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RESIDENTIAL COMBUSTION VENTING FAILURE
A SYSTEMS APPROACH

FINAL TECHNICAL REPORT

PROJECT 7

COMMUNICATIONS STRATEGY

Prepared for:

The Research Division

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Canada Mortgage and Housing Corporation

Prepared by:

Scanada Sheltair Consortium

Principal Consultants: Ron Argue
Sheltair Scientific

CMHC Project Manager: Don Fugler

CMHC Scientific Authority: Jim H. White

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Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

The legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part V of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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ABSTRACT

A summary is presented of the results of various communications tasks undertaken within a project to investigate combustion venting failures in Canadian houses. These tasks involve:

- (a) the finalization of key communications products including -*
- a computer model of house/furnace/flue interaction,*
 - chimney safety test procedures,*
 - guidelines for choosing and implementing remedial measures in houses experiencing combustion venting problems, and*
 - an overall summary report on the results of the entire study.*
- (b) the development of a network of interested agencies; and*
- (c) the development of pilot training programs and supporting training materials for the computer model and the chimney safety test procedures.*

In addition, a follow-up communications strategy is proposed. The strategy outlines various approaches for transferring the results of the study to key target groups including government agencies, consumers, HVAC manufacturers, energy utilities, HVAC trades, and home renovation and weatherizing trades.



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EXECUTIVE SUMMARY

This summary outlines the various communications products which have been developed during the course of the study, RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH, performed for CMHC by the Scanada Sheltair Consortium. In addition, the main elements of a follow-up communications strategy are presented.

To facilitate public dissemination of the results of the study, the following communications products have been developed.

FLUE SIMULATOR Model and Manual

The FLUE SIMULATOR computer model has been designed for use by flue researchers and flue designers. The model is intended to assist these groups in analyzing the venting performance of chimneys under a wide range of operating configurations. A comprehensive manual has been developed to help users operate the program.

Chimney Safety Tests

User's manuals have been developed to describe all chimney testing procedures developed during the study. The manuals present the design principles underlying the tests, explain the test procedures in detail, and provide the checklists and report forms necessary to do the tests. The audiences for these manuals include house holders, building trades and heating trades.

Remedial Measures Guidelines

Research on remedial measures produced a considerable amount of useful information on how each remedial measure should be designed and installed. "Prototype" guidelines on how to install promising remedial measures have been developed. The primary audience is the heating research community.

Summary Report

A large amount of information on venting failure issues has been documented in interim and final reports on the various tasks. Based on these findings, a summary report was produced to highlight the key findings and products in each of the 7 tasks in the study.

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Pilot training workshops and supporting resources

As a first step towards the development of the necessary training resources, prototype training programs have been developed for both FLUE SIMULATOR and the Chimney Safety Tests. These were delivered as separate workshops in September 1986.

An information package describing the study was sent to about 160 organizations across Canada as part of a "networking" exercise. These organizations represented a broad cross-section of government, industry and consumer groups with an interest in chimney safety issues.

A need was identified for a moderately-paced communications strategy which would ensure that the results of the study are disseminated and acted on. The objective of such a "follow-up" communications strategy would be to establish a broader awareness of the venting safety issue and to encourage the use of the diagnostic and remedial techniques that have emerged from this work. A strategy involving 10 key activities was drawn up and presented to CMHC.

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INTRODUCTION

This report describes one of seven sub-projects of an overall project entitled -

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- which was carried out for Canada Mortgage and Housing Corporation by the Scanada Sheltair Consortium Inc. A summary of the overall project is provided in Appendix A.

The overall project consisted of seven sub-projects. This report is concerned with Project 7, Communication Strategy.

An important objective of the overall project involves technology transfer - the development and dissemination of tools and techniques which can be used to identify, diagnose, and remedy chimney venting failures in the Canadian housing stock.

Effective technology transfer requires careful attention to the arrangements by which technical information will be communicated. Because of this, communications has been designated as a separate project within the study.

COMMUNICATIONS SUB-TASKS

The following discussion outlines the various communications tasks included in the project. These tasks include:

- (a) finalization of key communications products including the FLUE SIMULATOR model, the chimney safety tests, the remedial measure guidelines, and an overall summary report on the results of the entire study covering Projects 1 to 7.
- (b) the development of a network of agencies who are interested in sharing information on various aspects of the venting failures problem
- (c) the development of pilot training workshops and supporting training materials for the FLUE SIMULATOR model and the chimney safety tests

Finalization of Key Communications Products

A number of the products developed during the project are intended for broad public distribution and use. Consequently, these products have been the main focus of our communications work. Particular emphasis has been placed on ensuring that they are appropriately designed to meet the specific needs of the various target groups.

These key communications products are summarized in Table 1 and discussed briefly below.

FLUE SIMULATOR Model

The FLUE SIMULATOR model has been developed as a tool for use by flue researchers and flue designers. More specifically, the model is intended to assist this target group in analyzing the venting performance of chimneys under a wide range of operating configurations.

During the software design process, considerable attention has been focussed on developing a "user-friendly" interface with the model to ensure optimum ease-of-use. In addition, a comprehensive manual is available to help users to operate the program, to make optimal use of its features, and to modify it to suit their own needs.

Chimney Safety Tests

Three levels of chimney safety test procedures (formerly called "checklist" procedures) have been developed to meet the needs of various target groups. The term "safety test" has been substituted for "checklist" to emphasize the fact that the procedures involve more than a simple "check-off" of factors on a list. Nonetheless, a checklist is still used in each test to ensure that each step of the test procedure is completed in full and in proper sequence.

(a) Chimney Venting Safety Check For Householders

This is a simple procedure by which householders in gas-heated houses may quickly determine the susceptibility of their chimney systems to combustion gas spillage events caused by house depressurization.

The procedure has not been significantly changed from the version presented by Sheltair Scientific in a December 1984 report to CMHC entitled Residential Combustion Safety Checklists. However, the text has been edited to improve clarity and ease-of-use and graphics have been added.

Further refinements may be required to develop a "polished" version suitable for public distribution. However, the extent of such refinements will depend on what arrangements are ultimately set in place for publication and distribution of the Safety Check.

(b) Venting Systems Tests For The Building Trades

A Venting Systems Test has been developed which permits building tradesmen to ensure that the modifications they make to a residence do not adversely affect venting safety. In addition, a shorter Venting Systems Pre-test procedure has been developed to permit tradesmen to identify houses which have low potential for venting failure and which therefore do not require the more time-consuming Venting Systems Test.

Both tests are described in a draft Chimney Safety Test User's Manual which presents the design principles underlying the tests, explains the test procedures in detail, and provides the checklists and report forms necessary to do the tests.

To transfer the skills and procedures required to properly carry out the Venting Systems Test and Pre-test, it will be necessary to provide training sessions for prospective users

in the building trades (e.g. insulators, airtighteners, fan installers, renovators). The User's Manual is intended as the basic resource for training purposes. (The manual also covers the additional tests for use by the heating trades as outlined below).

(c) Chimney Safety Tests For Heating Tradesmen

An expanded package of chimney safety tests has been developed for heating tradesmen. The tests include the Venting Systems Test and Pre-Test described above plus three additional tests which are designed to detect potential for combustion gas spillage as a result of structural, maintenance or design problems in the chimney system. These tests include:

- (1) A Heat Exchanger Leakage Test which is designed to detect spillage potential via major leaks in the heat exchanger of forced-air heating systems;
- (2) A Flue Performance Test which involves a measurement of flue gas temperature and static draft pressure. The temperature measurement can be used to assess potential problems due to flue condensation, inadequate insulation, or fire risk. The pressure measurement, in combination with the temperature measurement, can be used to pinpoint inadequate chimney draft pressures due to flue leaks or constrictions.
- (3) A Chimney Inspection Checklist procedure which is designed to determine maintenance requirements via visual inspection of the chimney, flue, flue connector, furnace, and furnace room.

These procedures will permit heating tradesmen to check the effect of any furnace, chimney or ventilation modification on venting safety. In addition, the procedures provide useful methods for diagnosing venting problems in houses in which combustion gas spillage is occurring or is suspected to be occurring but where the causes of such spillage are unknown.

All 5 tests are described in a draft Chimney Safety Test User's Manual which presents the design principles underlying the tests, explains the test procedures in detail, and provides the checklists and report forms necessary to do the tests. The manual will also introduce various remedial measures which are currently available such as labels, alarms, make-up air supply systems, chimney improvements, induced draft fans, and airtight fireplace doors.

To transfer the skills and procedures required to properly carry out the chimney safety tests, it will be necessary to provide training sessions for prospective users in the heating trades. The draft manual covering all 5 tests is intended as the basic resource for training purposes. In addition, a slide presentation with supporting script has been developed as an additional training resource.

Remedial Measures Guidelines

As noted above, the Chimney Safety Test User's Manual will provide tradesmen with information on remedial measures which are currently available.

A further set of promising but as yet commercially-unavailable remedial measures were investigated during the course of the study (see research reports on Project 5 - Remedial Measures). Our research on these remedial measures produced a considerable amount of useful information on how each remedial should be designed and installed. However, despite our initial hopes and best efforts, we were forced to conclude that none of the remedial measures we looked at are ready for implementation by tradesmen at the current time.

However, to foster broader awareness of promising remedial measures and to facilitate development of proven designs which can be used by tradesmen, "prototype" guidelines on how to install promising remedial measures were developed. The prototype guidelines were clearly in draft form and identified as not having been thoroughly tested and approved.

The guidelines are particularly intended for heating researchers who may wish to participate in further development of the remedial designs. In addition, they will be used in the pilot training workshop on the chimney safety tests to introduce tradesmen to advanced remedial concepts and the current state-of-the-art of promising remedial technologies.

Summary Report

During the course of the study, a large amount of information on venting failure issues has been documented in interim and final reports on the various tasks. To provide interested professionals with a concise point-of-entry to this large and useful information base, a summary report

will be developed. The report highlights the key findings and products in each of the sub-projects in the study. In addition, it will outline all of the main research reports and background material produced during the study so that interested readers may order the detailed reports as required.

The summary report is an important communications document since it will be the principal means by which the main results of the study are disseminated. A wide distribution is anticipated.

Development of a Network of Interested Agencies

The interdisciplinary nature of the chimney venting problem means that a broad range of groups have a role to play in transferring appropriate solutions. A basic communications requirement is simply to generate awareness of the study results amongst all such groups.

Three broad target categories have been identified as follows:

- (1) Government - This includes a range of Federal and Provincial Departments which have an interest in the chimney venting safety issue from various points of view such as energy conservation, housing, fire safety, health, building and heating appliance inspection, municipal affairs, consumer affairs, standards and codes, and research. The governmental groups concerned with these issues serve sizeable constituencies and hence provide important channels both for conveying the results of the study and for eliciting appropriate action.

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- (2) Industry and Related Private Sector Groups - This includes HVAC manufacturers and service trades, energy utilities and suppliers, and renovation and weatherizing trades. Since this group will be required to deliver the technical solutions to the venting problem, particular care needs to be taken in the following:
- (a) informing such companies about the study results
 - (b) inviting their participation in on-going technology transfer
 - (c) soliciting feedback on appropriate technical responses to the problem

In addition, various private sector groups which relate to and support the HVAC industry also need to be aware of the chimney venting safety issue. This includes health and fire safety associations, standard-setting agencies, research or university groups, consumer associations and consultants.

- (3) Householders - Householders require information on how to avoid venting failures and what to do if they suspect combustion gas spillage is occurring in their homes. A variety of existing government and private sector programs, particularly in the energy conservation area, provide natural avenues for transferring new information on venting failures to householders. In addition, householders can also be reached through a wide variety of media outlets which deal with home maintenance issues. These outlets include magazines, newspapers, radio and TV.

