM: Duct leakage & pressure balancing SOLUTION: Proper installation practices Equipment cost $2000, install cost $2000

Boiler, natural gas-fired

1. Installation	AHC (Alaska)	Freeze-up potential prevented by using and maintaining antifreeze solution Equipment cost $2500, install cost $3000

Hydronic radiant heat

1. Installation	CMHC NWT:	No problems
2. Servicing	CMHC NWT:	No problems
3. Maintenance	CMHC NWT:	Requires trained personnel for annual servicing, occupant not capable
4. Operation	CMHC NWT:	Requires separate air exchange system

Most suitable system

CMHC NWT:	Forced air and hydronic heating coil through typical duct system. Provides required ductwork for air quality control, greater comfort
YHC:	High efficiency, forced air, oil or propane
CMHC Yukon:	First: Mid-efficiency, oil-fired, forced air furnace; preferably with an HRV Second: If can afford installation, an oil-fired, hot water system; more comfortable and cheaper over long term
AHC (Alaska)	Natural gas, boiler

VENTILATION SYSTEMS CURRENTLY INSTALLED

Fresh air duct directly into return air plenum; exhaust fans

1. Installation	NWTHC:	Exhaust fan engaged together with furnace or manually Humidity controller engaged with exhaust fan and second speed of the furnace motor Design provided by NWTHC, equipment provided by NWTHC or contractor Equipment cost $1000, install cost $1000
	CMHC NWT:	Dehumidistat also installed
	YHC:	75% are of this type with exhaust fans in bathrooms and kitchen, 7" fresh air duct Equipment cost $250, install cost $200
2. Servicing	NWTHC:	No problems; community housing assoc. has maintenance staff to service and deal with problems on site; they keep spare parts in warehouse
	CMHC NWT:	No problems
	YHC:	No problems if required
3. Maintenance	NWTHC:	Maintenance schedule carried out by trained staff; upgrading provided for staff Repairs cost $200 / house / year PROBLEM: Occupant does not inform maintenance staff about problem SOLUTION: Tenant education
	CMHC NWT:	No problems
	YHC:	None required
4. Operation	NWTHC:	Tenant education required if systems are to be accepted and operated properly otherwise systems will be disconnected Key is to provide equipment with low noise levels Ventilation rates should be higher when compared to Code requirements; cost $300/yr
	CMHC NWT:	No problems
	YHC:	No problems

TYPE 1 COMMUNITY

Heat recovery ventilator

1. Installation	CMHC NWT:	No problems
	YHC:	25% of systems are HRV's; Installations are fair and start up commissioning is poor Equipment cost $3000, install cost $1000
	CMHC Yukon:	Do not feel the limited number of installers fully understand these systems
2. Servicing	CMHC NWT:	Do not know
	YHC:	Parts availability, manufacturers response, and life expectancy all poor
	CMHC Yukon:	Do not feel the limited number of installers fully understand these systems
3. Maintenance	CMHC NWT:	Maintenance by occupant not a problem Skilled trades people seem to be in short supply
	YHC:	Units not maintained by occupants and yearly maintenance by skilled trades required Cost: $150/yr
	CMHC Yukon:	Virtually no expertise on HRV's
4. Operation	CMHC NWT:	PROBLEM: In bathroom and kitchen SOLUTION: Install manual fan or dehumidistat PROBLEM: Initial acceptance, then frustration SOLUTION: Available trained trades PROBLEM: Systems not operated correctly SOLUTION:Training
	YHC:	Not easy for occupants to operate and there is poor acceptance of system
	CMHC Yukon:	People do not understand their benefits but see them as using electricity and blowing cold air into the house so they disconnect

Bathroom and kitchen fans

1. Installation	AHC (Alaska)	Equipment cost $300, install cost $300

Most suitable system

CMHC NWT:	Fresh air duct into return air plenum, exhaust fans with dehumidistat, hot water radiant preheat system for fresh air to house
YHC:	Properly installed and balanced HRV's

TYPE 2 COMMUNITY

RESPONDENTS: 7 Housing Agencies

GENERAL

House Type: 1-2 storeys, bilevel; 1200 - 1400 ft²; PWF, piles, space frame, pads; R40 ceiling, R20 - 30 walls, R20 - 40 floors; double - triple glazing, Low E/argon, wood/vinyl; Tyvek/poly, relatively airtight to airtight

Indoor Temps: Living Area: Day 20-24°C Night 15-24°C SASK GOVT: Day 24-27°C Night 22-25°C
Bedrooms: Day 18-24°C Night 15-24°C

Humidity Levels: Moderate to high from cooking, cleaning, laundry, bathroom, crawlspace, occupancy

Housing Starts:
NWTHC - 20 new, 20 retrofit
YHC - 10 new, 10 retrofit
SASK GOVT - 15 new, 93 retrofit
AHC (Alaska) - 100 new

SYSTEM INSTALLATION, OPERATION, SERVICE AND MAINTENANCE

Heating:

Installed as per code:
YHC - 70%
NWTHC - 100%
SASK GOVT - 100%
AHC (Alaska) - 100%

Maintained by:
YHC - 50% occupants, 50% First Nations
NWTHC - occupant/housing corp
SASK GOVT - Housing Corp
AHC (Alaska) - occupants

Typical fuel
YHC - 75% fuel oil, 20 % propane, 5% wood
NWTHC - 90% fuel oil, 10% wood
AHC (Alaska) - 80% natural gas, 15% propane, 5% wood

Ventilation:

Installed as per code:
YHC - 50%
NWTHC - 100%
SASK GOVT - 100%

Maintained by:
YHC - 50% occupants, 50% First Nations
NWTHC - occupant/housing corp
SASK GOVT - Housing Corp
AHC (Alaska) - occupants

Annual costs

Yukon:
Mechanical repairs - $100
Maintenance - $200 - $300
Operation - $1500 - $2500

Sask.:
Mechanical repairs - $300
Maintenance - $200
Operation - $2000 - $3000

Future role:
YHC - moderate, some influence through training, developing standards, and home ownership programs
CMHC Yukon - very little except some input in Band housing units
NWTHC - currently active in future advisory
CMHC NWT - none, provide only mortgage insurance
SASK GOVT - limited to availability of Federal/Provincial funding
AHC (Alaska) - responsible to insure Alaska Building Energy Efficiency standards are complied with

TYPE 2 COMMUNITY

HEATING SYSTEMS CURRENTLY INSTALLED

Forced air, oil-fired

1. Installation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	Mainly mid-efficient units; equipment cost $4000, install cost $3000 Start up commissioning not done; need education, training, enforcement;
	CMHC Yukon:	Same systems as available in Type 1 communities Combined equipment/install cost $10,000 - $12,000
2. Servicing	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	Replacement part availability fair, otherwise no problems
	CMHC Yukon:	Fewer service companies who control market, when they do work and what they charge
3. Maintenance	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	Little maintenance required by occupant Annual servicing required by serviceperson; cost $150
	CMHC Yukon:	No problems; replace air filters and service burners
4. Operation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	Continuous fan operation possible but not used; cost $1500/yr
	CMHC Yukon:	No comments

Forced air, propane-fired

1. Installation	CMHC Yukon:	Nobody has a gas ticket in Dawson City, have to bring installer in from Whitehorse Combined equipment/install cost $10,000 - $12,000
	SASK GOVT:	Clearance/location of fuel tank not always properly addressed; Equipment cost - $1400; Installation cost - $700
2. Servicing	CMHC Yukon:	Lack of skilled personnel to service
	SASK GOVT:	Lack of skilled personnel to service; non-vaporization of fuel in extreme temperatures so some form of heating blanket required
3. Maintenance	CMHC Yukon:	No problems; replace air filters and service burners
	SASK GOVT:	Includes filters, burner, thermocouple; grouping of maintenance for O/S ????
4. Operation	CMHC Yukon:	Propane cost higher, lower BTU's / litre; Yukon Electric studies state propane cost higher than oil or electricity. Propane is a colder heat and introduces lots of moisture into house.
	SASK GOVT:	Backdrafting has been a problem

Forced air, combination wood/oil-fired, thermostat control

1. Installation	SASK GOVT:	PROBLEM: Size & weight of furnace SOLUTION: Timing of installation PROBLEM: Fireproofing SOLUTION: Noncombustible barriers Equipment cost - $2400; Installation cost - $1600
2. Servicing	SASK GOVT:	PROBLEM: Ongoing cleaning of chimney & cpnts SOLUTION: Regular maintenance
3. Maintenance	SASK GOVT:	Includes air/fuel filter replacement, burner adjustment
4. Operation	SASK GOVT:	PROBLEM: Wood compartment not cleaned; green wood causes creosote build-up SOLUTION: Regular maintenance

TYPE 2 COMMUNITY

Wood-fired space heater or forced air system

1. Installation	YHC:	Same comments as Type 1 community
2. Servicing	YHC:	Same comments as Type 1 community
3. Maintenance	YHC:	Same comments as Type 1 community
4. Operation	YHC:	Same comments as Type 1 community

Hydronic radiant heat

1. Installation	CMHC NWT:	Same comments as Type 1 community
2. Servicing	CMHC NWT:	Same comments as Type 1 community
3. Maintenance	CMHC NWT:	Same comments as Type 1 community
4. Operation	CMHC NWT:	Same comments as Type 1 community

Fuel oil boiler

1. Installation	AHC (Alaska)	Equipment cost $2500, install cost $3500

Monitor or Toyo space heater

1. Installation	AHC (Alaska)	Equipment cost $1500, install cost $250
4. Operation	AHC (Alaska)	Limited heat distribution so best in energy efficient house with open floor plan

Most suitable system

CMHC NWT:	Same system as Type 1 community
YHC:	Mid-efficiency, forced air, oil-fired
CMHC Yukon:	Mid-efficiency, oil-fired, forced air furnace but not side venting and no HRV; requires good exhaust fans

VENTILATION SYSTEMS CURRENTLY INSTALLED

Fresh air duct directly into return air plenum; exhaust fans

1. Installation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	98% are of this type with exhaust fans in bathrooms and kitchen, 7" fresh air duct Equipment cost $250, install cost $200
	CMHC Yukon:	Exhaust fans in bathroom and kitchen; 200cfm fans installed in floor joists to limit noise using wall cavities as plenums; some have humidistats installed
2. Servicing	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	No problems if required
3. Maintenance	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	None required
4. Operation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Same comments as Type 1 community
	YHC:	No problems

TYPE 2 COMMUNITY

Heat recovery ventilator

1. Installation	CMHC NWT:	Usually not a problem
	YHC:	2% of systems are HRV's; Installations are fair and start up commissioning is poor Equipment availability is poor; equipment cost $3000, install cost $1500
	CMHC Yukon:	Limited use of HRV's
	AHC (Alaska):	Equipment cost $1500, install cost $1500
2. Servicing	CMHC NWT:	Qualified service personnel usually not available
	YHC:	Parts availability, manufacturers response, and life expectancy all poor
3. Maintenance	CMHC NWT:	Maintenance by occupant is questionable, may not know what is required Skilled trades people usually not available
	YHC:	Units not maintained by occupants and yearly maintenance by skilled trades required Cost: $200/yr
4. Operation	CMHC NWT:	PROBLEM: In bathroom and kitchen SOLUTION: Install manual fan or dehumidistat PROBLEM: Initial acceptance, then frustration SOLUTION: Available trained tradespeople PROBLEM: Systems not operated correctly SOLUTION: Training
	YHC:	Not easy for occupants to operate and there is poor acceptance of system

Continuous central exhaust from kitchen and bathroom

1. Installation	SASK GOVT:	PROBLEM: Condensation and frost SOLUTION: Insulate vent ducts in unheated space PROBLEM: Exhaust too close to grade SOLUTION: Relocate exhaust air outlet Equipment cost - $200; Installation cost - $200
2. Servicing	SASK GOVT:	PROBLEM: Poor access SOLUTION: Locate in accessible area
3. Maintenance	SASK GOVT:	PROBLEM: Dirty fans and grills SOLUTION: Clean routinely; clean ductwork in "groups"
4. Operation	SASK GOVT:	PROBLEM: Fan noise SOLUTION: More efficient, quieter motors PROBLEM: Additional energy costs SOLUTION: Multispeed fan motors PROBLEM: Perception of draft SOLUTION: Heat recovery

Separate kitchen hood fan and bathroom fan intermittent

1. Installation	SASK GOVT:	PROBLEM: Condensation and frost SOLUTION: Insulate vent ducts in unheated space Equipment cost - $250; Installation cost - $150
2. Servicing	SASK GOVT:	PROBLEM: Poor access SOLUTION: Locate in accessible area
3. Maintenance	SASK GOVT:	PROBLEM: Dirty fans and grills SOLUTION: Clean routinely; clean ductwork in "groups"
4. Operation	SASK GOVT:	PROBLEM: Fan noise SOLUTION: More efficient, quieter motors PROBLEM: Additional energy costs SOLUTION: Multispeed fan motors PROBLEM: Perception of draft SOLUTION: Heat recovery

Most suitable system

CMHC NWT:	Fresh air duct into return air plenum, exhaust fans with dehumidistat, hot water radiant preheat system for fresh air to house
YHC:	Fresh air intake with exhaust fans designed and balanced

TYPE 3 COMMUNITY

RESPONDENTS: 7 Housing Agencies

GENERAL

House Type:	1-2 storeys; 900 - 1400 ft²; PWF, piles, space frame, pads; R40 - 50 ceiling, R20 - 30 walls, R20 - 40 floors; double - triple glazing, Low E/argon, wood/vinyl; Tyvek/poly, relatively airtight to airtight
Indoor Temps:	Living Area: Day 20-24°C Night 15-24°C * Higher end temps for seniors Bedrooms: Day 18-24°C Night 15-24°C
Humidity Levels:	Moderate to high from cooking, cleaning, laundry, bathroom, crawlspace, occupancy
Housing Starts:	NWT - minimal new, 5 retrofit Yukon - 10 new, 5 retrofit N. Ont. - 0 new, 34 retrofit

SYSTEM INSTALLATION, OPERATION, SERVICE AND MAINTENANCE

Heating:	Installed as per code:	YHC - 50% NWTHC - 100% N. ONT. - 70% AHC (Alaska) - 100%
	Maintained by:	YHC - First Nations NWTHC - occupant/housing corp N. ONT. - First Nations AHC (Alaska) - occupants
Typical fuel	Yukon - 80% fuel oil, 20 % propane NWT - 90% fuel oil, 5% propane, 5% natural gas AHC (Alaska) - 100% natural gas	
Ventilation:	Installed as per code:	YHC - 30% NWTHC - 100% N. ONT. - 80%
	Maintained by:	YHC - First Nations NWTHC - occupant/housing corp N. ONT. - First Nations AHC (Alaska) - occupants
Future role:	YHC - moderate, some influence through training, developing standards, and home ownership programs CMHC Yukon - Band housing only; bands are taking greater responsibility through self-govt. agreements NWTHC - currently active in future advisory CMHC NWT - none, provide only mortgage insurance N. ONT. - advisory role re construction practices AHC (Alaska) - Ensure AHC (Alaska) Building Energy Efficiency standards are complied with	

TYPE 3 COMMUNITY

HEATING SYSTEMS CURRENTLY INSTALLED

Forced air, oil-fired

1. Installation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	CMHC NWT:	Equipment must be flown in or delivered by ship
	YHC:	Mid-efficient units; equipment cost $4000, install cost $4000 Start up commissioning not done; need education, training, enforcement;
	AHC (Alaska)	PROBLEM: Duct leakage & pressure balancing SOLUTION: Proper installation practices Equipment cost $2000, install cost $2000
2. Servicing	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	Replacement part and serviceperson availability poor
	CMHC Yukon:	Fewer service companies who control market, when they work and what they charge
3. Maintenance	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	Little maintenance required by occupant but rarely carried out Annual servicing required by serviceperson; cost $200
	CMHC Yukon:	No problems; replace air filters and service burners
4. Operation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	Continuous fan operation possible but not used; cost $2000/yr
	CMHC Yukon:	No comments

Forced air, combination wood/electric or oil, thermostat control

1. Installation	N. ONT.	Experienced service people hard to find locally Equipment cost - $3500; Installation cost - $4000
2. Servicing	N. ONT.	Parts must be ordered in and may take days of weeks to arrive
3. Maintenance	N. ONT.	Occupants not too knowledgeable about systems; First Nations maintenance person usually assists

Wood-fired space heater

1. Installation	YHC:	No problems
	CMHC Yukon:	All installers have to be flown in; combined equipment/installation cost $5000
2. Servicing	YHC:	Not applicable
	CMHC Yukon:	Not applicable
3. Maintenance	YHC:	Chimney cleaning carried out monthly by occupant
	CMHC Yukon:	Occupant has limited expertise on system and do not know how to maintain
4. Operation	YHC:	System accepted by occupant; gather own wood; $1200/yr
	CMHC Yukon:	No comments

Hydronic radiant heat

1. Installation	CMHC NWT:	Same comments as Type 1 community
2. Servicing	CMHC NWT:	Same comments as Type 1 community
3. Maintenance	CMHC NWT:	Same comments as Type 1 community
4. Operation	CMHC NWT:	Same comments as Type 1 community

Monitor or Toyo space heater

1. Installation	AHC (Alaska):	Equipment cost $1600, install cost $250
4. Operation	AHC (Alaska):	Limited heat distribution so best in energy efficient house with open floor plan

TYPE 3 COMMUNITY

Most suitable system

CMHC NWT:	Same system as recommended for Type 1 community
YHC:	Wood-fired space heater or forced air system
CMHC Yukon:	Wood burning space heater with electric baseboard backup; no fossil fuels since to expensive to fly in
N. ONT.	Wood/electric probably ideal as wood has always been a source of heat for the First Nations and electricity would backup the wood heating option

VENTILATION SYSTEMS CURRENTLY INSTALLED

Fresh air duct directly into return air plenum: exhaust fans

1. Installation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	10% are of this type with exhaust fans in bathrooms and kitchen, 7" fresh air duct Equipment cost $250, install cost $200
	CMHC Yukon:	Exhaust fans in bathroom and kitchen range hood;
2. Servicing	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	No problems if required
3. Maintenance	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	None required
	CMHC Yukon:	No maintenance done
4. Operation	NWTHC:	Survey comments apply to all communities, they do not differentiate
	YHC:	No problems
	CMHC Yukon:	Limited success in removing moisture from unit but is offset with wood heat Bigger problem as units are retrofitted and sealed up; more indoor air quality complaints Are used sometimes which is better than HRV record

Fan driven fresh air intake past a heating coil to preheat; fans with humidistats for exhaust

1. Installation	CMHC NWT:	Usually not a problem as equipment sent in with qualified staff
2. Servicing	CMHC NWT:	Not too much of a problem
3. Maintenance	CMHC NWT:	Minimal maintenance required by occupant; usually available by skilled people
4. Operation	CMHC NWT:	Does not appear to present any problems

Heat/air exchangers, thermostat controlled, bathroom fans

1. Installation	N. ONT.	Most often need to hire outside personnel
2. Servicing	N. ONT.	Most often need to hire outside personnel
3. Maintenance	N. ONT.	First Nation maintenance man does upkeep
4. Operation	N. ONT.	Not too knowledgeable; First Nation maintenance man assists

Bathroom fans and rangehood, with and without dehumidistats

1. Installation	CMHC Yukon:	OK; with dehumidistats
	N. ONT.	Local trades people involved; manual switches Equipment cost: $300 Installation cost: $200
2. Servicing	CMHC Yukon:	OK
	N. ONT.	Local trades people involved
3. Maintenance	CMHC Yukon:	OK
	N. ONT.	First Nation maintenance man does upkeep
4. Operation	CMHC Yukon:	OK
	N. ONT.	First Nation maintenance man assists if required

TYPE 3 COMMUNITY

Opening and closing of doors and windows

1. Installation	YHC:	Not applicable; used in 90%
2. Servicing	YHC:	Not applicable
3. Maintenance	YHC:	Not applicable
4. Operation	YHC:	Not applicable

Heat recovery ventilator

1. Installation	AHC (Alaska):	Equipment cost $1500, install cost $2000 PROBLEM: Wind SOLUTION: Proper location of vents

Most suitable system

CMHC NWT:	System outlined above
YHC:	What they are doing
CMHC Yukon:	System noted above

TYPE 1 COMMUNITY

RESPONDENTS: 3 Installation & Service Contractors

GENERAL

Years in business: 10, 28, 18 Employees: 20, 18, 10
How many install systems: Sub-contract, 6, 10
Expertise: House and commercial building; residential & commercial HVAC; plbg, htg & ventilating.
Source of Knowledge: Local experience; local experience, HRAI, industry publications and manufacturers; and designs produced by engineers.

TABLE 1 HOUSES CURRENTLY BEING BUILT

Typical heating systems: Forced air, hydronic and Space Heater
Fuel: Propane and oil.
Typical ventilation system: HRV; and Exhaust fans with fresh air duct.

Indoor Temperatures: Living area- Day 20-22°C Night 15-21°C
Bedrooms - Day 19-20°C Night 15-19°C

Humidity Levels: Moderate Source: Showers

Who maintains: Owner.
Are they maintained: Yes; no; sometimes; yes.
What maintenance is missed: Filter, oil fuel filter, oil combustion efficiency set-up.
Consequences of Poor Maintenance: Poor Combustion Efficiency.

TABLE 2 SYSTEMS THEY INSTALL

What service provided: Design, Installation & Servicing.
Systems Designed: New 15,12,3 Retrofit 0, 4, 0 Client: Varies, homeowners.
Who else designs systems they install: Local installer; no one; engineers.
Systems Installed: New 15, 12, ? Retrofit 0, 4, ?
Most Frequent Service Calls: Installation problems, air adjustment, electrical controls, fuel supply, poor combustion and chimney problems.
Codes used: NBC
Codes Appropriate: Yes; No; No.
Inspection Agency: City of Whitehorse; Engineers and plumbing inspector (hydronic).
Desired Code changes: Ventilation requirements in 1995 Code.
Heating Design Restraints: None; architectural design to accommodate duct systems - especially custom built houses.
Ventilating Design Restraints: None; architectural design to accommodate duct systems.

TABLE 3 INFO ON HEATING SYSTEM'S CURRENTLY BEING INSTALLED

Forced Air Propane (Rudd)
Forced Air Oil (Kerr, York & Summeraire)

Propane Furnace- Equipment Cost: $2500 Installation Cost $2500
Oil Furnace - Equipment Cost: $1500 Installation Cost $8000
Oil Hydronic System (baseboards & in-floor) - Equipment Cost: $5000 Installation Cost $5000

1. Installation
Installation Problems: Some commissioning problems (air supply)
Installation Problem Solutions: Adjust air supply.

2. Service
Service Parts Availability: Good.
Boiler Life Expectancy: 20 Years
Service Problems: None for standard furnaces, hi-tech furnaces can be a problem.

3. Maintenance
Occupant Maintenance Requirements: Filter Change/Clean.
Occupants Ability to Maintain:
Skilled Technician Maintenance Required: Occasional Service and annually for oil.
Average Annual Maintenance Cost: $100-$125 (oil)

4. Operation
Fan Operation: Intermittent
Average Annual Operating Cost $3000

5. Most Suitable System
Oil forced air with Riello burner.

TABLE 6 VENTILATION SYSTEMS BEING CURRENTLY INSTALLED

System Types:

Type 1: Homes with forced air system - Bathroom & kitchen fans with 5" fresh air ducts to furnace return air plenum.
Equipment Cost: $200 Installation Cost: $200

Type 2: Homes without forced air system - HRV, continuous run, timer switch in bathroom & dehumidistat in kitchen.
Equipment Cost: $1500-3000 Installation Cost: $2000-3500

1. Installation
HRV - Involved installation and commissioning. Poor architectural design for running ductwork.

2. Servicing
Systems are durable. Parts available.

3. Maintenance

HRV systems require annual cleaning and motor lubrication by homeowner. Filters may need cleaning more often. Typical annual maintenance cost $15.

4. Operation
HRV's somewhat complicated for homeowner. Higher operating costs. Operate at low speed continuously. Timer in bathroom and dehumidistat in kitchen switch HRV to high speed.

5. Most Suitable Ventilation System:

HRV. HRV with no forced air system and exhaust fans with make-up air when a forced air system is present.

IMPROVEMENTS TO HEATING & VENTILATING EQUIPMENT

1. Equipment Improvements: Need simple extractor fans tied to humidistat. Allow use of "L" vents for oil fired equipment.

2. Maintenance Design Improvements: Improved air filtration set-up.

3. Service Design Improvements: Install in proper mechanical area or room.

4. Reliability Design Improvements: Better oil burner fuel pumps.

5. Cost Reduction Improvements:

6: Additional Comments: HRV's should be checked after 6 mos to a year and this should be built into contract price. Owners need to be educated to understand their systems. Equipment with common parts an low technology should be used until high technology is standardized.

TYPE 2 COMMUNITY

RESPONDENTS: 3 Installation & Service Contractors

GENERAL

Years in business: 10, 30, 28 Employees: 20, 18, 3
How many install systems: Sub-contract, 6, 2
Expertise: House and commercial building; residential & commercial HVAC; a gas fitter with oil burner experience.
Source of Knowledge: Local experience; local experience, HRAI, industry publications and manufacturers; and experience.

TABLE 1 HOUSES CURRENTLY BEING BUILT

Typical heating systems: Forced air and Space Heater
Fuel: Propane, electricity (grid), wood and oil.
Typical ventilation system: HRV in RCMP housing only; and Exhaust fans with fresh air duct.

Indoor Temperatures: Living area- Day 22°C Night 18-26°C
Bedrooms - Day 20-23°C Night 18-23°C

Humidity Levels: Moderate to high. Source: Showers, cooking, clothes drying.

Who maintains: Owner or local housing authority.
Are they maintained: No; sometimes; sometimes.
What maintenance is missed: Filter, oil fuel filter, oil combustion efficiency set-up; everything.
Consequences of Poor Maintenance: System inefficient, poor Combustion Efficiency.

TABLE 2 SYSTEMS THEY INSTALL

What service provided: Design, Installation & Servicing; design & installation; and installation & servicing..
Systems Designed: New 15,1,0 Retrofit 0, 0, 0 Client: Homeowners.
Who else designs systems they install: Local installer; my company; and Sask. Gov't Housing..
Systems Installed: New 15, 1, 20 Retrofit 0, 0, 50
Most Frequent Service Calls: None; Na; oil burners broken, electronic ignition for propane furnaces and electronics damage by crawl space flooding (common).
Codes used: NBC; NBC; Gas Code - none for oil.
Codes Appropriate: Yes except for ventilation; No; No.
Inspection Agency: Na; Territorial inspectors; none.
Desired Code changes: Ventilation requirements in 1995 Code.
Heating Design Restraints: None; architectural design to accommodate duct systems - especially custom built houses.
Ventilating Design Restraints: None; architectural design to accommodate duct systems.

TABLE 3 INFO ON HEATING SYSTEM'S CURRENTLY BEING INSTALLED

Forced Air Propane
Forced Air Oil
Wood Stove

Propane Furnace- Equipment Cost: $2500-3000 Installation Cost $2500-1000
Oil Furnace - Equipment Cost: $1500-4500 Installation Cost $11,000-1000
Wood Stove - Equipment Cost: $1500 Installation Cost: $1000

1. Installation
Installation Problems: None.
Installation Problem Solutions: Na.

2. Service
Service Parts Availability: By mail so contractor has to stock more parts.
Service Problems: None for standard furnaces, hi-tech furnaces can be a problem. No problems with wood stove.
Furnace Life Expectancy: 20 years

3. Maintenance
Occupant Maintenance Requirements: Filter Change/Clean.
Occupants Ability to Maintain: Wood stove chimney cleaning - poor. Gas or oil furnace- owner waits until it quits then advises local housing agency.
Skilled Technician Maintenance Required: Occasional Service and annually for oil. Wood stove require chimney cleaning monthly.
Average Annual Maintenance Cost: $100-$125 (oil). Wood stove $50 monthly.

4. Operation
Fan Operation: Intermittent
Average Annual Operating Cost $ Na

5. Most Suitable System
Oil forced air with Riello burner. Wood stove with back-up electric heat.

TABLE 6 VENTILATION SYSTEMS BEING CURRENTLY INSTALLED

System Types:

Type 1: Homes with forced air system - Bathroom & kitchen fans with 5" (fresh air ducts to furnace return air plenum) or a central in-line fan that exhausts from kitchen and bathroom through 5" flex duct to a manifold with a 6" duct out set to run continuously on low speed and a switch for high speed operation

Equipment Cost: $200-400 Installation Cost: $200-400

Type 2: Homes without forced air system - HRV, continuous run, timer switch in bathroom & dehumidistat in kitchen.
Equipment Cost: $1500-3000 Installation Cost: $2000-3500

1. Installation
HRV - Involved installation and commissioning. Poor architectural design for running ductwork.

2. Servicing
Systems are durable. Parts available.

3. Maintenance

HRV systems require annual cleaning and motor lubrication by homeowner. Filters may need cleaning more often. Typical annual maintenance cost $15.

4. Operation
HRV's somewhat complicated for homeowner. Higher operating costs. Operate at low speed continuously. Timer in bathroom and dehumidistat in kitchen switch HRV to high speed.

5. Most Suitable Ventilation System:

HRV. HRV with no forced air system and exhaust fans (with make-up air) when a forced air system is present.

IMPROVEMENTS TO HEATING & VENTILATING EQUIPMENT

1. Equipment Improvements: Need simple extractor fans tied to humidistat. Allow use of "L" vents for oil fired equipment.

2. Maintenance Design Improvements: Improved air filtration set-up.

3. Service Design Improvements: Install in proper mechanical area or room.

4. Reliability Design Improvements: Better oil burner fuel pumps.

5. Cost Reduction Improvements:

6: Additional Comments: HRV's should be checked after 6 mos. to a year and this should be built into contract price. Owners need to be educated to understand their systems. Equipment with common parts and low technology should be used until high technology is standardized.

TYPE 3 COMMUNITY

RESPONDENTS: 2 Installation & Service Contractors

GENERAL

Years in business: 10, 15 Employees: 20, 6
How many install systems: Sub-contract
Expertise: House and commercial building; building construction.
Source of Knowledge: Local experience; local experience form building over 100 units in Northern Communities.

