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WHAT CMHC HAS BEEN DOING ABOUT INDOOR AIR QUALITY

Canada

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Canada Mortgage and Housing Corporation

July 1991

INTRODUCTION

Most people think of air quality in terms of smog, acid rain and industrial pollutants that affect our breathing and well-being in the outdoor environment. Few are aware that one of the most serious environmental threats to health is indoor air pollution in our homes, workplaces, shopping malls and other buildings.

Concern about indoor air quality is not new. Numerous studies have been carried out over the last 50 years in industrial environments to determine the effects of prolonged exposure to hazardous materials and toxic gases on the health and longevity of workers. What is different today, is that the concern has shifted to housing, schools and offices where any one of us may be exposed to low levels of pollutants for long periods of time.

Several factors have intensified the focus on indoor air quality in recent years. The increased use of synthetics in building materials, furnishings and consumer products has raised the concentration of chemical compounds in the indoor air. The need for energy conservation has led to the construction of air-tight buildings often with insufficient ventilation for adequate air exchange. Lastly, there is growing evidence of the effects of indoor air pollutants on health. "Sick building syndrome", "building related illness" and "environmental sensitivity" are expressions coined in the 1980s for very real reasons.

Canada Mortgage and Housing Corporation, the federal government's housing agency, was one of the first agencies to take a serious look at the issue of indoor air quality in residential environments. CMHC's research has gained international recognition. In this booklet, CMHC outlines its studies of indoor air quality problems in housing, the available solutions and sources of further information.

WHY CMHC IS INVOLVED IN INDOOR AIR QUALITY

Canada Mortgage and Housing Corporation has been researching the nature and problems associated with indoor air quality since the early 1980s. Here are some of the reasons for this involvement.

- **Importance of Residential Environments on Health:** In Canada we spend 93% of our time indoors, much of it at home. This is especially true of those people whose health is most fragile, such as the very young, the elderly and the infirm. Studies have found that concentrations of certain pollutants in the home may be as high or even higher than in the workplace. In addition, recent studies have shown a strong correlation between dampness in housing and respiratory diseases, with moulds believed to be the link. Improvements to residential indoor air quality may therefore represent an effective way of improving health.

- **The Need for Building Science Expertise in Housing**: While the effect of indoor air quality is primarily a health issue, the solution depends on an in-depth understanding of building science, particularly concerning the flows of air, moisture and heat within the interior space and within the building envelope. CMHC's recognized expertise in building science, combined with its knowledge of the Canadian housing industry, make it uniquely qualified to contribute to solutions to residential indoor air quality problems.

- **The Impact of Energy Conservation Measures**: Some of the energy conservation methods used in new and retrofitted housing in the 1970s and early 1980s created air quality and moisture problems. At that time, CMHC became involved in indoor air quality as part of its "systems approach" to housing technology, in which energy efficiency was studied for its impact not only on energy consumption but on other

components of the house. Today, there is renewed interest in energy conservation to minimize carbon dioxide emissions that lead to global warming. The optimum balance must be found among energy efficiency, ventilation and air quality.

- **Canada's IAQ Exposure Guidelines**: In 1987, Health and Welfare Canada released the "Exposure Guidelines for Residential Indoor Air Quality". Prepared by the Federal-Provincial Advisory Committee on Environmental and Occupational Health, it is the first document of its type in the world, and provides recommended guidelines for a range of typical residential pollutants. A guideline for radon levels was added in 1988. CMHC's research complements the guidelines by gathering data on concentrations of pollutants in Canadian housing, determining their sources and developing practical remedial measures.

- **Environmental Hypersensitivity**: In 1986, CMHC adapted its Residential Rehabilitation Assistance Program for the Disabled (RRAP) to provide grants for home modifications required by hypersensitive clients. Research is needed to determine cost-effective methods of building new housing and retrofitting existing homes for people suffering from this disability.

