# *Healthy* MATERIALS

**Issue No. 1** **Spring 1994**

**A Communiqué on Material Emission Testing and Standards Activities**

**Published by Canada Mortgage and Housing Corporation**

## Welcome to Healthy Materials !

On behalf of Canada Mortgage and Housing Corporation (CMHC), Canada's federal housing agency, I would like to welcome you to the first issue of ***Healthy Materials*** - A Communiqué on Material Emission Testing and Standards Activities. The primary focus will be on activities, although some context will be inevitably involved.

This twice-yearly publication will attempt to bring the international community of those who are involved with, or interested in, emission testing in touch with each other. With your input, we hope to communicate what you and your colleagues are doing and what you think needs to be done, as well as the status of emissions testing protocol development and standardization. As the result of this communiqué, we hope to avoid unnecessary duplication, improve the quality of standards and emission data, increase the efficiency with which such standards and data are produced, foster the development of lower emission materials and help create a market for them. That is a tall order, but something that we believe must be done.

This first issue of ***Healthy Materials*** is more conversational than future issues will be, so that we can introduce the concepts of this community to you and make you feel welcome, while provoking your interest. Please feel free to comment on this issue, as well as to contribute articles and information on who is doing what, so that we become an integrated community which is efficiently developing quality procedures, standards and materials.

*Jim White, Co-Editor*
*CMHC Research Division*

## *Inside...*



### Aussi Disponible en Français

***Healthy Materials*** est aussi disponible en français, sous le titre ***Matériaux sains***. Si vous voulez recevoir votre communiqué en français, s.v.p informez la SCHL ou Scanada Consultants Ltd.

# *About This Issue...*

This first issue of ***Healthy Materials*** strives to present an overview of the current state of emission testing and standards development, with a particular focus on Canadian activities. There are reports on industry testing and labelling programs, government research, current activities of the Task Force on Material Emissions, demonstration projects and recent publications. We hope to include similarly detailed coverage of international activities in future issues.

Dr. Bruce Tichenor, one of the international deans of emissions research, has written a summary article on the current state-of-the-art in emissions testing.

Listings are provided of existing and proposed emission test standards and Priority Substance reports. These will be updated in subsequent issues. There is also a report on the current activities of the ASTM D22.05 Subcommittee on Indoor Air. The results of a survey of the research community and industry are presented, identifying some priority directions for action.

Lastly, one of the most valuable information items a newsletter can provide is simply the names and numbers of key contacts in order to encourage collaboration. Each article is followed by such information.

***Healthy Materials*** is funded by Canada Mortgage and Housing Corporation (CMHC), which has a long-standing interest in healthy indoor environments and a respected track record in research and demonstration activities. It is CMHC's intention to distribute ***Healthy Materials*** twice yearly free-of-charge to a broad international audience of researchers, regulators, manufacturers, specialist builders and designers, and government agencies.

We are eager to hear from you, and would welcome any comments and submissions.

Terry Robinson

*Terry Robinson, Co-Editor*
*Scanada Consultants Ltd.*

# News and Announcements

## Forintek Evaluates VOCs from Composite Panels

To address the current lack of data on VOC emissions, Canada's Structural Board Association (SBA) is undertaking a two-year project to characterize emissions from composite panel products. While emissions data are available from American and European sources, the nature and quantity of VOCs associated with composite wood panels vary greatly from mill to mill, depending upon the product, the species of wood and the manufacturing process, and so there is a pressing need for Canadian data.

Testing is being performed by Forintek Canada Corporation, under the direction of Jack Shields. The project was initiated in the spring of 1993, with the first phase focusing on identifying and quantifying typical emissions. Forintek staff visited laboratories throughout North America prior to setting up and calibrating a test facility at their Eastern Division laboratories in Ottawa. Emissions testing is now being conducted on a series of composite panel products, including particleboard, medium density fibreboard (MDF), oriented strandboard (OSB) and plywood. A preliminary report has been submitted this spring to SBA.

The second phase, to be undertaken in 1994-95, will involve the completion of product testing and a comparison of wood sources used in the production process. Additional testing next winter will determine the effects of altering key process parameters on VOC emission levels.

The results of the project will provide manufacturers with a Canadian VOC database, recommended VOC reduction strategies, a knowledge of international VOC regulations and a reliable third party test facility for future testing.

*For further information:*

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*John Lowood, President, Structural Board Association*
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## ASTM To Host Symposium on Emissions

The testing and characterization of emissions from indoor materials is a constantly evolving field, with new approaches and methods being developed at a rapid pace. To bring together leading researchers and IAQ professionals to discuss the issues and current developments, ASTM's Subcommittee D22.05 on Indoor Air is sponsoring a special Symposium. "Methods for Characterizing Indoor Sources and Sinks" will be held September 25-28 in Washington, DC. Dr. Bruce Tichenor of the US Environmental Protection Agency is the Symposium Chair.

Major themes to be covered at the Symposium will include:

- design and operation of test facilities;
- testing protocols for determining emission factors;
- methods for determining sink adsorption and desorption rates;
- models for predicting the behaviour of sources and sinks;
- interpretation and application of test results.