To generate initial awareness of the study within the government and industry target groups, an information package describing the

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study was sent to about 160 organizations across Canada as part of a "networking" exercise. A list of the organizations contacted is provided in Appendix B and the letter sent to them is provided in Appendix C.

The information package included a feedback form, which permitted respondents to order the summary report for the study as well as to order various background reports on venting failure topics. To gauge general interest in the FLUE SIMULATOR and chimney safety tests products, respondents were invited to indicate if they would be interested in attending pilot training workshops on FLUE SIMULATOR and the chimney safety tests. General comments were also solicited.

Feedback forms were received from about 80 respondents. Most of these used the form to order a summary report and various background publications. Interest in the pilot workshops was high with about 55% of respondents expressing such interest. There were 39 respondents interested in attending the FLUE SIMULATOR workshop and 41 for the chimney safety tests workshop. Table 2a summarizes the results of the networking mail-out. Table 2b summarizes the results of the feedback received.

The extent of the networking exercise was limited by constraints of time and budget. It is anticipated that many opportunities exist to expand the current network. For example, subsequent to the August advisory committee on the project, arrangements were made between CMHC and the Heating, Refrigeration and Air Conditioning Institute (HRAI) to distribute information on the study to all 600 HRAI members. It is hoped that similar arrangements can be reached with other trade associations to ensure that all interested tradesmen are aware of the study and can access its

results. This is particularly important to ensure broad adoption of the chimney safety tests which were specifically designed for the trades.

Development of Pilot Training Workshops

The communications products involve a variety of new techniques that will have to be understood and mastered by potential users. This means that it will be very important to provide adequate training arrangements to ensure that both FLUE SIMULATOR and the Chimney Safety Tests are broadly adopted and effectively used within their intended target groups.

The training requirements for FLUE SIMULATOR are relatively straightforward since the target group is a relatively small and technically sophisticated group of researchers. It is likely that many users will be capable of learning to use the model on their own. Nevertheless, the development of a suitable training program is advisable in order to facilitate broader adoption of FLUE SIMULATOR and to obtain valuable direct feedback on the model and the supporting training manual.

The training requirements for the Chimney Safety Tests are more complicated since a large and diverse group of tradesmen must be trained to learn procedures which, although simple to execute, require mastery of a variety of unfamiliar tools, techniques and concepts. Because of this, the delivery of training to all of the targeted trades groups in all regions of Canada will be a lengthy and difficult process and will require the assistance of the various trades associations serving the heating, ventilation,

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weatherizing, and renovation trades. The fact that at least some of those who deliver the chimney safety tests should be also be trained in appropriate remedial measures to correct venting problems diagnosed by the tests, adds further complication to the training process, due to the current lack of a complete set of proven remedial measures.

While the necessary training arrangements will have to evolve over time, the current project has been structured to provide a foundation for training development by (1) developing the basic training resources necessary to deliver FLUE SIMULATOR and the Chimney Safety Tests and (2) developing and delivering pilot training workshops.

The purpose of the pilot training workshops was to test training materials and approaches developed during the study, to assess learner reaction to the FLUE SIMULATOR and the Chimney Safety Tests, to identify needs for improved training materials and, to more precisely identify appropriate training delivery mechanisms.

The pilot workshops provided a first-cut at the training process and provided a useful foundation for the follow-up work on venting safety training and communications now being undertaken for CMHC by Ashton and Associates.

The workshops were held September 1986. A small group of 10-15 participants was invited to each workshop. Evaluation reports outlining the structure of each workshop and the comments of both

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participants and evaluators were collected and indicated that both were very well received.

A rough outline of the structure of the training workshops is provided in Table 3.

FOLLOW-UP COMMUNICATIONS STRATEGY

Introduction

General

The results of our field research indicate that undesirable combustion gas spillage events may be occurring in up to ten percent of Canadian homes. However, the precise nature of the health and safety risk posed by such spillage events cannot be defined without further study (see our reports on Project 4 - Hazard Assessment). Consequently, there is insufficient evidence to warrant the major communications initiative which would be required if a serious and widespread health and safety risk had been identified.

Nevertheless, we feel there is a need for a moderately-paced communications strategy which would ensure that the results of the study are disseminated and acted on. The objective of such a "follow-up" communications strategy would be to establish broader awareness of the venting safety issue and to encourage the use of the diagnostic and remedial techniques that have emerged from our work. Implementation of training programs for the chimney safety tests and associated remedial measures would be a key element of the follow-up program.

Rationale For A Follow-up Communications Strategy

The strong interest in the study expressed during the networking process and the fact that most Federal and Provincial energy conservation programs have already begun to warn consumers about the "backdrafting" problem indicates

that (1) there is broad consensus that a venting failure problem exists and (2) that there is a growing demand for information on how to avoid or correct such failures. This in itself suggests that a follow-up communications program would be desirable. Furthermore, it is our view that if adequate communications initiatives are not taken, there is a significant risk that the "spillage" problem will encompass a growing number of Canadian houses with detrimental effects on health and safety. To underline our concern in this respect, it is worth reviewing the results of our field research on about 1000 houses located in 5 regions of Canada (see Project 1 - Canada-wide survey). The research involved the installation of combustion gas spillage detectors on both oil and gas-heating appliances. Results from the 606 gas-heated houses tested indicate that spillage occurred in about 10% of the houses on at least one occasion during the months of January to May 1986. On-site investigations into the cause of the spillage in 13 of these "spillage" houses showed that depressurization was a contributing factor in about 75% of the cases. However, a number of other factors were also involved such as equipment problems, damaged and leaky chimneys, and improper installation of retrofit appliances.

Results from the 255 oil-heated houses tested indicate that about 50% of these houses experienced excessive spillage of combustion gas. Unfortunately, the statistics on the oil-heated sample are less reliable than those for the gas-heated sample. This is because, in several cases, the spillage detectors were triggered as a result of malfunctioning barometric dampers instead of gas spillage. Despite this problem with data interpretation, the occurrence of spillage in 50% of the oil-heated houses indicates a

surprising amount of start-up spillage problems with oil furnaces, and also suggests a significant amount of combustion gas spillage. Moreover, detailed analysis of eight of the oil-heated houses revealed 2 houses with continuous spillage due to chimney problems and another 3 houses where pressure-induced spillage could be simulated. (Pressure-induced spillage refers to spillage caused by excessive house depressurization.)

Since the Canada-wide survey was roughly representative of the Canadian housing stock at large, the results indicate that, even though the overall percentage of affected houses may be relatively low, a substantial number of individual Canadian houses equipped with gas furnaces and water heaters may be suffering from excessive spillage, at least occasionally, during the heating season. For example, if 60% of the 4 million houses in Canada are gas heated, the number of "spillage" houses heated with gas would be a full 240,000 houses. A substantial number of oil-heated "spillage" houses may also exist.

Furthermore, the number of affected houses is likely to grow due to current trends towards tighter houses, greater use of exhaust fans and supplementary wood heaters, and widespread fuel conversions and furnace modifications. Each of these factors creates adverse operating conditions for chimneys and hence greater potential for chimney failure and resulting combustion gas spillage.

As noted, the health and safety risks associated with such spillage events cannot be clearly defined at this time. Fortunately, our research does indicate that life-threatening incidents due to spillage-related carbon monoxide

build-up are likely to be rare. A low incidence of carbon monoxide production was found during our research studies on simulated venting failures (see Project 6 - Problem House Follow-Up). Although carbon monoxide is sometimes associated with spillage from furnaces and water heaters (especially in tight rooms with boilers and with poorly maintained burners), there is not usually a direct relationship with spillage events.

However, the longer-term health risk, especially from corrosive gases such as NO₂ and SO₂ may be of greater concern, especially in view of the potentially large number of "spillage" houses noted above. Therefore, until the precise nature of the risk is clarified via future research, it would appear to be advisable to develop a communications strategy aimed at providing both tradesmen and the public with information on how to minimize exposures to spillage gases.

Summary Of Key Elements of the Communications Strategy

In view of the above considerations, we believe that a follow-up communications strategy should be developed. In our view, the communications strategy should involve the following key elements:

- (1) direct distribution of the summary report to key government and industry officials to raise awareness of the venting safety issue and to encourage appropriate action

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- (2) distribution of the summary report to key media outlets serving the industry and the general public to broaden awareness of the venting safety issue
- (3) dissemination of the FLUE SIMULATOR model to appropriate users so that the model can be put to use in research and design applications
- (4) refinement of the draft training packages for the chimney safety tests to facilitate transfer of the test procedures to new users
- (5) development of awareness and training programs on appropriate remedial measures for use in association with the chimney safety tests
- (6) development of arrangements to transfer the chimney safety tests procedures to the appropriate industry groups via training arrangements with key trades organizations such as HRAI, NECA, and CHBA
- (7) consideration of pilot programs to test the delivery of the chimney safety tests procedures by tradesmen in a non-research environment
- (8) distribution of the Householder Venting Safety Checklist and development of supporting consumer information materials which would raise awareness of the venting failures problem without generating undue concern
- (9) liaison with relevant government programs, standard-setting agencies, and code authorities to encourage

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information-sharing and coordinated action on venting safety issues

- (10) development of a longer-term communications strategy to promote full implementation of the chimney safety tests and remedials after industry training programs have been completed

Discussion of Follow-Up Communications Requirements

Each of the elements of the follow-up communications strategy noted above is discussed briefly in the following sections.

Generating Government And Industry Awareness

The simplest way to generate awareness of the study results is to ensure that the summary report on the project is broadly distributed. The networking process has already identified 69 agencies who wish to receive the report.

It would be desirable to include a feedback form with each summary report. Respondents could use the form to order the detailed technical reports on the wide range of topics examined within the study. In addition, respondents could be invited to use the form to make comments on issues raised by the study, and to identify other individuals or agencies who should receive the summary report. Handled in this manner, the summary report can serve a valuable role in expanding the existing network of agencies interested in the combustion venting safety issue.

Generating Media Coverage Of The Venting Safety Issue

It would be desirable to generate broader awareness of the venting safety issue in general, and the results of the study in particular, by distribution of the summary report to key media outlets serving the industry and the general public.

This would involve sending the summary report to representatives of key journals and newsletters serving the heating, ventilation, weatherizing, and renovation trades. Examples of such publications include Solplan Review, Habitat 2000, NECA Outlook, Quality Assurance Bulletin, SOL, Focus, Alumi-news, Air Infiltration Review, Homeowner's Guide, Energy Design Update, and RSI.

In addition, wide dissemination of the technical results of the study could be achieved by the presentation of technical papers to various technical conferences, symposia, and journals. Examples of such outlets include the semi-annual meetings of ASHRAE, and the upcoming BTECC symposium.

To reach a broader audience, various media outlets serving the home maintenance market could be contacted either informally or, if possible, by a formal press release on the study. Products of the study of immediate interest to householders, such as the Chimney Venting Safety Check For Householders and the chimney safety tests for use by tradesmen, should be highlighted in communications with members of the general media.

It should also be noted that discussions with media consultant Jon Eakes indicate that opportunities may exist to create video material on the venting failures problem which

could be presented to householders as part of a syndicated television series.

Distribution Of The FLUE SIMULATOR Model

Because the number of potential users of FLUE SIMULATOR is relatively small compared to, say, the chimney safety tests, the communications efforts can be commensurately more modest.

It will be necessary to develop a distribution system for the FLUE SIMULATOR model including arrangements -

- (1) to deliver FLUE SIMULATOR to those who have already requested it,
- (2) to make other potential users aware of FLUE SIMULATOR's availability, and
- (3) to provide back-up technical support to assist users with any problems they might encounter in using the software package and supporting manual and to assist them in adapting the program to their own specialized needs.