- **Toxic Lands**: Housing located on or near "toxic lands" such as former garbage dumps, landfills and industrial sites must be protected against hazards in the soil. The use of such sites has been increasing due to pressures of urbanization. Research is required to find the best protective methods.

- **Responsiveness to the Housing Industry**: Long active on the technical committees of the Canadian Home Builders' Association and the Heating, Refrigerating and Air-conditioning Institute, CMHC tailors its research to industry needs. Since the mid-1980s, ventilation and indoor air quality have been major concerns of the industry.

CMHC'S APPROACH TO INDOOR AIR QUALITY RESEARCH

CMHC's studies of indoor air quality are carried out in a variety of ways. Directed research takes an integrated approach to IAQ and includes field surveys to identify the specific problem, theoretical and computer modelling studies, and laboratory and field testing of solutions. Responsive research programs offer funding to external researchers to develop new products and technologies and to undertake independent studies. Joint research studies are also carried out with federal agencies such as the National Research Council of Canada, Energy Mines and Resources Canada and Health and Welfare Canada, and with others interested in indoor air quality.

Directed Research

CMHC's directed research applies a "systems approach" to indoor air quality. Such research considers the house as a complex system of inter-related components and examines the relationships between the building envelope, the mechanical systems, the outdoor environment, the soil, the occupants and the indoor environment as they relate to indoor air quality.

CMHC's directed research activities on indoor air quality attempt to identify and understand problems, to identify and test solutions, and to disseminate the results. Current work focusses on the following specific goals:

- To reduce pollution sources in the home;
- To minimize the spillage of combustion gases into the indoor environment;
- To decrease the risk from toxic lands;
- To protect homes from radon gas without negatively affecting other components of the house;
- To identify cost-effective solutions for the environmentally hypersensitive;

- To develop construction and retrofitting techniques to control mould in housing;
- To work with the housing industry to produce cost-effective and easily controlled ventilation systems; and
- To publicize the results of such research to the housing industry, regulatory agencies and the public.

Responsive Research Programs

CMHC's responsive research programs fund research by others into all types of housing related concepts including indoor air quality. Such programs include the Housing Technology Incentives Program (HTIP), the External Research Program (ERP) and the Scholarship Program for graduate students.

Collaborating with Others

In 1987, CMHC initiated the Working Group on Residential Indoor Air Quality which includes most of the major participants in indoor air quality research in Canada, including federal and provincial government agencies, the housing industry, universities and major utilities. The Working Group meets twice yearly to identify issues, set priorities, share information and encourage joint ventures.

CMHC is also a member of the interdepartmental Panel for Energy Research and Development (PERD). Funds received by CMHC from PERD have been directed toward research on the relationships between energy efficiency, air quality and moisture problems.

CURRENT INDOOR AIR QUALITY RESEARCH

CMHC's research activities into indoor air quality cover the following fields:

- combustion spillage,
- pollutant surveys, material emissions studies and development of sampling techniques,
- toxic lands, soil gas and radon,
- environmental hypersensitivity,
- ventilation in both low-rise housing and high rise apartments, and
- indoor air quality and ventilation in northern and remote housing.

Here is a summary of the major issues CMHC examines in each of these fields and some of the findings to date.

Combustion Spillage

When a heating appliance, such as a furnace or fireplace, does not successfully vent its combustion products to the outdoors, toxic gases can spill into the indoor environment.

CMHC has earned international recognition for its expertise in combustion venting in the home. CMHC found that a major cause of carbon monoxide poisoning was spillage of combustion gases from improperly vented appliances. Other combustion gases such as sulfur dioxide, nitrogen oxides and wood smoke also create health hazards. Increased air-tightness, powerful exhaust fans, and a lack of adequate ventilation can combine to depressurize a house interior to the point where the natural draft of a chimney is not sufficient to exhaust all the combustion gases. Blocked or poorly maintained chimneys can add to the problem.