ASTM will be preparing a Special Technical Publication, based on peer-reviewed Symposium papers. Authors who have had their abstracts accepted should submit their final manuscripts no later than July 28 to be included in the Publication.

*For further information:*

*Dr. Bruce Tichenor*
*US Environmental Protection Agency*
*Air and Energy Engineering Research Laboratory*
*Indoor Air Branch, MD-54, Research Triangle Park, NC 27711*
*Tel: (919) 541-2991 Fax: (919) 541-2157*

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## Thanks Hal !

*Healthy Materials* salutes Hal Levin, editor of *Indoor Air BULLETIN*, for his kind assistance with the distribution of this first issue.

## 1995 Conference To Link IAQ and Energy

Inter-relationships and integrated approaches will be the theme of the 2nd International Conference in the series "Indoor Air Quality, Ventilation and Energy Conservation in Buildings" to be held in Montreal, Quebec on May 10-12, 1995.

Concordia University's Centre for Building Studies is again providing the organization, with Dr. Fariborz Haghighat serving as the Chair. Additional sponsors include Canada Mortgage and Housing Corporation, Health Canada, the National Research Council of Canada, Natural Resources Canada and Public Works and Government Services Canada, with support from the American Industrial Hygiene Association, ASHRAE, the International Energy Agency and the World Health Organization. Many leading international IAQ experts are represented on the 11-country Scientific Committee.

The 1st Conference, held in 1992, attracted 170 participants from 16 countries and was very well received, according to Haghighat, because of its holistic approach. EPA urged Concordia to host a follow-up conference. Haghighat expects 300-400 for next year's gathering.

Conference themes relating to material emissions include the effect of ventilation rates on source strengths, the health effects of contaminant exposure, standards and guidelines, and commissioning for IAQ. The Conference will feature both platform and poster sessions. Simultaneous translation will be provided in English and French.

Fees are $325 (Cdn) for early registration before March 1, 1995 and $385 (Cdn) for on-site registration. The Second Announcement and Call for Abstracts has been distributed. Abstracts of 400-500 words are due June 1 and papers should be submitted by September 25.

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# Psychiatric Hospital Tests Building Materials

*by Bruce Small, Green-Eclipse Inc*

Whitby Psychiatric Hospital is undertaking a $133 million, 500,000 square foot redevelopment of its facilities on the shore of Lake Ontario near Whitby, east of Toronto. The new buildings, linked by a 1500 foot long interior gallery or "street", represent a significant advance in interior environments for the treatment of patients with psychiatric disorders. The redevelopment is designed to be as environmentally conscious as possible, and incorporates low-maintenance, ecological landscaping outdoors and advanced air quality considerations indoors.

Prior to tender, the Ontario Ministry of Health commissioned a study by Green-Eclipse Inc. entitled "Ecological Design Considerations for the Whitby Psychiatric Hospital", in order to ensure that the indoor environment in the new hospital will be healthy for both patients and staff. The study included testing of the emissions from proposed interior finishes. Gas chromatograph/flame ionization detector (GC/FD) and gas chromatograph/mass spectrometer (GC/MS) tests for the study were performed by Ortech Corporation. Specific emissions of volatile organic compounds were identified as well as total VOCs and formaldehyde. Toxicological analysis of the test results was performed by Globaltox International of Guelph, Ontario.

An opinion of the suitability of the various materials for hypersensitive individuals was rendered by Green-Eclipse, based on experience in creating rehabilitation environments for people who react adversely to lower indoor pollutant levels than those tolerated by the general population. The study identified a number of materials that have emissions significantly above an estimated "no effect" range proposed by Lars Mølhave of Denmark in recent research into the relationship between levels of volatile organic compounds and the incidence of building illness.

The study raised a number of issues regarding emission testing and the choice of materials:

- better methods are required to determine the acceptability of materials for hypersensitive individuals;
- strategies are required to shorten emission testing procedures for materials that can be easily eliminated by simple screening tests;
- acceptable standardized protocols and sampling procedures for diverse building and finishing materials are required to simplify the assessment of materials at the design stage and to minimize testing costs.

Copies of the study are available from Green-Eclipse. A follow-up study is being considered by the Ontario Government to assess the more general problem of establishing practical and economical emission screening protocols for building materials and building maintenance chemicals included in government specifications.

*For further information:*

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# Comments Sought on Standards

## Material Screening Standard Available

Hal Levin has written a first draft of a proposed standard for screening and selecting building materials, based on simple emission tests. The purpose of this standard is to assist designers and facility managers with material selection. Hal will send a copy to those willing to review the draft and provide comments.

*For a copy of the draft:*
*Hal Levin, Hal Levin and Associates*
*Tel: (408) 426-3946 Fax: (408) 426-6522*

## Chamber Guide to be Revised

ASTM D5116-90, "Guide for Small-Scale Environmental Chamber Determination of Organic Emissions from Indoor Materials/Products", is due for revision in 1995. Revisions are being coordinated by Bruce Tichenor. Any comments should be sent by October 1994.