TABLE 1 HOUSES CURRENTLY BEING BUILT

Typical heating systems: Forced air, hydronic and Space Heater
Fuel: Electricity (generator) and oil.
Typical ventilation system: HRV ; and Exhaust fans with fresh air duct.

Indoor Temperatures: Living area- Day 22°C Night 22°C
Bedrooms - Day 22°C Night 22°C

Humidity Levels: Moderate to high. Source: Showers, cooking, clothes drying.

Who maintains: Owner.
Are they maintained: No; sometimes.
What maintenance is missed: HRV filters and motors; everything.
Consequences of Poor Maintenance: High humidity; possible health problems.

TABLE 2 SYSTEMS THEY INSTALL

What service provided: Design, Installation & Servicing; installation.
Systems Designed: New 8,0 Retrofit 0, 0 Client: Homeowners & Gov't housing.
Who else designs systems they install: Local installer; Gov't engineers and mechanical contractors.
Systems Installed: New 8, 15 Retrofit 0, 3
Most Frequent Service Calls: None; no heat - lack of fuel, cold - air exchanger - coils off.
Codes used: NBC; NBC.
Codes Appropriate: Yes except for ventilation; No.
Inspection Agency: Na; Territorial inspectors;.
Desired Code changes: Ventilation requirements in 1995 Code.
Heating Design Restraints: None; None.
Ventilating Design Restraints: Occupant knowledge of operation.

TABLE 3 INFO ON HEATING SYSTEM'S CURRENTLY BEING INSTALLED

Hydronic - Oil (Viesman or Weil MacLean)
Forced Air Oil (Olsen)
Wood Stove

Hydronic Boiler - Equipment Cost: $5000 Installation Cost: $3000
Oil Furnace - Equipment Cost: $4000 Installation Cost $1500
Wood Stove - Equipment Cost: $1500 Installation Cost: $1000

1. Installation
Installation Problems: Wood stove - none. Hydronic - difficult, long delivery time, installation by professional only. Oil Furnace - Moderately difficult, installation by professional only.
Installation Problem Solutions: Na.

2. Service
Service Parts Availability: By mail so contractor has to stock more parts.
Service Problems: None for standard furnaces, hi-tech furnaces can be a problem. No problems with wood stove.
Furnace Life Expectancy: Hydronic - very good. Forced air - good.

3. Maintenance
Occupant Maintenance Requirements: Little by occupant for Hydronic or wood stove. Forced air - filter.
Occupants Ability to Maintain: Wood stove chimney cleaning - poor. Oil furnace or boiler - professional only.
Skilled Technician Maintenance Required: Occasional Service and annually for oil. Wood stove require chimney cleaning monthly.
Average Annual Maintenance Cost: $125 (oil). Wood stove $50 monthly.

4. Operation
Forced Air: Easy operation, noisy and occupancy likes simplicity of system.
Hydronic: Easy but occupant can be intimidated by complexity of system.
Average Annual Operating Cost: Hydronic Oil: $1600 Forced Air Oil $2200.

5. Most Suitable System
Wood stove with back-up electric heat. Forced air furnace for effectiveness, reliability, ease of maintenance by homeowner and ease of service by the local community. Hydronic for efficiency and fuel costs.

TABLE 6 VENTILATION SYSTEMS BEING CURRENTLY INSTALLED

System Types:

Type 1: Bathroom & kitchen fans with 5" (fresh air ducts to furnace return air plenum) or a central in-line fan that exhausts from kitchen and bathroom through 5" flex duct to a manifold with a 6" duct out set to run continuously.

Equipment Cost: $200-400 Installation Cost: $200-400

Type 2: HRV.
Equipment Cost: $1500 Installation Cost: $1500

Type 3: Fresh Air Ducts
Equipment Cost: $500 Installation Cost: $1000

1. Installation
HRV - Involved installation and commissioning.
Fresh air ducts - Moderate installation complexity, could be installed by handy man with good instruction.

2. Servicing
Systems are durable. Easy servicing for HRV's and exhaust fans. Fresh air ducts require no servicing.

3. Maintenance

HRV systems - require annual cleaning and motor lubrication by homeowner. Filters may need cleaning more often. Typical annual maintenance cost $15.
Exhaust fans and fresh air ducts require no maintenance.

4. Operation
HRV's somewhat complicated for homeowner. Higher operating costs. Operate at low speed continuously. Timer in bathroom and dehumidistat in kitchen switch HRV to high speed.

5. Most Suitable Ventilation System:

All systems: Easy
Annual operating costs: HRV- $100 Fresh air ducts - $0

IMPROVEMENTS TO HEATING & VENTILATING EQUIPMENT

1. Equipment Improvements: Use very simple extractor fans tied to humidistats.

2. Maintenance Design Improvements:

3. Service Design Improvements:

4. Reliability Design Improvements:

5. Cost Reduction Improvements:

6: Additional Comments: HRV's should be checked after 6 mos. to a year and this should be built into contract price. Owners need to be educated to understand their systems.

SUMMARY OF SURVEYS

TYPE 1 COMMUNITY

RESPONDENTS: 3 Experts & System Designers

GENERAL

House type: 1-3 storeys; 600 ft^2-4000 ft^2; 170-370 m^3; slab on grade, pads& wedges or concrete piles; R 40 ceiling, R20-30 walls, R20-40 floor; double - triple glazing and/or Low E; 2x6 framing, and relatively air tight to airtight.

Indoor Temperatures: Living Area- Day 20-22°C Night 16-22°C
Bedrooms - Day 18-22°C Night 20-22°C

Humidity levels: Moderate from showers/baths, dishwashers, food drying, humidifiers and cooking.

Housing Starts: NWT new 42-200, retrofits 12.

TABLE 2 HEATING & VENTILATING SYSTEMS

Systems installed annually by their company: None.
Building Code used: 1990 NBC

What percentage comply with Code: 100%

Heating System Design & Installation problems: Installers not always knowledgeable. Mechanical engineers used for design. Minimum oil furnace/boiler capacity is 70,000 Btuh but heat losses may be only 40,000 Btuh. Initial capital cost high.

Ventilating Design & Installation problems: Few installers can balance or understand Code requirements. Some houses require higher ventilation rates than mandated by Building Code. Noise level too high. Space limitations.

Maintained by: Homeowner and/or local contractor

TABLE 3 HEATING SYSTEMS CURRENTLY INSTALLED

Propane Furnace, direct vented.

Equipment cost: $5000-6000. Installation cost: $3000-4000.
Advantages: Clean burning, lower capital cost, efficient, quick response time, can distribute ventilation air, can provide humidification, and low maintenance.
Disadvantages: Ductwork location a problem because of lack of basement.
Problems: Tanks freeze, tanks need heat blanket, 25% higher operating cost than wood or oil, explosion hazard and requires gas fitter, plumber, ventilation, and electrical trades for installation.

Oil Furnace Chimney Vented

Equipment cost: $5500-7000. Installation cost: $4000-6000.
Advantages: Low operating costs, quick response time, can distribute ventilation air, and can provide humidification. Simple system and historically acceptable.
Disadvantages: Needs expensive chimney, exhaust is corrosive, exhaust smells, direct venting needs condensate neutralizer and needs regular maintenance that they do not get. Ductwork location a problem because of lack of basement. Noisy, controls temperature in only one part of house, not economical due to method of control, and system requires direct fired oil hot water heater.
Problems: Fuel storage and fill-up can create environmental hazard. Air filter must be changed regularly.
Solutions: Should use cleaner burning Riello Burners, could use "L" Vent though the roof and provide over-fill and spill protection.

Hydronic Systems

Equipment costs: $12,000 Installation costs: $10,000
Advantages: Comfortable, dependable, and easy to zone. Eliminates most of the forced air system disadvantages.
Disadvantages: Slow response time, high initial cost, requires professional maintenance and takes important floor space
Problems: Expensive to repair if freezes.
Solutions: Maintain regularly.

TABLE 6 VENTILATION SYSTEMS CURRENTLY INSTALLED

HRV System

Equipment Cost: Installation Cost:
Advantages: Heat recovery.
Disadvantages: Requires maintenance, qualified technicians and owner education. It is hard to tell if the system is operating properly and a component failure can result in total ventilation system failure.
Problems: Freezing and exhausts air from all inlets whether required in that area or not.
Solutions: Better defrost capabilities, use controllable inlets and use back-up ventilation system.

Fresh Air Duct into Heating System Plenum

Equipment Cost: Installation Cost:
Advantages: Simple to install.
Disadvantages: Does not provide heat recovery.

Exhaust Fans with Make-up Air Duct to Furnace Return System

Bathroom & kitchen fans with 5" with fresh air ducts to furnace return air plenum. Both exhaust fans and furnace blower operate continuously at low speed with a manual switch and humidistat to turn both to high speed.
Advantages: Provides permanent comfort and no structural decay.
Disadvantages: Relatively complicate system, no permanent pre-heater for fresh air and a lot of equipment is involved in providing ventilation.
Solutions: Inspect system during installation and balance system.

Most Suitable Ventilation System

1. Natural ventilation.
Advantages: No mechanisms involved in operation, permanent operation and an economical system.
Disadvantages: Must be carefully designed and built.
Problems: Drafts.
Solution: Proper air distribution and layout.

2. Permanently Operated Preheated Supply Air System with Natural Exhaust System.
Advantages: Ideal for providing comfort and no structural decay problem in house.
Disadvantages: Requires boiler system for heat supply.
Problems: Noise. Control system required.
Solution: Proper equipment selection. Control system maintenance required.

IMPROVEMENT TO HEATING/VENTILATING SYSTEMS

1. Equipment improvement for simple operation recommendations: They are simple already.

2. Equipment improvement for simple maintenance recommendations: HRV's could be made more rugged, less fragile.

3. Equipment improvement for simple service recommendations: Ensure good access to all components.

4. Equipment improvement for increased reliability recommendations: They are reliable now.

5. Methods to make systems less expensive:
Heating: Avoid multiple zone systems.
Ventilating: Find way to make heat wheel exchangers cheaper.

6. Additional Comments: Use polyethylene piping.

Summary of Surveys

TYPES 2 & 3 COMMUNITIES

RESPONDENTS: 4 Experts & System Designers

GENERAL

House type: On piles; R 40 ceiling, R30 walls, R30 floor; triple glazing and Low E; Tyvec air barrier and airtight.

Indoor Temperatures: Living Area - Day 20°C Night 20°C
Bedrooms - Day 20°C Night 20°C

Humidity levels: Moderate from showers/baths and cooking.

Housing Starts: NWT new 6, retrofits 4.

TABLE 2 HEATING & VENTILATING SYSTEMS

Systems installed annually by their company: None.

Building Code used: 1990 NBC

What percentage comply with Code: 100%

Heating System Design & Installation problems: Mechanical engineers used for design.

Ventilating Design & Installation problems:

Maintained by: Homeowner - Dept. of Public Works & Housing Corp.

TABLE 3 HEATING SYSTEMS CURRENTLY INSTALLED

Hydronic Systems

Equipment costs: $ Na Installation costs: $ Na

Advantages: Comfortable, dependable, propane boiler relatively easy to maintain, and easy to zone.
Disadvantages: Slow response time, separate ventilation system required and takes important floor space

Problems: Expensive to repair if freezes.
Solutions:

Oil Furnace chimney vented

Equipment cost: $6000. Installation cost: $6000.
Advantages: Simple system and historically acceptable.
Disadvantages: Noisey, controls temperature in only one part of house, not economical due to method of control, and system requires direct fired oil hot water heater.
Problems: Air filter must be changed regularly.
Solutions:

TABLE 6 VENTILATION SYSTEMS CURRENTLY INSTALLED

Exhaust Fans with Make-up Air Duct to Furnace Return System

Bathroom & kitchen fans with 5" with fresh air ducts to furnace return air plenum. Both exhaust fans and furnace blower operate continuously at low speed with a manual switch and humidistat to turn both to high speed.
Advantages: Provides permanent comfort and no structural decay.
Disadvantages: Relatively complicate system, no permanent preheater for freah air and a lot of equipment is involved in providing ventilation.
Solutions: Inspect system during installation and balance system.

Most Suitable Ventilation System

1. Natural ventilation.
Advanages: No mechanisms involved in operation, permanent operation and an economical system.
Disadvantages: Must be carefully designed and built.
Problems: Drafts.
Solution: Proper air distribution and layout.

2. Permanently Operated Preheated Supply Air System with Natural Exhaust System.
Advantages: Ideal for providing comfort and no structural decay problem in house.
Disadvantages: Requires boiler system for heat supply.
Problems: Noise. Control system required.
Solution: Proper equipment selection. Control system maintenance required.

IMPROVEMENT TO HEATING/VENTILATING SYSTEMS

1. Heating/Ventilating equipment improvement for simple operation recommendations:
(a) They are simple already.
(b) Ventilating equipment a big problem. Cheap noisy inefficient bathroom and range-top fans are too often used. This, with tight envelopes results in high humidity levels that can deteriorate building structure. A continuous ventilation rate of 15 cfm per occupant is required (WDG adds, this is the same rate that Alaska researchers are focusing on). A good basic design could include a low noise, low power, quality fan such as the Panasonic that runs continuously (WDG notes that an Alaskan study showed that this fan sometimes resonated producing an annoying sound causing the occupants to disconnect it).

(c) i. Smart equipment with self diagnostic features which at minimum allow for regulation of operating times and that would announce the nature of any problems that arise and corrective measures.
ii. Use very simple passive systems such as the European window vents.

2. Equipment improvement for simple maintenance recommendations:
(a) HRV's could be made more rugged, less fragile.
(b) i. Limit ventilation control to a circuit breaker.
ii. Use constant speed fan.
iii. Use central exhaust from kitchen and bathroom.
iv. Undercut doors and use grilles to provide circulation to bedrooms.
v. Minimize the use of filters on exhaust fans - use a blade design that minimizes dirt accumulation.

3. Equipment improvement for simple service recommendations:
(a) Ensure good access to all components.
(b) i. I areas where electricity is cheap, use baseboard electric heat.
ii. Choose furnaces with standard easily accessible parts.
iii. Locate ventilating equipment in accessible spaces.

4. Equipment improvement for increased reliability recommendations:
(a) They are reliable now.
(b) i. Build housed with higher insulation levels & better windows to minimize heating required.
ii. Use passive solar design through orientation, where appropriate.
iii. Provide wood heat as a back-up, where appropriate.
(c) Install systems properly and train occupants in its use.

5. Methods to make systems less expensive:
(a) i. Heating: Avoid multiple zone systems.
ii. Ventilating: Find way to make heat wheel exchangers cheaper.
(b) i. Increase building envelope performance to reduce space heating needs. Use savings from heating system to help fund building envelope improvements.
ii. Install Panasonic fan in central location to exhaust bathroom. Higher first cost but lower operating cost.

6. Additional Comments:
(a) Use polyethylene piping.
(b) i. Ventilation equipment used in the north has either been too cheap and ineffective or too expensive and complex.
ii. HRV's with relatively inefficient fans do not make sense in the north where electricity is so expensive, freeze-up is also a problem.
iii. Here is what does not work: complicated controls for ventilation, like humidistats that have to be changed in accordance with outdoor conditions; cheap bath & kitchen exhaust fans; grossly over-sized space heating systems in poorly insulated houses; ventilation systems that need balancing, especially as filters clog over time; and variable speed systems for exhaust fans.
iv. We don't expect people to change the flow rate of their furnace, a similar argument can be made for constant speed ventilation systems.
v. It is not practical to expect any heating system that uses combustion to be low maintenance.
(c) i. Balancing is essential.
ii. Fan speeds are often too high making occupants feel cold, so HRV's are turned-off or removed.
iii. Ice build-up on the exhaust side (of an HRV) is a problem in severe climates (7500 Degree days or colder) which causes occupants to turn-off HRV. Installing an 8" duct through the exterior wall

for the exhaust side will solve this problem in areas that have extended cold spells of around -40°C for 2-3 weeks.

APPENDIX C

Combination Heating System Guidelines

Combination "COMBO" forced air space and domestic hot water heating systems

guidelines

May, 1994. First edition.
June, 1995. Second edition

CONTENTS

Further copies of these guidelines are available from:

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1111 West Georgia Street
Vancouver, BC
Canada V6E 4M4

Attn: Kal Minhas
Phone (604) 443-6892
Fax: (604) 443-6552

Acknowledgements:

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With the above in mind, the following people (and their employers) are acknowledged:

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B. Barchard	B.C. Hydro
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N. Thompson	Pepper Group
G. Dickie	Axford Agencies
G. Ferguson	Western Supplies
R. Lenuik, P.Eng.	Wirsbo of Canada
P.B. Cavens, P.Eng.	BC Gas
D.H. Ellis, P.Eng.	BC Gas
W.G. Hennessey, P.Eng.	BC Gas
K.S. Minhas, M.Sc.,P.Eng.(Ont.)	BC Gas

Disclaimer

These guidelines are to be used for information purposes only and must be adapted by the designers and installers to their particular situation. No liability is assumed for the application or suitability of these guidelines.

Combination "COMBO" forced air space and domestic hot water heating systems guidelines

1.0 DEFINITION

A combo system supplies hot water for both forced air space heating and domestic hot water heating. Combo systems may be single units, modular units, or separate components assembled together as designed.

2.0 COMPLIANCE

All combo systems must comply with the following:

2.1 All piping and components must be approved for use with potable water, as referenced in the B.C. Plumbing Code. (ie. Type "L" Copper minimum).

2.2 The water heating appliance and the fan coil unit must be certified by an approved agency, such as CGA, and labelled for dual purpose space and domestic tap water heating.

2.3 Ferrous material are not acceptable for potable use.

2.4 Non-potable chemicals are prohibited.

2.5 Combo systems may not be connected to any heating systems or components previously used for non-potable water heating systems.

2.6 A pump cycle timer (may be factory installed in the air handling unit) must be installed to circulate all water contained in the fan coil space heating piping and components at least once every 24 hours.

2.7 Hot water tanks shall be set at a <u>minimum</u> temperature of 140°F and a maximum temperature of 167°F; systems designed to operate with tank temperatures in excess of 140°F shall be equipped with a thermostatically controlled mixing valve conforming to CSA Standard B125, Plumbing Fittings. The thermostatically controlled mixing valve shall be installed so as to control the temperature of the hot water distribution system at 140°F and be placed in an accessible location at the hot water tank.

2.8 The design velocity of the water passing through the heating system must not exceed 4 feet per second for temperatures not exceeding 140°F and 3 feet per second for temperatures exceeding 140°F.

2.9 The total length of supply and return piping from the water heating appliance to the fan coil unit shall not exceed 50 feet.

3.0 DESIGN & INSTALLATION

3.1 Space heating system section

The minimum capacity or portion of the total capacity of an appliance used for space heating shall be based on the heat loss of the dwelling unit. The system shall be designed and installed according to industry engineering data and software programs or one of the following resource documents:

- Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)
- American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)
- Air Conditioning Contractors of America (ACCA)
- Quality First Program, (HRAI, Heating, Ventilating and Cooling Industry Association of BC, (HVCI), and Gas Contractors Association)
- Hot 2000, EMR, CHBA Builder Material
- Residential Hot Water Heating Association (BC) Guidelines

3.2 Domestic hot water heating system section

The minimum capacity or portion of the total capacity of an appliance used for supplying domestic hot water shall be based on industry engineering data and software programs or one of the following resource documents:

3.2.1 Storage Water Heaters

- ASHRAE HVAC Applications Handbook HUD-FHA Table 5

3.2.2 Instantaneous Water Heaters or Hot Water Boilers (with or without storage tanks)

- ASHRAE HVAC Applications Handbook HUD-FHA Table 5

3.2.3 American Society of Plumbing Engineers (ASPE), Water System Design

3.3 "COMBO" space and domestic hot water heating system

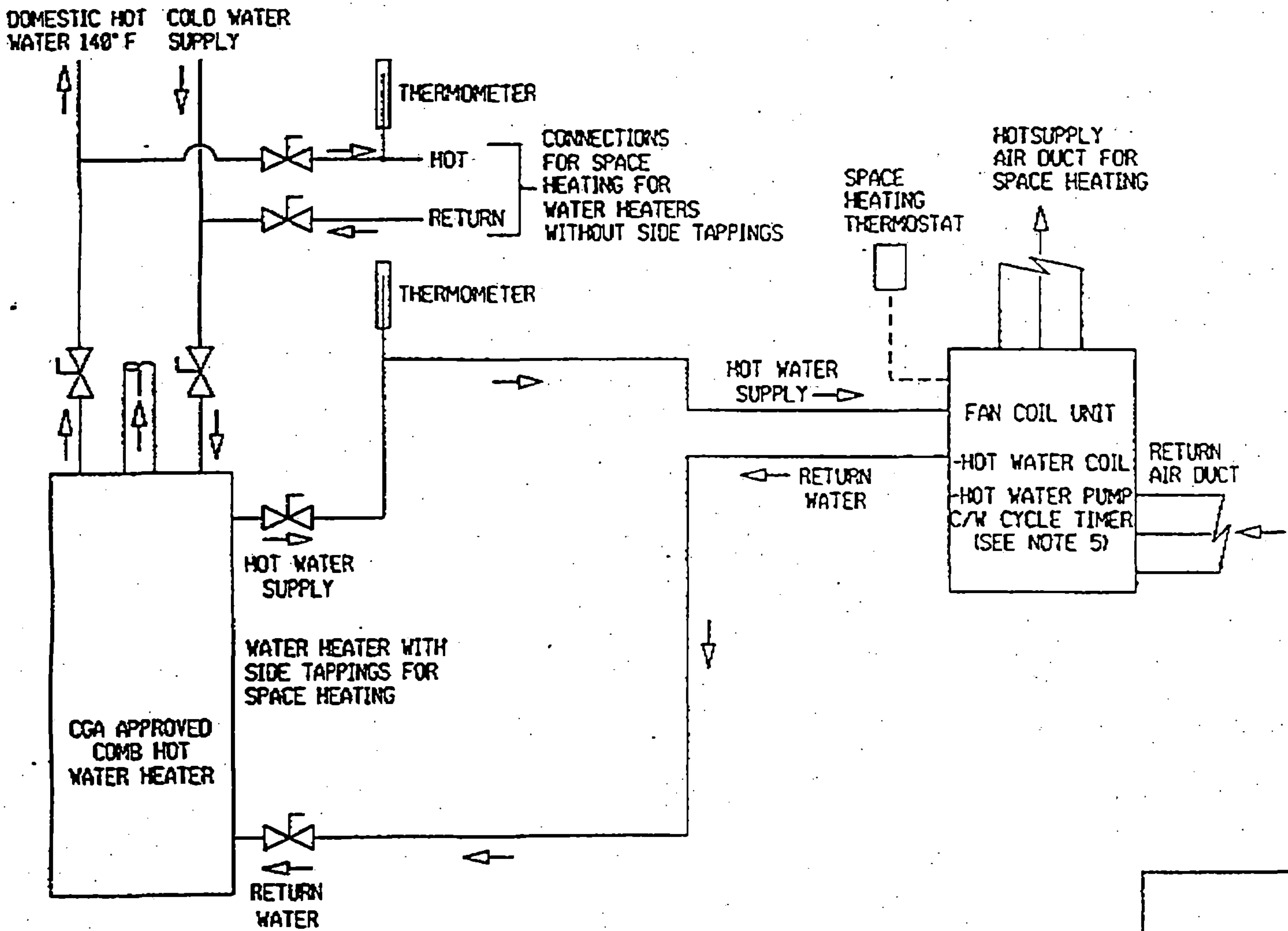
Capacities of Combo Hot Water Tank (HWT) and Fan Coil must be in accordance with the "Combo System HWT/Fan Coil sizing" design worksheet (Appendix 1). The system shall be designed and installed according to industry engineering data and software programs or this document.

The basic drawings may be used by the designer to show the basic principles of the proposed combo system. Other accessories or components may be required in accordance with local codes.

3.3.1 Fan Coil Combo Systems

3.3.1.1 Fan Coil with Hot Water Heater (Drawing No. GA 19151-1 R1)
3.3.1.2 Fan Coil with Instantaneous Water Heater (Drawing No. GA 19151-2 R1)

3.3.1.1 COMBINATION (COMBO) FAN COIL HEATING SYSTEM WITH STORAGE TYPE WATER HEATER

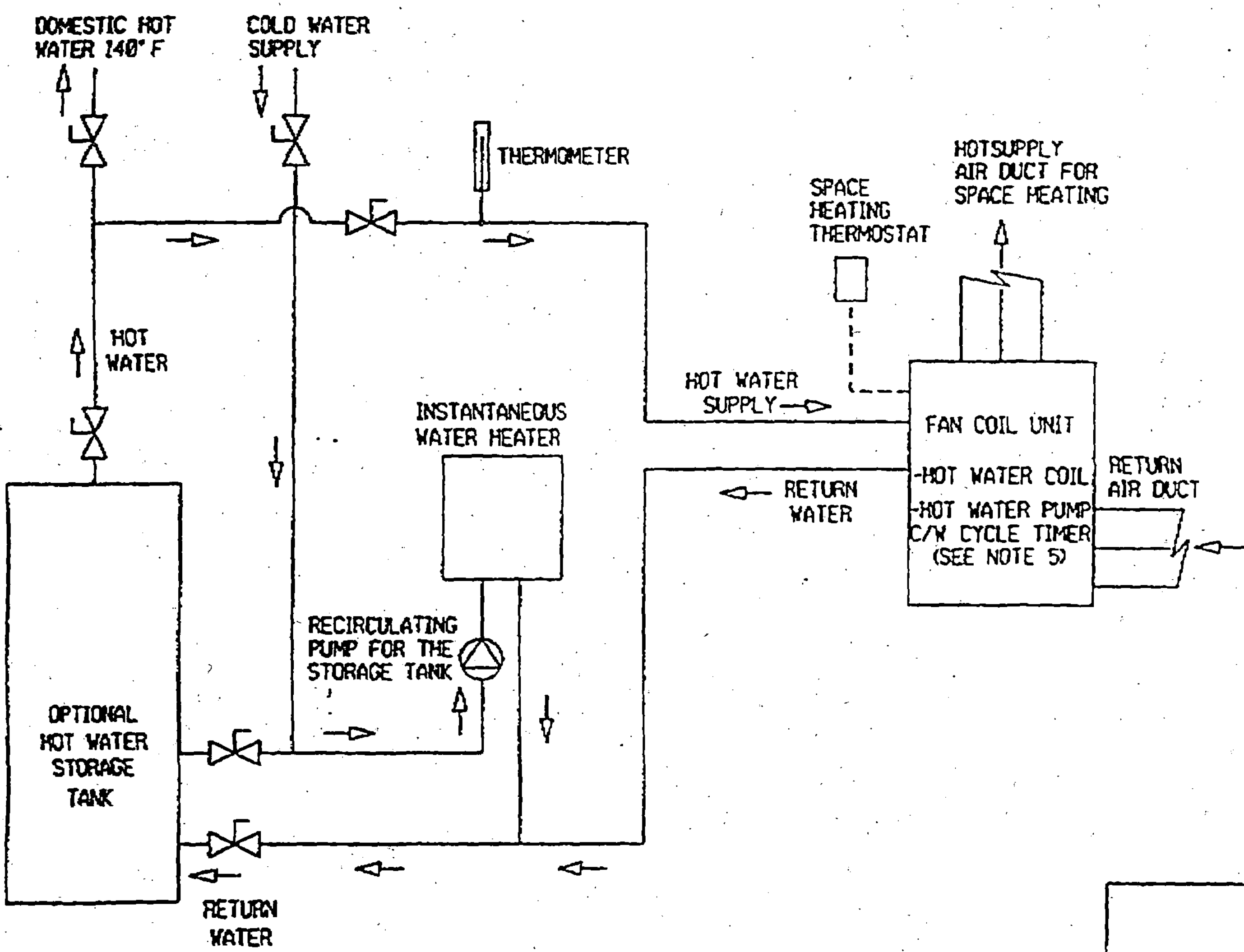


NOTES:

1. All piping and components to be approved for potable use.
2. All copper tubing to be type "K" or "L".
3. All plastic piping must be approved for potable use.
4. If hot water is produced at higher than 140° F, a mixing valve confirming to CSA standard B125 is required to supply domestic hot water at 140° F.
5. For single or multiple space heating units, zones, or loops, a cycle timer must be used to circulate all the water in the space heating system once every 24 hours.
6. Other accessories or components may be used for different types of controls and/or required in accordance with local codes.

DESIGNED	DRAWN	DATE	DWG. No.	
K.W.	J.T.	95.05.29	DWG. No. CA 19151 -1	R 1

3.3.1.2 COMBINATION (COMBO) FAN COIL HEATING SYSTEM WITH INSTANTANEOUS WATER HEATER



NOTES:

1. All piping and components to be approved for potable use.
2. All copper tubing to be type "K" or "L".
3. All plastic piping must be approved for potable use.
4. If hot water is produced at higher than 140° F, a mixing valve confirming to CSA standard B125 is required to supply domestic hot water at 140° F.
5. For single or multiple space heating units, zones, or loops, a cycle timer must be used to circulate all the water in the space heating system once every 24 hours.
6. Other accessories or components may be used for different types of controls and/or required in accordance with local codes.

DESIGNED	DRAWN	DATE		

COMBO SYSTEM HWT/FAN COIL SIZING

FAN COIL		
Heated area of occupancy	sq. ft.	A
Heating demand from acceptable heat loss calculations or sq. ft. method	Btu/hr.	B
Minimum fan coil required [B] ________ Btu/hr. x 1.15	Btu/hr.	C
Selected fan coil Btu/hr. capacity @ ________ E.W.T.	Btu/hr.	D
Make: ________ Model: ________ CFM @ .3" ESP ________		

DOMESTIC DEMAND		
Minimum demand as per Table 5-HUD-FHA (below)	Baths	
	Bedrooms	
	Gal. Storage	
	Btu/hr. Input	E
	Gal. 1st Hr. Draw	F

COMBO WATER HEATER

Domestic 1st Hr Draw		Selected Storage Capacity		Domestic Recovery Necessary	
[F] ________ gal	—	________ gal	=	________ gal	G

[G] ________ gal X 830 (Factor for conversion gal to Btu/hr.) = ________ Btu/hr. output — H

[H] ________ Btu/hr. output ÷ ________ heater efficiency = ________ Btu/hr. input — I

AVAILABLE FOR FAN COIL USE

Selected Water Heater

________ Btu/hr. input — [I] ________ Btu/hr. input = ________ Btu/hr. input — J

[J] ________ Btu/hr. input X Heater Efficiency ______ = ________ Btu/hr. output — K

[K] ________ Btu/hr. output available for fan coil must be equal to or greater than [D]

Table 5 HUD-FHA Minimum Water Heater Capacities for One and Two-Family Living Units

Number of Baths	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
GAS											
Storage, gal.	20'	30	30	30	40	40	50	40	50	50	50
1000 Btu/hr. Input	27	36	36	36	36	38	47	38	38	47	50
1-h draw, gal	43	60	60	60	70	72	90	72	82	90	92
Recovery, gph	23	30	30	30	30	32	40	32	32	40	42

NOTE: All volume calculations are in U.S. gallons.