CMHC has undertaken surveys to determine the extent and causes of the such spillage problems. Computer models have been created that simulate the venting performance of combustion appliances such as gas and oil furnaces, hot water heaters, fireplaces and wood stoves, to help predict optimum system designs and configurations. Retrofit measures to improve existing furnaces and fireplaces have been field tested. Recommendations for better chimney design, furnace installation and make-up air have also been made. Recent work has focussed on spillage from higher efficiency induced-draft furnaces and from wood stoves.

CMHC has developed a series of combustion safety tests or checklists that enable the homeowner to quickly assess, without the use of sophisticated equipment, how susceptible a house is to combustion spillage.

CMHC is now transfering its findings to codes and standards bodies, utilities, furnace service personnel and other interested associations.

Pollutant Surveys, Material Emissions Studies and Development of Sampling Techniques

CMHC's initial IAQ studies in the 1980s were often undertaken in association with the monitoring of energy-efficiency in airtight houses. In recent projects, CMHC has developed appropriate sampling techniques for residential environments, collected data on the level of pollutants in typical housing and examined specific indoor air quality problems. A recently completed study evaluated IAQ in manufactured housing. Current surveys are measuring volatile organic compounds and moulds in typical housing.

In recognition that pollutant source control is the key to improving IAQ, CMHC has organized an inter-agency Materials Emissions Task Force to oversee the development of emission standards for building materials. The Task Force will also

investigate standardized test methods for measuring emissions and will promote the availability of emissions data to designers, builders and the public.

Toxic Lands, Soil Gas and Radon

Housing is particularly vulnerable to pollutants from the soil, since basements are often the "leakiest" part of the house. Radon, which is associated with increased rates of lung cancer, is just one of the hazardous soil gases that penetrate the house in this way. Toxic lands can create problems of their own. Pollutants such as PCBs, methane gas, gasoline and oils and radioactive materials can migrate via sub-surface air movement or groundwater.

CMHC has assisted with the development of products and technologies to block the entry of radon and other soil gases into homes. These remedial measures have included improved basement construction technologies. CMHC also developed simple sampling techniques to analyze the soil gas entering basements.

Recently, the Corporation tested remedial measures to effectively prevent methane from entering an 80-unit housing project which had been abandoned because of soil gas. Current work includes the development of radon entry simulation models and the evaluation of radon remedial measures. Also underway is a national survey of toxic land sites and the type of protective measures which have been employed to protect housing.

Radon and soil gas research findings attract a wide audience among the housing industry, the public, housing and financial agencies.

Environmental Hypersensitivity

Through its pioneering studies in the early 1980s, CMHC was among the first to recognize the disability of the environmentally hypersensitive and the importance of indoor air quality, building materials and other home environment factors to their well being. CMHC's research work graded housing construction materials, mechanical systems, furnishings and consumer products according to their effect on the environmentally hypersensitive, proposed alternatives for "low-pollution" housing and documented measures which have been implemented across Canada. Current work includes identifying cost effective methods of building homes for the chemically sensitive, since at present, such specialized housing is highly customized and very expensive.

This type of information is, of course, of intense interest to the environmentally hypersensitive themselves and their associations as well as to the public. The building industry may also find that "clean" houses offer both health and marketing advantages.

Ventilation for Low-Rise Housing

In recent years, new Canadian housing has become increasingly airtight to the point where average air leakage does not provide a level of air change considered adequate (ie. 0.3 air changes per hour). Even in older, leakier homes, the volume of fresh air provided by reliance on "natural" or "passive" ventilation in housing is unpredictable and largely uncontrollable. This can result in high energy losses and uncomfortable drafts in the coldest periods, and inadequate fresh air during mild periods.

Mechanical ventilation systems are therefore increasingly common in Canada. However, many ventilation systems currently on the market are ineffective, such as a conventional bathroom exhaust fan which has a typical efficiency of only 3%. Similarly,

residential filtration systems which are commonly installed, such as a conventional furnace filter, tend to be ineffective.