*To submit comments:*
*Dr. Bruce Tichenor, US Environmental Protection Agency*
*Tel: (919) 541-2991 Fax: (919) 541-2157*

# European Developments

Dr. Helmut Knöppel of the CEC Joint Research Centre and Ir. J. F. van der Wal of TNO Building and Construction Research in the Netherlands have provided a summary of current European activities. The fall issue of ***Healthy Materials*** will contain further details. Three activities related to material emissions are currently being undertaken under the framework of the European Collaborative Action (ECA) "Indoor Air Quality and its Impact on Man".

## Focus on Flooring Materials

Working Group 10, "Evaluation of Building Materials and Products", is preparing a procedure on how to evaluate organic emissions. Three subgroups have been formed to prepare proposals on the chemical and sensory characterization of emissions, their toxicological evaluation, and estimating exposures based on emission data. Based on the work of the subgroups, the Working Group will then propose models to predict the prevalence of discomfort and health risks. Due to the vast range of materials and situations which could be analyzed, the Working Group has decided to focus on a comparison of flooring materials used in apartments. Preliminary draft reports from the subgroups are expected at the end of June 1994, and the Working Group's final report is scheduled for early 1995.

*For further information on WG 10: Dr. Lars Mølhave (chair)*
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## Lab Comparisons

As a follow-up to the 1991-92 interlaboratory comparisons of emission testing (see "Determination of VOCs Emitted from Indoor Materials and Products: Interlaboratory Comparison of Small Chamber Measurements", EUR 15054, 1993), further comparisons using a latex paint are being undertaken. Each of the 20 labs involved are being given additional guidance on testing. The results will be available in the fall of 1994.

## TVOC Guidelines

Another ECA Working Group is collaborating with the World Health Organization to develop a definition of TVOCs and a guideline value. This group will analyze whether the TVOC concept is meaningful, and if so, which would be the best combination of VOCs to use as an indicator of exposure, and how should such a combination be measured.

*For general information on ECA activities:*
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## Pollutant Source Database

Under the Joule II Cost-shared Research Programme on non-nuclear energies and energy conservation, a group of 14 European laboratories are collaborating on a "European Database for Indoor Air Pollution Sources in Buildings".

*For further information: Dr. Geo Clausen*
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## European Emission Test Standards Being Developed

A Working Group has recently been formed to draft European standards for the characterization and determination of VOC emissions from building materials. CEN / TC 264 / WG 7, "Indoor Air Quality - Emission of Chemical Substances from Building Materials", will be addressing four aspects: performance and operation of test chambers; VOC sampling and analysis; reporting of results; and material preparation and pre-conditioning. The work on test chambers is being given priority. ***TR***

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## *Coming This Fall...*

The second issue of ***Healthy Materials*** will be distributed in November. The following lists some of the articles being considered for publication:
▪ Highlights of the ASTM symposium "Methods of Characterizing Indoor Sources and Sinks" ▪ Summary of the October meeting of the Task Force on Material Emissions ▪ Emissions from recycled products ▪ Survey of current activities in testing labs ▪ Overview of European emissions testing and labelling programs ▪ Review of CMHC's materials guide for the environmentally hypersensitive ▪Update on emission test standards development ▪

## BACKGROUNDER

# Evaluating Emissions From Indoor Materials and Products

*by Bruce Tichenor, U.S. Environmental Protection Agency*

This article discusses the approaches currently used by indoor air quality (IAQ) researchers and practitioners to characterize the emissions from indoor materials, including the interaction of these emissions with indoor sinks. Procedures for analyzing chamber test data to produce emission rates and adsorption/desorption rate constants are discussed. *Note: This article is condensed from the paper, **Evaluating Materials for Healthy Buildings**, published in the Proceedings of the 5th International Jacques Cartier Conference on Indoor Air Quality, Ventilation, and Energy Conservation, Montreal, Canada, 1992, pp. 27-38.*

### Sources and Sinks

There are myriad sources of indoor air pollution, including building materials, furnishings, consumer products, combustion (e.g., environmental tobacco smoke, cooking, heating appliances), and outdoor air. All sources are of concern when considering the design and operation of a healthy building. As a first step, the building designer needs to determine the indoor pollutant load imposed by the construction materials and building furnishings. Indoor sources can be broken down into dry and wet materials.

**Dry Materials**: Dry materials, which include the majority of materials used to construct and furnish residential and commercial environments, are characterized by relatively low emission rates which decay slowly. Such materials include: wood products, floor coverings (e.g., carpet, vinyl), wall coverings (e.g., wallpaper, fabric), ceiling materials (e.g., acoustic tiles, "blown" gypsum), and insulation (e.g., fibreglass, rigid foam). Heating, ventilating, and air-conditioning (HVAC) systems also include potential indoor air pollution sources, such as duct liners. Furnishings, composed of pressed wood products and/or upholstery, are additional potential sources.

**Wet Materials** - Modern construction techniques rely heavily on a wide variety of architectural coatings (e.g., paints, stains, varnishes), adhesives, caulks, and sealants. Such materials are applied "wet" and their emission rates (mostly from petroleum based solvents) are relatively high and decay rapidly.