Sample calculations

Example: Dwelling with 2 bedrooms, 2 bathrooms, and 21,000 Btu/h heat loss.

Two types of Combo water heaters available:

1. Conventional Combo water heater
   Specification say:

Storage capacity	=	50 gal.
Input	=	50,000 Btu/h
Recovery efficiency	=	76%
Output	=	38,000 Btu/h

By using the "Combo System Hot Water Tank/Fan Coil Sizing Worksheet" as shown on page 11, the designed domestic draw of 60 gal. is satisfied by the selected conventional combo hot water heater with 29,700 Btu/h available for the fan coil to satisfy the 24,150 Btu/h space heat loss requirement.

2. High efficiency condensing Combo water heater
   Specification say:

Storage capacity	=	34 gal.
Input	=	100,000 Btu/h
Recovery efficiency	=	94%
Output	=	94,000 Btu/h

Page 12 shows that the high efficiency condensing hot water heater satisfies the designed domestic draw of 60 gal. with 72,420 Btu/h available for the fan coil to satisfy the space heat loss of 24,150 Btu/h.

Note: Both of the above examples assume typical domestic hot water requirements, if the dwelling has extra ordinary hot water demands, (eg. a hot tub), then the system must be designed accordingly.

① SAMPLE CALCULATION — CONVENTIONAL COMBO HOT WATER HEATER

COMBO SYSTEM HWT/FAN COIL SIZING

FAN COIL

Heated area of occupancy	------ sq. ft.	A
Heating demand from acceptable heat loss calculations or sq. ft. method	21,000 Btu/hr.	B
Minimum fan coil required [B] 21,000 Btu/hr. x 1.15	24,150 Btu/hr.	C
Selected fan coil Btu/hr. capacity @ 140°F E.W.T.	24,150 Btu/hr.	D
Make: ------ Model: ------ CFM @ .3" ESP ------		

DOMESTIC DEMAND

Minimum demand as per Table 5-HUD-FHA (below)	2 Baths	
	2 Bedrooms	
	30 Gal. Storage	
	36,000 Btu/hr. Input	E
	60 Gal. 1st Hr. Draw	F

COMBO WATER HEATER — SPECIFICATION OF SELECTED COMBO WATER HEATER

Domestic 1st Hr Draw [F] 60 gal — Selected Storage Capacity 50 gal = Domestic Recovery Necessary 10 gal	G
[G] 10 gal X 830 (Factor for conversion gal to Btu/hr.) = 8,300 Btu/hr. output	H
[H] Btu/hr. output ÷ 0.76 heater efficiency = 10,921 Btu/hr. input	I

AVAILABLE FOR FAN COIL USE

Selected Water Heater 50,000 Btu/hr. input — [I] 10,921 Btu/hr. input = 39,079 Btu/hr. input	J
[J] 39,079 Btu/hr. Input X Heater Efficiency 0.76 = 29,700 Btu/hr. output	K
[K] 29,700 Btu/hr. output available for fan coil must be equal to or greater than [D] ✓	

Table 5 HUD-FHA Minimum Water Heater Capacities for One- and Two-Family Living Units

Number of Baths	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
GAS											
Storage, gal.	20	30	30	30	40	40	50	40	50	50	50
1000 Btu/hr. Input	27	36	36	36	36	38	47	38	38	47	50
1-h draw, gal	43	60	60	60	70	72	90	72	82	90	92
Recovery, gph	23	30	30	30	30	32	40	32	32	40	42

NOTE: All volume calculations are in U.S. gallons.

(2) SAMPLE CALCULATION — HIGH EFFICIENCY COMBO WATER HEATER

COMBO SYSTEM HWT/FAN COIL SIZING

FAN COIL

Heated area of occupancy	- - - -	sq. ft.	A
Heating demand from acceptable heat loss calculations or sq. ft. method	21,000	Btu/hr.	B
Minimum fan coil required [B] 21,000 Btu/hr. x 1.15	24,150	Btu/hr.	C
Selected fan coil Btu/hr. capacity @ 140°F E.W.T.	24,150	Btu/hr.	D
Make: - - - - Model: - - - CFM @ .3" ESP - - -			

DOMESTIC DEMAND

Minimum demand as per Table 5-HUD-FHA (below)	2	Baths	
	2	Bedrooms	
	30	Gal. Storage	
	36,000	Btu/hr. Input	E
	60	Gal. 1st Hr. Draw	F

COMBO WATER HEATER SPECIFICATION OF SELECTED COMBO WATER HEATER

Domestic 1st Hr Draw [F] 60 gal — Selected Storage Capacity 34 gal = Domestic Recovery Necessary 26 gal	G
[G] 26 gal X 830 (Factor for conversion gal to Btu/hr.) = 21,580 Btu/hr. output	H
[H] 21,580 Btu/hr. output ÷ 0.94 heater efficiency = 22,957 Btu/hr. input	I

AVAILABLE FOR FAN COIL USE

Selected Water Heater 100,000 Btu/hr. input — [I] 22,957 Btu/hr. input = 77,043 Btu/hr. input	J
[J] 77,043 Btu/hr. input X Heater Efficiency 0.94 = 72,420 Btu/hr. output	K
[K] 72,420 Btu/hr. output available for fan coil must be equal to or greater than [D] ✓	

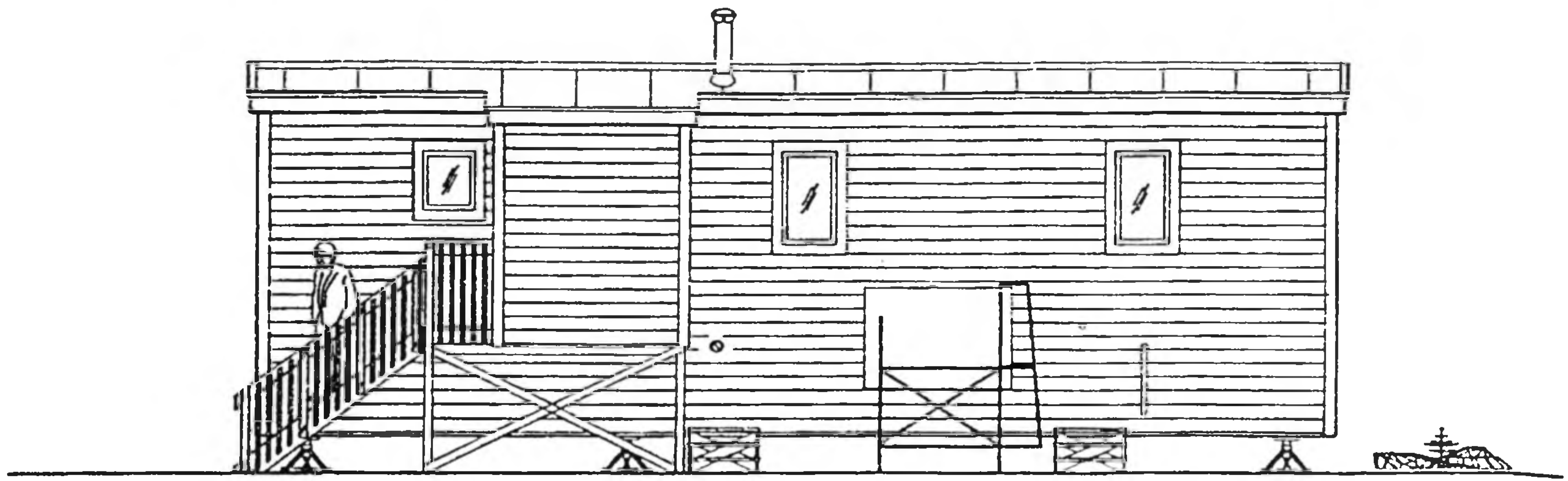
Table 5-HUD-FHA Minimum Water Heater Capacities for One- and Two-Family Living Units

Number of Baths	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
GAS											
Storage, gal.	20	30	30	30	40	40	50	40	50	50	50
1000 Btu/hr. input	27	36	36	36	36	38	47	38	38	47	50
1-h draw, gal	43	60	60	60	70	72	90	72	82	90	92
Recovery, gph	23	30	30	30	30	32	40	32	32	40	42

NOTE: All volume calculations are in U.S. gallons.

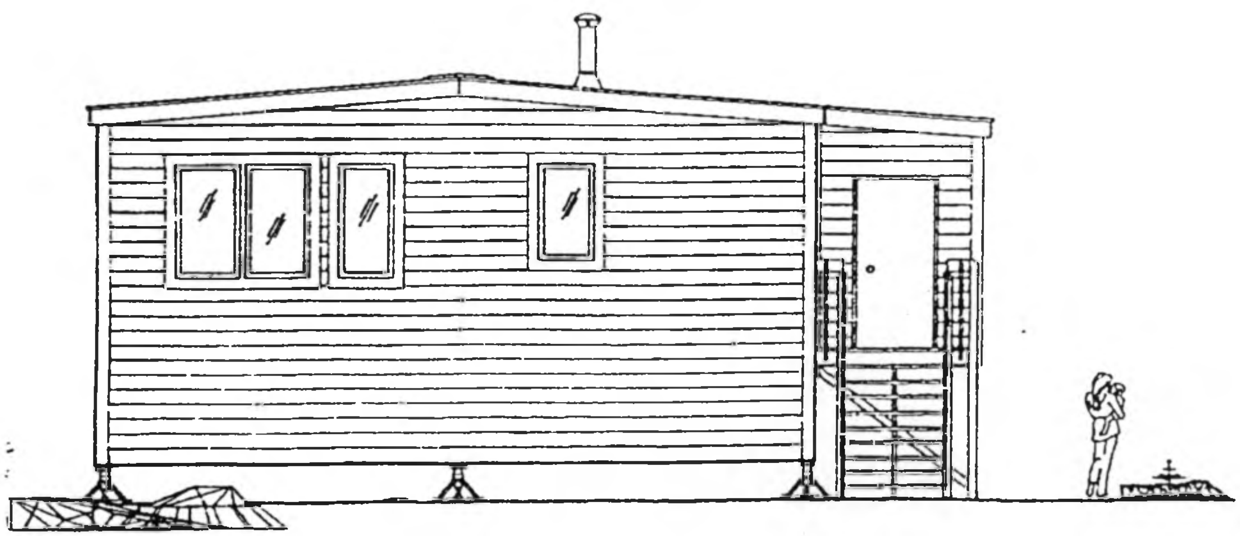
APPENDIX D

1. Sample House Plan for Type 2 Community
2. HOT2000 Weather Data Locations
3. Design Temperature Information
4. Fuel and Electricity Cost Information



RIGHT ELEVATION

East



FRONT ELEVATION

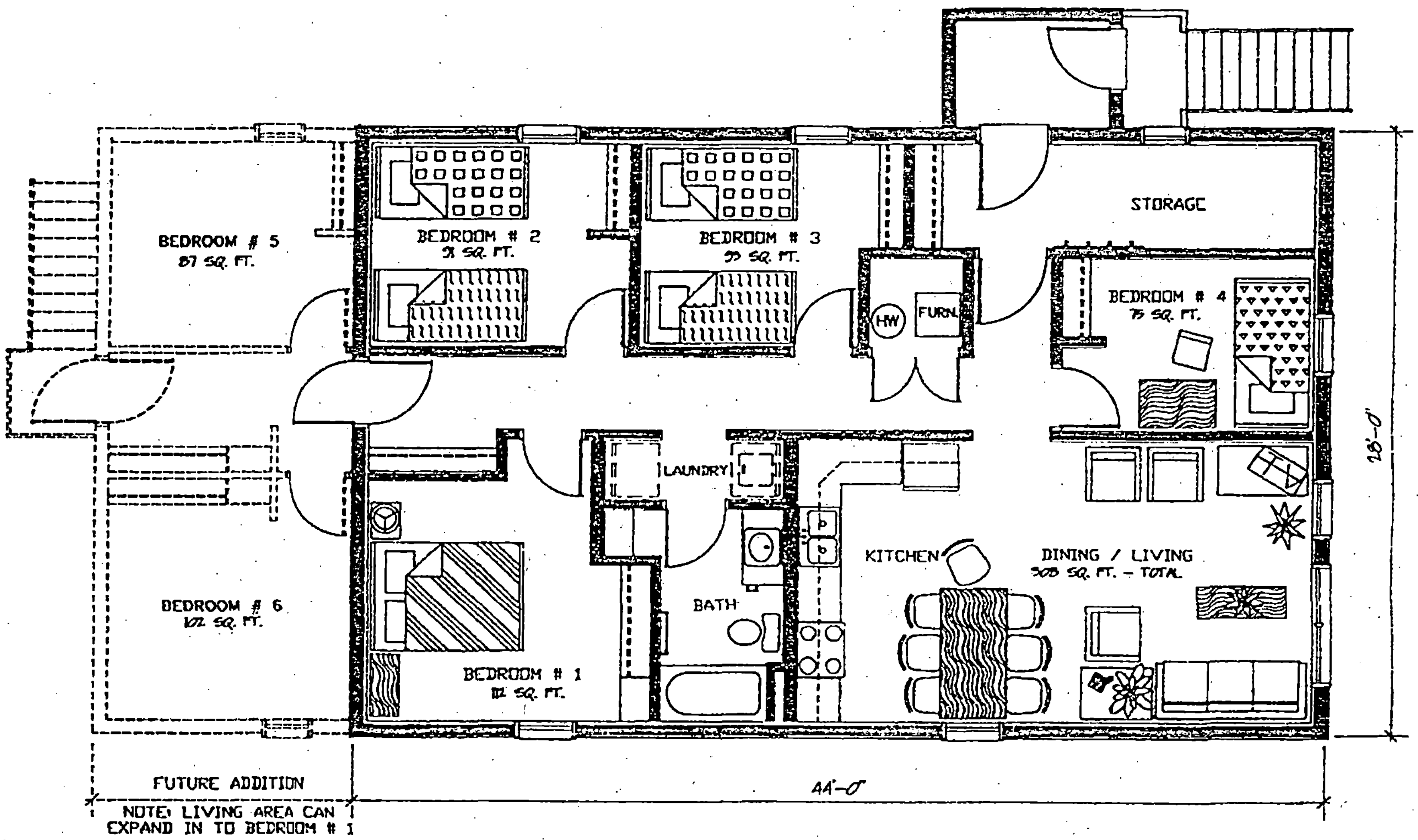
South

FOUR BEDROOM

ABOVE THE TREELINE

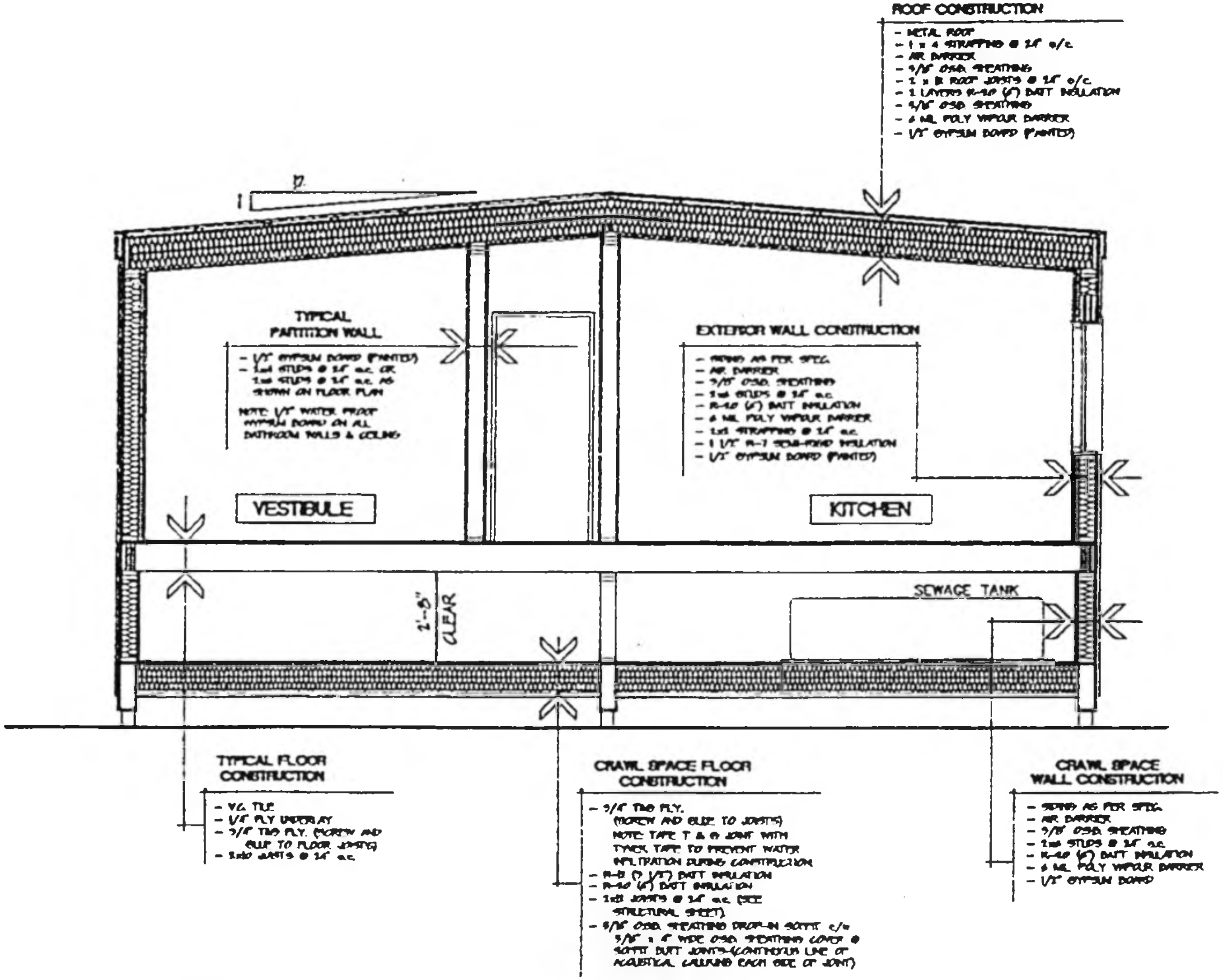
Northwest Territories Housing Corporation

6



1232 SQ. FT.

BEDROOM
THE TREELINE
...est Territories
...orporation

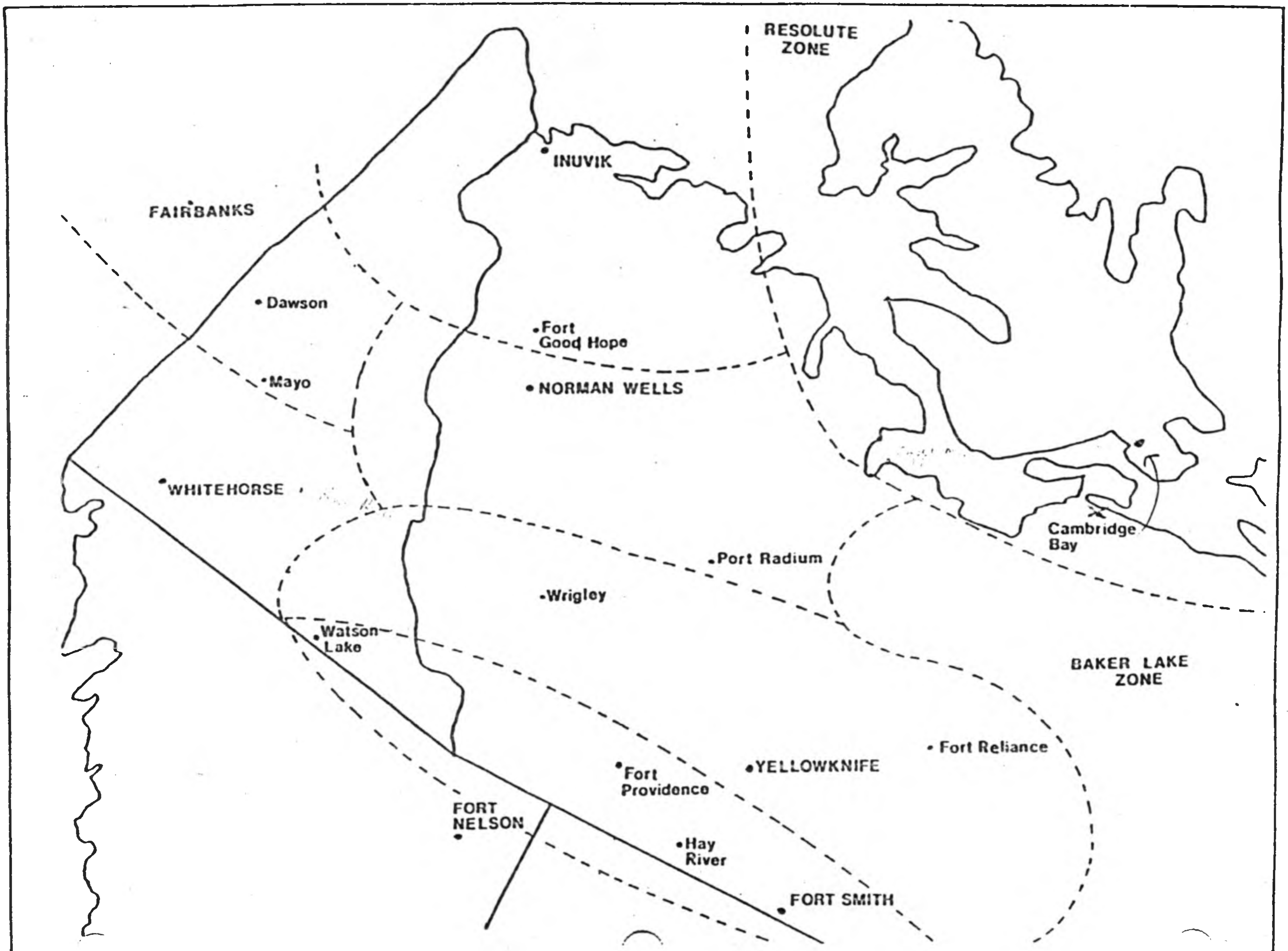


BUILDING SECTION - PILE FOUNDATION

5 BEDROOM
TREELINE
rritories
tion

YUKON AND NORHTWEST TERRITORIES WEATHER DATA FILE DETERMINATION

Location	Degree Days	Latitude
WHITEHORSE	6879	60.72
Watson Lake	7510	60.07
FORT SMITH	7852	60.02
Hay River	7950	60.51
Fort Providence	8020	61.21
Dawson	8274	64.1
YELLOWKNIFE	8593	62.47
NORMAN WELLS	8830	65.17
Port Radium	9170	65.62
Fort Good Hope	9340	66.14
Frobisher Bay	9845	63.75
Eskimo Point	9990	61.1
INUVIK	10174	68.32
Chesterfield Inlet	10750	63.3
BAKER LAKE	10870	64.3
Cambribge Bay	11900	69.1
RESOLUTE	12549	74.72



RESOLUTE ZONE
INUVIK
FAIRBANKS
Dawson
Fort Good Hope
Mayo
NORMAN WELLS
WHITEHORSE
Cambridge Bay
Port Radium
Wrigley
Watson Lake
BAKER LAKE ZONE
Fort Reliance
YELLOWKNIFE
Fort Providence
FORT NELSON
Hay River
FORT SMITH

LOCATION	North Lat.	Outdoor Design Temp. Heating C	Outdoor Design Temp Cooling C	Summer Mean Daily Temp. Range C	Mean Soil Design Temp. C
		YUKON TERRITORY			
Aishihik	61.5	-44	23	14	2
Dawson	64	-50	26	14	1
Destruction Bay	61	-43	24	14	2
Snag	62	-51	23	14	2
Teslin	60	-41	25	12	4
Watson Lake	60	-46	26	12	4
Whitehorse	60.5	-41	25	12	3
		NORTHWEST TERRITORIES			
Aklavik	68	-44	24	11	*
Alert	82	-43	13	6	*
Artic Bay	73	-43	14	8	*
Baker Lake	64	-45	21	10	*
Cambridge Bay	69	-45	16	8	*
Chesterfield Inlet	63	-40	20	9	*
Clyde	70	-41	15	7	*
Coppermine	67.5	-44	20	8	*
Coral Harbour	64	-41	18	9	*
Eskimo Point	61	-40	21	9	*
Eureka	79.5	-47	12	6	*
Fort Good Hope	66	-46	27	13	- 1
Fort Providence	61	-44	24	13	3
Fort Resolution	61	-42	26	10	2
Fort Simpson	61.5	-45	27	13	2
Fort Smith	60	-43	28	13	3
Frobisher Bay	63.5	-40	16	8	*
Hay River	60.5	-41	26	10	3
Holeman Island	70.5	-43	18	8	*
Inuvik	68	-46	25	12	*
Isachen	78.5	-46	12	5	*
Mould Bay	76	-45	10	5	*
Norman Wells	65	-46	27	13	0
Nottingham Island	63	-38	14	8	*
Port Radium	66	-44	22	9	- 1
Rae	62.5	-44	24	10	0
Rankin Inlet	62.5	-40	20	9	*
Resolute	74.5	-44	11	5	*
Resolution Island	61	-35	8	6	*
Tungsten	61.5	-49	26	12	2
Yellowknife	62	-43	25	10	0

* indicates area of continuous permafrost.

The Yukon Electrical Company Limited

09-Jan-95

Electrical Rates - January 1, 1995

Non - Government

Residential

		Hydro	Small Diesel	Large Diesel	Old Crow
Rate Schedule		1160	1260	1360	1460
Rate Code		1160	1260	1360	1460
Rate Area		Hydro	Small Diesel	Large Diesel	Old Crow
Customer Charge		$11.90 /month	$11.90 /month	$11.90 /month	$11.90 /month
Energy Charge					
	First 1,000 KW.h	10.12 ¢/KW.h	10.12 ¢/KW.h	10.12 ¢/KW.h	10.12 ¢/KW.h
	Over 1,000 KW.h	9.84 ¢/KW.h	11.98 ¢/KW.h	9.84 ¢/KW.h	26.03 ¢/KW.h
Minimum Bill		$11.90 /month	$11.90 /month	$11.90 /month	$11.90 /month
Income Tax Rebate		-2.0%	-2.0%	-2.0%	-2.0%
*Bill Relief	3 (1) applicable to Customer charge	-11.312%	-11.312%	-11.312%	-11.312%
	2 (2) applicable to 1st blk energy charge	-18.501%	-18.501%	-18.501%	-18.501%
	1 (3) applicable to 2nd blk energy charge	5.260%	43.660%	48.020%	54.120%
Fuel Rider		0.00 ¢/KW.h	0.00 ¢/KW.h	0.00 ¢/KW.h	0.00 ¢/KW.h
Rider D		0.000%	0.000%	0.000%	0.000%
Rider H		0.000%	0.000%	0.000%	0.000%
Rider J		0.000%	0.000%	0.000%	0.000%
G.S.T.		7.0%	7.0%	7.0%	7.0%

Applies To	Hydro	Small Diesel	Large Diesel	Old Crow
	Carcross	Beaver Creek	Dawson	Old Crow
	Carmacks	Burwash	Lower Post	
	Champagne	Destruction Bay	Upper Liard	
	Elsa	Pelly Crossing	Watson Lake	
	Faro	Stewart Crossing		
	Haines Junction	Swift River		
	Johnson's Crossing			
	Keno			
	Marsh Lake			
	Mayo			
	Ross River			
	Tagish			
	Teslin			
	Whitehorse			

*Note: Total Bill Relief equal to the lesser of the sum of (1) + (2) + (3) or ZERO.