This last point is particularly important because such back-up technical support is required for any software of this complexity and the program will not achieve any significant use without it. One of the objectives in developing FLUE SIMULATOR was to encourage more thorough exploration of the theoretical basis of combustion venting performance by the industry. Thus modification of the program to suit the

needs of particular sectors of the heating industry should be encouraged by the provision of the necessary back-up service.

We do not believe that CMHC staff are in a position to offer this type of service. Therefore CMHC should consider a formal "contracted out" arrangement such as provided for the National Research Council's HOTCAN program.

Refinement Of Training Materials For The Chimney Safety Tests

The training materials for the chimney safety tests will be delivered in draft form. It would be desirable to develop improved training materials to facilitate the training process which will be required for each of the 3 general user groups of (1) householders (2) building trades and (3) heating trades.

Improvements may be required in the following areas:

(1) Checklists and Forms

The draft training package includes checklists and forms which guide the on-site delivery of each test. It is possible that these could be improved to facilitate ease-of-use by type-setting the forms and providing additional graphics to accompany the checklists.

(2) Training Manual

The draft training manual covers all 5 chimney safety tests. While the draft manual should be suitable for

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use in initial training exercises, a more polished version would be desirable. The improved version could include a better background section on the mechanisms by which venting failures occur, a glossary of terms, and improved schematics and photographs. In addition, it would be desirable to add details on appropriate remedials, as these become available.

It may also be advisable to develop two separate manuals - one for non-heating trades focussed on the Venting Systems Test and Pre-Test, and one for heating trades which would include all 5 tests.

In addition, there will be a need to develop lesson plans and instructor's notes to accompany the user's manual (some of this work is already being done by NECA as noted below). The exact material required for instructors will depend, to some extent, on how CMHC decides to deliver the training courses.

(3) National Energy Conservation Association (NECA)
Training Materials

It should be noted that, as part of a separate project, additional training materials on venting safety issues were prepared for the EMR-NECA training program for Air Leakage Control Installers. Members of the current study team were involved in this work, which was undertaken concurrently with the preparation of the CMHC Chimney Safety Test User's Manual. (The NECA work largely involved adjusting and augmenting some of the basic CMHC materials to fit the NECA training format).

The main product of the NECA work was a preliminary manual which shows members of the weatherizing trades how to perform the Venting Systems Test. It is written in an informal style appropriate for installers working for weatherizing companies (i.e. companies involved in insulation and air-sealing work). However, with a few modifications, the NECA materials would be suitable for all non-heating tradesmen.

The NECA materials have been prepared in a format suitable for competency-based training (CBT). In addition to a student's text, the material includes a set of Instructor's Notes and Lesson Plans which contain agendas, key words, key processes, training materials, references, slides shows and scripts, overheads, introductory discussion formats, advice to the instructor on how to teach each section, multiple choice tests, formal exams, and suggested practice procedures.

The materials are designed to support the student's text and allow the course to be taught by any competent instructor. Students are required to achieve a "standard of performance" which helps focus the learning and maximize the success of the course.

Unfortunately, the approach used in the NECA Lesson Plans and Instructor Notes is not suitable for a more sophisticated audience such as the heating trades or building inspectors. In addition, the NECA material will not cover the 3 chimney safety tests which were intended for use by heating tradesmen only, nor will it

cover the more advanced remedial measures.

Despite the limitations of the NECA training material, it still represents a valuable training resource. Therefore, we would suggest that arrangements should be made with NECA so that the NECA materials can be used to serve appropriate target groups within CMHC's communications program. Plans for refining both the CMHC and NECA training materials should also be coordinated.

(4) Slide Presentation

A slide presentation has been developed for use by instructors in training sessions for the chimney safety tests. The presentation covers the basic components of the 5 tests. It would be desirable to expand the presentation to cover a broader range of delivery situations and to provide better coverage of remedials.

(5) Video

Budget and time constraints prevented the development of a training video on the chimney safety tests. Ideally, the video would have outlined how venting failures occur, explained the design of each chimney safety test, introduced the necessary tools, presented a demonstration of the delivery of each test, and discussed diagnostic and remedial techniques.

In our view, a video presentation would be particularly useful as an introductory element in training sessions. The video would provide a good overview of the material

to be studied, and convey, better than any other method, a clear sense of the actual field procedures involved. Training audiences would be quickly oriented to the material and motivated to work on the technical details which would be presented in the body of the training session.

In addition, a video would help to introduce various professional groups to the procedure. Policy-makers, standard-setters, and regulatory officials do not require training in the Safety Tests but could benefit from a clear video presentation of the actual on-site procedure.

For these reasons, consideration should be given to developing the video within the follow-up communications program. However, some attention should be given to the timing of any video production to ensure that the chimney safety tests procedures will not be subject to significant revision after the video is made. Problems in keeping material up-to-date is perhaps the most significant disadvantage of the video format.

(6) Nomenclature

The chimney safety tests introduce a variety of new concepts and techniques which cannot be described without the introduction of a new terms. Terms such as house depressurization limits, pressure-induced spillage, venting systems test and flue performance test are only some of the new nomenclature we have had to invent to describe the tests.

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We have tried to use terms which are concise, descriptive, and easy-to-use. However, improvements may be possible in some areas. Consequently, we suggest that some consideration be given to ensuring that the nomenclature is as clear and jargon-free as possible. The objective is to provide the tradesmen who use the tests with a good working language.

Develop Awareness And Training Programs For Remedial Measures

At the present time, a variety of remedial measures are available or are almost available for use including labels, alarms, chimney improvements, make-up air supply systems, airtight fireplace doors, induced draft fans, flue and duct sealing techniques, and delayed action solenoid valves. In addition, "prototype" installation guidelines on the set of promising remedial measures which were examined in Project 5- Remedial Measures will be submitted at the end of this study. Nevertheless, considerable development work is still required to finalize a full set of proven and approved remedial measures.

As currently available remedial measures are refined and "prototype" remedial measures are finalized over the coming months, communications arrangements will be required to -

- (1) develop awareness of the new remedial techniques amongst the trades,
- (2) produce training materials on how to select, install, and service appropriate remedials, and
- (3) integrate the remedial training material into the chimney safety tests training packages.

These communications tasks will be demanding in both technical and organizational terms. The objective will be to encourage the development and application of new technologies in ways which are not only safe and economical, but also compatible with our increasing understanding of the venting failures problem.

In addition, performance standards may need to be developed in order to regulate the use of certain remedial measures such as induced draft fans and active make-up air supply systems.

Arrangements For Training Delivery

The chimney safety tests have been designed for a diverse range of user groups including heating trades, airtighteners, and fan installers. To reach individual tradesmen, it will be necessary to work through industry associations representing the various trades.

A major opportunity to work with key industry associations exists via the current Industry and Technology Program operated within the Home Energy Programs Division at Energy Mines and Resources Canada (EMR). This program is specifically designed to assist various national industry groups in the home service field to provide training in up-to-date techniques to their members. Heating trades, weatherizers, and renovators are represented in the program by their respective trades organizations, namely the Heating, Refrigeration and Air Conditioning Association (HRAI), the National Energy Conservation Association (NECA) and the Canadian Home Builders Association (CHBA).

Agreement in principle has already been reached to include the chimney safety tests materials within these training programs, where appropriate.

The EMR program clearly represents a major opportunity for nationwide technology transfer of venting safety techniques to our key target groups. Therefore, a key objective of the follow-up communications strategy should be to ensure that appropriate training materials are developed, delivered and evaluated within the different training contexts provided by HRAI, NECA, and CHBA training programs.

It should also be noted that all provincial governments have training courses for building and heating inspectors. These courses might be another outlet for the training materials on the chimney safety tests.

Development Of Pilot Delivery Programs For The Chimney Safety Tests

The chimney safety tests have been developed and tested in a research environment. Consequently, it may be desirable to evaluate the test procedures as they are delivered by tradesmen under the actual field conditions they were designed for. Inclusion of the chimney safety tests within pilots planned for other purposes, for example, HRAI's Total Tune-Up program or the Ontario Ministry of Energy's Draft-proof Ontario program, might be desirable first steps in this direction.

Feedback from the pilot projects could be used to fine-tune the field procedures as well as the training curriculum. In addition, successful demonstration of the tests under actual delivery conditions would help to build credibility for the tests within the industry, and would thereby expedite the technology transfer process.

Development Of Appropriate Consumer Information Mechanisms

Since the brunt of the combustion venting failures problem is borne by householders, consumer assistance should be an important part of the follow-up communications program.

Provision of information to increase consumer awareness of the problem is the first step. This should be followed by efforts to upgrade the quality of heating service. In addition, manufacturer's should be encouraged to develop a range of items such as upgraded alarms, appropriate remedial devices, cautionary appliance information and labels, and fail-safe products. Improved standards and regulations are also required to ensure that heating trades and manufacturers offer consumers effective products and services which will ensure safe operation of combustion venting equipment.

Initial communications initiatives aimed at consumers should be focussed on raising awareness of the potential problem (without generating undue concern) with emphasis on the following points:

- (1) explaining the causes of venting failures and outlining the general characteristics of potential problem houses

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- (2) highlighting symptoms of spillage events (e.g. visual symptoms, noises, odours, health impacts, and moisture effects) so that consumers are better able to identify possible problem situations
- (3) emphasizing the value of regular furnace servicing and flue maintenance
- (4) promoting the use of the Chimney Venting Safety Check For Householders
- (5) providing information on carbon monoxide alarms and other detection devices for use in suspected problem houses
- (6) highlighting the value of fail-safe furnace-flue designs in new units

As the chimney safety tests and associated remedial measures become more widely available via the trades, consumers should be informed about the availability of these diagnostic and remedial services and encouraged to use them, where appropriate.

With regard to outlets for consumer information, our networking exercise confirmed that most Federal and Provincial energy conservation offices already provide at least some information to consumers on chimney venting safety. For example, the EMR publication "Billpayer's Guide to Furnace Servicing" highlights the potential for combustion gas spillage under conditions of inadequate combustion air supply (see page 5 of the Guide). In addition, various provincial publications have been produced including

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"Ventilation and Air Quality In Homes" by the Saskatchewan Power Corporation (Regina, 1984), and "Ventilating Your Home", a new booklet in the Alberta Energy-Savers Series, produced by the Energy Conservation Office, Alberta Department of Energy And Natural Resources (Edmonton, 1986).

Consequently, it is likely that the results of the current study which are applicable to consumers can be incorporated into existing consumer information programs, if appropriate contacts are made.

As mentioned previously, media coverage of the issue could also be used to help increase consumer awareness of the issue, and to provide access to consumer resources as these are developed over time.

Liaison With On-going Programs, Standard-Setting Committees, and Code Authorities

The follow-up communications program should include liaison with on-going government, industry and standard-setting programs to encourage information-sharing and co-ordinated action on venting safety issues.

It may be desirable to arrange forums at which representatives of the aforementioned groups can meet on a regular basis to discuss developments in the venting safety field in general, and the current status of FLUE SIMULATOR, the chimney safety tests, and remedial measures in particular. Such forums might be useful to develop co-ordinated programs for delivering information to consumers and training to the trades.

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Participation in key technical conferences may also serve an important role in information exchange. Plans are already in place for members of the current team to report on the results of study at the upcoming BTECC symposium entitled "Air Infiltration, Ventilation, and Moisture Transfer" to be held in December in Fort Worth under the sponsorship of the National Conference of States on Building Codes and Standards. In addition, the semi-annual ASHRAE meetings provide another valuable technical forum.