**Sinks**: Indoor surfaces act as sinks by adsorbing and later re-emitting vapour-phase organic indoor air pollutants. Indoor sinks play a major role in determining the concentration vs. time history associated with indoor sources, especially wet sources. Indoor sinks of interest include: floors (particularly carpets and rugs), walls, ceilings, HVAC systems (including supply and return ducts and filters), and furnishings.

**Factors Affecting Emissions**: In developing and using methods for determining the emission characteristics of indoor sources, the governing physical and chemical processes, as well as the important variables, need to be considered. The important factors are presented in Table 1.

**Table 1. Factors Affecting Source Emissions and Sink Adsorption/Desorption**

MASS TRANSFER PROCESSES
- Evaporation (from wet products)
- Adsorption (to/from indoor sinks)
- Diffusion (in air, in material)
- Convection (bulk flow)

ENVIRONMENTAL VARIABLES
- Temperature (affects rate of evaporation, adsorption, diffusion)
- Humidity (affects emission rates of formaldehyde)
- Air Exchange Rate (affects indoor concentration via dilution/flushing)
- Boundary Layer (controls rate of gas-phase mass transfer)
  - Velocity, Turbulence

MATERIAL CHARACTERISTICS/COMPOSITION
- Amount Used (affects emission rate and total emissions)
- Surface Roughness (affects mass adsorbed to sink)
- Number and Type of Chemical Constituents
  - Vapour Pressure, Diffusivity (affect emission rates)

### Source Testing Methods

A variety of methods are used by IAQ investigators to determine the chemical emissions from indoor materials and furnishings (see Table 2). Each of these methods requires the use of appropriate techniques for sampling (e.g., syringe, canister, sorbent) and analysis (e.g., gas chromatography) of the organic chemicals of interest.

**Dynamic Chamber Studies**: While laboratory extraction and headspace studies provide information on the composition of emissions, dynamic flow-through chamber testing is needed to develop emission rate data. Both small and large chambers are used to conduct such testing.

Small Chambers: Small (< 5 $m^3$) environmental test chambers are used throughout the world to evaluate emissions from indoor materials. A typical small chamber facility includes: a clean air delivery system, one or more well mixed test chambers (build with non-adsorbent interiors), environmental controls (temperature, humidity, air flow rate), and sampling and analysis equipment. Emissions testing is conducted by placing a sample in the chamber and measuring the concentration (individual compounds or total organics) at the chamber outlet. The sample size is usually determined by the "loading factor" (i.e., the ratio of the test specimen area to the chamber volume). Generally, the loading factor would be set equal to the surface area to volume ratio one would expect for normal use of the material in full-scale environments. Concentration data are collected over a sufficient time interval to adequately describe the time history of the emission rate. While small chamber testing methods are still being improved, the technology has matured enough to result in an ASTM standard guide (1) and a Commission of the European Communities guideline (2).

Small chambers have obvious limitations. Normally, only samples of larger materials (e.g., carpet) can be tested. Small chambers may not be applicable for testing complete assemblages (e.g., furniture, work stations). For some materials, small chamber testing may provide only a portion of the emission profile of interest. For example, the rate of emissions from the application of paints and coatings via brushing, spraying, rolling, etc. is higher that the rate during the drying process. Small chamber testing cannot be used to evaluate the application phase of the coating process.

Large Chambers: Large, room sized (e.g., 15 - 30 $m^3$) chambers are used to overcome the limitations of small chambers noted above. As with small chamber testing, careful control of the environmental variables is necessary to ensure accurate results from large chamber testing. Emissions testing procedures using large chambers are essentially the same as with small chambers, except in large chambers the sample is usually collected at one or more locations in the chamber instead of in the outlet flow.

**Table 2. Emission Source Testing Methods**

**LABORATORY STUDIES**

- EXTRACTION AND DIRECT ANALYSIS
  - Provide Information on Material Composition
  - Do Not Provide Emissions Composition or Emissions Rate Data
- STATIC HEADSPACE
  - Provide Information on Emissions Composition
  - Do Not Provide Emissions Rate Data

**DYNAMIC CHAMBER STUDIES**

- SMALL CHAMBERS
  - Provide Emissions Composition and Emissions Rate Data under Controlled Environmental Conditions
  - Chamber Size May Limit Use for Some Material Sources (e.g., furniture, work stations)
- LARGE CHAMBERS
  - Provide Emissions Composition and Emissions Rate Data under Controlled Environmental Conditions
  - May Be Required for Evaluating Emissions During the Application Phase of Wet Materials

**FULL-SCALE STUDIES**

- TEST HOUSES
  - Provide Emissions Composition and Emissions Rate Data under "Semi-controlled" Environmental Conditions; Sink Factors Must Be Considered
  - Very Useful for Validating Chamber Emissions Test Results Using IAQ Models
- FIELD STUDIES
  - Provide Integrated Emissions Profile of All Sources and Re-emitting Sinks under Uncontrolled Conditions
  - Emission Rate Determinations Generally Not Possible
  - Differentiating Between Source and Sink Emissions Extremely Difficult

**Full-Scale Studies**: While dynamic chamber studies are useful for determining emission rates of indoor materials under controlled conditions, full-scale test house and/or field studies are necessary to validate the chamber data. Full-scale studies also provide the opportunity to evaluate the interaction of source emissions with indoor sinks. In addition, evaluation of such factors as variable air exchange rates, operation of heating/cooling systems, room-to-room air movement, and occupant activities is possible with full-scale studies.