CMHC's initial work in low-rise ventilation consisted of monitoring different types of ventilation systems and evaluating their on-site performance. To facilitate the control of make-up air, CMHC has developed a low-pressure sensor. CMHC has tested demand-controlled systems which can vary the rate and location of ventilation in response to pollutant levels. A current multi-year project is the development of more efficient and durable ventilation fans.

Considerable work has gone into assisting in the development of ventilation standards, such as the new Canadian Standards Association F326 "Residential Mechanical Ventilation Requirements", and helping the housing industry to develop practical solutions to meet the requirements of such standards and building codes.

The Canadian Home Builders' Association (CHBA), the Heating, Refrigerating and Air-conditioning Institute (HRAI) and ventilation system manufacturers are just some of the beneficiaries of this type of research.

Ventilation for High-Rise Apartments

Fresh air enters high-rise apartment buildings mostly through unplanned air leakages which occur between units and in service chases. Most apartment buildings provide mechanical ventilation air only to corridors and common areas such as the lobby. Little is known about air change rates and pollutants in high-rises.

CMHC is currently developing test methods for air quality sampling and for tracing air flow patterns in high-rise buildings. The Corporation has recently completed an industry practice survey of typical heating, ventilation and air conditioning systems

to determine potential problems in design, installation and maintenance of such systems. New research initiatives depend on the results obtained from these projects.

The Heating, Refrigerating and Air-conditioning Institute (HRAI) and local chapters of the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), as well as designers, suppliers and installers of mechanical equipment and ultimately the public will benefit from this research.

Indoor Air Quality and Ventilation in Northern Housing

The harsh climate and high costs of fuel transportation in Canada's northern and remote areas create special housing problems. Houses must be energy-efficient yet have sufficient ventilation, and their mechanical systems must be easy to maintain.

CMHC has carried out several major projects with Energy, Mines and Resources Canada and the territorial governments of the Yukon and the Northwest Territories on the development and field testing of both passive and active ventilation systems for northern housing. CMHC has recently completed an extensive survey of indoor pollutants, including combustion gases and mould, in housing units in the Northwest Territories.

Much of the housing technology developed specifically for Canada's north can effectively be adapted to less demanding environments. The territorial housing corporations and the Northern and Remote Technology in Housing Committee (NORTH Committee) are primarily interested in this research.

Related Research: Moisture and Energy Conservation

In its "systems approach" to housing research, CMHC conducts major studies into fields such as moisture, energy efficiency and envelope airtightness, that are related to indoor air quality.

Moisture studies initiated in the late 1970s focused on the structural and cosmetic deterioration caused by dampness in housing in order to protect the longevity of the housing stock. With the recent emphasis on mould as a health hazard, CMHC's current studies concentrate on controlling moisture sources and condensation to prevent the occurence of mould in housing. Theoretical research has included data collection from test huts and the development of computer models to simulate the flows of moisture, air and heat in walls and roofs. Practical research has focussed on solutions for basements, crawl spaces, attics and exterior walls.

Energy conservation measures in housing can improve or aggravate air quality and moisture problems. With concern for the global environment, interest in energy conservation has revived. CMHC has undertaken several energy related projects to ensure that any new conservation measures do not adversely affect the indoor environment in homes.

CMHC's studies on the airtightness of building envelopes are closely related to both energy efficiency and indoor air quality. While increasing airtightness was initially promoted for conserving energy, it is now seen as also essential for preventing moisture problems and ensuring the durability of the building enclosure. Airtightness in a home reduces the infiltration of pollutants from building materials and from the soil but at the same time increases the need for controlled mechanical ventilation to avoid pollution build-up.

HOW CMHC PUBLICIZES ITS RESEARCH FINDINGS

The overall objective of CMHC's research is to improve the quality of housing and living conditions in Canada. CMHC disseminates its research findings to:

- the housing industry - builders, renovators, trades, manufacturers of building materials, architects, designers and utilities;
- the Canadian public - homeowners, renters, landlords;
- North American regulatory agencies - codes and standards bodies;
- policy makers at the federal, provincial and municipal levels, including provincial and municipal housing authorities; and
- the Canadian and international research communities.