Tel. (403) 633-7000
Fax (403) 668-6892

The Yukon Electrical Company Limited
Electrical Rates - January 1, 1995
Government

09-Jan-96

Residential

Rate Schedule	1180	1280	1380	1480
Rate Code	1180	1280	1380	1480
Rate Area	Hydro	Small Diesel	Large Diesel	Old Crow
Customer Charge	$15.00 /month	$15.00 /month	$15.00 /month	$15.00 /month
Energy Charge				
First 1,000 KW.h	14.05 ¢/KW.h	14.05 ¢/KW.h	14.05 ¢/KW.h	14.05 ¢/KW.h
Over 1,000 KW.h	9.84 ¢/KW.h	11.98 ¢/KW.h	9.84 ¢/KW.h	26.03 ¢/KW.h
Minimum Bill	$15.00 /month	$15.00 /month	$15.00 /month	$15.00 /month
Income Tax Rebate	0.0%	0.0%	0.0%	0.0%
Bill Relief	0.0%	0.0%	0.0%	0.0%
Fuel Rider	0.00 ¢/KW.h	0.00 ¢/KW.h	0.00 ¢/KW.h	0.00 ¢/KW.h
Rider D	0.000%	0.000%	0.000%	0.000%
Rider H	0.000%	0.000%	0.000%	0.000%
Rider J	0.000%	0.000%	0.000%	0.000%
G.S.T.	7.0%	7.0%	7.0%	7.0%

Applies To	Carcross	Beaver Creek	Dawson	Old Crow
	Carmacks	Burwash	Lower Post	
	Champagne	Destruction Bay	Upper Liard	
	Elsa	Pelly Crossing	Watson Lake	
	Faro	Stewart Crossing		
	Haines Junction	Swift River		
	Johnson's Crossing			
	Keno			
	Marsh Lake			
	Mayo			
	Ross River			
	Tagish			
	Teslin			
	Whitehorse			

NORTHLAND UTILITIES (YELLOWKNIFE) LIMITED - CAL[illegible]TION SHEET: AUGUST '95

Northland Utilities - Yellowknife
(403) 873-4865

DOMESTIC RATE SCHEDULE

	RATES - $		SAMPLE RESIDENTIAL BILL-$	
	31 Aug '95	01 Sep '95	1000 KWH @ 31 Aug '95	1000 KWH @ 30 Sep '95
Fixed Charge per Dwelling	12.00	12.00	12.00	12.00
Energy Charge, per KWH	0.1119	0.1119	111.90	111.90
Monthly Minimum Bill	12.00	12.00	--	--
Base Bill Sub Total (1)			123.90	N/A
Purchase Power Increase % @ EFF. 01SEP95	4.33		N/A	129.26
Low Water Surcharge per KWH	0.0130	0.0130	13.00	13.00
Sub Total (2)			136.90	142.26
Franchise Tax, % Sub Total (2)	2.9		3.97	4.13
Sub Total (3)			140.87	146.39
Income Tax Rebate % Sub T. (3)	-1.50		-2.11	-2.20
Sub Total (4)			138.76	144.19
GST, % Sub Total (4)	7		9.71	10.09
TOTAL BILL			148.47	154.29

14.23¢/kwh (without Fixed charge)
⇒ 15.43¢/kwh (all charges on 1000 kwh)

GENERAL SERVICE (COMMERCIAL) RATE SCHEDULE

	RATES - $		SAMPLE COMMERCIAL BILL - $				SAMPLE COMMERCIAL BILL SUMMARY - $	
			ENERGY USAGE (KWH)		POWER DEMAND (KVA)			
	31 Aug '95	01 Sep '95	1000 KWH @ 31 Aug '95	1000 KWH @ 30 Sep '95	10 KVA @ 31 Aug '95	10 KVA @ 30 Sep '95	@ 31 Aug '95	@ 30 Sep '95
Demand Charge per KVA or Fraction Thereof	8.00	8.00	N/A	N/A	80.00	80.00	80.00	80.00
Energy Charge, per KWH	0.0939	0.0939	93.90	93.90	N/A	N/A	93.90	93.90
Monthly Minimum Bill	20.00	20.00	--	--	--	--	--	--
BASE BILL Sub Total (1)							173.90	N/A
Purchase Powr Increase % @ EFF. 01SEP95	4.33						N/A	181.43
Low Water Surcharge/KWH	0.0130	0.0130	13.00	13.00	N/A	N/A	13.00	13.00
Sub Total (2)							186.90	194.43
Franchise Tax, % Sub Total(2)	2.9						5.42	5.64
Sub Total (3)							192.32	200.07
Income Tax Rebate % Sub T. (3)	-1.5						-2.88	-3.00
Sub Total (4)							189.44	197.07
GST, % Sub Total (4)	7						13.26	13.79
TOTAL BILL							202.70	[illegible]

NWT Power Corporation Rates Effective September 1, 1995
Supersedes April 1, 1992 Rates

Domestic Service

Community	Rate Schedule	Monthly Energy Charge Non-Government (cents/kW.h)	Monthly Energy Charge Government (cents/kW.h)
AKLAVIK	KL - 11	31.91	44.41
ARCTIC BAY	AB - 26	37.78	55.19
ARVIAT	AV - 37	36.21	49.63
BAKER LAKE	BL - 18	38.24	49.10
BROUGHTON ISLAND	BT - 40	44.67	71.38
CAMBRIDGE BAY	CB - 16	38.68	45.08
CAPE DORSET	CP - 38	34.62	55.97
CHESTERFIELD INLET	CH - 19	47.77	72.54
CLYDE RIVER	CL - 24	28.26	47.97
COLVILLE LAKE	CV - 12	123.52	171.46
COPPERMINE	CM - 15	34.59	46.76
CORAL HARBOUR	CO - 28	35.30	45.57
DELINE	FK - 22	29.74	47.09
DETTAH	S - 01 - 3	8.92	
FORT LIARD	LA - 47	34.11	66.21
FORT MCPHERSON	MP - 08	29.11	43.06
FORT NORMAN	FN - 23	39.78	47.06
FORT RESOLUTION	FR - 10	8.94	12.93
FORT SIMPSON	SP - 04	24.87	31.79
FORT SMITH	FS - 02	9.45	
GJOA HAVEN	GJ - 33	32.97	57.42
GRISE FIORD	GF - 48	34.08	54.35
HALL BEACH	HB - 45	32.80	63.09
HOLMAN	HL - 35	39.24	71.69
IGLOOLIK	GK - 44	27.93	42.33
INUVIK	NK - 06	27.56	28.46
IQALUIT	FB - 07	31.71	37.34
JEAN MARIE RIVER	JM - 51	32.78	77.23
K'ASHO GOT'INE	FGH - 20	33.45	55.88
LAC LA MARTRE	LM - 50	32.50	78.84
LAKE HARBOUR	LK - 42	48.67	69.88
LUTSEL K'E	SD - 56	30.21	53.69
NAHANNI BUTTE	NB - 52	37.36	81.26
NORMAN WELLS	NW - 17	21.32	28.04
PANGNIRTUNG	PA - 30	33.90	54.36
PAULATUK	PL - 53	45.34	81.26
PELLY BAY	PB - 39	65.64	81.26
PINE POINT	PP - 62	8.94	12.93
POND INLET	PD - 31	33.31	42.25
RAE-EDZO	S - 01 - 2	8.05	13.60
RAE LAKES	RL - 55	33.38	76.25
RANKIN INLET	RK - 25	35.87	45.70
REPULSE BAY	RB - 29	31.79	46.39
RESOLUTE	RE - 32	37.96	38.43
SACHS HARBOUR	SA - 43	41.13	60.40
TALOYOAK	SB - 34	36.70	54.83
TSIIGEHTCHIC	RR - 27	46.92	81.26
TUKTOYAKTUK	TK - 21	31.63	40.85
WHALE COVE	WC - 36	40.78	73.73
WRIGLEY	WR - 46	30.81	56.76

Monthly Service Charge for Domestic Customers = $6.15

NWT Power Corporation Rates Effective September 1, 1995
Supersedes April 1, 1992 Rates

Commercial Service

Community	Rate Schedule	Monthly Energy Charge Non-Government (cents/kW.h)	Monthly Energy Charge Government (cents/kW.h)
AKLAVIK	KL - 11	39.47	44.41
ARCTIC BAY	AB - 26	40.96	54.87
ARVIAT	AV - 37	36.72	49.63
BAKER LAKE	BL - 18	38.08	49.10
BROUGHTON ISLAND	BT - 40	47.27	71.38
CAMBRIDGE BAY	CB - 16	42.24	45.08
CAPE DORSET	CP - 38	36.94	55.97
CHESTERFIELD INLET	CH - 19	55.19	72.54
CLYDE RIVER	CL - 24	35.37	48.70
COLVILLE LAKE	CV - 12	106.80	154.33
COPPERMINE	CM - 15	41.74	46.76
CORAL HARBOUR	CO - 28	46.02	46.60
DELINE	FK - 22	39.67	44.36
DETTAH	S - 01 - 3	13.31	
FORT LIARD	LA - 47	36.45	66.21
FORT MCPHERSON	MP - 08	35.08	43.06
FORT NORMAN	FN - 23	39.67	47.07
FORT RESOLUTION	FR - 10	15.17	15.87
FORT SIMPSON	SP - 04	29.27	43.04
FORT SMITH	FS - 02	7.44	
GJOA HAVEN	GJ - 33	49.70	57.42
GRISE FIORD	GF - 48	41.00	58.04
HALL BEACH	HB - 45	44.16	63.09
HOLMAN	HL - 35	50.35	71.69
IGLOOLIK	GK - 44	31.67	42.33
INUVIK	NK - 06	27.10	28.46
IQALUIT	FB - 07	29.51	37.84
JEAN MARIE RIVER	JM - 51	54.87	81.26
K'ASHO GOT'INE	FGH - 20	44.76	49.69
LAC LA MARTRE	LM - 50	47.76	78.39
LAKE HARBOUR	LK - 42	54.62	69.88
LUTSEL K'E	SD - 56	37.39	53.12
NAHANNI BUTTE	NB - 52	57.07	81.26
NORMAN WELLS	NW - 17	22.84	28.34
PANGNIRTUNG	PA - 30	37.23	49.01
PAULATUK	PL - 53	61.98	81.26
PELLY BAY	PB - 39	67.26	81.26
PINE POINT	PP - 62	15.17	15.87
POND INLET	PD - 31	37.41	42.25
RAE-EDZO	S - 01 - 2	14.39	18.30
RAE LAKES	RL - 55	44.19	76.25
RANKIN INLET	RK - 25	35.03	45.70
REPULSE BAY	RB - 29	40.11	46.39
RESOLUTE	RE - 32	43.89	38.67
SACHS HARBOUR	SA - 43	53.46	61.43
TALOYOAK	SB - 34	43.60	56.11
TSIIGEHTCHIC	RR - 27	59.60	81.26
TUKTOYAKTUK	TK - 21	38.66	40.85
WHALE COVE	WC - 36	53.56	75.42
WRIGLEY	WR - 46	44.23	58.57

First 5 kW = $24.60 All Remaining kW = $4.92/kW

NORTH 60 PETRO LTD.

RESIDENTIAL HEATING FUEL

Effective December 23, 1995 the following rates will be in place for local and linehaul residential heating fuel deliveries:

	FURNACE OIL	STOVE OIL
WHITEHORSE	$0.3890	$0.3990
BURWASH LANDING	$0.4300	$0.4400
DESTRUCTION BAY	$0.4500	$0.4600
CARMACKS	$0.4170	$0.4270
PELLY CROSSING	$0.4270	$0.4370
STEWART CROSSING	$0.4350	$0.4450
BEAVER CREEK	$0.4600	$0.4700
HAINES JUNCTION	$0.3990	$0.4090

The above prices do not include 7% GST.

SPECIAL INTEREST DISCOUNT GROUPS:

	DISCOUNT
SENIOR CITIZENS (65+)	$0.0200
FSAC	$0.0200
YTG EMPLOYEES	$0.0200
RCMP	$0.0200
NORTH 60 PETRO EMPLOYEES	$0.0400

APPENDIX E

HOT2000 Computer Simulation for Each Community

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***************************************
*                                     *
*             AUDIT2000               *
*           Version 7.14d             *
*              CANMET                 *
*      Natural Resources CANADA       *
*           Jun 11, 1996              *
*         Reg. # BETAC016             *
***************************************
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File = C:\HME\9504-VNT\AUDIT\TYPE1-O.HDF

Weather Data for YELLOWKNIFE, NORTHWEST TERRITORY

Builder Code =TYPE 1
Data Entry by: HOWELL-MAYHEW ENGINEERING   Date of entry 09/04/1996

Client name: SAMPLE HOUSE WITH BASEMENT
Street address: LATITUDE 62
City: 8500 Degree Days   Region:
Postal code: Telephone:

*** GENERAL HOUSE CHARACTERISTICS ***

House type: Single detached
Number of storeys: One storey
Wall construction: Platform frame, single stud wall
Year House Built: 1996
Wall colour: Default 0.40   Value .400
Plan shape: Rectangular   Front orientation: South

SOIL TYPE: Normal conductivity: dry sand, loam, clay, low water table

HOUSE THERMAL MASS LEVEL: (A) Wood frame construction, 12.5 mm (0.5 in.) gyproc walls and ceiling, wooden floor

Effective mass fraction 1.000

Occupants : 1 Adults for .1 % of the time
0 Children for .0 % of the time
0 Infants for .0 % of the time

Sensible Internal Heat Gain From Occupants = .00 kWh/day

*** HOUSE TEMPERATURES ***

Heating Temperatures	Main Floor	= 21.0 C
	Basement	= 20.0 C
	TEMP. Rise from 21.0 C	= 3.5 C

Basement is- Heated: Yes   Cooled: No   Separate T/S: No
Fraction of internal gains released in basement : .150

Indoor design temperatures for equipment sizing

Heating	= 22.0 C
Cooling	= 24.0 C

*** FOUNDATION CONSTRUCTION CHARACTERISTICS ***

Foundation Construction	Attachment Sides	Insulation Placement	Volume m3
Full Basement	None	Interior	342.0

*** WINDOW CHARACTERISTICS ***

Direc-tion	Seq #	Loc. Code	# of Windows	Type	Window Width m	Window Height m	OverHang Width m	Header Height m	SHGC	Curtain Factor
South	1	M1	2	200204	.914	.914	.61	.30	.6354	1.000
	2	M1	1	200214	1.219	1.219	.61	.30	.6010	1.000
	3	M1	1	200204	1.524	1.219	.61	.30	.6745	1.000
East	1	M1	2	200214	.914	1.219	.00	.00	.5761	1.000
North	1	M1	2	200214	.914	.914	.61	.30	.5523	1.000
	2	M1	1	200204	1.219	1.219	.61	.30	.6654	1.000
	3	M1	1	200204	1.524	1.219	.61	.30	.6745	1.000
West	1	M1	2	200214	.914	1.219	.00	.00	.5761	1.000

*** WINDOW PARAMETER CODES SCHEDULE ***

	Code	Description (Glazings, Coatings, Fill, Spacer, Type, Frame)
1	200204	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Picture, Vinyl, ER* = -13.8, Eff. RSI= .36
2	200214	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Hinged, Vinyl, ER* = -24.9, Eff. RSI= .36

Window Standard Energy Rating estimated for assumed dimensions, and
Air tightness type: CSA - A1; Leakage rate = 2.79 m3/hr/m

*** BUILDING PARAMETER DETAILS ***

CEILING COMPONENTS

	Construction Type	Code Type	Roof Slope	Heel Ht. m	Section Area m2	R-Value RSI
C1	Attic/Gable	2403391000	6.00 / 12	.20	139.35	6.82

WALL COMPONENTS

	Wall Type Code	Lintel Type	Facing Dir	Number of Corners	Number of Inter.	Height m	Perim. m	Area m2	R-Value RSI
	Main Walls								
M1	1211301101	101	N/A	4	10	2.44	54.9	133.78	2.65
	Basement Walls above grade								
B1	112X4+R8	101	N/A	4	2	.46	47.5	21.74	2.95
B2	1502300361	N/A	N/A	4	0	.25	47.5	12.03	3.73
	Upper Basement Walls								
1	112X4+R8	N/A	N/A	4	2	.61	47.5	28.99	2.99
	Lower basement walls								
1	112X4+R8	N/A	N/A	4	2	1.27	47.5	60.44	3.13

FLOORS

	Seq #	Construction Type	Section Area m2	R-Value RSI
Full Depth Floor Perimeter	1	3610000000	43.78	.28
Full Depth Floor Centre	1	3610000000	88.24	.28
Floors above Basement	1	0000000000	132.02	.50

DOORS

	Location	Type	Height m	Width m	Gross Area m2	R-value RSI
D1	M1	Steel polyurethane core	2.13	.91	1.95	1.14
D2	M1	Steel polyurethane core	2.13	.91	1.95	1.14

*** Wall PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	1211301101	Wood frame, 38 x 140 mm (2 x 6 in), 400 mm (16 in), RSI 3.5 (R 20) Batt, None, 12 mm (0.5 in) Gypsum board, Waferboard/OSB 9.5 mm (3/8 in), None, 3 studs
2	1502300361	Composite wood joist, 38 x 241 mm (2 x 9.5 in), 487 mm (19 in), RSI 3.5 (R 20) Batt, None, None, Waferboard/OSB 15.9 mm (5/8 in), Stucco, 3 studs

*** Ceiling PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	2403391000	Truss, 38 x 89 mm (2 x 4 in) Attic truss, 600 mm (24 in), RSI 3.5 (R 20) Batt, Same as Insulation Layer 1, 12 mm (0.5 in) Gypsum board, N/A, N/A, N/A

*** Exterior Floor PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Drop Floors)
1	3610000000	Solid, 200 mm (8 in) Concrete, None, None, None, None, None, None, No

*** USER-DEFINED STRUCTURE CODES SCHEDULE ***

	Code	Description
1	112X4+R8	Offset 2x4, R12 Wall + R8 Batt

*** Lintel PARAMETER CODES SCHEDULE ***

	Code	Description (Type, Material, Insulation)
1	101	Double, Wood, Same as wall framing cavity

Roof Cavity Inputs

Gable Ends		Total Area	23.2 m2
Sheathing Material:	Plywood/Part. bd 9.5 mm (3/8 in)		.08 RSI
Exterior Material:	Hollow metal/vinyl cladding		.11 RSI
Sloped Roof		Total Area	155.8 m2
Sheathing Material:	Plywood/Part. bd 12.7 mm (1/2 in)		.11 RSI
Roofing Material:	Asphalt shingles		.08 RSI

Roof colour: Medium brown 0.84 Absorptivity: .840
Total cavity volume 167.9 m3 Ventilation rate .50 ACH/hr

*** BUILDING ASSEMBLY DETAILS ***

CEILING COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
C1	2403391000	6.99	7.09	6.82

WALL COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
	Main Walls			
M1	1211301101	3.22	2.66	2.65
	Basement Walls above grade			
B1	112X4+R8	3.12	2.95	2.95
B2	1502300361	3.50	3.73	3.73
	Upper Basement Walls			
1	112X4+R8	3.12	2.99	2.99
	Lower basement walls			
1	112X4+R8	3.12	3.13	3.13

FLOORS

Component	Seq #	Construction Code	Nominal RSI	System RSI	Effective RSI
Full Depth Floor Perimeter	1	3610000000	.00	.28	.28
Full Depth Floor Centre	1	3610000000	.00	.28	.28

WINDOWS

Orientation Location	Number	Type (Code)	Total Area(m2)	RSI Window	RSI (Shutter)
South					
M1	2	200204	1.67	.36	
M1	1	200214	1.49	.36	
M1	1	200204	1.86	.36	
East					
M1	2	200214	2.23	.36	
North					
M1	2	200214	1.67	.36	
M1	1	200204	1.49	.36	
M1	1	200204	1.86	.36	
West					
M1	2	200214	2.23	.36	

*** BUILDING PARAMETERS SUMMARY ***

Component	Area (m2) Gross	Net	Effective RSI	Heat Loss MJ	% Annual Heat Loss
ZONE 1 : ABOVE GRADE					
Ceiling	139.35	139.35	6.82	14621.6	7.10
Main Walls	133.78	115.39	2.65	34380.5	16.69
Doors	3.90	3.90	1.14	2829.9	1.37
South windows	5.02	5.02	.36	11528.2	5.60
East windows	2.23	2.23	.36	5127.8	2.49
North windows	5.02	5.02	.36	11531.6	5.60
West windows	2.23	2.23	.36	5127.8	2.49
			ZONE 1 Totals:	85147.4	41.33
INTER-ZONE Heat Transfer : Floors Above Shallow and Full Basement	132.02	132.02	.50	19802.7	
ZONE 2 : SHALLOW / FULL BASEMENT					
Basement Walls above grade	33.77	33.77	3.18	8029.3	3.90
Upper Basement Walls	28.99	28.99	3.08	3408.3	1.65
Lower Basement Walls	60.44	60.44	3.08	5148.9	2.50
Full Depth Floor Perimeter	43.78	43.78	.28	14444.7	7.01
Full Depth Floor Centre	88.24	88.24	.28	9303.4	4.52
			ZONE 2 Totals:	40334.6	19.58

Ventilation

House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
681.83 m3	.392 ACH	80554.0	39.10

*** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area = 528.3 m2
Air Tightness Level is Present (3.57 ACH @50 Pa.)

Terrain Description		Height	m
@ Weather Station :	Open flat terrain, grass	Anemometer	10.0
@ Building site :	Suburban, forest	Bldg. Eaves	3.7

Local Shielding- Walls: Very heavy
Flue : Light local shielding

Leakage Fractions - Ceiling: .300 Walls: .500 Floors: .200

Estimated Equivalent Leakage Area @ 10 Pa.	= 862.6 cm2
Normalized Leakage Area @ 10 Pa.	= 1.6326 cm2/m2
Estimated Airflow to cause a 5 Pa Pressure Difference	= 55 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference	= 86 L/s
ELA used to calculate Estimated Airflows	= 345.0 cm2

*** F326 VENTILATION REQUIREMENTS ***

Kitchen,living,dining:	3 rooms @ 5 L/s	= 15 L/s
Utility rooms:	1 rooms @ 5 L/s	= 5 L/s
Bedrooms:	1 rooms @ 10 L/s	= 10 L/s
Bedrooms:	2 rooms @ 5 L/s	= 10 L/s
Bathrooms:	1 rooms @ 5 L/s	= 5 L/s
Other habitable rooms:	1 rooms @ 5 L/s	= 5 L/s
Basement Rooms:		10 L/s

*** CENTRAL VENTILATION SYSTEM ***

System Type : Fans without heat recovery
Manufacturer:
Model Number:

Mechanical Ventilator Fan Power = 125. Watts

*** AIR LEAKAGE AND VENTILATION SUMMARY ***

F326 Required continuous ventilation rate = 60.0 L/s (.32 ACH)
Central Ventilation Rate (Balanced) = 30.0 L/s (.16 ACH)
Total house ventilation is Balanced

Gross Air Leakage and Ventilation Energy Load = 76264.7 MJ
Seasonal Heat Recovery Ventilator Efficiency = .0 %
Estimated Ventilation Electrical Load: Heating Hours = 3873.8 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours = 68.2 MJ
Net Air Leakage and Ventilation Energy Load = 82490.9 MJ

*** SPACE HEATING SYSTEM ***

PRIMARY Heating Fuel : Oil
Equipment : Furnace/Boiler with flame ret. head
Manufacturer :
Model :
Output Capacity = 26.3 kW

Steady State Efficiency = 84.0 %

Fan Mode : Auto Fan Power 500. watts
Flue Diameter = 152.4 mm

*** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY Water Heating Fuel :
Water Heating Equipment : No DHW system installed

*** ANNUAL SPACE HEATING SUMMARY ***

Design Heat Loss at -43.0 C = 25.72 Watts/m3 = 17536. Watts

Gross Space Heat Loss =206036. MJ

Gross Space Heating Load =206036. MJ
Usable Internal Gains = 2. MJ
Usable Internal Gains Fraction = .0 %
Usable Solar Gains = 21975. MJ
Usable Solar Gains Fraction = 10.7 %
Auxiliary Energy Required =184059. MJ

Space Heating System Load =184059. MJ
Furnace/Boiler Seasonal efficiency = 81.2 %
Furnace/Boiler Annual Energy Consumption =223115. MJ

*** BASE LOADS SUMMARY ***

	kwh/day	Annual kWh
Interior Lighting	.0	.0
Appliances	.0	.0
Other	.0	.0
Exterior use	.0	.0
HVAC fans		
HRV/Exhaust	3.0	1095.0
Space Heating	2.6	952.6
Space Cooling	.0	.0
Total Average Electrical Load	5.6	2047.6

*** FAN OPERATION SUMMARY (kWh) ***

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	1076.1	952.6	.0
Neither	18.9	.0	.0
Cooling	.0	.0	.0
Total	1095.0	952.6	.0

*** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption	=	226544. MJ =	62928.9 kWh
Ventilator Electrical Consumption: Heating Hours	=	3874. MJ =	1076.1 kWh
Estimated Annual DHW Heating Energy Consumption	=	0. MJ =	.0 kWh
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	=	230418. MJ =	64005.0 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET	=	118995. MJ =	33054.2 kWh

*** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel		Space Heating	Space Cooling	DHW Heating	Appliances	Total
Oil	(Litres)	5791.6	.0	.0	.0	5791.6
Electricity	(kWh)	2028.7	.0	.0	18.9	2047.6

*** ESTIMATED ANNUAL FUEL CONSUMPTION COSTS ***

Fuel Costs Library = C:\HME\9504-VNT\AUDIT\9504FUEL.CST

RATE	Electricity (T1-ELEC)	Natural Gas (T1-NG-ND)	Oil (T1-OIL)	Propane (T1-PR-ND)	Wood (T1-WD-ND)	Total
$	307.14	.00	2289.16	.00	.00	2596.30

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*              AUDIT2000               *
*            Version 7.14d             *
*               CANMET                 *
*      Natural Resources CANADA        *
*            Jun 11, 1996              *
*           Reg. # BETAC016            *
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File = C:\HME\9504-VNT\AUDIT\TYPE2-O.HDF

Weather Data for INUVIK, NORTHWEST TERRITORY

Builder Code =TYPE 2
Data Entry by: HOWELL-MAYHEW ENGINEERING Date of entry 09/04/1996

Client name: Sample House Without Basement
Street address: Latitude - 66
City: 10,000 Degree Days Region:
Postal code: Telephone:

*** GENERAL HOUSE CHARACTERISTICS ***

House type: Single detached
Number of storeys: One storey
Wall construction: Platform frame, single stud wall
Year House Built: 1996
Wall colour: Default 0.40 Value .400
Plan shape: Rectangular Front orientation: South

SOIL TYPE: Perma-Frost soil

HOUSE THERMAL MASS LEVEL: (A) Wood frame construction, 12.5 mm (0.5 in.) gyproc walls and ceiling, wooden floor

Effective mass fraction 1.000

Occupants : 1 Adults for .1 % of the time
0 Children for .0 % of the time
0 Infants for .0 % of the time

Sensible Internal Heat Gain From Occupants = .00 kWh/day

*** HOUSE TEMPERATURES ***

Heating Temperatures	Main Floor	= 21.0 C
	Basement	= 20.0 C
	TEMP. Rise from 21.0 C	= 3.5 C

Indoor design temperatures for equipment sizing

Heating	= 22.0 C
Cooling	= 24.0 C

*** WINDOW CHARACTERISTICS ***

Direc-tion	Seq #	Loc. Code	# of Windows	Type	Window Width m	Window Height m	OverHang Width m	Header Height m	SHGC	Curtain Factor
South	1	M1	3	200204	.914	1.372	.00	.61	.6552	1.000
	2	M1	1	200214	.914	1.219	.00	.61	.5761	1.000
East	1	M1	2	200214	.914	1.219	.15	.30	.5761	1.000
	2	M1	1	200214	.914	.914	.15	.30	.5523	1.000
West	1	M1	2	200214	.914	1.219	.15	.30	.5761	1.000

*** WINDOW PARAMETER CODES SCHEDULE ***

	Code	Description (Glazings, Coatings, Fill, Spacer, Type, Frame)
1	200204	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Picture, Vinyl, ER* = -13.8, Eff. RSI= .36
2	200214	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Hinged, Vinyl, ER* = -24.9, Eff. RSI= .36

Window Standard Energy Rating estimated for assumed dimensions, and
Air tightness type: CSA - A1; Leakage rate = 2.79 m3/hr/m

*** BUILDING PARAMETER DETAILS ***

CEILING COMPONENTS

	Construction Type	Code Type	Roof Slope	Heel Ht. m	Section Area m2	R-Value RSI
C1	Cathedral	2243391000	1.20 / 12	.30	108.26	6.84

WALL COMPONENTS

	Wall Type Code	Lintel Type	Facing Dir	Number of Corners	Number of Inter.	Height m	Perim. m	Area m2	R-Value RSI
Main Walls									
M1	1213301121	101	N/A	4	8	2.44	42.1	102.56	2.86
M2	1213301121	N/A	N/A	4	4	.18	15.8	2.82	1.94
M3	1233300620	N/A	N/A	0	0	.25	42.1	10.64	3.01
M4	1213301121	N/A	N/A	4	0	.81	42.1	34.23	2.85

FLOORS

	Seq #	Construction Type	Section Area m2	R-Value RSI
Exposed or overhanging floors	1	3243366100	107.86	6.21

DOORS

	Location	Type	Height m	Width m	Gross Area m2	R-value RSI
D1	M1	Steel polyurethane core	2.13	.91	1.95	1.14
D2	M1	Steel polyurethane core	2.13	.91	1.95	1.14

*** Wall PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	1213301121	Wood frame, 38 x 140 mm (2 x 6 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, None, 12 mm (0.5 in) Gypsum board, Waferboard/OSB 9.5 mm (3/8 in), Hollow metal/vinyl cladding, 3 studs
2	1233300620	Wood frame, 38 x 235 mm (2 x 10 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, None, None, Plywood/Particle board 15.5 mm (5/8 in), Hollow metal/vinyl cladding, 2 studs

*** Ceiling PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	2243391000	Wood frame, 38 x 286 mm (2 x 12 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, Same as Insulation Layer 1, 12 mm (0.5 in) Gypsum board, N/A, N/A, N/A

*** Exterior Floor PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Drop Floors)
1	3243366100	Wood frame, 38 x 286 mm (2 x 12 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, 64 mm (2.5 in) XTPS IV, Wood, Waferboard/OSB 9.5 mm (3/8 in), None, No

*** Lintel PARAMETER CODES SCHEDULE ***

	Code	Description (Type, Material, Insulation)
1	101	Double, Wood, Same as wall framing cavity

Roof Cavity Inputs

Sloped Roof	Total Area	.0 m2
Sheathing Material: Plywood/Part. bd 12.7 mm (1/2 in)		.11 RSI
Roofing Material: Asphalt shingles		.08 RSI

Roof colour: Medium brown 0.84	Absorptivity: .840
Total cavity volume .0 m3	Ventilation rate .50 ACH/hr

*** BUILDING ASSEMBLY DETAILS ***

CEILING COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
C1	2243391000	6.99	6.84	6.84

WALL COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
	Main Walls			
M1	1213301121	3.22	2.86	2.86
M2	1213301121	3.22	1.94	1.94
M3	1233300620	3.50	3.01	3.01
M4	1213301121	3.22	2.85	2.85

FLOORS

Component	Seq #	Construction Code	Nominal RSI	System RSI	Effective RSI
Exposed or overhanging floor	1	3243366100	5.72	6.21	6.21

WINDOWS

Orientation Location	Number	Type (Code)	Total Area(m2)	RSI Window	(Shutter)
South					
M1	3	200204	3.76	.36	
M1	1	200214	1.11	.36	
East					
M1	2	200214	2.23	.36	
M1	1	200214	.84	.36	
West					
M1	2	200214	2.23	.36	

*** BUILDING PARAMETERS SUMMARY ***

Component	Area (m2) Gross	Net	Effective RSI	Heat Loss MJ	% Annual Heat Loss
ZONE 1 : ABOVE GRADE					
Ceiling	108.26	108.26	6.84	13182.6	7.38
Main Walls	150.26	136.18	2.84	44240.5	24.78
Doors	3.90	3.90	1.14	3273.6	1.83
Exposed floors	107.86	107.86	6.21	15374.2	8.61
South windows	4.88	4.88	.36	12957.7	7.26
East windows	3.07	3.07	.36	8152.7	4.57
West windows	2.23	2.23	.36	5931.8	3.32
		ZONE 1 Totals:		103113.1	57.75

Ventilation

House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
396.57 m3	.589 ACH	75446.7	42.25

*** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area = 366.4 m2
Air Tightness Level is Present (3.57 ACH @50 Pa.)