Test Houses: IAQ test houses are used to investigate a variety of indoor air pollution research questions, including the behaviour of sources and sinks. Test houses are generally unoccupied and are provided with instruments and equipment for monitoring a variety of variables, including: temperature, humidity, air exchange rate, and operation of the heating/cooling system. Systems are installed to allow indoor air samples to be collected at various locations within the house. Both on-site and off-site analytical instruments are used to quantify indoor pollutant levels. IAQ test houses are generally single family residences, with construction features typical of the area where they are located. Since they are unoccupied, test houses can be used to investigate the behavior of single sources without the confounding effects of occupant activities. Unlike chamber studies, precise control of the environmental variables is difficult, especially the air exchange rate which is controlled by the weather. In addition, the multitude and complexity of interior surfaces make it imperative that the interaction of sources and sinks be considered during data analysis. Consideration must also be given to the pollutant levels in the outdoor air and the background levels in the test house prior to any experiments. In spite of these complications, IAQ test houses are extremely valuable research tools for investigating sources and sinks in a realistic manner.

Field Studies: Literally hundreds of field studies have been conducted to investigate indoor air pollution problems. Field studies often provide insight into the "source" of the IAQ problem. For example, finding excessive levels of a compound associated with a specific source (e.g., paradichlorobenzene from moth repellent) can enable the source to be identified. Unfortunately, many indoor sources (e.g., solvent containing products) share common emission profiles in terms of the compounds emitted. Thus, isolating the source of a common indoor pollutant based on indoor measurements may be impossible. In addition, re-emissions from indoor sinks can cause elevated indoor concentrations of some pollutants to exist long after the original source of the pollutant has been depleted. Thus, field study results generally provide an integrated assessment of IAQ due to the emissions from a multitude of sources and re-emitting sinks under uncontrolled conditions, and using field study results to determine the emission rates of individual sources is extremely difficult if not impossible.

## Evaluation of Indoor Sinks

Methods used to evaluate indoor sinks with respect to their adsorptive and desorptive behavior parallel the source characterizations methods described above.

**Dynamic Chamber Tests**: Dynamic flow-through chambers can be used to evaluate the sink rates (adsorption/desorption) for indoor surfaces. Samples of the sink material are placed in chambers and exposed to known concentrations of pollutants. As with source testing, concentration vs. time data are collected. These data are then analyzed, using appropriate sink models, to determine the mass adsorbed and the adsorption and desorption rates.

**Test House Studies**: IAQ test house studies can be used to evaluate the validity of chamber derived adsorption and desorption sink rates. Concentration vs. time data collected in test house studies are evaluated using IAQ models containing equations describing the sink behavior. To date, such experiments have been only partially successful in validating dynamic chamber sink results.

## Analysis of Dynamic Chamber Test Results

Dynamic chamber testing is the most common method being used to determine: a) source emission rates, b) mass adsorbed on sinks, and c) sink adsorption and desorption rates. Computational techniques have been developed to analyze dynamic chamber test data to produce source and sink rates.

**Source Evaluations**: Source emission factors are determined by fitting appropriate source models to chamber concentration vs. time data. The model selected is based on the source behavior. For sources with constant emission rates, the calculation of the source emission factor is straightforward:

$$\mathbf{EF = C(N/L)}$$

where EF = emission factor ($mg/m^2$-hr); C = chamber concentration at equilibrium ($mg/m^3$); N = chamber air exchange rate ($hr^{-1}$); and L = chamber loading ($m^2/m^3$). For sources with decaying emissions, a common approach is to assume a first order decay (3):

$$\mathbf{EF = EF_0 e^{-kt}}$$

where $EF_0$ = initial emission factor ($mg/m^2$-hr); k = first order rate constant ($hr^{-1}$); and t = time (hr). Another approach for some sources is to assume two first order rate constants (3). Source models have also been developed that are based on fundamental mass transfer processes (4).

**Sink Evaluations**: Methods for determining sink characteristics (e.g., mass adsorbed; adsorption and desorption rates) from dynamic chamber test data are not as well developed as the source evaluation methods. One approach fits the concentration vs. time data using models based on adsorption/desorption theory (e.g., Langmuir isotherms) (5). This method provides adsorption and desorption rate constants, as well as estimates of mass adsorbed by calculating the difference between "sink" and "no sink" concentration vs. time profiles.

## Summary and Conclusions

Test methods have been developed to determine emission rates of organic vapours from a variety of indoor sources. Dynamic chamber methods have been published by ASTM (1) and the Commission of European Communities (2), and interlaboratory comparison studies have been conducted (6). The methods are being used by manufacturers to evaluate their products. For example, in the United States, the carpet industry and the U.S. Environmental Protection Agency agreed on a test procedure for determining total VOC emissions from carpets (7). Continued progress in the standardization and application of test methods for specific products and materials is anticipated.