Furthermore, it is important that appropriate code authorities are briefed on adjustments to various building and heating codes which may be required to facilitate the adoption of particular remedial measures.

In addition, it will be important to ensure that the results of the study are fully integrated into various standard-setting processes on issues relating to venting safety, such as the CSA Task Group On Controlled Ventilation In Housing; the CSA Executive Management Committee On Chimneys, Flues and Fireplaces; the CGSB Working Group On Combustion Ventilation Requirements For Residential Dwelling Units After Air Sealing; and the Associate Committee On The National Building Code. The development of useful standards which encourage the use of the chimney safety tests would be a desirable ingredient of the follow-up communications strategy.

Longer-term Communication Strategy Development

The technical development focus in the short-term will be on clarifying the extent of the hazard, training tradesmen in

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the chimney safety tests, establishment of standards for the use of the chimney safety tests, and finalizing proven and approved remedials. The thrust of the follow-up communications strategy is to facilitate this development through effective information exchange arrangements.

Once the short-term development work has been accomplished, there will be a requirement for a communications program designed to achieve full implementation of appropriate measures to prevent chimney venting failures. This would include:

- (1) widespread use of the Venting Systems Test to check all residential modifications which could affect chimney performance
- (2) widespread use of the chimney safety tests to diagnose problem houses or suspected houses
- (3) improved sensitivity of the heating service trades to the venting safety issue during normal furnace maintenance
- (4) implementation of better alarms and advisers to warn occupants of venting failures
- (5) use of a proven set of remedial measures (e.g., blast fans, induced draft fans etc.)
- (6) improved consideration of venting safety in the design and installation of all new fan, fireplace, DHW, and furnace appliances

COMMUNICATION BARRIERS AND PROBLEMS

In developing the follow-up communications strategy, a variety of barriers and problems need to be considered. Some of these are outlined below to provide further insight on communications requirements.

Service Company Resistance

Some heating service companies may be reluctant to develop a capability to deliver the chimney safety tests. They may wish to avoid the training responsibilities and additional costs which would be required to expand their service beyond the basic servicing provided under service contracts. Efforts will be required to encourage service company participation, and to show contractors how they might profit from the adoption of the safety tests.

In addition, it would be advisable to find ways to make the adoption of the safety tests as easy as possible for individual contractors whose time and interest may be very limited. For example, access to tools and forms should be facilitated by offering a "kit" or "package" which would be available by phone order for one price. The kit would contain a manometer, smoke pencils, and all other specialized items which are required for a Venting Systems Test.

Low Consumer Awareness

Consumer demand for venting safety services will help motivate companies to expand their services. However, consumer awareness of the venting safety issue is currently low. In addition, consumers may be reluctant to pay the additional costs of a proper safety check on their furnace. Efforts will be needed to inform consumers of the importance of venting safety precautions, especially in gas-heated households where very little service work is currently taking place.

Heating Trades Resistance

Some furnace service personnel will be resistant to the new ideas and techniques contained in the chimney safety tests. It may be difficult to get servicemen to shift from old ways and concepts which have worked well enough in the past when heating configurations offered much broader safety margins. However, without proper training in new techniques, it is highly unlikely that servicemen will be able to properly analyze and correct venting problems.

To overcome trades resistance, it will be necessary to establish the credibility of the chimney safety tests via (a) endorsement by industry associations, (b) development of standards, (c) successful demonstration of the test procedures in the field, (d) acceptance of the test procedures by service managers and (e) revision of existing standards, particularly B149, so that they encourage a "systems approach" to correcting problems.

In addition, training programs need to be structured in ways which make the new concepts accessible to service personnel and which generate confidence in the new procedures.

Lack Of Quality Control On Service

Absence of effective quality control arrangements for furnace servicing is an important problem since poor or incomplete furnace servicing may contribute to spillage events. Even before training in the chimney safety tests is considered, there is a need to encourage servicemen to perform their current functions to adequate levels.

A possible response to this problem is to promote the use of spillage alarms by householders. This would give householders improved protection against inadequate maintenance and would also provide a degree of quality control over the maintenance work itself.

A pilot test of the effectiveness of spillage alarms would be worthwhile, especially if it could be combined with programs that train the tradesmen, and use alternative devices such as spillage detectors.

Inadequate Infrastructure

In some areas of Canada, there may be an inadequate infrastructure through which both consumer information and improved furnace safety services can be broadly delivered. An effort is needed to develop appropriate programs in all regions of the country.

In this regard, it should be noted that training videos and media coverage are especially suitable for areas without a well-developed delivery infrastructure (e.g., remote regions). Alarms may also be useful in these regions, since many Canadians will find their own solutions once they are informed of the nature and extent of their problem.

Interdisciplinary Problems

Various non-heating trades group need to be involved in ensuring venting safety. This includes renovators, insulators, airtighteners, and fan installers. It may be difficult to get these groups to participate in venting safety testing since they may view chimney failures as beyond their area of expertise and responsibility. There is a need to encourage both heating and non-heating trades to understand the "systems" nature of modern housing problems and to co-operate with each other in ensuring safe interactions between the various interventions made by each trade.

Lack Of Remedial Measures

As noted previously, a full range of remedial measures still needs to be developed (see our reports on remedial measures - Project 5). In some cases, existing codes and regulations may be a barrier to their implementation. In others, more research is required. In all cases, a major training effort will be required to teach servicemen how to select appropriate remedial measures, how to install them, and how to service them.

Poor Building Practices

It is possible that additional venting safety hazards may inadvertently be added to the housing stock by builders and renovators who are unaware of the effect of their work on chimney venting safety. An effort is needed to inform these groups of building techniques which ensure venting safety by providing a positive environment for chimney operation.

Hazard Definition

The hazard created by venting failures is difficult to precisely define. The problem in definition is not with acute spillage events which are usually detected by the householder and acted on, but with the problems created by chronic spillage events. Chronic spillage may eventually lead to serious equipment failures, but it may also produce adverse health impacts on residents.

The long-term health hazard is likely to be highly variable because of individual differences in sensitivity to combustion gas spillage. For some individuals, any amount of spillage may be unacceptable.

Because of the uncertain and variable nature of the health hazard, communications messages on the health hazard must be structured to avoid unnecessarily alarming the general public, while generating sufficient interest and awareness to ensure that venting problems are corrected where high-sensitivity householders may be at risk.

It would also be advisable to find means to ensure that the medical community is aware of the possible contribution of combustion gas spillage events to chronic health problems experienced by their patients.

TABLES

TABLE 1

SUMMARY OF KEY COMMUNICATIONS PRODUCTS

<u>Product</u>	<u>Target Audience</u>	<u>Information Support</u>
FLUE SIMULATOR	Flue Researchers/ Designers	User-friendly software User manual
Chimney safety tests	1. Householders 2. Building trades (non- heating specialists) Venting Systems Pre-Test Venting Systems Test 3. Heating trades Venting Systems Pre-test Venting Systems Test Flue Performance Test Heat Exchanger Leakage Test Chimney Inspection Checklist	Guidelines on use Report forms and checklists Training manual Slide module Report forms and checklists Training manual Slide module
REMEDIAL MEASURES	Heating Researchers	Prototype installa- tion guidelines for each remedial studied
SUMMARY REPORT	All target groups	Summary of key findings in each project in the study

TABLE 2a

SUMMARY OF NETWORKING CONTACTS

Category	Contacts
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* Federal agencies -	10
* Provincial departments -	95
* Private sector -	55

Total	160
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Notes:

- (1) The Federal and Provincial Departments contacts included groups involved in energy, housing, fire safety, health, inspection services, municipal affairs, consumer affairs, and various research initiatives.
- (2) The private sector contacts included construction and renovation associations, fuel industries, furnace manufacturers, health and fire safety agencies, consumer associations, standard-setting agencies, research groups, universities and consultants.
- (3) Most of the private sector contacts were already involved in various Federal working groups on issues related to chimney venting safety including groups on air sealing, ventilation requirements and chimneys.

TABLE 2b

SUMMARY OF FEEDBACK RESPONSES

Feedback forms returned	72
Summary report requests	69
Background publication requests	60
FLUE SIMULATOR workshop interest	39 (+ 4 maybe)
Checklist workshop interest	41 (+ 7 maybe)

TABLE 3

OUTLINE OF PILOT TRAINING WORKSHOPS

<u>Workshop</u>	<u>Location</u>	<u>Curriculum</u>
1. FLUE SIMULATOR (1 day)	Ottawa	Theory and algorithms Applications and limitations of model Demonstration on how to use FLUE SIMULATOR Hands-on practice sessions
2. CHIMNEY SAFETY TESTS (1 day)	Vancouver	Introduction - health and safety - hazards - venting failure - causes - HD limits - tools Explanation of tests Venting systems test Venting systems pre-test Heat exchanger leakage test Flue performance test Chimney inspection checklist Slide presentation of test procedures Discussion of diagnostic and remedial strategies Site demonstration and practice

A P P E N D I X A

OVERALL PROJECT SUMMARY

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OVERALL PROJECT SUMMARY

The project reported on here was designed to expand on previous studies of the problem of incomplete venting of combustion products from heating appliances in order to approach a more nearly comprehensive understanding of the extent and nature of the problem in the Canadian housing stock. This project, which was carried out for Canada Mortgage and Housing Corporation by the Scanada Sheltair Consortium Inc., consisted of the seven sub-projects described below.

PROJECT 1 COUNTRY-WIDE SURVEY

Spillage detectors were installed on the draft hoods or barometric dampers of gas and oil furnaces and water heaters in 937 houses spread throughout the Vancouver, Winnipeg, Toronto, Ottawa and Charlottetown regions. The detectors were left in place for approximately 2 months in late winter.

Of the gas heated houses surveyed, 10% had experienced prolonged and unusual amounts of combustion gas spillage and 65% had experienced either short duration start-up spillage or prolonged spillage of small amounts of combustion gas. Of the oil heated houses, 55% had experienced significant spillage of high temperature combustion gas, but some of these spillage events may have been of only short duration.

Preliminary analysis indicates that spillage problems seem to be related to the following house or heating system characteristics:

- Winnipeg houses (believed to be more nearly airtight due to extensive use of stucco)
- pre-1945 houses
- post-1975 houses
- one storey houses
- exterior chimneys
- masonry chimneys with under-sized metal liners
- houses with three or more exhaust fans
- houses with two open masonry fireplaces
- poorly maintained heating appliances

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PROJECT 2 MODIFICATIONS AND REFINEMENTS TO THE FLUE SIMULATOR MODEL

FLUE SIMULATOR, a detailed theoretical computer-based model of the combustion venting process had been developed for CMHC prior to this project. It is intended for use as an aid in understanding the mechanisms of combustion venting failure and the circumstances that give rise to them. The modifications undertaken in this project were intended to make the program easier to use and to allow it to model a wider variety of furnace/flue/house systems. The modifications included -

- o refinements to algorithms
- o more efficient operation of the program
- o modelling additional features and system types
- o user-friendly input and output

The modified model was validated against field test data and used to investigate a number of issues.

A separate developmental version of the program, called WOOD BURNING SIMULATOR, was successfully developed to model the combustion and combustion venting process in wood stoves and fireplaces.