Terrain Description		Height	m
@ Weather Station :	Open flat terrain, grass	Anemometer	10.0
@ Building site :	Open flat terrain, grass	Bldg. Eaves	3.7

Local Shielding- Walls: Light local shielding
Flue : Light local shielding

Leakage Fractions - Ceiling: .300 Walls: .500 Floors: .200

Estimated Equivalent Leakage Area @ 10 Pa.	=	501.7 cm2
Normalized Leakage Area @ 10 Pa.	=	1.3693 cm2/m2
Estimated Airflow to cause a 5 Pa Pressure Difference	=	32 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference	=	50 L/s
ELA used to calculate Estimated Airflows	=	200.7 cm2

*** F326 VENTILATION REQUIREMENTS ***

Kitchen,living,dining:	3 rooms @ 5 L/s	= 15 L/s
Bedrooms:	1 rooms @ 10 L/s	= 10 L/s
Bedrooms:	2 rooms @ 5 L/s	= 10 L/s
Bathrooms:	1 rooms @ 5 L/s	= 5 L/s
Basement Rooms:		0 L/s

*** CENTRAL VENTILATION SYSTEM ***

System Type : Fans without heat recovery
Manufacturer:
Model Number:

Mechanical Ventilator Fan Power = 125. Watts

*** AIR LEAKAGE AND VENTILATION SUMMARY ***

F326 Required continuous ventilation rate	=	40.0 L/s (.36 ACH)
Central Ventilation Rate (Balanced)	=	28.3 L/s (.26 ACH)
Total house ventilation is Balanced		

Gross Air Leakage and Ventilation Energy Load	=	79372.7 MJ
Seasonal Heat Recovery Ventilator Efficiency	=	.0 %
Estimated Ventilation Electrical Load: Heating Hours	=	3909.9 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours	=	32.1 MJ
Net Air Leakage and Ventilation Energy Load	=	77401.7 MJ

*** SPACE HEATING SYSTEM ***

PRIMARY Heating Fuel : Oil
Equipment : Furnace/Boiler with flame ret. head
Manufacturer :
Model :
Output Capacity = 18.7 kW

Steady State Efficiency = 84.0 %

Fan Mode : Auto   Fan Power 500. watts
Flue Diameter = 152.4 mm

*** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY Water Heating Fuel :
Water Heating Equipment : No DHW system installed

*** ANNUAL SPACE HEATING SUMMARY ***

Design Heat Loss at -46.0 C = 35.23 Watts/m3 = 13972. Watts

Gross Space Heat Loss	=	178560. MJ
Gross Space Heating Load	=	178560. MJ
Usable Internal Gains	=	2. MJ
Usable Internal Gains Fraction	=	.0 %
Usable Solar Gains	=	18177. MJ
Usable Solar Gains Fraction	=	10.2 %
Auxiliary Energy Required	=	160380. MJ
Space Heating System Load	=	160380. MJ
Furnace/Boiler Seasonal efficiency	=	82.1 %
Furnace/Boiler Annual Energy Consumption	=	191258. MJ

*** BASE LOADS SUMMARY ***

	kwh/day	Annual kWh
Interior Lighting	.0	.0
Appliances	.0	.0
Other	.0	.0
Exterior use	.0	.0
HVAC fans		
HRV/Exhaust	3.0	1095.0
Space Heating	3.2	1161.9
Space Cooling	.0	.0
Total Average Electrical Load	6.2	2256.9

*** FAN OPERATION SUMMARY (kWh) ***

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	1086.1	1161.9	.0
Neither	8.9	.0	.0
Cooling	.0	.0	.0
Total	1095.0	1161.9	.0

*** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption	= 195441. MJ	= 54289.0 kWh
Ventilator Electrical Consumption: Heating Hours	= 3910. MJ	= 1086.1 kWh
Estimated Annual DHW Heating Energy Consumption	= 0. MJ	= .0 kWh
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	= 199350. MJ	= 55375.1 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET	= 88648. MJ	= 24624.4 kWh

*** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel		Space Heating	Space Cooling	DHW Heating	Appliances	Total
Oil	(Litres)	4964.6	.0	.0	.0	4964.6
Electricity	(kWh)	2248.0	.0	.0	8.9	2256.9

*** ESTIMATED ANNUAL FUEL CONSUMPTION COSTS ***

Fuel Costs Library = C:\HME\9504-VNT\AUDIT\9504FUEL.CST

RATE	Electricity (T2-ELEC)	Natural Gas (T2-NG-ND)	Oil (T2-OIL)	Propane (T2-PR-ND)	Wood (T2-WD-ND)	Total
$	677.07	.00	2698.65	.00	.00	3375.72

*** SPACE HEATING SYSTEM PERFORMANCE ***

Month	Space Heating Load MJ	Furnace Input MJ	Pilot Light MJ	Indoor Fans MJ	Heat Pump Input MJ	Total Input MJ	System Cop
Jan	25233.2	29661.4	.0	658.1	.0	30319.5	.832
Feb	22106.8	26001.3	.0	576.6	.0	26577.9	.832
Mar	20946.4	24715.9	.0	546.3	.0	25262.2	.829
Apr	13759.5	16405.7	.0	358.9	.0	16764.6	.821
May	7475.4	9175.0	.0	195.0	.0	9369.9	.798
Jun	2569.3	3446.7	.0	67.0	.0	3513.7	.731
Jul	1194.4	1801.7	.0	31.2	.0	1832.8	.652
Aug	3097.0	4052.1	.0	80.8	.0	4132.9	.749
Sep	6880.1	8467.8	.0	179.4	.0	8647.2	.796
Oct	13346.4	15948.1	.0	348.1	.0	16296.2	.819
Nov	19388.6	22901.0	.0	505.7	.0	23406.7	.828
Dec	24383.2	28680.8	.0	635.9	.0	29316.8	.832
Ann	160380.3	191257.6	.0	4182.9	.0	195440.5	.821

*** MONTHLY ESTIMATED ENERGY CONSUMPTION BY DEVICE (MJ) ***

	Space Heating Primary	Space Heating Secondary	DHW Heating Primary	DHW Heating Secondary	Lights & Appliances	HRV & FANS	Air Conditioner
Jan	29661.4	.0	.0	.0	.0	992.9	.0
Feb	26001.3	.0	.0	.0	.0	879.0	.0
Mar	24715.9	.0	.0	.0	.0	881.1	.0
Apr	16405.7	.0	.0	.0	.0	682.9	.0
May	9175.0	.0	.0	.0	.0	529.8	.0
Jun	3446.7	.0	.0	.0	.0	391.0	.0
Jul	1801.7	.0	.0	.0	.0	366.0	.0
Aug	4052.1	.0	.0	.0	.0	415.6	.0
Sep	8467.8	.0	.0	.0	.0	503.4	.0
Oct	15948.1	.0	.0	.0	.0	682.9	.0
Nov	22901.0	.0	.0	.0	.0	829.7	.0
Dec	28680.8	.0	.0	.0	.0	970.7	.0
Total	191257.6	.0	.0	.0	.0	8124.9	.0

*** ESTIMATED FUEL COSTS (Dollars) ***

	Electricity	Natural Gas	Oil	Propane	Wood	Total
Jan	82.74	.00	418.52	.00	.00	501.27
Feb	73.25	.00	366.88	.00	.00	440.13
Mar	73.43	.00	348.74	.00	.00	422.17
Apr	56.91	.00	231.49	.00	.00	288.39
May	44.15	.00	129.46	.00	.00	173.61
Jun	32.58	.00	48.63	.00	.00	81.22
Jul	30.50	.00	25.42	.00	.00	55.92
Aug	34.63	.00	57.18	.00	.00	91.81
Sep	41.95	.00	119.48	.00	.00	161.43
Oct	56.91	.00	225.03	.00	.00	281.94
Nov	69.14	.00	323.13	.00	.00	392.27
Dec	80.90	.00	404.69	.00	.00	485.58
Total	677.07	.00	2698.65	.00	.00	3375.72

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Energy units: MJ = Megajoules (3.6 MJ = 1 kWh)

The calculated heat losses and energy consumptions are only estimates, based upon the data entered and assumptions within the program. Actual energy consumption and heat losses will be influenced by construction practices, localized weather, equipment characteristics and the lifestyle of the occupants.

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*              AUDIT2000               *
*            Version 7.14d             *
*               CANMET                 *
*       Natural Resources CANADA       *
*            Jun 11, 1996              *
*           Reg. # BETAC016            *
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File = C:\HME\9504-VNT\AUDIT\TYPE3-O.HDF

Weather Data for RESOLUTE, NORTHWEST TERRITORY

Builder Code =TYPE 3
Data Entry by: HOWELL-MAYHEW ENGINEERING Date of entry 09/04/1996

Client name: Sample House Without Basement
Street address: Latitude - 70
City: 12,000 Degree Days Region:
Postal code: Telephone:

*** GENERAL HOUSE CHARACTERISTICS ***

House type: Single detached
Number of storeys: One storey
Wall construction: Platform frame, single stud wall
Year House Built: 1996
Wall colour: Default 0.40 Value .400
Plan shape: Rectangular Front orientation: South

SOIL TYPE: Perma-Frost soil

HOUSE THERMAL MASS LEVEL: (A) Wood frame construction, 12.5 mm (0.5 in.) gyproc walls and ceiling, wooden floor

Effective mass fraction 1.000

Occupants : 1 Adults for .1 % of the time
0 Children for .0 % of the time
0 Infants for .0 % of the time

Sensible Internal Heat Gain From Occupants = .00 kWh/day

*** HOUSE TEMPERATURES ***

Heating Temperatures	Main Floor	= 21.0 C
	Basement	= 20.0 C
	TEMP. Rise from 21.0 C	= 3.5 C

Indoor design temperatures for equipment sizing

	Heating	= 22.0 C
	Cooling	= 24.0 C

*** WINDOW CHARACTERISTICS ***

Direc-tion	Seq #	Loc. Code	# of Windows	Type	Window Width m	Window Height m	OverHang Width m	Header Height m	SHGC	Curtain Factor
South	1	M1	2	200204	.914	1.372	.00	.61	.6552	1.000
	2	M1	1	200214	.914	1.219	.00	.61	.5761	1.000
East	1	M1	3	200214	.914	1.219	.15	.30	.5761	1.000
West	1	M1	1	200214	.914	.914	.15	.30	.5523	1.000
	2	M1	1	200214	.914	1.219	.15	.30	.5761	1.000

*** WINDOW PARAMETER CODES SCHEDULE ***

	Code	Description (Glazings, Coatings, Fill, Spacer, Type, Frame)
1	200204	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Picture, Vinyl, ER* = -13.8, Eff. RSI= .36
2	200214	Double/Double with 1 coat, Clear, 13 mm Air, Insulating, Hinged, Vinyl, ER* = -24.9, Eff. RSI= .36

Window Standard Energy Rating estimated for assumed dimensions, and
Air tightness type: CSA - A1; Leakage rate = 2.79 m3/hr/m

*** BUILDING PARAMETER DETAILS ***

CEILING COMPONENTS

	Construction Type	Code Type	Roof Slope	Heel Ht. m	Section Area m2	R-Value RSI
C1	Cathedral	2243391000	1.20 / 12	.30	93.15	6.84

WALL COMPONENTS

	Wall Type Code	Lintel Type	Facing Dir	Number of Corners	Number of Inter.	Height m	Perim. m	Area m2	R-Value RSI
	Main Walls								
M1	1213301121	101	N/A	4	6	2.44	39.0	95.13	2.88
M2	1213301121	N/A	N/A	4	3	.18	15.8	2.82	1.94
M3	1233300620	N/A	N/A	0	0	.25	39.0	9.87	3.01
M4	1213301121	N/A	N/A	4	0	.81	39.0	31.75	2.84

FLOORS

	Seq #	Construction Type	Section Area m2	R-Value RSI
Exposed or overhanging floors	1	3243366100	92.81	6.21

DOORS

	Location	Type	Height m	Width m	Gross Area m2	R-value RSI
D1	M1	Steel polyurethane core	2.13	.91	1.95	1.14
D2	M1	Steel polyurethane core	2.13	.91	1.95	1.14

*** Wall PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	1213301121	Wood frame, 38 x 140 mm (2 x 6 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, None, 12 mm (0.5 in) Gypsum board, Waferboard/OSB 9.5 mm (3/8 in), Hollow metal/vinyl cladding, 3 studs
2	1233300620	Wood frame, 38 x 235 mm (2 x 10 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, None, None, Plywood/Particle board 15.5 mm (5/8 in), Hollow metal/vinyl cladding, 2 studs

*** Ceiling PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Studs)
1	2243391000	Wood frame, 38 x 286 mm (2 x 12 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, Same as Insulation Layer 1, 12 mm (0.5 in) Gypsum board, N/A, N/A, N/A

*** Exterior Floor PARAMETER CODES SCHEDULE ***

	Code	Description (Str., typ/size, Spac., Insl, 2, Int, Sheath, Ext., Drop Floors)
1	3243366100	Wood frame, 38 x 286 mm (2 x 12 in), 600 mm (24 in), RSI 3.5 (R 20) Batt, 64 mm (2.5 in) XTPS IV, Wood, Waferboard/OSB 9.5 mm (3/8 in), None, No

*** Lintel PARAMETER CODES SCHEDULE ***

	Code	Description (Type, Material, Insulation)
1	101	Double, Wood, Same as wall framing cavity

Roof Cavity Inputs

Sloped Roof	Total Area	.0 m2
Sheathing Material: Plywood/Part. bd 12.7 mm (1/2 in)		.11 RSI
Roofing Material: Asphalt shingles		.08 RSI
Roof colour: Medium brown 0.84	Absorptivity:	.840
Total cavity volume .0 m3	Ventilation rate	.50 ACH/hr

*** BUILDING ASSEMBLY DETAILS ***

CEILING COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
C1	2243391000	6.99	6.84	6.84

WALL COMPONENTS

Loc	Construction Code	Nominal RSI	System RSI	Effective RSI
	Main Walls			
M1	1213301121	3.22	2.88	2.88
M2	1213301121	3.22	1.94	1.94
M3	1233300620	3.50	3.01	3.01
M4	1213301121	3.22	2.84	2.84

FLOORS

Component	Seq #	Construction Code	Nominal RSI	System RSI	Effective RSI
Exposed or overhanging floor	1	3243366100	5.72	6.21	6.21

WINDOWS

Orientation Location	Number	Type (Code)	Total Area(m2)	RSI Window	(Shutter)
South					
M1	2	200204	2.51	.36	
M1	1	200214	1.11	.36	
East					
M1	3	200214	3.34	.36	
West					
M1	1	200214	.84	.36	
M1	1	200214	1.11	.36	

*** BUILDING PARAMETERS SUMMARY ***

Component	Area (m2) Gross	Net	Effective RSI	Heat Loss MJ	% Annual Heat Loss
ZONE 1 : ABOVE GRADE					
Ceiling	93.15	93.15	6.84	14305.3	6.21
Main Walls	139.58	126.76	2.85	51020.9	22.13
Doors	3.90	3.90	1.14	4044.2	1.75
Exposed floors	92.81	92.81	6.21	16342.9	7.09
South windows	3.62	3.62	.36	11893.2	5.16
East windows	3.34	3.34	.36	10992.2	4.77
West windows	1.95	1.95	.36	6407.7	2.78
				=========	=======
		ZONE 1 Totals:		115006.4	49.89

Ventilation

House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
321.43 m3	.915 ACH	115528.0	50.11

*** AIR LEAKAGE AND VENTILATION ***

Building Envelope Surface Area = 325.5 m2
Air Tightness Level is Present (3.57 ACH @50 Pa.)

Terrain Description		Height	m
@ Weather Station :	Open flat terrain, grass	Anemometer	10.0
@ Building site :	Open flat terrain, grass	Bldg. Eaves	3.7

Local Shielding- Walls: Light local shielding
Flue : Light local shielding

Leakage Fractions - Ceiling: .300 Walls: .500 Floors: .200

Estimated Equivalent Leakage Area @ 10 Pa.	=	406.6 cm2
Normalized Leakage Area @ 10 Pa.	=	1.2491 cm2/m2
Estimated Airflow to cause a 5 Pa Pressure Difference	=	26 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference	=	41 L/s
ELA used to calculate Estimated Airflows	=	162.7 cm2

*** F326 VENTILATION REQUIREMENTS ***

Kitchen,living,dining:	3 rooms @ 5 L/s	= 15 L/s
Bedrooms:	1 rooms @ 10 L/s	= 10 L/s
Bedrooms:	2 rooms @ 5 L/s	= 10 L/s
Bathrooms:	1 rooms @ 5 L/s	= 5 L/s
Basement Rooms:		0 L/s

*** CENTRAL VENTILATION SYSTEM ***

System Type : Fans without heat recovery
Manufacturer:
Model Number:

Mechanical Ventilator Fan Power = 125. Watts

*** AIR LEAKAGE AND VENTILATION SUMMARY ***

F326 Required continuous ventilation rate	=	40.0 L/s (.45 ACH)
Central Ventilation Rate (Balanced)	=	28.3 L/s (.32 ACH)
Total house ventilation is Balanced		

Gross Air Leakage and Ventilation Energy Load	=	119470.0 MJ
Seasonal Heat Recovery Ventilator Efficiency	=	.0 %
Estimated Ventilation Electrical Load: Heating Hours	=	3942.0 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours	=	.0 MJ
Net Air Leakage and Ventilation Energy Load	=	117499.0 MJ

*** SPACE HEATING SYSTEM ***

PRIMARY Heating Fuel : Oil
Equipment : Furnace/Boiler with flame ret. head
Manufacturer :
Model :
Output Capacity = 18.9 kW

Steady State Efficiency = 84.0 %

Fan Mode : Auto Fan Power 500. watts
Flue Diameter = 152.4 mm

*** DOMESTIC WATER HEATING SYSTEM ***

PRIMARY Water Heating Fuel :
Water Heating Equipment : No DHW system installed

*** ANNUAL SPACE HEATING SUMMARY ***

Design Heat Loss at -44.0 C = 43.89 Watts/m3 = 14106. Watts

Gross Space Heat Loss	=	230534. MJ
Gross Space Heating Load	=	230534. MJ
Usable Internal Gains	=	2. MJ
Usable Internal Gains Fraction	=	.0 %
Usable Solar Gains	=	15868. MJ
Usable Solar Gains Fraction	=	6.9 %
Auxiliary Energy Required	=	214665. MJ
Space Heating System Load	=	214665. MJ
Furnace/Boiler Seasonal efficiency	=	82.6 %
Furnace/Boiler Annual Energy Consumption	=	254293. MJ

*** BASE LOADS SUMMARY ***

	kwh/day	Annual kWh
Interior Lighting	.0	.0
Appliances	.0	.0
Other	.0	.0
Exterior use	.0	.0
HVAC fans		
HRV/Exhaust	3.0	1095.0
Space Heating	4.2	1536.8
Space Cooling	.0	.0
Total Average Electrical Load	7.2	2631.8

*** FAN OPERATION SUMMARY (kWh) ***

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	1095.0	1536.8	.0
Neither	.0	.0	.0
Cooling	.0	.0	.0
Total	1095.0	1536.8	.0

*** R-2000 HOME PROGRAM ENERGY CONSUMPTION SUMMARY REPORT ***

Estimated Annual Space Heating Energy Consumption = 259826. MJ = 72173.8 kWh
Ventilator Electrical Consumption: Heating Hours = 3942. MJ = 1095.0 kWh
Estimated Annual DHW Heating Energy Consumption = 0. MJ = .0 kWh

ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION = 263768. MJ = 73268.8 kWh
ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET = 92369. MJ = 25658.2 kWh

*** ESTIMATED ANNUAL FUEL CONSUMPTION SUMMARY ***

Fuel		Space Heating	Space Cooling	DHW Heating	Appliances	Total
Oil	(Litres)	6600.9	.0	.0	.0	6600.9
Electricity	(kWh)	2631.8	.0	.0	.0	2631.8

*** ESTIMATED ANNUAL FUEL CONSUMPTION COSTS ***

Fuel Costs Library = C:\HME\9504-VNT\AUDIT\9504FUEL.CST

RATE	Electricity (T3-ELEC)	Natural Gas (T3-NG-ND)	Oil (T3-OIL)	Propane (T3-PR-ND)	Wood (T3-WD-ND)	Total
$	1052.73	.00	4564.56	.00	.00	5617.29

APPENDIX F

TABLE F1: POTENTIAL HEATING SYSTEMS' LIFETIME COSTS IN THREE SAMPLE NORTHERN COMMUNITY TYPES

	TYPE1	TYPE2	TYPE3
	$/GJ	$/GJ	$/GJ
Oil	$10.26	$14.11	$17.95
Propane	$19.59		
Electricity	$41.67	$83.33	$111.11
	$/L	$/L	$/L
Oil	$0.40	$0.55	$0.70
Propane	$0.50	na	na
	$/kWh	$/kWh	$/kWh
Electricity	$0.15	$0.30	$0.40

	TYPE 1 OIL FURNACE 500W ELECTRICITY (300W for blower motor; 200W for fuel pump & components)	TYPE 1 OIL FURNACE 400W ELECTRICITY (200W for blower motor; 200W for fuel pump & components)	TYPE 1 OIL FAN COIL 570W ELECTRICITY (300W for blower motor; 270W for fuel pump & components)	TYPE 1 OIL BOILER 300W ELECTRICITY (300W for fuel pump circulation pump & components)	TYPE 1 PROPANE FURNACE 300W ELECTRICITY (300W for blower motor)	TYPE 1 PROPANE FURNACE 200W ELECTRICITY (200W for blower motor)	TYPE 1 ELECTRIC HEAT FURNACE	TYPE 1 ELECTRIC HEAT BASEBOARD
1. ELECTRICITY COST	$143	$114	$158	$118	$118	$79	$7,541	$7,541
Furnace Life 15 yr Cost	$2,145	$1,710			$1,770	$1,185	$113,115	
Boiler Life 20 yr Cost				$2,360				
Fan Coil / DHW Tank 15 yr Cost			$2,370					
Baseboard Life 30 yrs Cost								$226,230
2. FUEL COST:								
OIL	$2,289	$2,296	$2,398	$2,289				
PROPANE					$4,363	$4,381		
Furnace Life 15 yr Cost	$34,335	$34,440			$65,445	$65,715		
Fan Coil / DHW Tank 15 yr Cost			$35,970					
Boiler Life 20 yr Cost				$45,780				
Baseboard Life 30 yrs Cost								
3. ANNUAL MAINTENANCE & REPAIR	$180	$180	$200	$250	$50	$50	$25	$10
Furnace Life 15 yr Cost	$2,700	$2,700			$750	$750	$375	
Fan Coil / DHW Tank 15 yr Cost			$3,000					
Boiler Life 20 yr Cost				$5,000				
Baseboard Life 30 yrs Cost								$300
4. TOTAL OPERATING COSTS: (1. + 2.+ 3.)								
Furnace	$39,180	$38,850			$67,965	$67,650	$113,490	
Fan Coil / DHW Tank			$41,340					
Boiler				$50,780				
Baseboard								$226,230
5. EQUIPMENT & INSTALLATION COST	$5,700	$6,000	$7,000	$15,000	$6,500	$7,500	$6,500	$4,000
LIFE-TIME COST (4. + 5.)	$44,880	$44,850	$48,340	$65,780	$74,465	$75,150	$119,990	$230,230
LIFETIME COST PER YEAR OF LIFE	$2,992	$2,990	$3,223	$3,289	$4,964	$5,010	$7,999	$7,674

TABLE F1: POTENTIAL HEATING SYSTEMS' LIFETIME COSTS IN THREE SAMPLE NORTHERN COMMUNITY TYPES

	TYPE 2 OIL FURNACE 500W ELECTRICITY (300W for blower motor; 200W for fuel pump &components)	TYPE 2 OIL FURNACE 400W ELECTRICITY (200W for blower motor; 200W for fuel pump &components)	TYPE 2 OIL FAN COIL 570W ELECTRICITY (300W for blower motor; 270W for fuel pump &components)	TYPE 2 OIL BOILER 300W ELECTRICITY (300W for fuel pump, circulation pump &components)	TYPE 3 OIL FURNACE 500W ELECTRICITY (300W for blower motor; 200W for fuel pump &components)	TYPE 3 OIL FURNACE 400W ELECTRICITY (200W for blower motor; 200W for fuel pump &components)
1. ELECTRICITY COST	$349	$279	$385	$209	$615	$492
Furnace Life 15 yr Cost	$5,235	$4,185			$9,225	$7,380
Boiler Life 20 yr Cost				$4,185		
Fan Coil / DHW Tank 15 yr Cost			$5,775			
Baseboard Life 30 yrs Cost						
2. FUEL COST:						
OIL	$2,699	$2,711	$2,847	$2,699	$4,565	$4,565
Furnace Life 15 yr Cost	$40,485	$40,665			$68,475	$68,475
Fan Coil / DHW Tank 15 yr Cost			$42,705			
Boiler Life 20 yr Cost				$53,980		
3. ANNUAL MAINTENANCE & REPAIR	$240	$240	$260	$300	$240	$240
Furnace Life 15 yr Cost	$3,600	$3,600			$3,600	$3,600
Fan Coil / DHW Tank 15 yr Cost			$3,900			
Boiler Life 20 yr Cost				$6,000		
4. TOTAL OPERATING COSTS: (1. + 2.+ 3.)						
Furnace	$49,320	$48,450			$81,300	$79,455
Fan Coil / DHW Tank			$52,380			
Boiler				$64,165		
Baseboard						
5. EQUIPMENT & INSTALLATION COST	$9,500	$10,000	$11,000	$22,000	$9,500	$10,000
LIFE-TIME COST (4. + 5.)	**$58,820**	**$58,450**	**$63,380**	**$86,165**	**$90,800**	**$89,455**
LIFETIME COST PER YEAR OF LIFE	**$3,921**	**$3,897**	**$4,225**	**$4,308**	**$6,053**	**$5,964**

TABLE F2: VENTILATION SYSTEM OPERATING COSTS IN THREE SAMPLE NORTHERN COMMUNITIES

TYPE 1 COMMUNITY ELECTRICITY COST/kWh $0.15

	TYPE 1 CONTINUOUS OPERATION 125W DEDICATED HRV	TYPE 1 CONTINUOUS OPERATION 125 W HRV COUPLED WITH 300W FORCED AIR SYSTEM	TYPE 1 CONTINUOUS OPERATION 125 W HRV COUPLED WITH 200W FORCED AIR SYSTEM	TYPE 1 CONTINUOUS OPERATION 125W MIXING BOX	TYPE 1 CONTINUOUS OPERATION 300W BLOWER MOTOR 100W CENTRAL EXHAUST	TYPE 1 CONTINUOUS OPERATION 200W BLOWER MOTOR 100W CENTRAL EXHAUST
1. ELECTRICITY COST	$164	$557	$426	$164	$524	$393
Equipment Life 15 yr Cost	$2,458	$8,358	$6,391	$2,458	$7,866	$5,900
2. ANNUAL MAINTENANCE AND REPAIR	$25	$25	$25	$10	$10	$10
Equipment Life 15 yr Cost	$375	$375	$375	$150	$150	$150
3. TOTAL 15 YR OPERATING COST: (1. + 2.)	$2,833	$8,733	$6,766	$2,608	$8,016	$6,050
4. EQUIPMENT& INSTALLATION COST	$5,125	$4,125	$4,425	$3,300	$200	$500
LIFE-TIME COST (3. + 4.)	$7,958	$12,858	$11,191	$5,908	$8,216	$6,550
LIFE-TIME COST PER YEAR OF LIFE	$531	$857	$746	$394	$548	$437
HRV HEAT RECOVERY SAVINGS	($230)	($230)	($230)			
NET LIFE-TIME COST PER YEAR	$301	$627	$516	$394	$548	$437

TYPE 2 COMMUNITY ELECTRICITY COST/kWh $0.30 — **TYPE 3 COMMUNITY ELECTRICITY COST/kWh $0.40**

	TYPE 2 CONTINUOUS OPERATION 125W MIXING BOX	TYPE 2 CONTINUOUS OPERATION 300W BLOWER MOTOR 100W CENTRAL EXHAUST	TYPE 2 CONTINUOUS OPERATION 200W BLOWER MOTOR 100W CENTRAL EXHAUST	TYPE 3 CONTINUOUS OPERATION 125W MIXING BOX	TYPE 3 CONTINUOUS OPERATION 300W BLOWER MOTOR 100W CENTRAL EXHAUST	TYPE 3 CONTINUOUS OPERATION 200W BLOWER MOTOR 100W CENTRAL EXHAUST
1. ELECTRICITY COST	$328	$1,049	$787	$437	$1,398	$1,048.80
Equipment Life 15 yr Cost	$4,916	$15,732	$11,799	$6,555	$20,976	$15,732.00
2. ANNUAL MAINTENANCE AND REPAIR	$10	$10	$10	$10	$10	$10.00
Equipment Life 15 yr Cost	$150	$150	$150	$150	$150	$150.00
3. TOTAL 15 YR OPERATING COST: (1. + 2.)	$5,066	$15,882	$11,949	$6,705	$21,126	$15,882.00
4. EQUIPMENT& INSTALLATION COST	$3,100	$200	$500	$3,100	$200	$500.00
LIFE-TIME COST (3. + 4.)	$8,166	$16,082	$12,449	$9,805	$21,326	$16,382.00
LIFE-TIME COST PER YEAR OF LIFE	$544	$1,072	$830	$654	$1,422	$1,092.13

TABLE F3: CALCULATIONS ON POTENTIAL VENTILATION AIR DISCHARGE TEMPERATURES

	Mixed Air Temperature @ - 40°C with 21°C Return Air		Mixed Air Temperature @ - 50°C with 21°C Return Air	Mixed Air Temperature @ - 40°C with 30°C Return Air	Mixed Air Temp @ - 50°C with 30°C Return Air
FORCED AIR DISTRIBUTION SYSTEM					
Supply air into return air plenum	@ 60 cfm	@ 120 cfm	@ 60 cfm		
800 cfm forced air	16.7	12.9	16.0	NA	NA
700 cfm forced air	16.1	11.9	15.3	NA	NA
600 cfm forced air	15.4	10.7	14.5	NA	NA
500 cfm forced air	14.4	9.0	13.3	NA	NA

	Mixed Air Temperature @ - 40°C with 21°C Return Air	Mixed Air Temperature @ - 50°C with 21°C Return Air	Mixed Air Temperature @ - 40°C with 30°C Return Air	Mixed Air Temp @ - 50°C with 30°C Return Air
AIR EXCHANGER SYSTEM			SPACE HEATER	
Freshvent 1001DXB				
Vent rate 70 cfm	-1.8	-5.5	7.2	3.5
Vent rate 60 cfm*	1.4	-1.7	10.4	7.3
Freshvent 1001DXPRO				
Vent rate 85 cfm	0.3	-3.0	9.3	6.0
Vent rate 60 cfm*	6.4	4.1	15.4	13.1

* Ventilation rate dampered down to this level.