To reach the widest possible audience, CMHC publicizes the results of its research and development through workshops and seminars, participation at conferences, representation on technical committees, the publication of consumer and trade literature, and the distribution of research reports and technical papers.

Workshops and Seminars

Builders Workshop Series: Since 1985, this on-going series sponsored by CMHC, the Canadian Home Builders' Association (CHBA) and l'Association provinciale des constructeurs d'habitation du Québec (APCHQ) provides practical advice to builders and trades using an interactive format. The workshops cover topics including indoor air quality, moisture problems, ventilation and radon control.

Renovators' Seminars: On-going seminars, sponsored by CMHC, CHBA and APCHQ, offer technical skills and business training to Canada's growing renovation industry. The seminars cover a

systems approach to renovation that includes ventilation and safe combustion venting.

Combustion Spillage Course: Under development by CMHC and the Canadian Gas Association (CGA), this training course is being pilot tested for gas and oil furnace servicemen to help them recognize conditions of combustion spillage.

Conferences

Indoor Air '90 Conference: CMHC was a major sponsor of the 5th International Conference on Indoor Air Quality and Climate, held from July 29 to August 3, 1990 in Toronto. CMHC contributed in many ways to ensure its success - from providing a home for the Conference organizers to funding. Five technical presentations were made by CMHC researchers.

Public Forum: "The Air We Breathe" public forum was sponsored by CMHC during the Indoor Air '90 Conference to publicize the importance of indoor air quality to the general public and the media. Over 500 people attended, and heard case study presentations on how typical air quality problems can be solved. Participants were also given an opportunity to pose questions to a panel of the world's leading IAQ experts, who were in Toronto for Indoor Air '90.

Other Forums and Presentations: From time to time, CMHC organizes special forums for the housing industry to inform and discuss research projects and results. Examples have included forums for the gas, oil and wood heating industries on the topic of combustion spillage. CMHC researchers regularly make technical presentations on their IAQ research at national and international conferences. Examples include conferences of the Air and Waste Management Association (AWMA), the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) and the

International Energy Agency (IEA). Presentations are also made to lay audiences, such as school boards and allergy associations.

Healthy Housing Design Competition

In order to promote an integrated approach to housing which reflects the results of many years of research on indoor air quality, energy efficiency and environmentally responsible design and construction, CMHC is sponsoring a "Healthy Housing Design Competition". This competition encourages the development of prototypical house designs which are "healthy" for both the occupants and the global environment.

Representation on Technical Standards Committees

CMHC recognizes that amendments to building codes and standards are one of the best ways of making changes in building practices. CMHC is active in numerous codes and standards committees dealing with indoor air quality and ventilation. It has helped to develop various standards relating to indoor air quality sponsored by the Canadian Gas Association, the Canadian Standards Association, the Canadian General Standards Board, Underwriters Laboratories Canada and others.

Since the implementation of the Canada-U.S. Free Trade Agreement, CMHC researchers have become even more active on American standards bodies such as the American Standard and Testing Methods (ASTM).

In recognition of the need for standardized testing of pollutant emissions from building materials and for emissions data to be made available, CMHC has organized the inter-agency Materials Emissions Task Force to coordinate the development of emission standards.

The Canadian Housing Information Centre (CHIC)

CMHC maintains the largest collection of housing related information in Canada. The Centre's collection includes literature and bibliographies on research carried out in housing related subjects throughout the world. CHIC is the distribution point for CMHC research reports and for walk-in sales of CMHC publications.

Publications

All of the publications listed below are available in both English and French. They are numbered for easy reference when ordering, simply use the order form found on the last page of this booklet.