PROJECT 3 REFINEMENT OF THE CHECKLISTS

A procedure for identifying and diagnosing combustion venting failures had previously been developed for CMHC - the Residential Combustion Safety Checklist. This project provided an opportunity to refine the checklist and develop variations of it suitable for a variety of possible users such as furnace service personnel, air sealing contractors, homeowners, etc. Early in the project, it was decided to separate the identification procedures from the diagnostic procedures. This allowed the process of identifying houses with potential for combustion venting problems to remain relative simple and allowed the diagnostic process to become more complex since it would only be used on houses where the extra effort would likely be worthwhile. Thus the original backdraft checklist has grown into five separate tests/procedures

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Venting Systems Pre-test

- a quick, visual inspection procedure which identifies a house as either unlikely to experience pressure-induced spillage or requiring further investigation

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Venting Systems Test

- a detailed test procedure for determining to what extent the combustion venting system of a house is affected by the envelope airtightness and operation of exhaust equipment, perhaps the clearest descendent of the old backdraft checklist.

Chimney Performance Test

- a simple method of determining whether a chimney is capable of providing adequate draft

Heat Exchanger Leakage Test

- a quick method of determining if the heat exchanger of a furnace has a major leak

Chimney Safety Inspection

- a visual check for maintenance problems in the chimney system

These tests/procedures are all presented in a manual entitled "Chimney Safety Tests". Full trials of the procedures were carried out on the case study houses investigated in Project 6.

PROJECT 4 HAZARD ASSESSMENT

Although little was known at the outset of this project about the frequency of combustion spillage, even less was known about how much of a health hazard such spillage represents. Therefore this sub-project was included to investigate the real nature of the health and safety risk associated with venting failures. The work was divided into five tasks -

1. Review of current knowledge on pollutant generation due to improper venting of combustion appliances (literature review).
2. Development of a computer program to predict levels of various pollutants under various combustion venting failure scenarios.
3. Acquisition and calibration of a set of instruments required to measure the various pollutants at the levels predicted by the computer model.
4. Monitoring pollutant levels in problem houses identified in the Country-wide Survey (Project 1) using the instruments acquired in Task 3.
5. Analysis of the results of Task 4 to arrive at an overall assessment of the health hazard represented by combustion venting failures in Canadian houses.

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The results indicate that, in most houses, one would rarely encounter acute, immediately life-threatening concentrations of pollutants as a result of combustion spillage from furnaces or water heaters. However, chronic health risk due to low level, long term exposure to pollutants, particularly NO₂, may be a more significant problem which requires further investigation. High levels of CO do not seem to be caused by the problems which cause spillage and thus occur in spillage events only as a result of coincidence.

PROJECT 5 REMEDIAL MEASURES

Remedial measures for pressure-induced combustion venting problems were identified and researched for a number of different types of combustion appliances.

The remedial measures identified for FIREPLACES were:

Spillage Advisor

- This is an adjustable volume alarm triggered by a combination of particulate and CO detectors and intended to be mounted on the front of the mantle or on the wall just above the fireplace.

Airtight Glass Doors Combined With An Exterior Combustion Air Supply Duct

- The research indicated that conventional glass doors are not nearly airtight and do little to separate the fireplace from the house's pressure regime. Prototype doors using special glass, heavier than normal steel frames and special sealing techniques were fabricated and installed and tested. It was found that these doors increased the level of house depressurization required to cause prolonged spillage from the fireplace from 3 Pa to 22 Pa. It is estimated that the installed cost would be \$600. Further research on the effect of airtight doors on temperatures within the fireplace and flue and the possible hazard to surrounding combustible materials is required.

The remedial measures identified for GAS-FIRED APPLIANCES were:

Spillage Advisor

- This could be similar to the fireplace spillage advisor but would be triggered by a heat probe mounted in the dilution port of the appliance. The heat probes inves-

tigated could also be used to trigger other remedial measures discussed below.

Draft-inducing Fan

- A paddle-wheel-type fan mounted in the vent connector was found to increase the level of house depressurization required to cause irreversible spillage from a naturally aspirating gas furnace from 7 Pa to more than 20 Pa.

Draft-assisting Chamber

- A chamber surrounding the appliance's dilution port and extending downwards contains combustion products flowing out of the dilution port and prolongs the period before they are actually spilled into the room. It was expected that the chamber would also use the buoyancy of the contained combustion products to assist the flue in developing upward flow and thus would increase its resistance to house depressurization; however, the results obtained with the prototype tested did not live up to expectations. It is expected that modification of the design and testing with a furnace/flue/house combination more prone to pressure-induced spillage will improve this aspect of the chamber's performance.

The research on remedial measures for OIL-FIRED APPLIANCES indicated that stable backdrafting is unlikely to be a problem with oil-fired appliances since the pressure generated by the burner blowers is able to rapidly overcome backdrafting due to house depressurization and initiate upward flue flow. However, this pressurization of the flue system is what accounts for the start-up spillage associated with oil appliances and it is the duration of this spillage that remedial measures must address. The measures identified were:

Solenoid Valve

- By delaying the start of combustion until the burner has had a chance to overcome backdrafting and initiate upward flue flow, the solenoid valve reduces the duration of spillage but does not eliminate it altogether.

Draft-inducing Fan

- A fan, similar to that described above under gas appliances, mounted in the flue pipe downstream of the barometric damper is not needed to overcome backdrafting since the burner blower can do this. However, it

does relieve pressurization of that portion of the flue pipe upstream of itself and hence reduces spillage from that portion. There can still be spillage from the downstream portion; but, since that portion does not include the barometric damper, it is easier to seal.

Elimination of the Barometric Damper

- Provision of a well-sealed flue pipe without a barometric damper is one obvious way to reduce spillage. However, elimination of the barometric damper exposes the burner to the full chimney draft and disturbs the combustion process of conventional burners. Therefore this procedure must include replacement of the conventional burner with a high pressure burner which is less influenced by flue pressure. Provision of an insulated flue liner is often included as part of this measure.

The work on MAKE-UP AIR SUPPLY remedial measures was less directed towards specific measures but served to clarify a number of general air supply issues. It indicated that the provision of additional supply air is not likely to be effective as a remedy for pressure-induced spillage of combustion products if the supply air is introduced unaided through an envelope opening of any size likely to be considered practical. It is only likely to be effective if a supply air fan is used and if that fan has a capacity at least equal to the total capacity of all exhaust equipment it is attempting to counteract. The discharge from such a supply air fan can be introduced essentially anywhere in the house, but is likely to create fewer thermal comfort problems if introduced in a normally unoccupied area such as the furnace room.

The knowledge generated in the remedial measures research and already available to Consortium members was synthesized into the draft Remedial Measures Guide, a manual intended to be a decision-making guide for tradesmen and contractors who have identified pressure-induced spillage problems in houses with vented fuel-fired appliances and want to know how best to remedy these problems. It is designed to accompany the Venting Systems Test. Although the draft Guide is not yet comprehensive and in some cases describes procedures which have not been thoroughly field tested and/or approved by regulatory authorities, it is hoped it will stimulate thought and discussion and improve current trade practices.

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PROJECT 6 PROBLEM HOUSE FOLLOW-UP

Twenty of the houses identified in the country-wide survey as experiencing the worst combustion spillage problems were visited with the following objectives:

- to categorize and quantify the nature of venting failures
- to isolate contributing factors
- to collect field data on venting failures for use in the flue simulator model validation
- to measure the frequency and quantity of spillage in problem houses
- to measure the approximate impact on air quality of venting failures in houses
- to evaluate the effectiveness of the chimney safety tests in diagnosis of failures and identification of remedial measures
- to evaluate communications techniques
- to evaluate remedial measures under field conditions

In most of the houses, there were several factors that were assessed as contributing causes of the combustion spillage problem - thus confirming the "systems" nature of the problem. It is also worth noting that, in many houses, although the spillage observed was indeed pressure-induced, it occurred at quite low levels of house depressurization because the chimneys were only able to generate very weak draft due to some problem such as a blocked or leaky flue. The main problem in these cases, therefore, was not depressurization but weak chimneys.

PROJECT 7 COMMUNICATIONS STRATEGY

As the survey revealed that the problem, while substantial, is not epidemic in proportion, there is no need to create widespread alarm in the general public. A communication strategy has been drafted with this in mind. It places emphasis on motivating the heating and housing industries to be aware of the combustion venting problem and its causes and to make effective use of the diagnostic tools and preventive and remedial measures developed in this project.

OVERALL PROJECT SUMMARY AND CONCLUSIONS

The project has gone a long way towards meeting its original objectives and has significantly advanced the state-of-the-art in this field.

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

It has led to improved understanding of the combustion venting process and confirmed the "systems" nature of the failures that lead to combustion venting problems.

It appears that a significant portion of the Canadian housing stock has potential for combustion venting failure to occur on a regular basis. In most cases, this is unlikely to lead to immediate life-threatening pollution levels, but long term chronic health hazards could be a problem; however this latter concern requires further investigation before any definite conclusion can be reached.

A number of techniques are available for identifying houses prone to combustion venting failure and for diagnosing the causes of such failure. There are also available a number of measures for preventing combustion venting failure in new houses and for remedying it in existing houses. A communication strategy has been drafted for conveying these techniques and measures to relevant people in the housing and heating industries and for encouraging them to make use these tools.

A P P E N D I X B

PERSONS AND ORGANIZATIONS
CONTACTED IN "NETWORKING" EXERCISE

**RESIDENTIAL COMBUSTION VENTING FAILURE
PROJECT 7: COMMUNICATIONS STRATEGY**

- A SYSTEMS APPROACH

Mr. Ian Bartlett, Co-ordinator
Arch. Master Spec. Secretariat
c/o Science and Technology
Development Directorate
Riverside Drive
Ottawa, Ontario
K1A 0M2

Mr. Elliot Sherman
Sen. Building Science Architect
Public Works Canada
700 Industrial Avenue
Unit #5
Ottawa, Ontario
K1G 0Y9

Mr. A.L. St-Pierre
Ventilation Standards Engineer
UFFI Centre
200 Promenade de Portage
Hull, Quebec
K1A 0C9

Mr. Dave Scott
National Research Council
Division of Building Research
1411 Oxford Street
Halifax, N.S.
B3H 3Z1

Mr. J.T. Allston
Dir. of Urban & Rural Planning
Provincial Planning Office
Dept:Municipal Affairs & Housing
St. John's, Newfoundland
A1C 5T7

Mr. Carey Ryan
Energy Management Division
Department of Mines and Energy
P.O. Box 1087
Halifax, N.S.
B3J 2X1

Mr. R. Chill
Building Division
Tech. Serv. & Contracts Branch
Dept: Indian & Northern Affairs
11th Floor, 10 Wellington St.
Hull, Quebec
K1A 0H4

Mr. Myron N. Mech, Director
Construction Materials Board
National Defense Headquarters
Department of National Defense
10 Colonel Bay Drive
Ottawa, Ontario
K1A 0K2

Dr. Douglas Walkinshaw
Indoor Air Quality Co-ordinator
National Research Council
M24 Montreal Road
Ottawa, Ontario
K1A 3R6

Mr. Harold Orr
National Research Council
University of Saskatchewan
110 Gymnasium Road
Saskatoon, Saskatchewan
S7N 0W9

Ms. Jo Heringa
Energy Conservation Advisor
Department of Mines & Energy
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7

Mr. John DeGrace
Energy and Mineral Resources
Dept. of Energy and Forestry
P.O. Box 2000
Charlottetown, P.E.I.
C1A 7N8

Mr. Darwin Curtis
Conservation and Renewables
The N.B. Energy Secretariat
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

M. Daniel Mallette
Bureau des economies d'energie
425, rue Viger Ouest
Montreal, Quebec
H2Z 1W9

Mr. Jerry MacDonald
Chief Property Development Off.
P.E.I. Dept. of Municipal Affairs
P.O. Box 2000
Charlottetown, P.E.I.
C1A 7N8