## References

1. American Society for Testing and Materials. 1991. Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products. ASTM D5116-90, Philadelphia, PA.

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5. Tichenor, B., Z. Guo, J. Dunn, L. Sparks & M. Mason. 1991. The interaction of vapor phase organic compounds with indoor sinks. Indoor Air. 1: 23-35.

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7. U.S. Environmental Protection Agency. 1991. Carpet Policy Dialogue: Appendix E - Test Method for Determining Total Volatile Organic Compound Emission Factors from Carpet Under Defined Test Conditions Using Small Environmental Chambers. EPA/560/2-91-002. US EPA, Office of Prevention, Pesticides and Toxic Substances, Washington, DC.

*For further information:*
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# Acronyms

The following is a list of the more common acronyms used in this issue of ***Healthy Materials***:

| | |
|---|---|
| ASHRAE | American Society of Heating Refrigerating and Air-conditioning Engineers |
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing and Materials |
| CCI | Canadian Carpet Institute |
| CMHC | Canada Mortgage and Housing Corporation |
| CHBA | Canadian Home Builders' Association |
| CGSB | Canadian General Standards Board |
| CPA | Canadian Particleboard Association |
| CRI | Carpet and Rug Institute (U.S.) |
| CSA | Canadian Standards Association |
| ECA | European Collaborative Action |
| EPA | Environmental Protection Agency (U.S.) |
| FID | flame ionization detection |
| GC/MS | gas chromatography/mass spectroscopy |
| HUD | Housing and Urban Development (U.S.) |
| ISIAQ | International Society of Indoor Air Quality and Climate |
| LSCT | large scale chamber testing |
| MSDS | Material Safety Data Sheets |
| NMS | National Master Specification system |
| NRC | National Research Council of Canada |
| NRCan | Natural Resources Canada |
| OSHA | Occupational Safety and Health Association |
| PSL | Priority Substances List |
| PWGSC | Public Works and Government Services Canada |
| SBA | Structural Board Association |
| SBR | styrene butadiene rubber |
| SVOC | semi-volatile organic compounds |
| TVOC | total volatile organic compounds |
| VOC | volatile organic compounds |
| WHMIS | Workplace Hazardous Materials Information System |
| 4-PC | 4-phenylcyclohexene |

# MATERIAL LABELLING

## Carpet Labelling Program Update

In recent years, the "Carpet Dialogue" brought together American carpet manufacturing representatives, the U.S. Environmental Protection Agency (EPA) and indoor air quality experts, and has resulted in the carpet labelling program being undertaken by the Carpet and Rug Institute (CRI). The Canadian Carpet Institute (CCI) is a now partner with CRI in the labelling effort.

Mike Kronick, the Executive Director of CCI, reports that labels first began appearing on carpets in the fall of '92 in the U.S. and in May of '93 in Canada. Although carpet samples are not yet labelled, Kronick affirmed that this is intended to happen shortly. CCI members represent 85% of all carpets produced in Canada for the 80 million $m^2$/year carpet industry. With 95% of imports coming from the U.S. and presumably covered by the program, non-labelled carpets in Canada will soon be a rare sight.


Under the CRI/CCI program, carpets from all member-manufacturers are tested annually. Those that pass the test will bear the CRI/CCI label. Those that fail will not be allowed to bear the label and will have to modify their production process before being retested. Dr. Marilyn Black of Air Quality Sciences, a test facility instrumental in defining the labelling program, noted that in the first year of testing, about 20% of carpets failed. Although similar statistics haven't been determined for more recent testing, Kronick and Black concur that the failure rate is going down as manufacturers pay closer attention to their manufacturing processes and start looking for lower emitting raw materials. Black added that the program's annual testing requirement is soon to be replaced with a quarterly requirement, in order to improve manufacturing quality control. CCI and CRI are also undertaking a communications program to inform consumers, installers, and specifiers about carpet-related emissions and a research program to reduce emissions from carpets.

All testing is being performed at Air Quality Sciences Inc. in Atlanta, Georgia, but Kronick expects that some may eventually shift to Canadian labs. Tests are based on ASTM D5116-90, "Guide for Small Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials and Products." In accordance with this test, samples are placed in a chamber, and the emissions are measured during the first 24 hours.

**Table 3. Maximum Emissions Under CCI/CRI Carpet Labelling Program**

| Chemical | Emissions ($mg/m^2hr$) |
|---|---|
| 4-Phenylcyclohexene (4-PC) | 0.1 |
| Formaldehyde | 0.05 |
| Styrene | 0.4 |
| Total Volatile Organic Compounds (TVOC) | 0.6 |

Changes have been proposed to make the method more flexible. These include using any size chamber, provided the results are similar to those of a 50 L chamber, calibrating equipment with toluene alone, instead of a VOC mixture representative of the mixture of carpet emissions.

The characteristic "new-carpet odour" comes from 4-phenylcyclohexene (4-PC), emitted largely from the styrene butadiene rubber (SBR) latex used for backing in almost 95% of carpets. 4-PC is not a chemical required in the end product but is produced during the SBR manufacturing process. Kronick expects that 4-PC emissions will drop substantially now that latex suppliers are reducing 4-PC levels in their products by up to 70%. Black clarified that other changes may also be partly responsible for the 4-PC reductions, such as the carpet curing process.