For the Consumer

How to Improve the Quality of Air in Your Home, NHA 6177 (1989): Easy-to-understand explanation of the sources of indoor air pollution; description of the common pollutants and their effects on health; how to eliminate pollution sources, install a ventilation system; air cleaning and combustion venting methods. (Cost: $2.00)

Guide to Radon Control, NHA 6181 (1990): Advice to the homeowner about the health effects of radon; test methods for detecting radon; and what remedial and preventative measures are effective. (Cost: $2.00)

Moisture and Air, NHA 5968 (Revised 1989): Discussion of household moisture problems including mould. (Free)

In Preparation: Major consumer publications on moisture and mould problems and on ventilation systems. (Late 1991)

For the Housing Industry

Performance of House Systems, NHA 6130 (1989): Written for renovators, an explanation of how a "systems approach" to renovation solves problems; and how ventilation, energy efficiency, air quality, combustion venting and moisture problems are interrelated. (Cost: $1.00)

Indoor Air Quality, NHA 6069 (1989): Identifies indoor air quality problems and provides "how to" advice to builders on avoiding them in new housing. (Cost: $1.00)

Radon Control in New Houses, NHA 6067 (1989): Written for builders, an explanation of the radon problem, test methods for radon and what radon control features can be built into new housing. (Cost: $1.00)

Guide to Residential Exhaust Systems, NHA 6114 (1989): For builders and trades, recommendations on how to select and properly install residential exhaust systems. (Cost: $1.00)

Ventilation: Health and Safety Issues, NHA 5888 (1986): Explanation for builders on how ventilation solves moisture, air quality and combustion spillage problems. (Cost: $1.00)

Complying with Residential Ventilation Requirements in the 1990 National Building Code, NHA 6451 (1990): The specific ventilation systems and details of installation techniques that meet the 1990 National Building Code requirements and description of what upgrades are necessary to meet the CSA F326 standard. Also available from the Ontario New Home Warranty Program. (Cost: $10.00)

For the Researcher

CMHC has carried out more than 100 research projects in indoor air quality. Some of the most significant reports are listed here. They are available free of charge in both English and French.

Chimney Safety Tests User's Manual: Procedures for Determining the Safety of Residential Chimneys (1988): Detailed manual of test procedures to determine the safe venting performance of any type of residential heating appliance.

Indoor Air Pollution and Housing Technology: Summary Report (1984): Summary of a detailed indoor air quality study which included documentation of typical residential pollutants and their health effects, causes of IAQ problems and examples of low-pollution design.

Advances in Basement Technology (1989): A detailed study of current and future technology together with a proposal for a simplified, high performance basement system designed to prevent the entry of radon and other soil gases.

Housing for the Environmentally Hypersensitive (1990): Evaluation of houses built or retrofitted for the environmentally hypersensitive, their effectiveness and costs.

Survey of the Medical Impact on Environmentally Hypersensitive People of a Change in Habitat (1990): Case studies of health improvements related to house modifications.

Indoor Air Quality Initiatives at CMHC: 1980-1990 (1990): A detailed description of over 100 research projects undertaken by CMHC during the past decade.

CMHC REPORTS WORTH WRITING FOR

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Publications

___ 6177 How to Improve the Quality of Air in Your Home ($2)
___ 6181 Guide to Radon Control ($2)
___ 5968 Moisture and Air (free)
___ 6130 Performance of House Systems ($1)
___ 6069 Indoor Air Quality ($1)
___ 6067 Radon Control in New Houses ($1)
___ 6114 Guide to Residential Exhaust Systems ($1)
___ 5888 Ventilation: Healthy and Safety Issues ($1)
___ 6451 Complying with Residential Ventilation Requirements in the 1990 National Building Code ($10)

Research Reports

___ Chimney Safety Tests User's Manual
___ Indoor Air Pollution and Housing Technology: Summary
___ Advances in Basement Technology
___ Housing for the Environmentally Hypersensitive
___ Survey of the Medical Impact on Env. Hypersensitive
___ Indoor Air Quality Initiatives at CMHC: 1980-1990

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