M. Jean Couture
Ministere de l'Habitation et de
la Protection du Consommateur
425 rue St. Amable
Quebec, Quebec
G1R 4Z1

Ms. Sylvia Davis
Bldg. Industry Development Board
Ministry of Housing
2nd Floor, 777 Bay Street
Toronto, Ontario
M5G 2E5

Mr. Doug Leeies
Manitoba Housing
287 Broadway
Winnipeg, Manitoba
R3C 0R9

Mr. Paul Hagen
Mechanical Engineering Division
Manitoba Dept. of Labour
Rm. 500, 401 York Avenue
Winnipeg, Manitoba
R3C 0P8

M. Jacques Desbiens
Societe d'habitation du Quebec
Edifice G, bloc 2, 3e etage
1054 rue Conroy
Quebec, Quebec
G1R 5E7

Ms. Helena Whyte
Community Planning Division
Dept. of Municipal Affairs
P.O. Box 216
Halifax, Nova Scotia
B3J 2M4

Mr. Robert Lynch
Executive Director of Buildings
Dept. of Supply and Services
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

Mr. Chris Gates
Energy Technology Programs
Consumer & Commercial Relations
4th Floor, West Tower
3000 Bloor St. W.
Etobicoke, Ontario
M8X 2X4

Mr. George Petrycky
Office of the Fire Commissioner
Dept. of Labour & Employment
Rm. 611 - 401 York Avenue
Winnipeg, Manitoba
R3C 0P8

Mr. Bill McDonald
Energy Management Division
Department of Energy and Mines
555 - 330 Graham Avenue
Winnipeg, Manitoba
R3C 4A5

Mr. Bert Sheasby
Technical Safety Services
Branch
Department of Labour
1870 Albert Street
Regina, Saskatchewan
S4P 3V7

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. Dan McFadyen
Department of Energy and Mines
Toronto-Dominion Bank Building
1914 Hamilton Street
Regina, Saskatchewan
S4P 4V4

Mr. Ian Peacock
Building Standards Branch
Alberta Labour
Room 705, 10808-99th Avenue
Edmonton, Alberta
T5K 0G2

Mr. Goldie Edworthy
Energy Conservation Branch
Alberta Energy and Natural Resources
2nd Floor, 10010 - 106 Street
Edmonton, Alberta
T5J 3L8

Mr. Jim Smith
Gas Inspection Branch
Ministry of Labour
601 West Broadway
Vancouver, B.C.
V5Z 4G9

Mr. Bud Pollock
Protective Services Branch
Govt. of the Yukon Territory
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. McFee
Fire Safety Division
Justice & Public Services
Govt. of the Northwest Territories
Yellowknife, NWT
X1A 2L9

Mr. N. Massiah
Building Standards Branch
Alberta Labour
Room 705, 10808-99th Avenue
Edmonton, Alberta
T5K 0G2

Mr. Watson Smith
Building Standards Branch
Ministry of Municipal Affairs
9th Floor, 747 Fort Street
Victoria, B.C.
V8W 3E9

Ms. Donna Bagdan
Home Design Branch
Alberta Agriculture
2nd Floor, 7000-113th Street
Edmonton, Alberta
T6H 5T6

Mr. John Allen
Energy Branch
Energy, Mines & Pet. Resources
525 Superior Street
Victoria, B.C.
V8V 1T7

Mr. Larry Hipperson
Protective Services Branch
Govt. of the Yukon Territory
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Dr. Eugene Baranowski
Room #66
Health Protection Branch Bldg.
Health & Welfare Canada
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

Dr. V. Armstrong
Environ. Health Directorate
Bureau of Chemical Hazards
Monitoring & Criteria Div.
Health & Welfare Canada
Tunney's Pasture
Ottawa, Ontario K1A 0L2

Mr. Pierre Bois
President
Medical Res. Council of Canada
20th Fl. Jeanne Mance Bldg.
Tunney's Pasture
Ottawa, Ontario
K1A 0W9

Mr. Arthur R. Bray
Manager - Occupational Section
Canada Safety Council
1765 St. Laurent Blvd.
Ottawa, Canada
K1G 3V4

Mr. Gerald Dafde
Executive Director
Canadian Public Health
Association
1335 Carling Avenue, #210
Ottawa, Ontario
K1Z 8N8

Ms. M. Susan Daglish
President/Executive Director
Allergy Information Association
25 Poynter Drive, Rm. 7
Weston, Ontario
M9R 1K8

Mr. B.E. Freamo
Secretary General
The Canadian Medical Assn.
P.O. Box 8650
Ottawa, Ontario
K1G 0G8

Mr. Fayek Kelada
Chief Toxicologist
Saskatchewan Dept. of Labour
Occup. Health & Safety Branch
1150 Rose Street
Regina, Saskatchewan
S4P 3V7

Mr. Bill McLaren
President
Canadian Fire Safety Assn.
2175 Sheppard Avenue, East
Suite 110
Willowdale, Ontario
M2J 1W8

Mr. C.G. Schmelzle, P.Eng.
Manager
Warnock Hersey Prof. Services
Physical Test. & Inspect. Serv.
3210 American Drive
Mississauga, Ontario
L4V 1B3

Mr. Zain Shah, P.Eng.
Director, Standards Programs
Standards Division
Canadaian Standards Assn.
178 Rexdale Blvd.
Rexdale, Ontario
M9W 1R3

Mr. Brian Rossborough, P.Eng.
Manager - Standards Program
Building Construction &
Energy Standards Division
Canadian Standards Assn.
178 Rexdale Blvd.
Toronto, Ontario M9W 1R3

Mr. Derek Ashenden
Program Manager
Com. Electrical/Electronics
Canadian Standards Assn.
178 Rexdale Boulevard
Toronto, Ontario
M9W 1R3

Mr. Roger N. Le Blanc, P.Eng.
Project Engineer
Construction Materials
Underwriters' Labs. of Canada
7 Crouse Road
Scarborough, Ontario
M1R 3A9

Ms. Ellen Bujold
Information Officer
Standards Information Div.
Standards Council of Canada
350 Sparks Street, Ste. 1203
Ottawa, Ontario
K1R 7S8

Mr. Bob Charest
Standards and Specs. Branch
Canadian General Standards Board
Ottawa, Ontario
K1A 1G6

Mr. Scott Rogers
Director of Testing
Consumers Assn. of Canada
Box 9300
Ottawa, Ontario
K1G 3T9

Mr. Pierre Beauchamp
Vice-President
Canadian Institute of
Plumbing & Heating
99 Duncan Mill Road
Don Mills, Ontario
M3B 1Z2

Mr. John Clinkett
Chair: CSC Tech-Aids Committee
Construction Specs. of Canada
c/o John Clinkett & Associates
938 King Street, W.
Kitchener, Ontario
N2G 1G4

Col. L.G. Doiron
Executive Director
Propane Gas Assn. of Canada
500 Fourth Avenue, S.W.
Suite 1202
Calgary, Alberta
T2P 2U6

Mr. Robbins Elliott
Executive Director
Canadian Housing Design Council
M-2 L'Esplanade Laurier
171 Bank Street
Ottawa, Ontario
K2P 1W5

Mr. Barry Eon
Secretary
Caulking Contractors Assn.
of Ontario
1 Sparks Avenue
Willowdale, Ontario
M2H 2N1

Mr. Kit Kennard
Consultant (NIECCA)
Kit Kennard & Associates
620-1435 Prince of Wales Dr.
Ottawa, Ontario
K2C 1N5

Mr. Larry Lamarche
Sec. Treasurer
Assn. of Canadian Fire
Marshals & Fire Commissions
P.W.C. Riverside Drive
Ottawa, Ontario
K1A 0M2

Mr. J.E. McCracken
Executive Director
Canadian Window & Door
Manufacturers Assn.
27 Goulburn Avenue
Ottawa, Ontario
K1N 8C7

**RESIDENTIAL COMBUSTION VENTING FAILURE
PROJECT 7: COMMUNICATIONS STRATEGY**

- A SYSTEMS APPROACH

Mr. Phillip T. Nance CAE
President
Canadian Gas Assn. of Canada
5468 Dundas Street, West
Suite 414
Islington, Ontario
M9B 6E3

Mr. James Flood
Executive Officer
Ontario Home Builders Assn.
5218 Yonge Street
Willowdale, Ontario
M2N 5P6

Mr. Wayne Cole &
Mr. Peter Barclay
NIECCA
Suite 525, 5 Donald Street
Winnipeg, Manitoba
R3L 2T4

Mr. Terry Mills
Master Builders Group
740 Broadview Avenue
Toronto, Ontario
M4K 2P1

Mr. Ted Clare
Clare Brothers Ltd.
223 King St. East
Cambridge, Ontario
N3H 3M5

Mr. Glen Palmer
Manager of Service Admin.
Consumers' Gas
P.O. Box 650
Scarborough, Ontario
M1K 5E3

Mr. John Archer
Canadian Home Builders' Assn.
331 Cooper Street, Suite 701
Ottawa, Ontario
K2P 0G5

Mr. Frank Young
Executive Vice-President
Canadian Manufactured
Housing Institute
55 York Street, Suite 512
Toronto, Ontario
M5J 1S2

Mr. Eric Jones
Codes and Technical Services
Canadian Wood Council
85 Albert Street
Ottawa, Ontario
K1P 5A4

Mr. Robert Galt
Canadian Wood Energy Institute
85 Curlew Drive
Don Mills, Ontario
M3A 2P8

Mr. Pierre Dumouchel, P.Eng.
Manager, Energy Utilization
& Development
Union Gas Limited
50 Keil Drive, N.
Chatham, Ontario
N7M 5M1

Mr. John Rinella
Research and Development
Consumers' Gas
P.O. Box 650
Scarborough, Ontario
M1K 5E3

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. James Larkin
Service Manager
Ottawa Gas
400 Coventry Road
Ottawa, Ontario
K1K 2C7

Ms. Yvette Reidy
Air Seal Technology Ltd.
208 Pleasant Street
Darthmouth, Nova Scotia
B2Y 3R6

Dr. S.W. Khoo, Ph.D.
Assistant Director of Research
Canadian Gas Research Institute
55 Scarsdale Road
Don Mills, Ontario
M3B 2R3

Mr. Gordon Esplin
B.C. Research
3650 Westbrook Mall
Vancouver, B.C.
V6S 2L2

Mr. Eric Burnett
Director
Building Engineering Group
415 Phillip Street
Waterloo, Ontario
N2L 3X2

Prof. J. Timusk
Department of Civil Engineering
University of Toronto
Toronto, Ontario
M5S 1A4

Mr. Brian Marshall
Renewable Energy in Canada
334 King Street E., Studio 208
Toronto, Ontario
M5A 1K8

Mr. Bruce Fulcher
Ener-Corp Management Ltd.
2 Donald Street
Winnipeg, Manitoba
R3L 0K5

Mr. Len Wall
President
Comfort King Ltd.
13 A Enterprise Avenue
Nepean, Ontario
K2E 0A5

Mr. Malcolm Rode
Ontario Research Foundation
Sheridan Park Research
Community
Mississauga, Ontario
L5K 1B3

Prof. Bob Besant
Head - Dept. of Mechanical
Engineering
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0X0

Dr. P. Fazio
Director
Centre for Building Studies
Concordia University
1455 de Maisonneuve Blvd., West
Montreal, Quebec
H3G 1M8

Dr. Dave Wilson
Dept. of Mechanical Engineering
University of Alberta
Edmonton, Alberta

Mr. Mark Lawton
Buchan, Lawton, Parent, Ltd.
5370 Canotek Road
Ottawa, Ontario
K1J 8X7

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. Gary Proskiew
Unies Limited
1666 Dublin Avenue
Winnipeg, Manitoba
R3H 0H1

Mr. Kevin Fillbrook
Home Energy Group
P.O. Box 1360
Kitchener, Ontario
N26 4H9

Mr. Douglas W. DeWerth
American Gas Assn. Laboratories
8501 East Pleasant Valley Rd.
Cleveland, Ohio 44131
U.S.A.