NON-HEAT RECOVERY VENTILATOR				
Flair Constructo Air Changer				
Vent rate 60 cfm	6.1	3.7	15.1	12.7
HEAT RECOVERY VENTILATOR				
Effectiveness = 75%	6.5	4.0	12.5	10.0
Effectiveness = 60%	-2.8	-6.8	2.0	-2.0

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	TYPE1-O	TYPE2-O	TYPE3-O
*** COMPONENT ANNUAL HEAT LOSS (MJ) ***	Oil	Oil	Oil
ZONE 1 : ABOVE GRADE	Forced	Air	Furnace
Ceiling	14621.6	13182.6	14305.3
Main Walls	34380.5	44240.5	51020.9
Doors	2829.9	3273.6	4044.2
Exposed floors	.0	15374.2	16342.9
South windows	11528.2	12957.7	11893.2
East windows	5127.8	8152.7	10992.2
North windows	11531.6	.0	.0
West windows	5127.8	5931.8	6407.7
ZONE 1 Totals:	85147.4	103113.1	115006.4
INTER-ZONE Floors	19802.7	.0	.0
ZONE 2 : SHALLOW / FULL BASEMENT			
Basement Walls above grade	8029.3	.0	.0
Upper Basement Walls	3408.3	.0	.0
Lower Basement Walls	5148.9	.0	.0
Full Depth Floor Perimeter	14444.7	.0	.0
Full Depth Floor Centre	9303.4	.0	.0
ZONE 2 Totals:	40334.6	.0	.0
VENTILATION	80554.0	75446.7	115528.0
*** AIR LEAKAGE AND VENTILATION SYSTEMS ***			
House Volume (m3)	681.8	396.6	321.4
Envelope Surface Area (m2)	528.3	366.4	325.5
Natural Infiltration Rate (ACH)	.234	.332	.598
Equivalent Leakage Area (cm2)	862.6	501.7	406.6
Central Ventilation Supply Rate (ACH)	.158	.257	.317
Central Ventilation Exhaust Rate (ACH)	.158	.257	.317
Total Other exhaust flow Rate (ACH)	.000	.000	.000
Seasonal HRV Efficiency (%)	.0	.0	.0
Gross Air and Vent. Energy (MJ)	76264.7	79372.7	119470.0
Vent. Elec. Load: Heating Hrs (MJ)	3873.8	3909.9	3942.0
Vent. Elec. Load: Non Htg Hrs (MJ)	68.2	32.1	.0
Net Air and Vent. Energy (MJ)	82490.9	77401.7	117499.0
*** ANNUAL SPACE HEATING SUMMARY ***			
Design Heat Loss (Watts)	17536.	13972.	14106.
Gross Space Heat Loss (MJ)	206035.9	178559.8	230534.4
Sensible Occupancy Heat Gain (kWh/day)	.00	.00	.00
Usable Internal Gains (MJ)	1.9	2.0	2.0
Usable Internal Gains Fraction (%)	.0	.0	.0
Usable Solar Gains (MJ)	21975.0	18177.5	15867.8
Usable Solar Gains Fraction (%)	10.7	10.2	6.9
Vent. Electrical Contribution (MJ)	1936.9	1955.0	1971.0
Auxiliary Energy Required (MJ)	184059.0	160380.3	214664.6
SPACE + DHW ENERGY (MJ)	230418.0	199350.4	263767.6
R-2000 SPACE + DHW TARGET (MJ)	118995.2	88647.9	92369.4

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	TYPE1-O	TYPE2-O	TYPE3-O
*** LIGHTS, APPLIANCES AND FAN ENERGY SUMMARY ***			
Lighting and Appliances Energy (kWh)	.0	.0	.0
HRV/Exhaust Fan Energy (kWh)	1095.0	1095.0	1095.0
Space Heating Fan Energy (kWh)	952.6	1161.9	1536.8
Space Cooling Fan Energy (kWh)	.0	.0	.0
*** ANNUAL FUEL CONSUMPTION SUMMARY ***			
Electricity (kWh)	2047.6	2256.9	2631.8
Natural Gas (m3)	.0	.0	.0
Oil (Litres)	5791.6	4964.6	6600.9
Propane (Litres)	.0	.0	.0
Wood (1000 kg)	.0	.0	.0
*** ESTIMATED FUEL COSTS (Dollars) ***			
Electricity	307.14	677.07	1052.73
Natural Gas	.00	.00	.00
Oil	2289.16	2698.65	4564.56
Propane	.00	.00	.00
Wood	.00	.00	.00
Total	2596.30	3375.72	5617.29
*** SPACE HEATING SYSTEM PERFORMANCE ***			
Space Heating Load (MJ)	184059.0	160380.3	214664.6
Furnace Input (MJ)	223114.9	191257.6	254293.0
Pilot Light (MJ)	.0	.0	.0
Indoor Fans (MJ)	3429.3	4182.9	5532.6
Heat Pump Input (MJ)	.0	.0	.0
Total Input (MJ)	226544.2	195440.5	259825.6
System COP	.812	.821	.826

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	TYPE1-P	TYPE1-PE	TYPE1-E
*** COMPONENT ANNUAL HEAT LOSS (MJ) ***	Propane		Electric
ZONE 1 : ABOVE GRADE		H.E. Furnace	
Ceiling	14621.6	14621.6	14621.6
Main Walls	34380.5	34380.5	34380.5
Doors	2829.9	2829.9	2829.9
South windows	11528.2	11528.2	11528.2
East windows	5127.8	5127.8	5127.8
North windows	11531.6	11531.6	11531.6
West windows	5127.8	5127.8	5127.8
ZONE 1 Totals:	85147.4	85147.4	85147.4
INTER-ZONE Floors	19647.8	19647.8	19647.8
ZONE 2 : SHALLOW / FULL BASEMENT			
Basement Walls above grade	8024.3	8024.3	8024.3
Upper Basement Walls	3404.8	3404.8	3404.8
Lower Basement Walls	5143.7	5143.7	5143.7
Full Depth Floor Perimeter	14430.2	14430.2	14430.2
Full Depth Floor Centre	9294.0	9294.0	9294.0
ZONE 2 Totals:	40297.1	40297.1	40297.1
VENTILATION	77356.1	77356.0	77356.1
*** AIR LEAKAGE AND VENTILATION SYSTEMS ***			
House Volume (m3)	681.8	681.8	681.8
Envelope Surface Area (m2)	528.3	528.3	528.3
Natural Infiltration Rate (ACH)	.218	.218	.218
Equivalent Leakage Area (cm2)	862.6	862.6	862.6
Central Ventilation Supply Rate (ACH)	.158	.158	.158
Central Ventilation Exhaust Rate (ACH)	.158	.158	.158
Total Other exhaust flow Rate (ACH)	.000	.000	.000
Seasonal HRV Efficiency (%)	.0	.0	.0
Gross Air and Vent. Energy (MJ)	73381.2	73381.2	73381.3
Vent. Elec. Load: Heating Hrs (MJ)	3873.8	3873.8	3873.8
Vent. Elec. Load: Non Htg Hrs (MJ)	68.2	68.2	68.2
Net Air and Vent. Energy (MJ)	79293.0	79293.0	79293.0
*** ANNUAL SPACE HEATING SUMMARY ***			
Design Heat Loss (Watts)	17202.	17202.	17202.
Gross Space Heat Loss (MJ)	202800.6	202800.5	202800.6
Sensible Occupancy Heat Gain (kWh/day)	.00	.00	.00
Usable Internal Gains (MJ)	1.9	1.9	1.9
Usable Internal Gains Fraction (%)	.0	.0	.0
Usable Solar Gains (MJ)	21819.4	21819.4	21819.4
Usable Solar Gains Fraction (%)	10.8	10.8	10.8
Vent. Electrical Contribution (MJ)	1936.9	1936.9	1936.9
Auxiliary Energy Required (MJ)	180979.3	180979.2	180979.3
SPACE + DHW ENERGY (MJ)	229392.1	202472.8	184853.1
R-2000 SPACE + DHW TARGET (MJ)	118995.2	118995.3	95196.2

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	TYPE1-P	TYPE1-PE	TYPE1-E
***** LIGHTS, APPLIANCES AND FAN ENERGY SUMMARY *****			
Lighting and Appliances Energy (kWh)	.0	.0	.0
HRV/Exhaust Fan Energy (kWh)	1095.0	1095.0	1095.0
Space Heating Fan Energy (kWh)	784.3	784.3	784.3
Space Cooling Fan Energy (kWh)	.0	.0	.0
***** ANNUAL FUEL CONSUMPTION SUMMARY *****			
Electricity (kWh)	1879.3	1879.3	51367.0
Natural Gas (m3)	.0	.0	.0
Oil (Litres)	.0	.0	.0
Propane (Litres)	8699.0	7647.5	.0
Wood (1000 kg)	.0	.0	.0
***** ESTIMATED FUEL COSTS (Dollars) *****			
Electricity	281.89	281.89	7705.06
Natural Gas	.00	.00	.00
Oil	.00	.00	.00
Propane	4362.59	3835.25	.00
Wood	.00	.00	.00
Total	4644.48	4117.14	7705.06
***** SPACE HEATING SYSTEM PERFORMANCE *****			
Space Heating Load (MJ)	180979.3	180979.2	180979.3
Furnace Input (MJ)	222694.8	195775.6	178155.9
Pilot Light (MJ)	.0	.0	.0
Indoor Fans (MJ)	2823.4	2823.4	2823.4
Heat Pump Input (MJ)	.0	.0	.0
Total Input (MJ)	225518.2	198599.0	180979.3
System COP	.803	.911	1.000

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	T1-O-HRV	T1-O-FC	T2-O-FC
*** COMPONENT ANNUAL HEAT LOSS (MJ) ***	Oil	Oil	Oil
ZONE 1 : ABOVE GRADE	HRV	Fan Coil Unit	
Ceiling	14621.6	14621.6	13182.6
Main Walls	34380.5	34380.5	44240.5
Doors	2829.9	2829.9	3273.6
Exposed floors	.0	.0	15374.2
South windows	11528.2	11528.2	12957.7
East windows	5127.8	5127.8	8152.7
North windows	11531.6	11531.6	.0
West windows	5127.8	5127.8	5931.8
ZONE 1 Totals:	85147.4	85147.4	103113.1
INTER-ZONE Floors	20542.8	20022.1	.0
ZONE 2 : SHALLOW / FULL BASEMENT			
Basement Walls above grade	7996.1	8027.4	.0
Upper Basement Walls	3385.4	3407.0	.0
Lower Basement Walls	5114.3	5146.9	.0
Full Depth Floor Perimeter	14347.9	14439.2	.0
Full Depth Floor Centre	9241.1	9299.8	.0
ZONE 2 Totals:	40084.7	40320.3	.0
VENTILATION	61119.4	75386.0	70863.3
*** AIR LEAKAGE AND VENTILATION SYSTEMS ***			
House Volume (m3)	681.8	681.8	396.6
Envelope Surface Area (m2)	528.3	528.3	366.4
Natural Infiltration Rate (ACH)	.234	.218	.308
Equivalent Leakage Area (cm2)	862.6	862.6	501.7
Central Ventilation Supply Rate (ACH)	.158	.158	.257
Central Ventilation Exhaust Rate (ACH)	.158	.158	.257
Total Other exhaust flow Rate (ACH)	.000	.000	.000
Seasonal HRV Efficiency (%)	64.6	.0	.0
Gross Air and Vent. Energy (MJ)	75874.5	75318.2	78715.2
Vent. Elec. Load: Heating Hrs (MJ)	3167.2	7747.7	7819.8
Vent. Elec. Load: Non Htg Hrs (MJ)	60.0	136.3	64.2
Net Air and Vent. Energy (MJ)	62702.9	79259.8	74773.2
*** ANNUAL SPACE HEATING SUMMARY ***			
Design Heat Loss (Watts)	17530.	17201.	13816.
Gross Space Heat Loss (MJ)	186351.5	200853.6	173976.3
Sensible Occupancy Heat Gain (kWh/day)	.00	.00	.00
Usable Internal Gains (MJ)	1.9	1.9	2.0
Usable Internal Gains Fraction (%)	.0	.0	.0
Usable Solar Gains (MJ)	21613.5	21761.6	18044.0
Usable Solar Gains Fraction (%)	11.6	10.8	10.4
Vent. Electrical Contribution (MJ)	1583.6	3873.8	3909.9
Auxiliary Energy Required (MJ)	164736.0	179090.1	155930.4
SPACE + DHW ENERGY (MJ)	206888.8	245269.9	214187.2
R-2000 SPACE + DHW TARGET (MJ)	118995.2	118995.2	88647.9

*** HOUSE DATA COMPARISON REPORT ***

	House File Name		
	T1-O-HRV	T1-O-FC	T2-O-FC
*** LIGHTS, APPLIANCES AND FAN ENERGY SUMMARY ***			
Lighting and Appliances Energy (kWh)	.0	.0	.0
HRV/Exhaust Fan Energy (kWh)	896.4	2190.0	2190.0
Space Heating Fan Energy (kWh)	852.6	1053.9	1283.1
Space Cooling Fan Energy (kWh)	.0	.0	.0
*** ANNUAL FUEL CONSUMPTION SUMMARY ***			
Electricity (kWh)	1749.0	3243.9	3473.1
Natural Gas (m3)	.0	.0	.0
Oil (Litres)	5208.5	6067.1	5236.9
Propane (Litres)	.0	.0	.0
Wood (1000 kg)	.0	.0	.0
*** ESTIMATED FUEL COSTS (Dollars) ***			
Electricity	262.35	486.58	1041.94
Natural Gas	.00	.00	.00
Oil	2058.69	2398.05	2846.67
Propane	.00	.00	.00
Wood	.00	.00	.00
Total	2321.05	2884.64	3888.61
*** SPACE HEATING SYSTEM PERFORMANCE ***			
Space Heating Load (MJ)	164736.0	179090.1	155930.4
Furnace Input (MJ)	200652.3	233728.2	201748.1
Pilot Light (MJ)	.0	.0	.0
Indoor Fans (MJ)	3069.3	3794.0	4619.3
Heat Pump Input (MJ)	.0	.0	.0
Total Input (MJ)	203721.6	237522.2	206367.4
System COP	.809	.754	.756

APPENDIX G

State-of-the-Art Product Information

GSW

GSW WATER HEATING COMPANY
A Division of GSW Inc.
599 Hill Street West, Fergus, Ontario N1M 2X1

John Wood WATER HEATERS

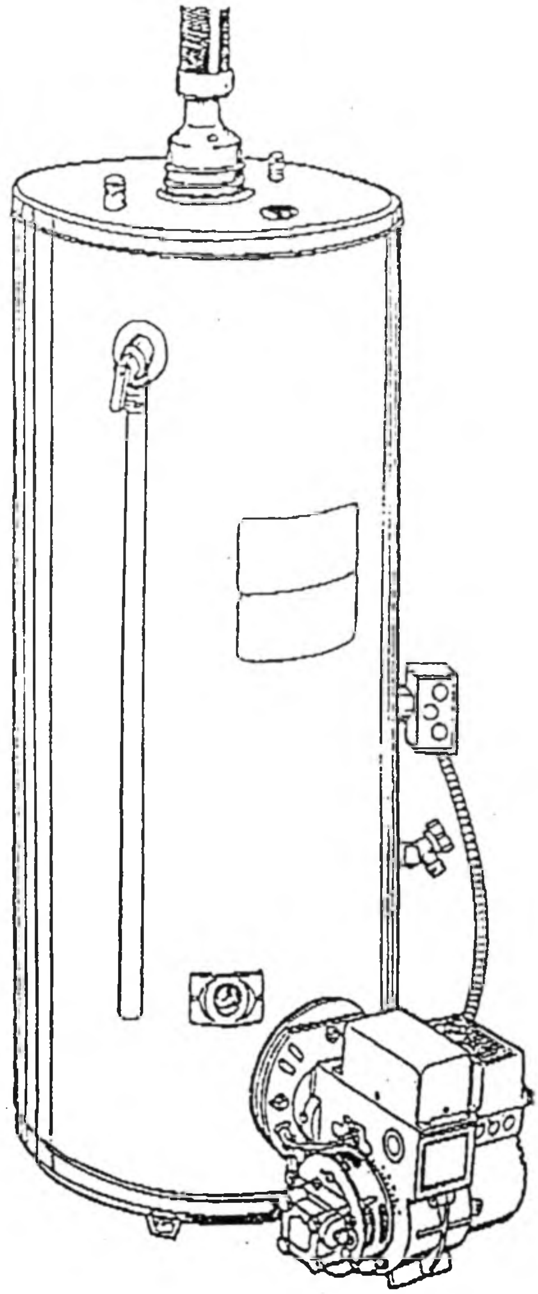
INSTALLATION INSTRUCTIONS FOR THROUGH - THE - WALL VENTING COMPONENTS

These Instructions apply for the installation of the venting duct Including the outdoor vent terminal for the JWF307V "Through-The-Wall" Vented Oil Fired Water Heater.

The general installation instructions in the manual, No. 62662 for GSW Oil Fired Water Heaters apply, with the exception of the applicable section under "Venting" and the method for "Air Adjustment". The Instructions contained hereln must be followed in its place.

Refer to the following diagram for the identification of the vent components: (Fig 1.)

NOTE: THE VENT COMPONENTS MUST BE USED AS SUPPLIED WITHOUT ANY ALTERATION.

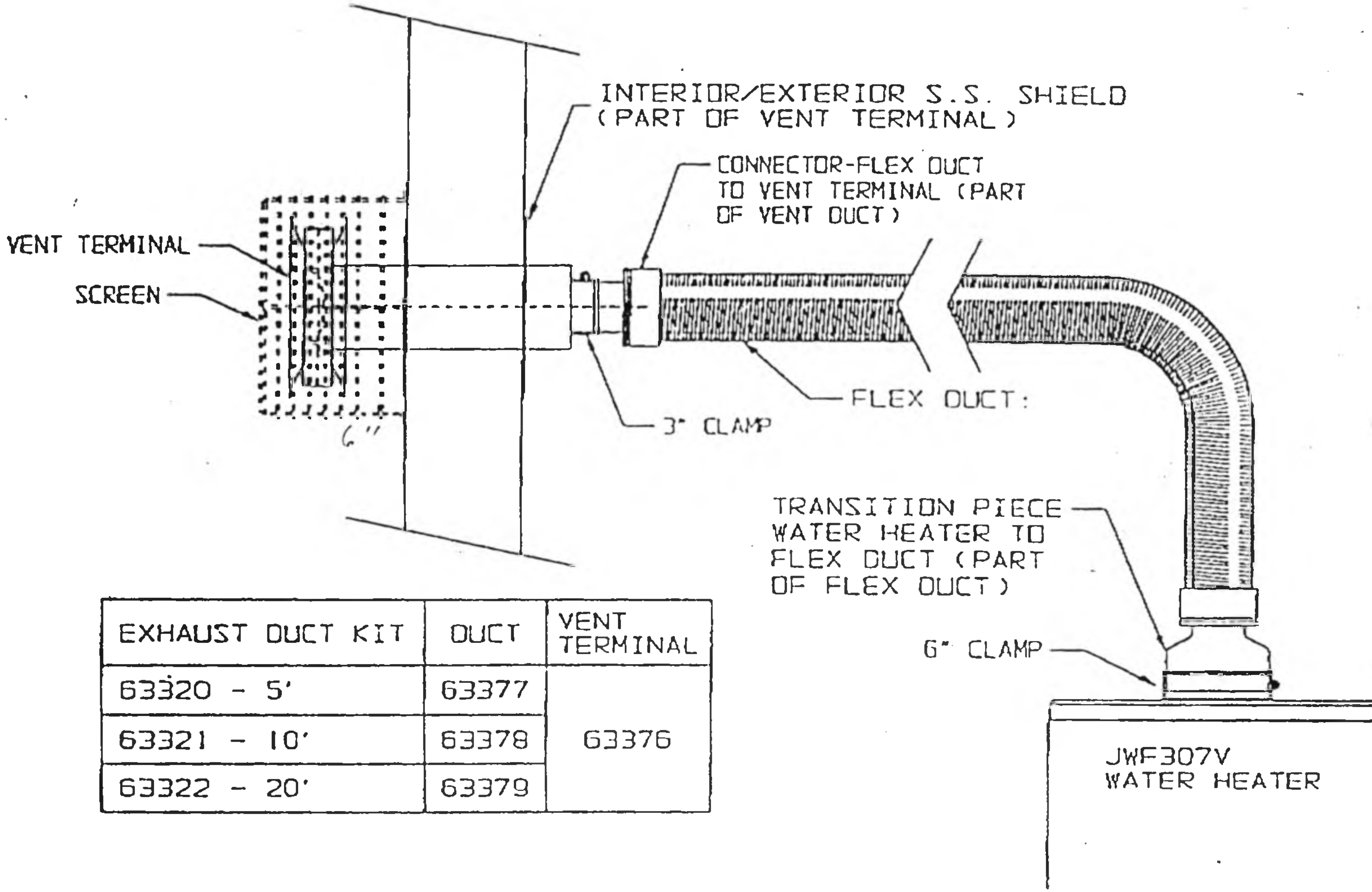


63371

Will Mayhew

403-484-3956

Figure 1

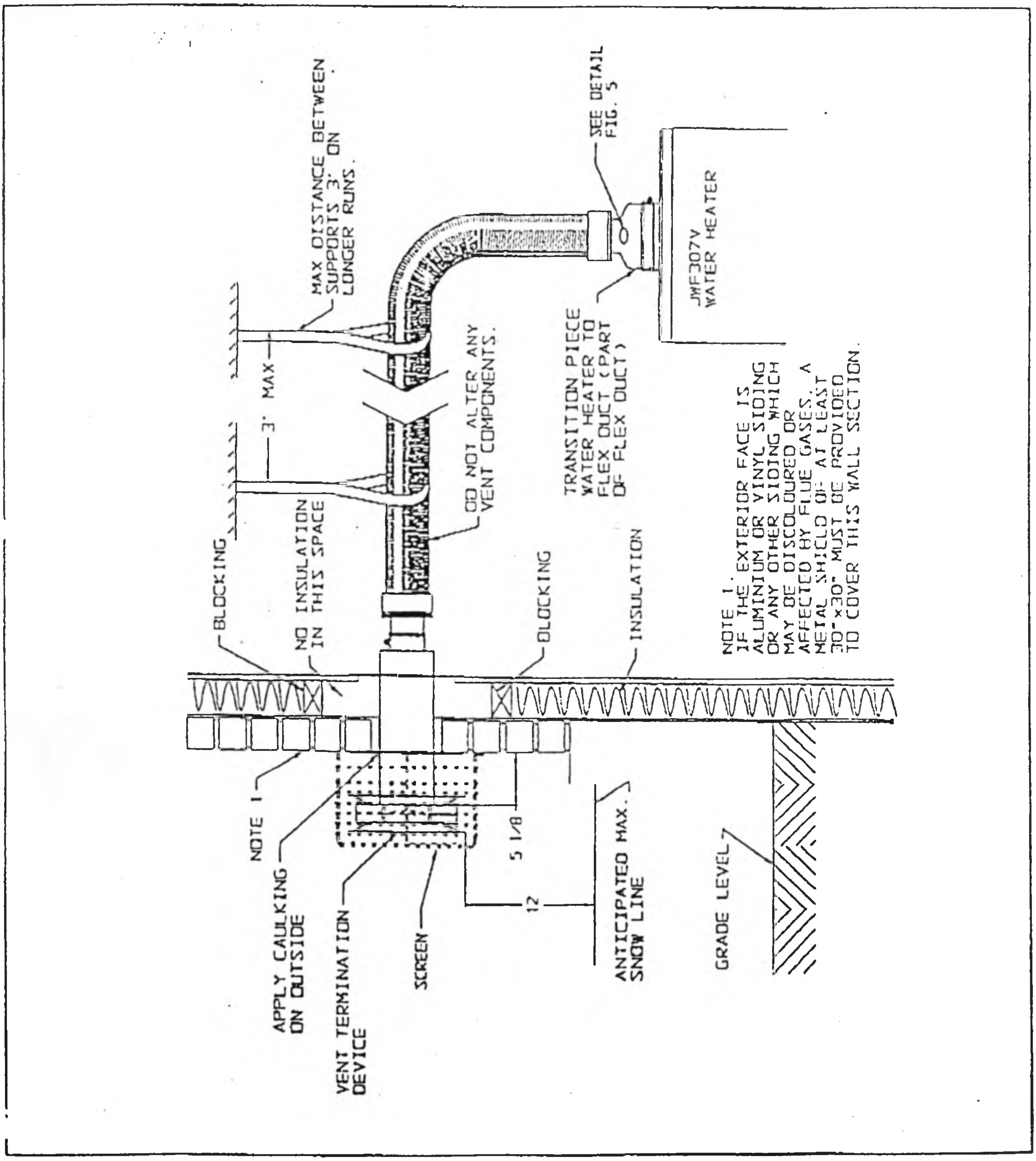


EXHAUST DUCT KIT	DUCT	VENT TERMINAL
63320 - 5'	63377	63376
63321 - 10'	63378	
63322 - 20'	63379	

LOCATION: (See Figure 2)

Locate the water heater as close as possible to an exterior wall to minimize the length of flex duct required. However, the minimum length available is 5 feet and under no circumstances must any component be altered. Consider the direction of predominant winds and the possible snow accumulation against that side of the building.

Figure 2



The vent terminal must have sufficient clearance from ground level so that it will not be buried in snow. The location of the vent terminal must also meet the regulations of the "Installation Code for Oil Burning quipment" CAN/CSA-B 139-M91, section 4.3.2.2: (see also Figure 3)

A vent shall not terminate:

(a) directly above a paved sidewalk or a paved driveway that is located between two buildings, and that serves both buildings;

(b) less than 2.13 m (7 ft.) above any paved sidewalk or any paved driveway;

(c) within 1.8 m (6 ft.) of a window, door, or mechanical air supply inlet to any building, including soffit openings;

(d) above a gas meter/regular assembly within 1 m (3 ft.) horizontally of the vertical centreline of the regulator;

(e) within 1.8 m (6 ft.) of any gas service regulator vent outlet or within 1 m (3 ft.) of an oil tank vent or an oil tank fill inlet;

(f) less than 0.3 m (1 ft.) above grade level;

(g) within 1.8 m (6 ft.) of any combustion air inlet, unless the appliance is otherwise certified;

(h) within 1.8 m (6 ft.) of the property line;

(i) underneath a veranda, porch or deck;

(j) so that the flue gases are directed at combustible material or any openings of surrounding buildings that are within 1.8 m (6 ft.)'

(k) les that 1 m (3 ft.) from an inside corner of an L-shaped structure;

(l) so that the bottom of the vent termination opening is less than 0.3 m (1 ft.) above any surface that may support snow, ice or debris;

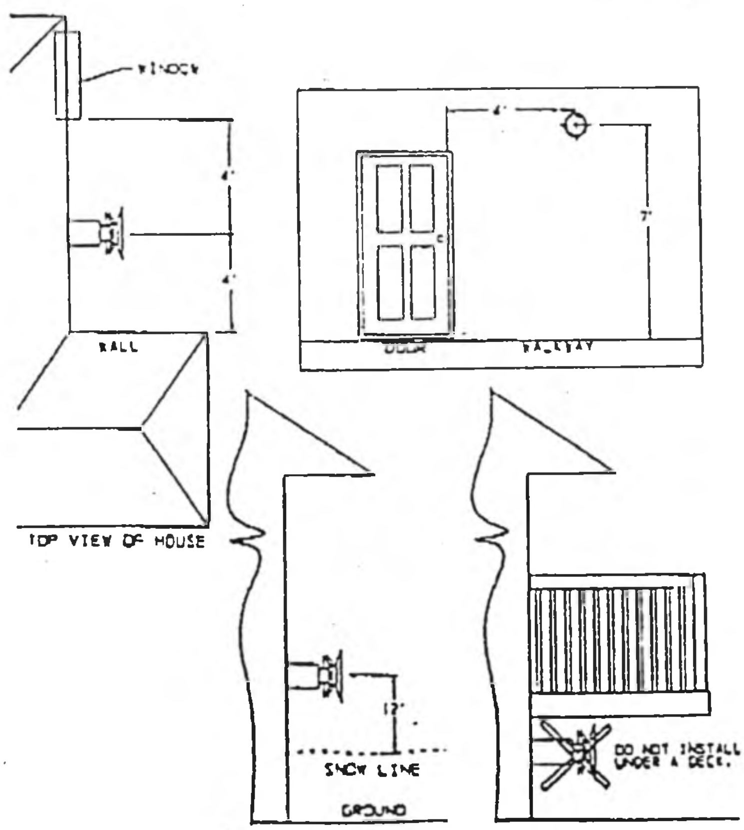
(m) so that the flue gases are directed towards brickwork, siding or other construction, in such a manner that may cause damage from heat or condensate from the flue gases.