Black feels that the 24-hour sampling is a good indicator of the total emissions over the carpet's life. Within a week of installation, almost all VOC emissions have occurred, and there is little interest in longer-term testing. An EPA study on the relationship between the 24-hour evaluation and the decay curve for carpets is soon to be released.

Despite the fact that 4-PC emissions drop significantly within a week of installation, 4-PC concentrations in the air decline more slowly, often over a period of weeks, probably due to chemical adsorption onto other surfaces and subsequent re-emission. ***PF***

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# Emissions and the Ecologo Label

The recent Advanced House demonstrations in Canada, the new standards for the R-2000 Program and the Canadian Home Builders' Association's new publication "Environmental Choices for Home Builders and Renovators" all rely heavily upon the "Ecologo" as a means for identifying low-emission products. Does this label provide the builder, designer or occupant with an assurance of non-toxic or low-emission performance? To answer this question, we interviewed Robert Sensenstein and Susan Herbert at Environment Canada's Environmental Choice Program.

"Ecologo" is the label of the Environmental Choice Program. Since the Program evaluates products on the basis of their total impact on the environment, a great many factors need to be analyzed, including energy consumption, outdoor emissions, resource depletion, recycled content and packaging. Susan Herbert explained the process followed by Environmental Choice, which usually involves the commissioning of a detailed technical document on the life cycle environmental impacts of a product, from which guidelines are drafted for stakeholder review. The guidelines are revised every three years.

Environment Canada considers VOC emissions to be an important environmental factor due to their role in both indoor and atmospheric pollution. Robert Sensenstein indicates that because of this broader concern over total emissions, particularly their contribution to low-level ozone formation, Ecologo standards specify limits on the total VOC emissive content of a material, rather than an emission rate. This also simplifies the testing process, since emission rates will depend on the type of coatings, the number of coats, environmental conditions and air exchange rates. According to Sensenstein, most international environmental labelling programs use this approach.

Environmental Choice calculates the TVOC content from confidential product formulations submitted by the manufacturer. This rating is expressed in grams of VOCs per litre of product. In addition, if there are complaints from competitors, plant inspections are undertaken and products may be tested for their actual VOC content, in accordance with ASTM D3960 Standard Practice for Determining Volatile Organic Compound Content of Paints and Related Coatings.

The Ecologo guidelines which have been adopted have been based on the industry's production capability at the time the guideline was developed. As technology changes, these guidelines may be revised. The following summarizes the Ecologo VOC emission requirements for residential and architectural coatings.

**Water-Based Paints** (ECP-07-89): The original VOC guideline of 250 g/L was adopted in 1989, representing the typical level within the Canadian industry. Sensenstein feels this standard is high, since most water-based paints are now in the range of 100 - 150 g/L, and 250 g/L represents the high-gloss enamel paints. The draft 1994 version includes a Notice of Intent that the VOC guideline will likely be revised downward to 200 g/L in 1997. The present guideline also requires that neither the formulation nor the manufacturing process involve aromatic solvents, formaldehyde, halogenated solvents or compounds of mercury, lead, cadmium or hexavalent chromium. Limits on these substances are established for recycled water-borne paints in the draft 1994 version. Sensenstein notes that zero-emission paints are now available, although they require a longer drying period to develop a durable coat.

**Solvent-Based Paints** (ECP-12-89): As one of the original priorities of the Environmental Choice Program, a VOC guideline of 380 g/L was selected, which is lower than the industry average of 400 - 450 g/L. Only a small number of products have received the Ecologo label, since meeting the guidelines has usually entailed a reformulation of the product. Since new water-based paints boast almost equal durability, a Notice of Intent in the draft 1994 version notes that the labelling of solvent-based paints will be phased out in 1997. The 1994 draft also lowers the content of aromatic solvents from 10% to 8% by weight.

**Wood Finishes and Stains** (ECP-07-89): The guideline for water-based paints is being expanded to include other water-borne coatings. The draft 1994 version stipulates maximum VOC contents of 300 g/L for varnishes and 250 g/L for stains. Solvent-based varnishes and stains are not eligible for an Ecologo label.

**Adhesives** (ECP-44-92): The VOC guideline for adhesive products, introduced in 1992, is 20 g/L. In addition to the substances banned for water-borne paints, borax is not allowed in the formulation or manufacture.

**Sealants and Caulking Compounds** (ECP-45-92): A similar limit of 20 g/L has been set for caulks and sealants. Sensenstein notes that testing these products can be problematic, since a skin forms initially and VOCs may bubble through later, resulting in multiple VOC release peaks. *TR*

**Table 4. Ecologo Emission Guidelines**

| Material | | TVOC Emissive Content [g/L] |
|---|---|---|
| Paints | Water-borne<br>Solvent-borne | 250<br>380 |
| Wood Finishes | Water-borne<br>Solvent-borne | 300<br>ineligible |
| Wood Stains | Water-borne<br>Solvent-borne | 250<br>ineligible |
| Adhesives | | 20 |
| Caulks & Sealants | | 20 |

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## EMISSIONS RESEARCH

# Federal Government Studies Re-Carpeting

The flurry of activity following the U.S. Environmental Protection Agency's "Carpet Dialogue" has drawn a recent Public Works and Government Services Canada (PWGSC) research project into the limelight. Over the past three years, PWGSC, the manager of federal government properties and undoubtedly Canada's single largest provider of office space, has undertaken research related to VOC emissions from re-carpeting. This is, in part, a response to tenant complaints.