Information Officer
Combustion Safety Division
U.S. Dept. of Health & Human
Services
Office of Consumer Affairs
200 Independence Avenue, S.W.
Washington, D.C. 20201
U.S.A.

Information Officer
Indoor Air Quality Group
U.S. Environmental
Protection Agency
401 M Street, S.W.
Washington, D.C. 20460
U.S.A.

Mr. Harry Mitchell
Dept of Consumer Affairs
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7

Mr. Warrick Swyers
Public Health Inspection Services
Dept. of Health
Confederation Bldg.
St. John's, Newfoundland
A1C 5T7

Dr. J. Martin
Occupational Health and Safety
Division
Dept. of Labour
P.O. Box 4750
St. John's, Newfoundland
A1C 5T7

Mr. J. Cardoulis
Provincial Fire Commissioner
Pleasantville,
St. John's, Newfoundland
A1A 1N8

Mr. W. Miller
Boiler Inspection Branch
Dept. Of Fisheries and Labour
Box 2000
Charlottetown, P.E.I.
C1A 7N8

Mr. John Carr
Chairman
Occupational Health and Safety Council
Dept. of Fisheries and Labour
Box 2000
Charlottetown, P.E.I.
C1A 7N8

Mr. Sterling Breedon
General Manager
P.E.I. Housing Corporation
Box 2000
Charlottetown, P.E.I.
C1A 7N8

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. Robert Brandon
General Manager
P.E.I. Energy Corporation
Charlottetown, P.E.I.
C1A 7N8

Mr. Robert Martin
Director
Consumer Services Division
Dept of Consumer Affairs
P.O. Box 998
Halifax, Nova Scotia
B3J 2X3

Mr. T. Mejnzer
Occupational Health
Environmental Health Division
Dept of Health
P.O. Box 488
Halifax, Nova Scotia
B3J 2R8

Mr. Ernest Clarke
Planning Services
Dept. of Housing
P.O. Box 815
Dartmouth, Nova Scotia
B2Y 3Z3

Dr. Bidgood
V-P, Applied Science
Nova Scotia Research Foundation
P.O. Box 790
Dartmouth, Nova Scotia
B2Y 3Z3

Mr. Charles Findlay
Fire Marshall
Fire Marshall's Office
Dept. of Labour
P.O. Box 697
Halifax, Nova Scotia
B3J 2T8

Mr. Jack Noonan
Executive-Director
Occupational Health and Safety Division
Dept of Labour
P.O. Box 697
Halifax, Nova Scotia
B3J 2T8

Mr. Peter Fitzpatrick
Fire Marshall
Engineering Services Division
Dept of Labour and Human
Resources
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

Mr. Luke Morrison
Chairman
Fire Prevention Advisory Board
Dept. of Labour and Human Resources
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

G.R. Black
Vice-President
Operations
N.B. Housing Corporation
Box 611
Fredericton, New Brunswick
E3B 5B2

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. R. Brian Connell
Director
Health and Safety Services
Occupational Health and Safety Commission
Box 6000
Fredericton, New Brunswick
E3B 5H1

Jean - Louis Bertrand
Vice-President
Prevention-inspection
Commission de la sante
et de la securite du travail du
Quebec
1199 de Bleury, CP 6056
Succursale A
Montreal, Quebec
H3C 4E1

Yvon Poirier
Directeur-General
Fonds de la recherche en sante du Quebec
550, rue Sherbrooke Ouest
bureau 1950
Montreal, Quebec
H3A 1B9

Sohel Zariffa
Directeur
Direction-generale des
economies d'energie
Ministere de l'energie et des
ressources
200 Chem Ste. Foy 6e etage
Quebec, Quebec
G1R 4X7

Claude Roch
Directeur
Direction-Generale de la
prevention des incendies
Ministeres des Affaires Municipales
20 ave Chauveau
Quebec, Quebec
G1R 4J3

Claude Michaud
Vice-president
Regie des entreprises de
construction du Quebec
577 boul. Henri-Bourassa
Ministeres des Affaires
Municipales
Montreal, Quebec
H2C 1E2

Dr. R. Higgin
Asst. Deputy Minister
Energy Programs and Technology Research
Ministry of Energy
56 Wellesley St.
12th Floor
Toronto, Ontario
M7A 2B7

Bob Greven
Energy Technology Research
Ministry of Energy
56 Wellesley St.
12th Floor
Toronto, Ontario
M7A 2B7

Bob Youtz
Director
Public Health Branch
Ministry of Health
5th Floor
15 Overlea Blvd.
Toronto, Ontario
M4H 1A8

Dr. P. Pelmear
Occupational Health Branch
Occupational Health and Safety
Division
Ministry of Health
400 University Ave.
Toronto, Ontario
M7A 1T7

A. Zdanowicz
Research Director
Community Housing
Ministry of Housing
2nd Floor, 777 Bay St.
Toronto, Ontario
M5G 2E5

Mr. Ken Cassin
Director
Planning Division
Dept of Housing
287 Broadway Ave
Winnipeg, Manitoba
R3C 0V8

Dr. P. Warner
Community Health Services Branch
Environmental Health Division
Dept of Health
189 Evanson St.
Manitoba, Winnipeg
R3G 0V8

Director
Industrial Technology Centre
Manitoba Research Council
1329 Niakwa Rd E.
Winnipeg, Manitoba
R2J 3T4

Dr. D. Johnson
Saskatchewan Health Research Board
5-3002 Louise St.
Saskatoon, Saskatchewan
S7J 3L8

Mr. Larry Boys
V-P, Policy Development
Saskatchewan Housing Corporation
2500 Victoria Ave
Regina, Saskatchewan
S4P 3V7

E. Reimer
Director
Workplace Safety and Health
Branch
Dept of Environment and
Workplace Safety and Health
1000 - 330 St. Mary Ave.
Winnipeg, Manitoba
R3C 2L6

Dr. F.C. Stevens
Executive-Director
Manitoba Health Research
Council
750 Bannatyne Ave, Rm. 5107
Winnipeg, Manitoba
R3E 0W3

Mr. D. Robidoux
Consumer's Bureau
Dept of Consumer and Corporate
Affairs
405 Broadway Ave
Winnipeg, Manitoba
R3C 2L6

Ms. Audrey Roadhouse
Communication and Health
Education Branch
Dept of Health
2350 Albert St.
Regina, Saskatchewan
S4P 4A6
Education and Communications
Branch
Dept of Consumer and Commercial
Affairs
1871 Smith St.
Regina, Saskatchewan
S4P 3V7

Mr. Gerry Stinson
Director
Northern Municipal Services
Branch
Dept of Urban Affairs
P.O. Box 5000
La Range, Saskatchewan
S0J 1L0

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. R. Runge
Director
Planning Branch
Planning Services Branch
Dept. of Municipal Affairs
9925 - 107 St.
Edmonton, Alberta
T5C 2H9

Mr. Ken Shields
Director
Consumer Education and Information
Consumer and Corporate Affairs
10065 Jasper Ave.
Edmonton, Alberta
T5J 3B1

Mr. K. Smith
Research and Education Services
Occupational Health and Safety Division
Worker's Health, Safety and Compensation
10709 Jasper Ave
Edmonton, Alberta
T5J 3N3

Mr. Peter Robinson
Technical Services Branch
B.C. Housing Management Commission
Ministry of Lands Park and Housing
Suite 1701, 4330 Kingsway St
Burnaby, B.C.
V5H 4G7

Program Director
Consumer Education Division
Ministry of Consumer and Corporate
Affairs
3940 Blanchard St.
Victoria, B.C.
V8W 3EC

Mr. Linden Holmen
Director
Research and Development Branch
Dept of Housing
10050 -112 St.
Edmonton, Alberta
T5K 2J1

Mr. Alfred Roehl
Head
Materials and Testing Dept.
Applied Science Division
Alberta Research Council
1620 - 29th St NW
Calgary, Alberta
T2N 4L7

Dr. William Whitehead
Director
Occupational Health Unit
Industrial Health and Safety
Division
Workers Compensation Board
Ministry of Labour
6591 Westminster Highway
Richmond, B.C.
V7C 1C6

Mr. Gordon Anderson
Fire Commissioner
Office of the Fire Commissioner
2780 E. Broadway St.
Vancouver, B.C.
V5M 1Y8

Ms. Elsie Bagan
Consumer Services
Dept of Justice
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. Dale Ostrapowitch
Regional Manager
Engineering and Architecture Branch
Northern Affairs Program
Federal Dept of Indian Affairs and
Northern Development
Range Rd.
Whitehorse, Yukon
Y1A 3V1

Mr. Ben Larson
Manager
Housing Program
Dept of Community and Transportation
Services
Box 2703
Whitehorse, Yukon
Y1A 2C6

Mr. Nicholas Marach
Chief
Architectural Division
Public Works and Highways
P.O. Box 1320
Yellowknife, N.W.T.
X1A 2L9

Mr. Craig Johnson
Manager
Policy and Planning
N.W.T. Housing Corporation
P.O. Box 1320
Yellowknife, N.W.T.
X1A 2L9

Mr. A. W. Diamond
Director, Engineering &
Technical Services Branch
Dept. of Labour & Manpower
Gov't. of Newfoundland & Labrador
Confederation Building
St. John's, Newfoundland
A1C 5T7

Mr. Alan Davidson
Director
Health Services
Dept of Health and Human
Services
Box 2703
Whitehorse, Yukon
Y1A 2C6

Ms. Elaine Berthelet
Chief
Health Programs and Standards
Dept of Health
P.O. Box 1320
Yellowknife, N.W.T.
X1A 2L9

Mr. Don Hawkins
Chief
Energy Conservation
Public Works and Highways
P.O. Box 1320
Yellowknife, N.W.T.
X1A 2L9

Mr. Bob Bailey
Head
Regional Fire Centre
Federal Dept of Indian Affairs
& Northern Development
Box 1500
Yellowknife, N.W.T.
X1A 2K3

Mr. Murray Dunnett
Technical Inspection Branch
New Brunswick Dept. of Labour &
Manpower
P.O. Box 6000
Fredericton, New Brunswick
E3B 5H1

**RESIDENTIAL COMBUSTION VENTING FAILURE
PROJECT 7: COMMUNICATIONS STRATEGY**

- A SYSTEMS APPROACH

Mr. V.H. Perry
LP-Gas Inspector,
Office of the Fire Marshal
Nova Scotia Department of Labour &
Manpower
P.O. Box 697
Halifax, Nova Scotia
B3J 2T8

Ms. J. Samson
Chief, Gas Division
Ministere de l'Habitation et de
la Protection
du Consommateur, Division du
Gaz
255 est. boul. Crémazie Est.
Montreal, Quebec
H2M 1L5

Mr. Paul Pinnington
Director
Ontario Natural Gas Association
77 Bloor St. West,
Toronto, Ontario
M5S 1M2

Jim Clark
Chief
Residential & Transportation
Division
Dept. of Energy, Mines and
Resources
Suite 706, 119 Fourth Ave. S.,
Saskatoon, Saskatchewan
S7K 5X2

Mr. David Taggart, P.Eng.
Manager - Engineering
Clare Brothers
223 King St. E.,
Cambridge, Ontario
N3H 4T5

Dr. Bonnie Stern
E.O.T. Division
65A HPB Building
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

Mr. Raine Otson
Health & Welfare Canada
Environmental Health Centre Buildings
Room B19
Ottawa, Ontario
K1A 0L2