Do not locate the vent terminal near shrubs or garden plants since the hot flue gas may stunt or kill any growth.

Figure 3

LOCATION OF VENT TERMINAL

The following dimensions are minimum allowable distances



DETAILED INSTRUCTIONS

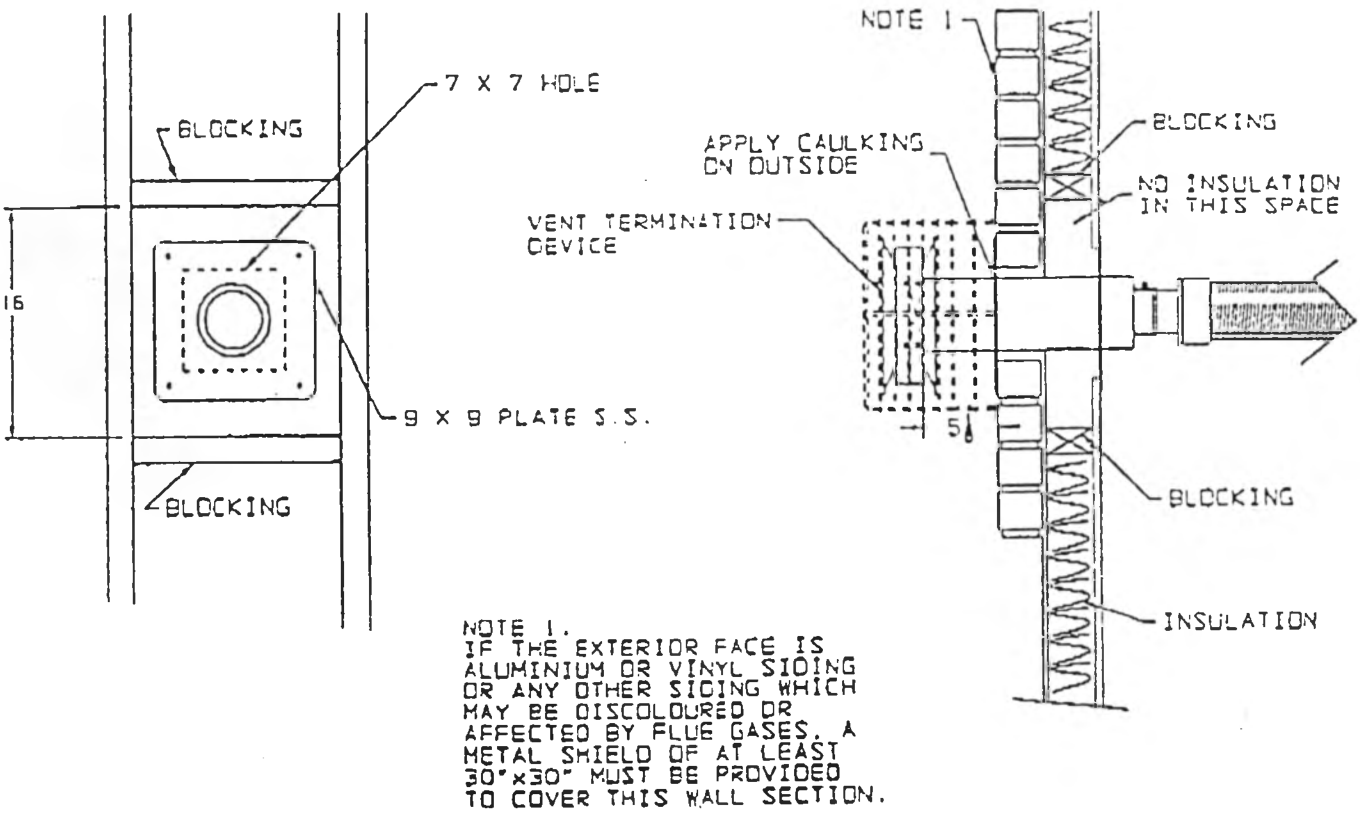
Drill or cut an opening through the exterior wall and fasten the vent terminal as shown in figure 4.

Push the vent terminal from the outside through the wall and fasten the outer shield with the 4 screws provided.

Seal around the perimeter of the outer shield with caulking material which has a temperature rating of at least 75° C (167° F). Note: a silicone type of caulking is recommended.

From inside the home, place the second shield around the tube of the vent terminal and fasten it with the 4 screws provided. Tighten the gear clamp securely. This completes the installation of the vent terminal.

Figure 4



Installation Clearances and Clearances to Combustible Materials:	
Heater Sides and Rear	2"
Front of Heater	24" (Access for servicing)
Above Heater	24"
To vent Duct - Horizontal	Above and one side - 1", other side 6" Below Duct - open to room
Floor	non combustible

Maintain clearances to Combustible material (2" x 4" or 2" x 6" framing) as per Table 1. Note: if the flex duct is to be located between joists, the spacers provided must be used to maintain clearances to combustible material.

Inside the home, attach the smaller end of the flex duct to the vent terminal. Use the 3" band clamp with the gasket attached (inside the clamp). The edges of the band clamp must engage both beads (the one on the vent terminal and on the flex duct) so that the gasket straddles the joint.

Run the flex duct to the water heater. All bends should be as generous as possible. Avoid sharp bends. Do not kink the duct.

Support longer horizontal runs. Maximum spacing must not exceed 3 feet. See Figure 2.

If the flex duct is run between ceiling joists, the spacers as provided must be used. See the details in illustration Figure 5.

Figure 5

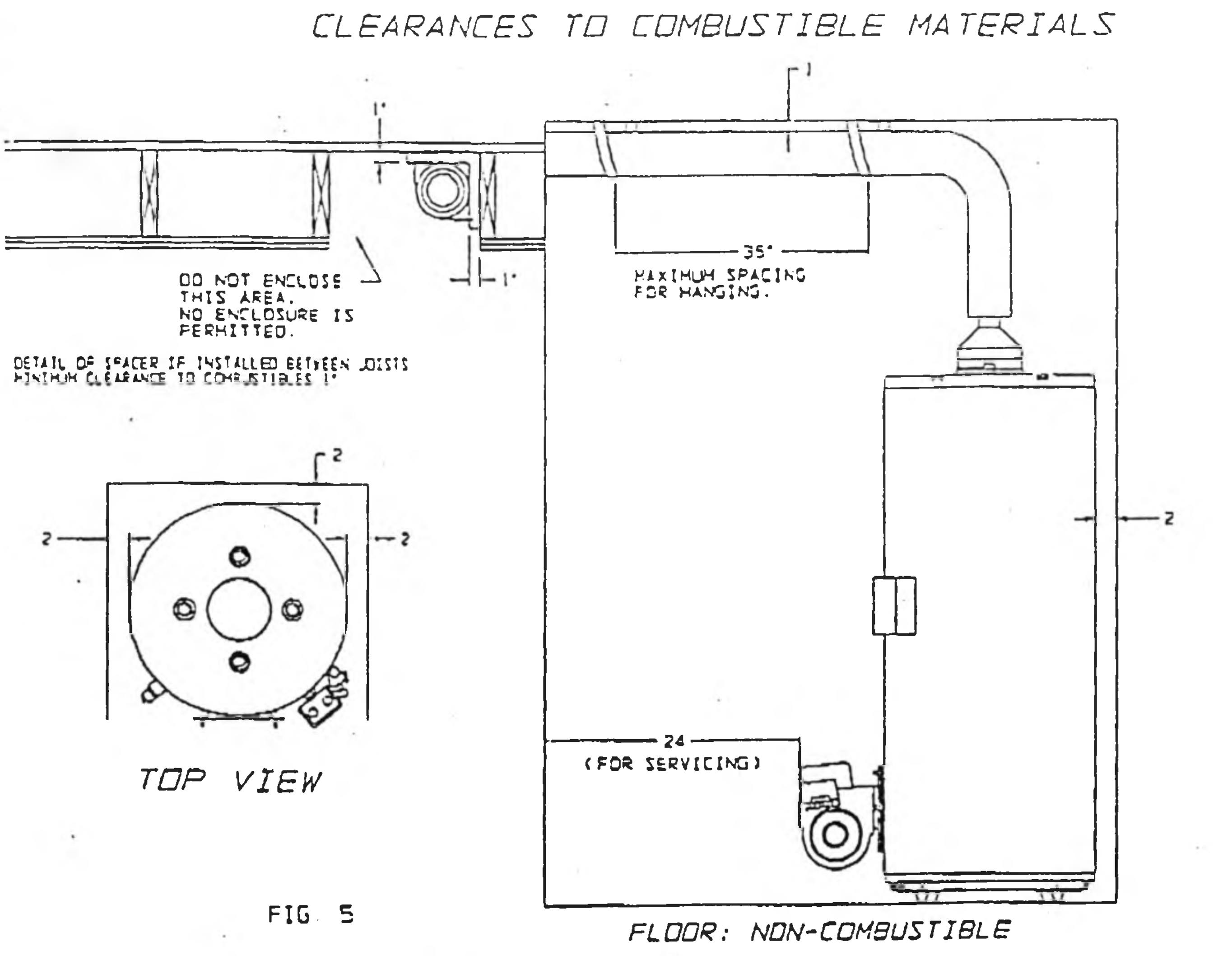


FIG 5

To attach the flex duct to the water heater see Figure 6.

1. Place the band clamp around the transition piece (6" diameter) of the flex duct.
2. Slide the transition piece over the water heater flue outlet.
3. Leave a gap of approximately 5/8" to 3/4" between the edge of the transition piece and the water heater casing top.
4. Slide the band clamp down so that the gasket straddles the edge of the transition piece. The crimp of the clamp must engage the bead on the transition piece.
5. Tighten the gear clamp.

INITIAL START-UP

The burner is equipped with pre-purge and post-purge control. The pre-purge is set for a timing of 15 seconds, +5 seconds, -0 seconds. The post purge is set for 3 minutes.

After the burner has started to fire, allow the heater to operate for 10 to 15 minutes (from a cold start).

Take a smoke reading. An opening for smoke readings is provided in the transition piece of the duct (Figure 7).

The smoke must be adjusted to a maximum of #1 smoke. With an adjustment of #1 smoke, the overfire pressure should be between .20" and .25" W.C. Take care to replace the sealing screw in the overfire pressure test port to prevent flue gas from escaping from the combustion zone into the home. (Figure 8).

TEST FOR LEAKS

With the heater still running, test around the band clamp at the flue connection of the heater for leaks. Use a smoke pencil or similar device. Make sure the clamp is tight and no flue gases escape at this point.

Repeat the procedure at the connection between the flex duct and the vent terminal (inside the house). If leakage is detected, it may be due to misplaced clamps over the joint. Please repair all leaks.

NOTE: The gasketing material is a special high temperature Teflon. DO NOT SUBSTITUTE. If more gasketing is required for repair it can be obtained from this company. See page 7 for replacement parts.

Figure 6

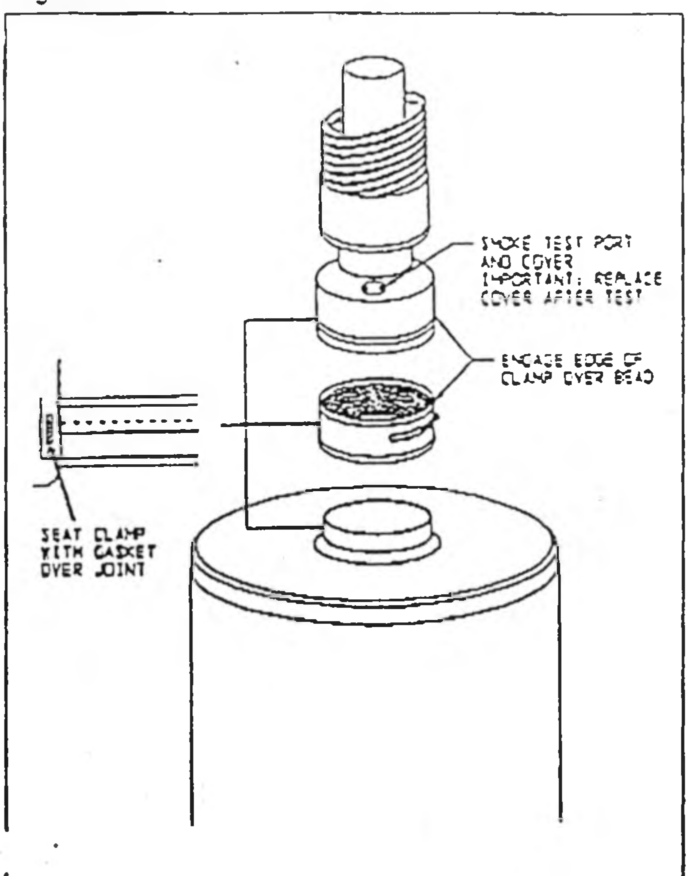


Figure 7

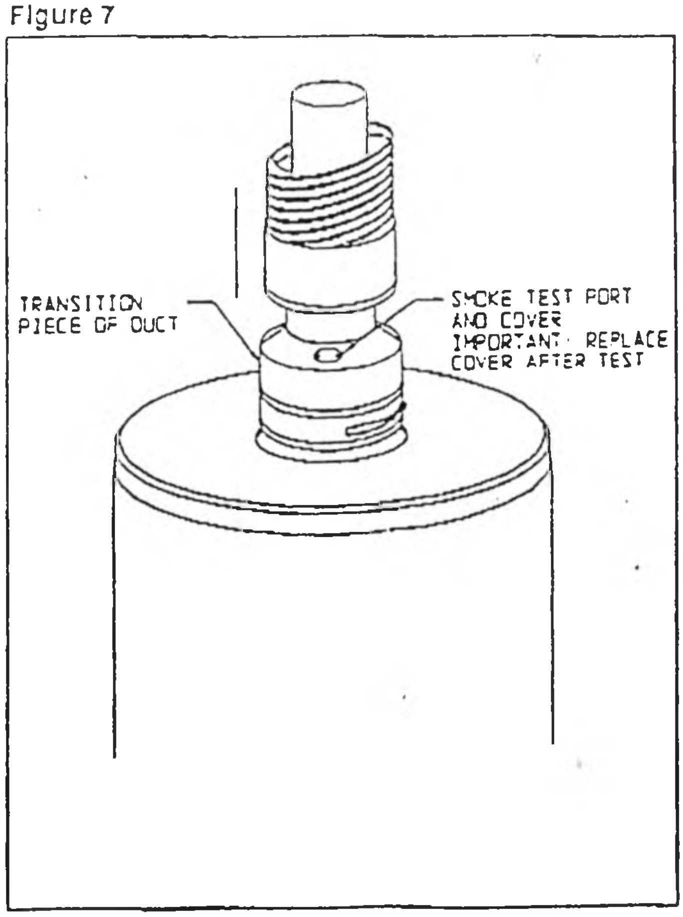
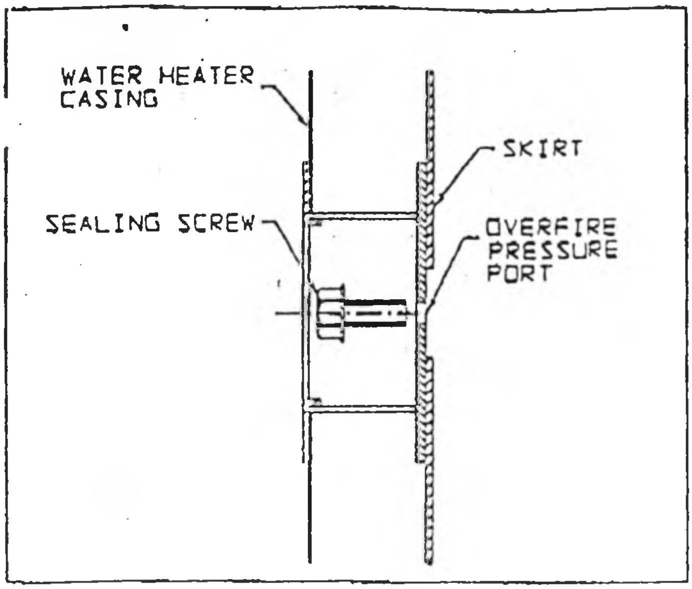


Figure 8



IF YOU CAN SMALL FLUE GASES IN THE HOME, IT IS A SIGN OF LEAKAGE SOMEWHERE IN THE FLUE SYSTEM. CHECK FOR LEAKAGE AT ALL JOINTS OF THE FLEX DUCT (AT THE HEATER CONNECTION AND THE VENT TERMINAL). MAKE SURE THE SMOKE TEST PORT IS SEALED WITH THE COVER AND GASKET. (Figure 7)

ANNUAL INSPECTION

Once a year, inspect all vent joints for leakage as described in the section under "Initial Setup". Inspect the outside vent terminal and remove any debris which may have accumulated.

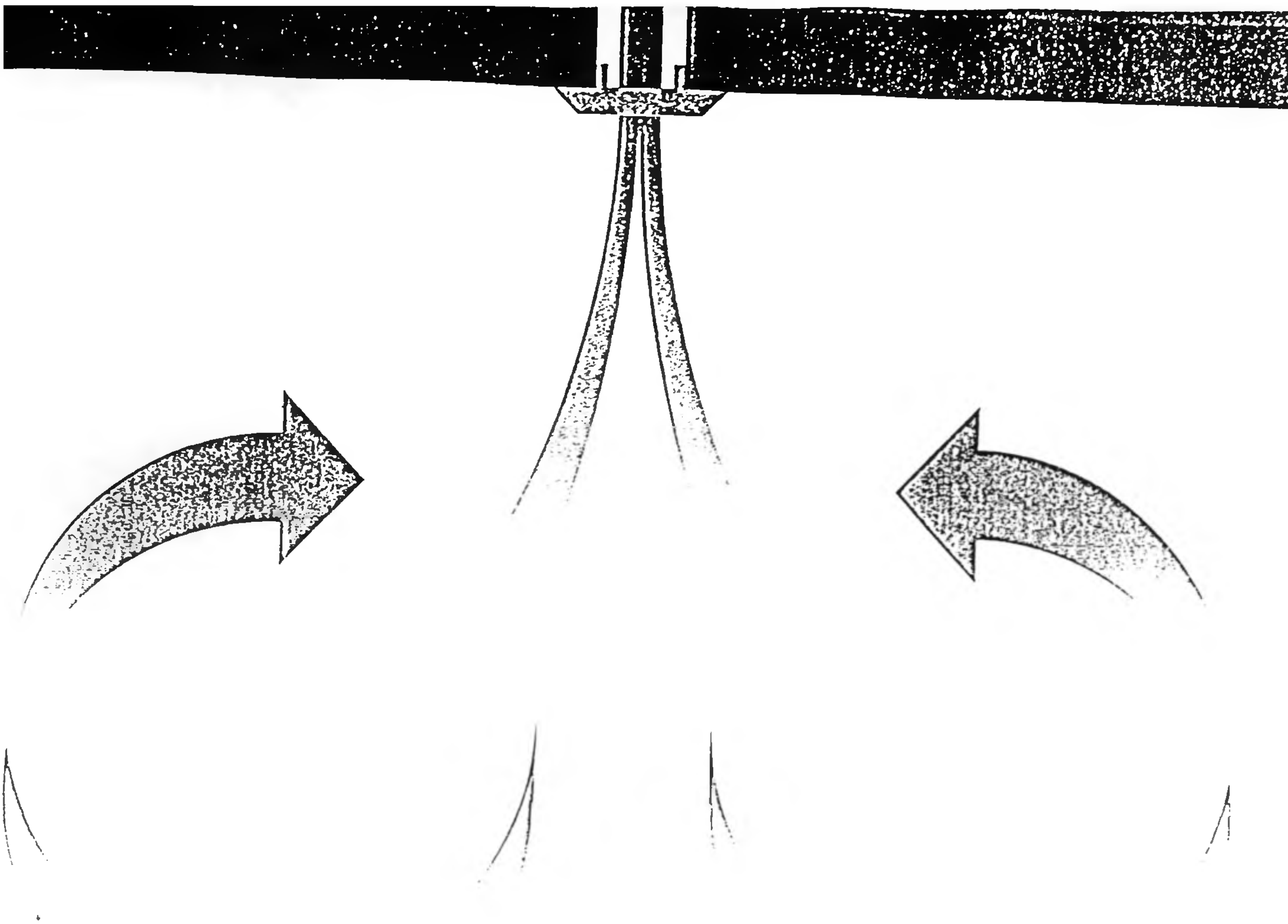
Perform a combustion test and overfire test as described in the same section.

Repair all leaks as required and make the necessary burner adjustments to obtain the prescribed smoke readings at the maximum overfire pressure.

Replace leaking band clamps with new ones as required.

REPLACEMENT PARTS

63376	Termination Device
63377	Flex Duct and Transition 5' Long
63378	Flex Duct and Transition 10' Long
63379	Flex Duct and Transition 20' Long
63386	Termination Screen
63400	Clamp 3" Complete with Gasket
63401	Clamp 6" Complete with Gasket



Hi-V

Presents

SOFT-AIRE

THE OPTIMUM IN HOME COMFORT SYSTEMS

ENERGY SAVING PRODUCTS LTD.

The Hi-Velocity Solution

The **Hi-V** Soft-Aire System provides a gentle air flow for a draft free environment. By utilizing two-inch sound-absorbing insulated flex ducting, it is possible to provide whisper quiet air delivery and near perfect in-room thermal efficiency. Room air is gently stirred to eliminate hot and cold spots associated with other heating systems.

The **Hi-V** system is the answer to all the old irritants home owners often complain about. Noise, dust, drafts, unsightly ducts, registers, and baseboards. Hot and cold spots, even the lack of a "fresh air feeling" are now things of the past.

Hi-V's uniquely designed fan coil and air delivery system allows for versatile unit location.

Each **Hi-V** fan coil has a variable two speed motor which can be adjusted to provide a constant airflow to meet individual home requirements.

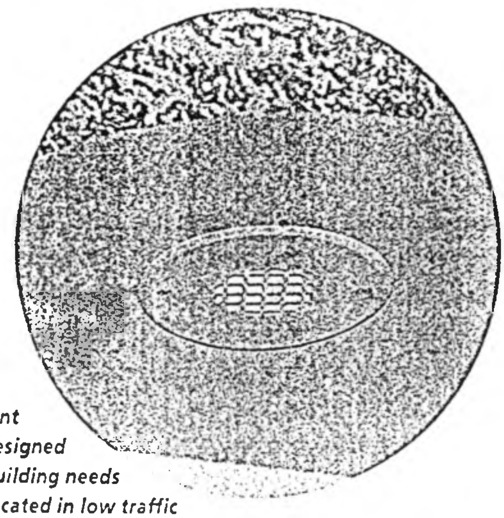
The **Hi-V** fan coil allows for use of night setback thermostats to maximize fuel savings and ensure a comfortable night's sleep.

Very versatile ...a total comfort system.

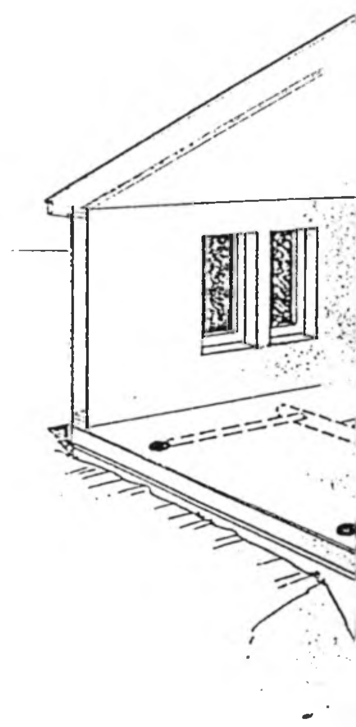
ELDON GJESDAL – DEVELOPER, MONTANA

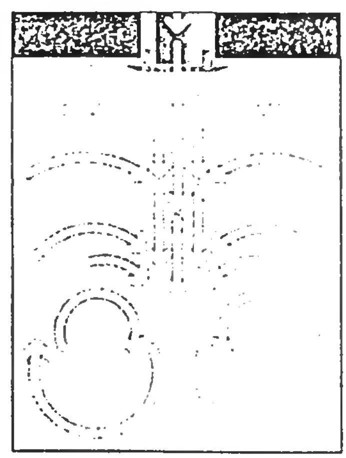
*...extremely satisfied with the performance and efficiency of our **Hi-V** system for more than 10 years.*

RICK LEHMANN – PLUMBING CONTRACTOR, ALBERTA



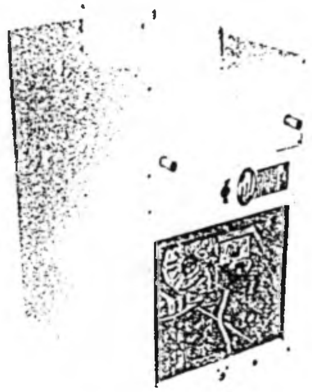
Floor or ceiling vent outlets designed around building needs may be located in low traffic areas. Five-inch round vent plates mean compact air outlets which blend into any decor to increase usable room space.



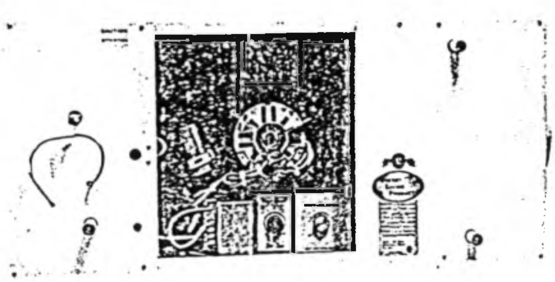


Versatility in outlet placement is enhanced by an air delivery system which uses the venturi effect to increase the mixing of the room air.

For peace of mind and quiet, energy efficient heating and cooling, **Hi-V** is the best choice you can make.



HV-100



HV-70 HDX

DEALER:

Hi-Velocity Specifications

Model	HV-30	HV-50	HV-70	HV-100	HV-100-2
Heating BTUH @ 190 E.W.T.	30,000	50,000	70,000	100,000	50,000 per zone
Heating BTUH @ 150 E.W.T.	22,000	38,000	50,000	72,000	36,000 per zone
Chilled Water BTUH @ 42 E.W.T.	15,000	18,000	22,000	33,000	16,500 per zone
DX-Cooling BTUH	18,000	24,000	36,000	48,000	48,000
Seer Rating	10.2	10.4	10.5	11.1	11.1
C.F.M. @ 1.5" S.P.	450	540	750	1100	1100
Motor H.P./R.P.M.	1/4-1625	1/3-1625	1/2-1625	1/2-1625	1/2-1625
F.L.A. Running	3.0	4.7	8.4	8.4	8.4
Voltage	115/1/60	115/1/60	115/1/60	115/1/60	115/1/60
Hydronic Supply	1/2" Sw.	1/2" Sw.	3/4" Sw.	3/4" Sw.	2-1/2" Sw.
Hydronic Return	1/2" Sw.	1/2" Sw.	3/4" Sw.	3/4" Sw.	3/4" Sw.
Plenum Duct	6" Spiral	8" Spiral	8" Spiral	2-8" Spiral	2-8" Spiral
Branch Duct	2" Flex	2" Flex	2" Flex	2" Flex	2" Flex
Return Air Size	10"	11"	12"	14"	14"
Minumum Outlets	7	13	19	30	30
Maximum Outlets	12	18	27	38	38
Single Coil L/W/H (inches)	24/14/14	30/14/16	32/19/18	32/26/18	32/26/18
Dual Coil L/W/H (inches)	34/14/14	40/14/16	42/19/18	42/26/18	42/26/18

- Seer — Seasonal energy efficiency rating based on WeatherKing Wakea Series
- E.W.T. — Entering water temperature (Deg.F)
- C.F.M. — Air flow in cubic feet per minute
- F.L.A. — Full load amps
- S.P. — Static pressure

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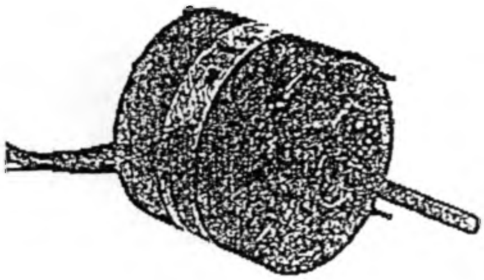
Air Moving Motors

Single Phase

Direct Drive Furnace and Central Air Conditioning



Features

- Energy Saver and standard efficiency designs
- Reversible rotation
- Mounting holes in shell for capacitor bracket
- Designed for 370 Volt capacitor (not furnished)
- 4" shaft extension
- Operational on 60 or 50 Hertz, unless otherwise noted
- Extended clamp screws on shaft end with a ring kit provided
- Ring kit allows both 2 1/4" and 2 1/2" resilient ring mounting
- Automatic thermal overload protection

Applications

Designed for continuous air over applications, such as furnace blowers or central air handling units with single shaft requirements

Permanent Split Capacitor - 5 1/2" Diameter - Two and Three Speed

	HP	RPM	Speeds	Volts	Brgs.	Base	Rotation	Full Load Amps @ NP Volts	Catalog No.	Price	Wt.	Mtg. Dim.	Cap (mfd)	'C' Dim.	Notes
ES	1/4	1625	3	115	Slv	RRE	CCW/CW	2.7	3992 ✱	166	12	E7	10.0	9.1	
ES	1/4	1625	3	208-230	Slv	RRE	CCW/CW	1.2	3993	168	12	E7	5.0	9.1	
	1/4	1075	2	115	Slv	RRE	CCW/CW	4.2	3383	89	12	E7	5.0	9.1	5
	1/4	1075	3	115	Slv	RRE	CCW/CW	4.2	3583	94	12	E7	5.0	9.1	5
ES	1/4	1075	3	115	Slv	RRE	CCW/CW	3.7	3983	120	13	E10	7.5	9.6	5
	1/4	1075	2	208-230	Slv	RRE	CCW/CW	2.0	3384	91	12	E7	5.0	9.1	
	1/4	1075	3	208-230	Slv	RRE	CCW/CW	2.0	3584	95	12	E7	5.0	9.1	5
ES	1/4	1075	3	208-230	Slv	RRE	CCW/CW	1.7	3984	122	12	E10	5.0	9.6	
ES	1/3	1625	3	115	Slv	RRE	CCW/CW	3.9	3994 ✱	172	14	E10	15.0	9.6	
ES	1/3	1625	3	208-230	Slv	RRE	CCW/CW	1.9	3995	174	13	E10	5.0	9.6	
	1/3	1075	2	115	Slv	RRE	CCW/CW	6.2	3385	95	14	E6	5.0	9.4	5
	1/3	1075	3	115	Slv	RRE	CCW/CW	6.2	3585	97	14	E6	5.0	9.4	5
ES	1/3	1075	3	115	Slv	RRE	CCW/CW	4.9	3985	127	15	E10	7.5	9.6	5
	1/3	1075	2	208-230	Slv	RRE	CCW/CW	2.9	3386	97	14	E6	5.0	9.4	
ES	1/3	1075	3	208-230	Slv	RRE	CCW/CW	2.5	3986	129	14	E10	5.0	9.6	
	1/3	1075	3	208-230	Slv	RRE	CCW/CW	2.7	3586	99	14	E6	5.0	9.4	5
ES	1/2	1625	3	115	Slv	RRE	CCW/CW	6.0	3996 ✱	166	16	E12	15.0	9.9	
ES	1/2	1625	3	208-230	Slv	RRE	CCW/CW	2.8	3997	168	16	E12	7.5	9.9	
	1/2	1075	2	115	Slv	RRE	CCW/CW	9.0	3387	112	18	E14	5.0	10.4	
ES	1/2	1075	3	115	Slv	RRE	CCW/CW	7.3	3987	142	19	E13	10.0	10.1	
	1/2	1075	3	115	Slv	RRE	CCW/CW	9.0	3587	119	18	E14	5.0	10.4	5
	1/2	1075	2	208-230	Slv	RRE	CCW/CW	4.3	3388	114	17	E13	5.0	10.1	
	1/2	1075	3	208-230	Slv	RRE	CCW/CW	4.3	3588	121	17	E13	5.0	10.1	5
ES	1/2	1075	3	208-230	Slv	RRE	CCW/CW	3.5	3988	144	17	E13	7.5	10.1	
ES	3/4	1625	3	115	Slv	RRE	CCW/CW	8.5	3998	205	18	E14	15.0	10.4	
ES	3/4	1625	3	208-230	Slv	RRE	CCW/CW	4.0	3999	208	19	E14	7.5	10.4	
	3/4	1075	2	115	Slv	RRE	CCW/CW	10.3	3389	147	18	E14	15.0	10.4	5
ES	3/4	1075	3	115	Slv	RRE	CCW/CW	10.3	3989	194	19	E13	15.0	10.1	5
	3/4	1075	3	115	Slv	RRE	CCW/CW	11.2	3589	162	19	E14	15.0	10.4	5
	3/4	1075	2	208-230	Slv	RRE	CCW/CW	5.2	3390	149	19	E14	10.0	10.4	5
	3/4	1075	3	208-230	Slv	RRE	CCW/CW	5.0	3590	164	18	E14	10.0	10.4	5
ES	3/4	1075	3	208-230	Slv	RRE	CCW/CW	4.8	3990	196	19	E13	10.0	10.1	5

Notes: For NEMA mounting dimensions, see section 9, Figure E

5 60 Hz operation only

Energy $aver®

Premium Efficiency Motors Save Energy

Based on 1/3 Hp standard vs. premium efficiency

COMPARISON

	1/3 Standard	1/3 Premium Efficiency
HP	1/3	1/3
SPEED	1725	1725
AMPS	6.4	3.5
EFFICIENCY	54%	73%
POWER FACTOR	67%	87%
WATTS SAVED		115

YEARLY SAVINGS

8760 Hr/Yr	$75.56 Savings/Yr
8 Hr/Day	$25.19 Savings/Yr

- Energy costs 7.5¢/KWHR
- Based on hours of operation
- Watts saved 115

BELTED FAN AND BLOWER MOTORS

• RESILIENT BASE • SLEEVE BEARINGS • THERMALLY PROTECTED

Single Speed

Hp	RPM	Type	Voltage	EEMAC Frame	Eff %	Model #	CG-IF List Price
1/4	1725	KHC	115	48Z	71%	7J421AX	$211.45
1/3	1725	KHC	115	48Z	73%	7J422AX	225.33
1/2	1725	KHC	115	48Z	75%	7J423AX	260.13
3/4	1725	KCR	115/230	56	77%	5J590GX	366.93

Dual Speed

Hp	RPM	Type	Voltage	EEMAC Frame	Eff %	Model #	CG-IF List Price
1/4	1725/850	KHC	115	56Z	70%	5J722GX	$275.83
1/3	1725/850	KHC	115	56Z	70%	5J723GX	300.31
1/2	1725/850	KHC	115	56Z	75%	5J724GX	407.80
1/4	1725/1140	KHC	115	56Z	70%	5J730GX	$275.83
1/3	1725/1140	KHC	115	56Z	70%	5J731GX	300.31
1/2	1725/1140	KHC	115	56Z	75%	5J732GX	407.80

Prices and data subject to change without notice

GE Motors

General Electric Canada Inc.
107 Park Street North
Peterborough, Ontario, Canada K9J 7B5
Telephone (705) 748-7633 • Facsimile (705) 748-7780

GEA-12085

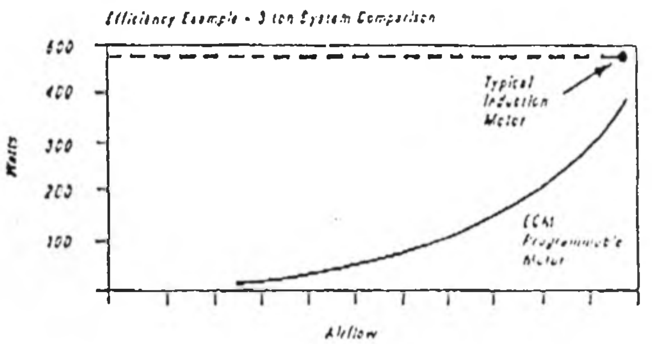
A motor with the brains to provide the highest efficiency under any conditions.

GE Motors introduces another breakthrough in motor technology. A programmable motor so smart, it works at maximum efficiency in every HVAC application. It's the new ECM™ Programmable Motor.

It's been completely redesigned for ultra-high efficiency. Improved with features that make servicing easier. And built around programmable controls that allow you to stock just one motor for every product you build. Whether it's in a furnace blower, fan coil, central A/C – whether it's a single speed, multi-speed or variable speed system – one motor does it all.

An HVAC system powered by a new ECM motor provides more comfort for less money. And it runs quieter, too. So your customer satisfaction will go way up while your inventory costs go down.

Ultra-high efficiency – ECM motors are, at full load, over 20% more efficient than standard induction motors. And they maintain their efficiency throughout the entire load range in variable speed applications. Dramatic energy savings result from both the efficiency of the motor and its unique control capability.



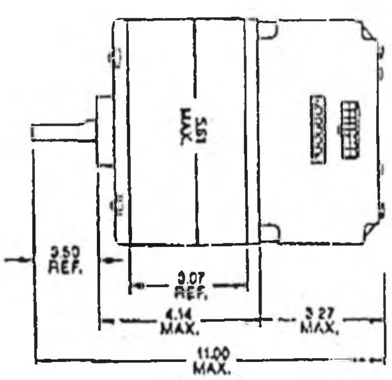
Programmable controls – You can program voltage (115v or 230v), rotation, ramp rates, blower delays, and many other functions, storing the information in the motor's internal chips. Just one motor can optimize your system performance and serve all your application needs.

Easy installation – The ECM can work with a standard thermostat. It needs no complicated, costly external controls. No sliding door interlocks, no hidden, hard-to-reach terminals, so it goes in with no hassle. And it can continually adjust itself to deliver a constant airflow independent of static pressure. So no measuring and calculating of the duct work restriction is necessary.

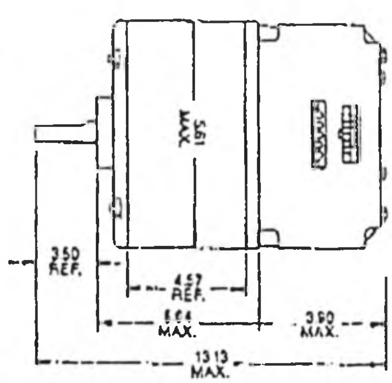
Greater user comfort – In heating, cooling or fan-only operation, the ECM delivers the desired air volume minute by minute. By directly interfacing with a humidistat, the unit will also control cooling humidity levels for even greater comfort and energy savings. And the ramped "soft-start" feature means quiet, inconspicuous operation.

One motor for all your HVAC applications. Higher efficiency. Lower inventory costs. And greater customer satisfaction. The ECM is the one choice. Call your GE Sales Engineer for complete information today.

½ Hp rating



1 Hp rating



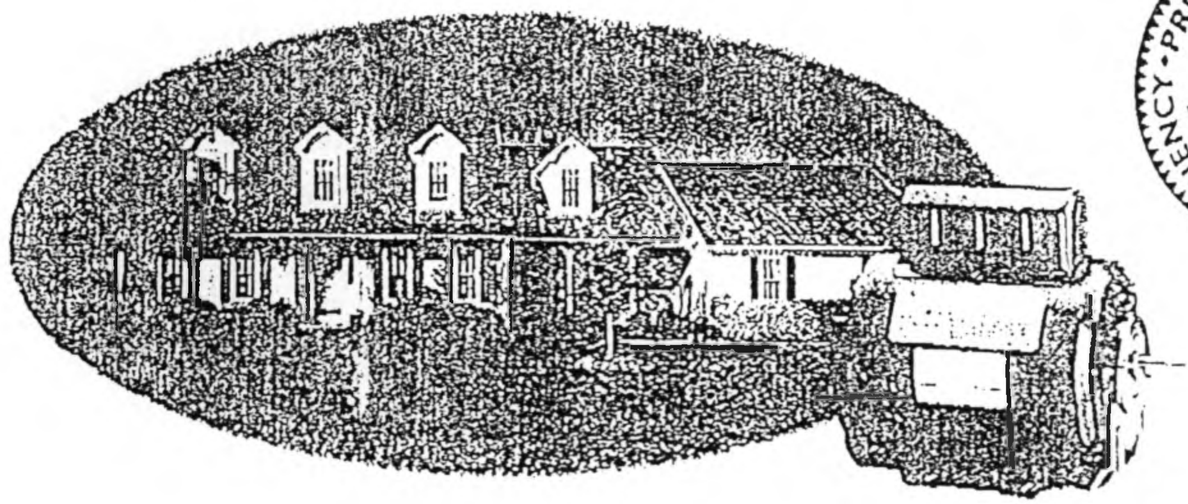
The power that brings things to life.

GE Motors

GEK-100905 (10M 6/92)

Fort Wayne, IN 46801

BUY A LEESON FHP® FURNACE MOTOR AND WE'LL THROW IN THE ELECTRICITY



It's in the Numbers

No matter how you say it, by changing your furnace motor to a high-efficiency LEESON **FHP**® furnace motor you'll *save money* year after year.

A typical "split-phase" furnace motor is initially cheaper than a high-efficiency motor but the difference in price can be made up very quickly in *energy cost savings* on your hydro bill - that's called "payback."

Homeowners are smarter today about the energy that they use, after all, why pay year after year for initially saving a few dollars on a cheap motor.

More Efficient by 25%!

Hydro tests[1] have shown that the most common belted fan motors in furnaces today have an efficiency of about 50%. That means for every watt of electricity you use to move air another watt is wasted.

LEESON's FHP® high-efficiency belted fan motors are up to 25% more efficient than the industry standard.

[1] Tests performed by Ontario Hydro.

Compare the Savings!

For a typical house that runs a 1/3 hp furnace fan year round for circulation and filtering, the cost of operation is $348 per year with the most commonly found split-phase fan motor.

*Compare that to a LEESON **FHP** fan motor at an operating cost of $232 ... that's a savings of $116 per year ... every year you run the LEESON **FHP** fan motor at today's rates!*

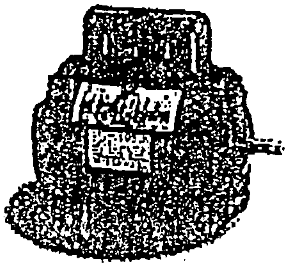
Compare the Specs![2]

Table 1

Split-phase Average		LEESON FHP®
51.5%	Efficiency	75.0%
70.0%	Power Factor	89.0%
6.1 A	Amp Draw	3.2 A
234 W	Watts Loss	83 W
--	Watts Saved*	151 W

*See over

[2] 1/3 hp belted fan motors



What is Payback?

"Payback" is the time it takes to make up the difference between the initial cost of an energy-efficient product versus a standard-efficient product via lower energy costs, e.g. your hydro bill.

*The following table gives an indication of typical energy savings if a homeowner has a LEESON **FHP**® 1/3 hp high-efficiency belted fan motor installed instead of a low cost, split-phase motor with an efficiency of 50%.*

Table 2

Type of Operation	Hours per Year	Annual Energy Savings
Continuous fan operation	8760	*$116 !*
Heating and Air Conditioning	3700	*$52 !*
Heating only	3100	*$41 !*

[1] Data on hours of operation of furnace and air conditioner from Ontario Hydro Residential Furnace Program documentation. Air conditioner COP (coefficient of performance) is 2.5. Cost of electricity is 8¢/kWhr.

And that's not All

*At $116 a year it could take as little as 6 months to cover the difference in price between a cheaper split-phase type motor and a high-efficiency one... but the benefits of the LEESON **FHP**® don't stop there...*

Many split-phase motors have what are called sleeve bearings. These bearings rely on the slippage provided by a lubricant between the two sleeves - they must be lubricated regularly. If you've ever had a furnace motor quit on you in the middle of a winter's night you'll appreciate the *lubricated for life* "no maintenance required" feature of LEESON's **FHP**® furnace fan motors.

FHP® motors use a combination of *precision balanced rotors with ball bearings* to provide:

- *quiet operation*
- *"no maintenance required" performance*
- *long life*

FHP® furnace fan motors are CSA approved and feature industry standard mounting and electrical connections.

The FHP® Line-up

H.P.	RPM @60hz	Frame	F.L. Amps	Full Load Efficiency	Catalogue Number
1/4	1725	J48	2.8	70.5%	M090602
1/3	1725	J48	3.2	75.0%	M090405
1/2	1725	N48	4.6	76.0%	M090585

Leeson is the Trendsetter

HVAC/Mechanical Buyer's Guide and Specifier has called LEESON "the trendsetter" in high-efficiency furnace motors. With the benefits of lower electrical costs, long life bearings and the highest possible paybacks, LEESON is also the "logical choice."

*So where's my free Electricity?

*Referring to Table 1, you'll save 151 watts by using a LEESON **FHP**® motor. Over the course of an average Canadian heating season that's equivalent to running a 60 W light bulb for 7800 hours or 975 days at 8 hours per day, absolutely free. It's in the numbers!*

LEESON CANADA
MISSISSAUGA, ONTARIO L5T 2J3

Distributed by:

BULLETIN [illegible]

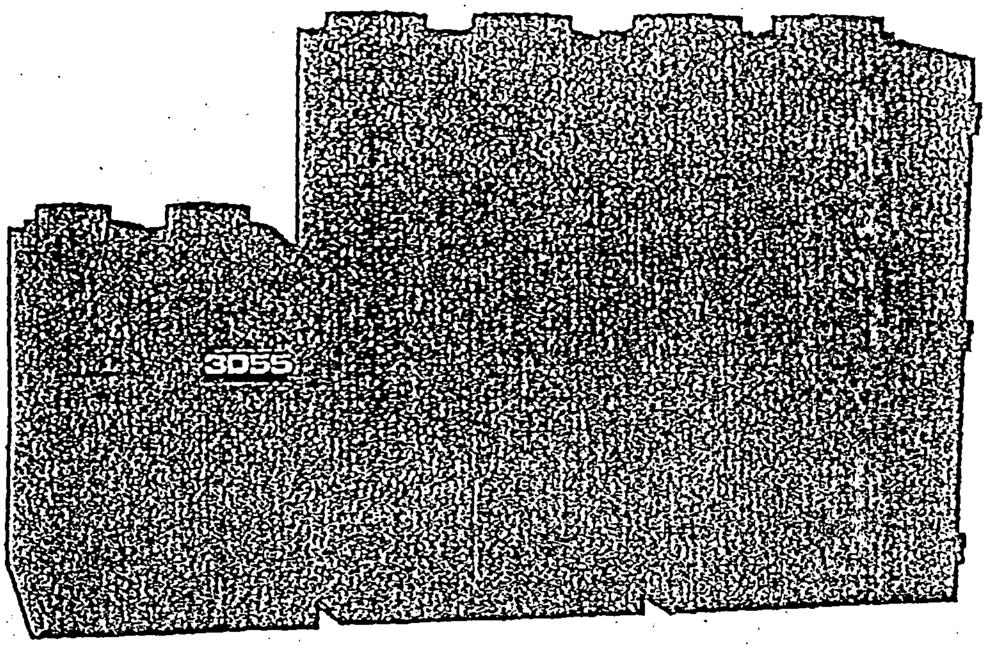
FLAIR BY VENMAR VENTILATION INC.

A quiet air of dependability

HEAT RECOVERY VENTILATOR

High Efficiency

THE FLAIR HIGH EFFICIENCY LINE: IDEAL FOR COLD REGIONS AND R-2000 HOMES



Compact installation with ports on top

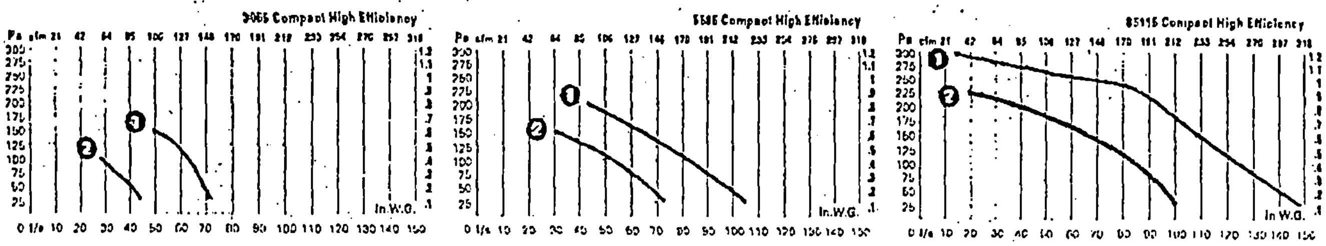
Reliable: 5-year warranty on the unit - Limited lifetime warranty on the heat recovery core

"SilentSure" operation: special design for noise reduction

Efficiency: the best on the market

Exclusive "Homeshield" defrosting system: defrost without negative pressure

VENTILATION CAPACITY



Legend 1 = high speed, 2 = low speed

For a variety of house sizes

EFFICIENCY

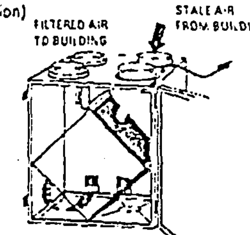
			APPARENT	NET
3055 Compact High Efficiency	0°C (32°F)	55 l/s (115 cfm)	92%	81%
	-25°C (-13°F)	55 l/s (115 cfm)	89%	69%
5585 Compact High Efficiency	0°C (32°F)	55 l/s (115 cfm)	94%	84%
	-25°C (-13°F)	55 l/s (115 cfm)	89%	79%
85115 Compact High Efficiency	0°C (32°F)	55 l/s (115 cfm)	94%	80%
	-25°C (-13°F)	55 l/s (115 cfm)	89%	74%

The best efficiency on the market

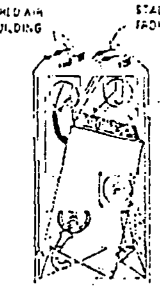
"HOMESHIELD" DEFROSTING SYSTEM

The HRV High Efficiency units use a unique defrost method. Thus, no negative pressure is created by air exhausted to the outside, as the air is recirculated into the house, avoiding any return from the chimney. Moreover, this defrost method by air circulation ensures that no shortage of air is created for the combustion units.

AIR FLOW
DURING DEFROST
(and in circulation)



3055 Compact H.E.



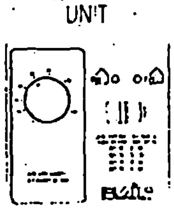
5585 & 85115 Compact H.E.

OUTSIDE TEMPERATURE °C	(°F)	DEFROST CYCLE defrosting min / operating min
+ THAN -5	(+ THAN 23)	—
-5 TO -30	(23 TO -22)	6/35
-31 AND -	(-22 AND -)	6/20

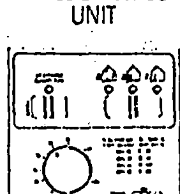
CONTROLS

Sold separately from the units, two types of wall controls, Standard and Auto, are available. The Standard control allows access to a dehumidistat and selection of one of two unit mode, depending on the user's ventilation requirements. The "Auto" Package, unique to FLAIR, includes a wall controll and an air ionizer. The Auto wall control also allows access to a dehumdistat, in addition to the selection of three unit operation modes. The air ionizer neutralizes bad odors, cigarette smoke, bacterias, pollen, etc.

STANDARD WALL CONTROL UNIT



AUTO WALL CONTROL UNIT



Continuous Mode:
If the RH* inside the house is lower than selected = circulation and filtration of the ambient air at high speed (closed circuit).
If the RH inside the house is higher than selected = air exchange with the outside at high speed.
Ensures: • Better heat distribution in the house, maximum comfort and economy.
• Year-long use (circulation of fresh air from the basement througout the entire house during the summer)

Automatic Mode
If the RH inside the house is lower than selected = air exchange with the outside at low speed.
If the RH inside the house is higher than selected = air exchange with the outside at high speed.
Ensures: - Constant air quality
- Complies with the R-2000 standards and, consequently, is ideal for high energy-efficient houses.

Intermittent Mode:
If the RH inside the house is lower than selected = The system stops
If the RH inside the house is higher than selected = air exchange with the outside at low speed
Ensures: - Minimum air exchange level when the house 's unoccupied to minimize costs.

*RH = Relative humidity inside the house

INSTALLATION

Because the four ports are located on the top, the units can be installed anywhere and are easier to handle. Furthermore, the work is made easier due to:

- variable resistor allowing adjustment of the PSC motors, etc.
- double-collar ports securing the insulated ducts.

Also, the unit is delivered with an installation kit consisting of:

- 10 ft PVC drain with connector.
- suspension chains.
- 1 flexible 8"Ø duct, 36" long.
- 40 ft wire for wall control.
- installation manual.

REPAIRS AND MAINTENANCE

All parts of the Compact High Efficiency HRVs can be removed in less than two minutes, allowing for direct access for easy repairs. The low power consumption, PCS motors are permanently lubricated. Even better, the entire motor subassembly can be removed for ease of maintenance. Finally, the electronic circuit board eliminates electromechanical parts, reducing repair time to a minimum.

REQUIREMENTS AND STANDARDS

- Complies with the CSA C22.2 #113 standard applicable to ventilators.
- Complies with the CSA C444 requirements regulating the installation of Heat Recovery Ventilators.
- Technical datas were obtained from published results of tests relating to the CSA C439 standards.

WARRANTY

The Compact High Efficiency HRVs units are fully protected by a 5-year warranty, the best in the industry, and the heat recovery core is covered by a lifetime warranty, for as long as the buyer owns the house in which the unit has been installed.

OPTIONS

- Line of wall controls.
- Line of registers and diffusers.
- Electric duct heater.
- The installation parts are available from your wholesaler.

HVI Home Ventilating Institute division of AMCA

Active member

R-2000 The complete line of Compact High Efficiency HRVs is accepted in R-2000 homes when installed according to R-2000 standards.

Vermar Quality Assurance

CSA Approved

Printed on recycled paper

WINNER Total Quality

Available at:

HVR SPECIFICATION SHEET

Testing Agency: ORTECH International
Date Tested: Apr. 1993
Manufacturer: Venmar Ventilation inc.
Address: 1715 Haggerty, Drummondville
Quebec, Canada J2C 5P7
Telephone: (819) 477-6226 fax (819) 474-3066

Model: Flair HRV 3055 Compact H.E.
Serial Number: HH-1000
Options Installed: Auto package including electronic 3 mode wall control unit and ionizer type air purifier.
Electrical Requirements: 120 Volts 1.2 Amps

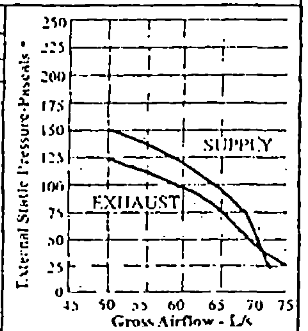
VENTILATION PERFORMANCE

Maximum Continuous Rated Airflows:
31 L/s @ -25 °C
54 L/s @ 0 °C

Airflow Range for Multispeed Units:
High speed: 54 L/s Low speed: 30 L/s

Lowest Temperature Unit Tested To: -25 °C
Low Temperature Ventilation Reduction During -25 °C Test: 12 %
Maximum Unbalanced Airflow During -25 °C Test: 5 L/s
Exhaust Air Transfer Ratio: 0.02

External Static Pressure *		Net Supply Air Flow		Gross Air Flow			
				Supply		Exhaust	
Pa	in. W.G.	L/s	cfm	L/s	cfm	L/s	cfm
25	.1	72	152	73	155	75	159
50	.2	69	145	70	148	69	146
75	.3	67	141	68	144	66	140
100	.4	63	133	64	136	60	127
125	.5	58	123	59	125	50	106
150	.6	49	104	50	106	3	6



ENERGY PERFORMANCE

		Supply Temperature °C	Supply Temperature °F	Net Airflow L/s	Net Airflow cfm	Supply / Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
HEATING	i	0	32	30	64	1.01	103	81**	92	0.02
	ii	0	32	46	99	1.00	115	76	85	0.03
	iii	0	32	54	106	1.01	117	72	80	0.02
	iv	-25	-13	30	64	0.99	110	69**	69	0.11
	v	-----	-----	-----	-----	-----	-----	-----	-----	-----
COOLING	vi	35	95	34	72	0.98	105	27***		
	vii	35	95	50	106	0.99	109	20***		

*Description of Defrost: During defrost (initiated by a sensor in the cold supply airstream with a -5°C set point) internal dampers would restrict the cold supply and exhaust flows and direct warm exhaust air through the core and out the warm supply port. The unit does not ventilate during defrost. Timing is 5 min. defrost, 30 min. run.

Comments from Test Agency: Test duct resistance for energy performance tests is based on low temp. test set up. Unit ran at a low speed for the low temperature test. HRV internal power resistor and duct resistance adjusted for 0°C -30L/s test.

Reference Report:
93-E31-R28
and 93-E31-R37
Sample No.: 93-E31D0012

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

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

HRV SPECIFICATION SHEET

Testing agency: ORTECH International
Date tested: Nov. 1990
Manufacturer: Venmar Ventilation inc.
Address: 1715 Haggerty, Drummondville
Quebec, Canada J2C 5P7
Telephone: (819) 477-6226 fax (819) 474-3066

Model: Flair HRV 5585 Compact High Efficiency
Serial Number: J-1000
Options Installed: "Auto" Package including electronic control board, wall control unit, ionizer type air purifier
Electrical Requirements: 120 Volts 2.2 Amps

VENTILATION PERFORMANCE

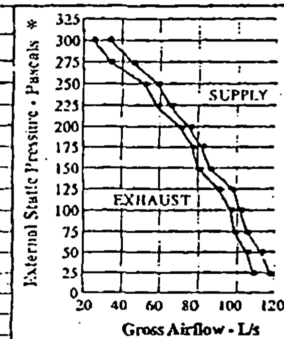
Maximum Continuous Rated Airflows:
57 L/s @ -25 °C
84 L/s @ 0 °C

Airflow Range for Multispeed Units:
High Speed: 84 L/s Low Speed: 52 L/s

Lowest Temperature Unit Tested To: -25 °C
Low Temperature Ventilation Reduction During -25 °C Test: 7 %
Maximum Unbalanced Airflow During -25 °C Test: 57 L/s
Exhaust Air Transfer Ratio: 0.06

External Static Pressure		Net Supply Air Flow		Gross Air Flow			
				Supply		Exhaust	
Pa	in. W.G.	L/s	cfm	L/s	cfm	L/s	cfm
25	.1	109	231	116	246	107	227
50	.2	107	227	114	242	103	218
75	.3	99	209	105	222	97	206
100	.4	93	197	99	210	93	197
125	.5	89	189	95	201	88	186
150	.6	81	171	86	182	81	172
175	.7	75	159	80	169	76	161
200	.8	68	143	72	153	69	146
225	.9	62	131	66	140	58	123
250	1.0	55	116	58	123	50	106
275	1.1	43	92	46	97	35	74
300	1.2	29	62	31	66	23	49

maximum speed data fan



ENERGY PERFORMANCE

		Supply Temperature °C	Supply Temperature °F	Net Airflow L/s	Net Airflow pcm	Supply/ Exhaust Flow Ratio	Average Power (Watts)	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
HEATING	i	0	32	52	111	1.01	156	84	95	0.05
	ii	0	32	55	117	-----	-----	84**	----	----
	iii	0	32	71	151	1.01	184	79	90	0.03
	iv	0	32	84	179	1.01	210	79	89	0.12
	v	-25	-13	55	117	-----	-----	72**	----	----
	vi	-25	-13	57	121	0.97	176	72	88	-0.04
COOLING	vii	35	95	55	117	0.99	160	22***		
	viii	35	95	76	162	1.00	198	23***		

Description of Defrost: This unit incorporated an indoor air recirculation system for defrosting of the heat exchanger core. An internal cold supply air temperature sensor (set pt. -5°C) would initiate a 35 minute run and a 6 minute defrost cycle. During defrost internal dampers would stop cold supply and exhaust flow and direct warm exhaust air through the core and out the warm supply port. Both fans would run at high speed during defrost.

Comments from Test Agency: The test duct installation and resulting ventilation performance was based on the unit being installed for 55 L/s operation.

ORTECH Reference Repport:
ESC 35-23188

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

Testing was performed in general accordance with CAN/CSA - CA39 - 88, Standard Methods for Rating the performance of Heat Recovery Ventilators and was conducted in accordance with normal professional standards. Neither ORTECH International nor their employees shall be responsible for any loss or damage resulting directly or indirectly from any default, error or omission. Specification Sheet format revised September, 1988.