Mr. J.T. Mercer
Director, Plumbing & Gas Safety
Services Branch
Department of Labour
I.B.M. Bldg., 8th Floor,
10808 - 99th Avenue
Edmonton, Alberta
T5K 0G5

Mr. M.G. Cherry
Director, Gas Safety Branch
Ministry of Labour
601 West Broadway
Vancouver, B.C.
V5Z 4G9

Mr. T.J. Dunfield
Director Fire Protection
Engineering
Office of the Fire Commissioner
of Canada
Dept. of Public Works Sir
Charles Tupper Building
Riverside Drive
Ottawa, Ont.
K1A 0M2

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

Mr. I.H. Grabke
Head, Mechanical/Electrical Section,
Safety Division
Department of Justice
Gov't of Northwest Territories
P.O. Box 1320
Yellowknife, N.W.T.
X1A 2L9

Mr. E. Grzesik
Chief Engineer
Ministry of Consumer and
Commerical Relations
Ontario Fuels Safety Branch,
Technical Standards Div.
Shipp Centre, West Tower
3300 Bloor St. West - 4th Floor
Toronto, Ontario M8X 2X4

Mr. W. Mault
Director, Mechanical & Engineering Branch
Manitoba Department of Labour &
Employment Services
500 Norquay Building
Winnipeg, Manitoba
R3C 0V8

Mr. K. Bales
Council Secretary
Canadian Gas Association
55 Scarsdale Road
Don Mills, Ontario
M3B 2R3

Mr. John Finnsson
Approtech Inc.
3244 Main Street
Vancouver, B.C.
V5V 3M5

Mr. Grant Wichenko
Appin Associates
13 - 77 Rue Eugenie
Winnipeg, Manitoba
R2H 0X6

RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH
PROJECT 7: COMMUNICATIONS STRATEGY

A P P E N D I X C

NETWORKING LETTER

Scanada ~~Sheltair~~ Consortium Inc.

PROJECT OFFICE:
436 MacLaren St., Ottawa, Ont. K2P 0M8

Tel (613) 236-7179
TELEX 053-4472

March 20, 1986

Dear Mr. :

In October 1985, our company was selected by the Canada Mortgage and Housing Corporation (CMHC) to undertake a major study entitled "Residential Combustion Venting Failure - A Systems Approach". Part of our mandate is to inform potentially interested groups about the study. To this end, we are forwarding this introductory letter to you along with about 200 other Canadian professionals who have an interest in combustion venting.

As you probably know, concern about chimney venting failures has been growing in recent years, due to the trend towards more airtight construction. As houses are made more airtight, there is a greater chance that they can be depressurized by exhaust fans and fireplaces to the point where the normal chimney draft is insufficient to properly remove combustion gases from the house. In addition, airtight houses are more susceptible to air quality problems created by the spillage of combustion gases due to blocked flues, broken heat exchangers, or inadequate combustion air.

Currently, the incidence of combustion venting failure in the Canadian housing stock and its causes are not fully understood. Consequently, the objectives of our project are to characterize the extent and severity of venting failure problems in Canada, to develop analytical techniques to identify and diagnose houses in which venting failures occur, and to evaluate and recommend remedial measures. A project description is appended.

~~Scanada Sheltair~~

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It is anticipated that the study will be completed in July 1986 and the results available shortly thereafter. If public health and safety concerns warrant, it is possible that a technology transfer program may be developed by the Federal Government. The program would begin the public education and industry training tasks which would be required to ensure that appropriate diagnostic and remedial measures are properly implemented.

We have identified your group as one which may wish to participate in, or at least stay informed about, such a technology transfer process, if and when it is initiated. Consequently, we wanted to let you know about our work and to give you an opportunity to respond.

To facilitate comment, we are enclosing a feedback form which you will complete and return to us. Your answers will help us develop an appropriate strategy for disseminating the results of the study.

Your anticipated assistance in this regard is greatly appreciated.

Yours truly,

Ron Argue
Communications Co-ordinator

P.S. If you wish to contact CMHC directly, the project manager for this study is Mr. Don Fugler, Research Division, Canada Mortgage and Housing Corporation, 682 Montreal Road, Ottawa, Ontario K1A 0P7.
Telephone: 1-613-748-2658.

Enclosures.
RA:lfm

FEEDBACK FORM

RESIDENTIAL COMBUSTION
VENTING FAILURES STUDY

Please answer the indicated questions which are designed to assist us in making appropriate arrangements for disseminating the results of our study. Then return the form to the following special address:

Ron Argue
Communications Co-ordinator
Sheltair Scientific Ltd.
153 Third Ave
Ottawa Ontario
K1S 2J9

1. Are you interested in receiving a summary report of the current study when it is completed later this year?
[]yes []no
2. Are you currently involved in training or information programs which touch on aspects of combustion venting?
[]yes []no
(If yes, please specify. Use separate sheet, if necessary.)

3. Are you interested in attending an orientation workshop on the FLUESIM computer model if such a workshop goes ahead and if space is available?
[]yes []no
4. Are you interested in attending a training workshop on the combustion venting safety check procedure if such a workshop goes ahead and if space is available?
[]yes []no
5. Do you have any comments or questions about any aspect of our work on combustion venting? (Use a separate sheet if necessary.)

(see reverse side)



RESIDENTIAL COMBUSTION VENTING FAILURE - A SYSTEMS APPROACH

PROJECT DESCRIPTION

1. SCOPE

The project is designed to develop methods to identify, diagnose, and remedy combustion venting failures in Canadian homes. A venting failure occurs when the pressure established in the chimney is insufficient to fully vent all of the combustion gases, resulting in some of the gases being "spilled" into the home.

Under certain conditions, a severe form of combustion gas spillage known as "backdrafting" occurs. In such cases, the normal flow up the chimney is reversed, resulting in a downward "backdraft" which causes complete spillage of all combustion gases. Spillage or backdrafting events may be very short-lived or prolonged depending on their causes.

Key products of our work on combustion venting failures include:

- A residential combustion safety inspection procedure suitable for on-site use in identifying and diagnosing houses which are experiencing combustion gas spillage. The procedure will be in a checklist format. Different versions will be produced for industry service professionals and householders.
- Documentation of possible remedial measures for eliminating spillage occurrences based on field evaluation in actual problem houses.
- A computer program which simulates the thermal and flow performance of furnace flues. Such a program already exists and will be refined as part of this study. It is of use to researchers and furnace/flue designers interested in ensuring spillage-free operating configurations.

In addition, an assessment will be made of the incidence of venting failures in Canada based on instrumented monitoring of 1000 houses from all regions of the country. This assessment will be accompanied by an investigation of the nature of the health hazard created by spillage events based on a literature review and pollution concentration measurements in problem houses identified in the 1000-house sample.

The problem houses will also be used to define a physical profile of houses likely to experience spillage and to test diagnostic and remedial techniques.

Communications strategies to expedite the technology transfer of diagnostic and remedial measures, if and where warranted, will also be explored. In addition, pilot training programs for the safety check procedure and the computer model will also be developed.

2. STUDY TEAM

The study team brings together Sheltair Scientific Ltd. of Vancouver and Scanada Consultants of Ottawa as equal partners in the Scanada-Sheltair Consortium.

Both companies have previously undertaken work for CMHC in the area of the current study. Sheltair has developed prototype inspection procedures for identifying and diagnosing houses which are experiencing combustion gas spillage. Scanada has developed the FLUESIM model which simulates thermal and flow performance of furnace flues. The current project will produce field-validated versions of both the inspection procedures and the FLUESIM model.

The study is national in scope. To deal with regional concerns, we are being assisted by Solsearch Ltd. in Charlottetown, G.K. Yuill and Associates in Winnipeg, and the Saskatchewan Research Council in Saskatoon. Assistance on health and safety issues will be provided by the McGill School of Occupational Health and Safety in Montreal. An advisory committee of interested professionals in the public and private sector has also been assembled by CMHC to advise the project.

3. FLUE SIMULATOR COMPUTER MODEL

Field tests and surveys conducted by CMHC between 1982 and 1984 indicated that chimney spillage and backdraft phenomena could lead to indoor air quality problems. To meet the need for a theoretical analysis of the conditions leading to such problems, CMHC contracted with Scanada Consultants in 1984 to develop a model of the thermal and flow performance of furnace flues in houses.

The objective was to develop an analytical method for understanding the complex relationships which cause combustion gas spillage. Key factors include house envelope tightness, heating system characteristics, flue chimney design and construction, and the capacity of installed exhaust systems.

To accomplish this task, algorithms and a working model of various furnace/flue systems were developed to simulate furnace/flue performance under adverse operating conditions - that is, conditions that lead to spillage, stalling or backdrafting. A first draft of the model called the flue simulator or FLUESIM program was submitted in 1984 after extensive refinement based on comparison of its predictions with actual field measurements.

The FLUESIM model is designed for use on the IBM PC or compatible computers. It is being further refined during the course of the current study in order to increase its capability, accuracy and ease of use.

The FLUESIM model will assist researchers to develop an understanding of the performance of furnace flues under various operating condition. This will help determine which characteristics should be encouraged or avoided in the design and construction of furnaces and furnace venting systems. It is believed that the model and the insights gleaned from its use will be of particular interest to codes and standards authorities, the building research community, manufacturers, builders, and energy utilities.

4. THE RESIDENTIAL COMBUSTION SAFETY CHECKLIST

In 1982, CMHC commissioned the first national survey of carbon monoxide episodes in Canadian housing. The survey investigated the frequency, severity, and causes of hazardous conditions arising due to the inadequate venting of combustion products, especially carbon monoxide.

As a result of this study, CMHC contracted with Sheltair Scientific of Vancouver to develop a procedure to identify potential for combustion venting failure in housing. The result was the development of the residential combustion safety checklist, a step-by-step analytical procedure for identifying and diagnosing the cause of any unintended spillage of combustion gases from oil-, gas-, or wood-fired appliances. Two versions of the checklist were developed - one for service tradesmen and a simpler version for use by householders.

The checklist procedure permits the user to test the backdraft potential of furnaces, hot water heaters, and fireplaces. It involves measuring the indoor-outdoor pressure difference under worst case conditions. Worst case conditions are created by sealing air intakes and turning on all exhaust fans. If the house is de-pressurized below the required flue pressure for the heating appliance, the appliance is considered

to have backdraft potential and fails the test.

The cause of the failure is then diagnosed. Causes could include inadequate air supply, unbalanced exhaust fans, appliance overfiring, wind downdrafts, a broken heat exchanger, or a blocked, damaged or poorly designed flue. Appropriate remedial measures are then suggested to the householder.

The objective of the current study is to produce refined versions of the checklist in formats suitable for various particular target groups including furnace installers, weatherizers, air tightness testers and householders. Appropriate orientation and training materials are also being developed.

5. REMEDIAL MEASURES

We also have a mandate to develop, field-test, evaluate, and document suitable remedial measures to eliminate combustion gas spillage problems.

Remedial measures being tested for oil appliances include delayed action solenoid valves, sealed combustion chambers, and induced draft kits.

For gas appliances, measures under consideration include a draft-assisting chamber with dilution port size modification, induced draft kits, and wind diverting caps.

For fireplaces, measures include make-up air supply systems, spillage chambers, airtight ceramic doors with direct combustion air supply, and improved draft control.

The potential for reliable and economical spillage detection and alarm systems for oil and gas appliances as well as fireplaces will also be examined. Detectors may prove to be a cost-effective way of identifying potential problem houses.

Finally, methods to ensure adequate household air supply will be explored. These include make-up air supply arrangements for powerful kitchen exhaust fans and clothes dryer, and wind-resistant household air supply inlets.