PWGSC's efforts have been coordinated by Dr. Gemma Kerr and chemical analyses have been undertaken at the National Research Council of Canada (NRC) by Dr. Yoshio Tsuchiya of the Institute for Research in Construction's Fire Research Section. Tsuchiya's lab has collected over 1000 air samples from Canadian buildings and houses during the past 10 years. Kerr and Tsuchiya's recent field work has consisted of three field testing projects.

The first project developed the test procedures used for sampling. An issue that had to be resolved was the variation in VOC levels in the vertical plane, based on height above the floor, and in the horizontal plane, based on distance from the centre of the area being re-carpeted. This information was used to determine appropriate locations for the sampling equipment in later studies.

The second project measured the effects of using a latex-based glue. The third project involved testing of a "VOC-free" glue. In both of these tests, Kerr was able to establish an accurate decay curve. She also found that her results were in good agreement with those obtained in the lab.

Kerr used two desktop samplers and one supply air sampler in the testing. One of the desktop samplers was located in a room not being re-carpeted. This provided a reference case that allowed her to separate the effect of re-carpeting from that of other "background" VOC sources. Sampling occurred both before and after the re-carpeting. Originally the three tubes were exposed sequentially. To improve the scientific method and reliability of results, Kerr later used three air sampling pumps to permit simultaneous sampling in the three locations.

After sampling, the absorbent tubes used are sent to NRC where 4% of each sample is subjected (without separating compounds) to Flame Ionization Detector (FID) testing and the remainder is subjected to gas chromatography/mass spectrometry (GC/MS). FID gives a rough idea of VOC levels by quantifying carbon atoms, while the GC/MS is used to first separate, and then identify and quantify the constituent compounds.

In all three of her studies, Kerr found that liquid-type photocopiers, common in federal government offices, were the largest source of background VOCs. During testing with the "VOC-free" glue, the background VOC contribution from photocopiers was so large it almost swamped the emissions from the carpet itself, although carpet-based emissions were still measurable. In related work, Tsuchiya tested books and newspapers in NRC's Canadian Institute for Science, Technology, and Industry (CISTI) library and in the National Public Archives. He determined that the books and newspapers were clearly acting as sinks for the emissions from the photocopiers.

Kerr also found that even carpets meeting the CCI's 4-PC criteria of less than 0.1 $mg/m^2$-hr (see "Carpet Labelling Program Update") cause odours two weeks after installation. Chamber testing with a load factor (emitting surface area ÷ chamber volume) of 0.4, representative of an office with 2.5 m high ceilings, showed no measurable 4-PC after one week. Raising the loading factor, however, to 2.5-4.0, as was done in a separate NRC/PWGSC project, did show the presence of 4-PC. Tsuchiya added that a higher loading factor reduces the edge effect. Since chambers are typically much lower that an office building storey, the test is performed with only a small fraction (often about 10%) of the floor carpeted to get the same loading factor as in an office. The freshly cut edges emit VOCs at much higher rates than the centre of the sample, causing what is known as the edge effect. By carpeting a larger surface, the edge/carpet area ratio is reduced, along with the edge effect.

Kerr feels that many people are able to smell 4-PC concentrations as low as 3 parts per billion (ppb). This corresponds to a mass concentration of 0.02 $mg/m^3$. Kerr hopes that the labelling program's 4-PC criterion will be made more stringent once manufacturers demonstrate that meeting the present 0.1 $mg/m^2$-hr target is not too onerous. If labs want to quantify 4-PC concentrations much lower than those common today, then the sensitivity of the test will eventually have to be increased. This may be done by increasing the loading factor, among other options.

On the implementation side, changes are gradually taking place. At present, the National Master Specification (NMS), maintained by PWGSC both for their use and for the design community as a whole, does not acknowledge the carpet labelling program. The specification related to carpet (# 09680) is currently under review, and Ian Bartlett of the National Master Specification Secretariat reports that it should be available by June 1995. The updated specification will include modifications resulting from the revision of CAN/CGSB Standard 4.129-93 "Carpet for Commercial Use" and references to the carpeting industry's labelling program. The CGSB standard covers various construction characteristics such as strength, pile height and density. Although there were discussions during the revision process about incorporating emissions considerations, the CGSB committee decided against this. At the next revision of the standard, the topic will likely be revisited. In the meantime, regional offices of PWGSC are already trying to use low-VOC carpet glues and are comparing the WHMIS Material Safety Data Sheets for all construction materials. Before long, efforts at reducing carpet emissions should trickle down through PWGSC's organization as well reaching the private sector.

Kerr hopes to continue her research, perhaps testing of other options such as Velcro-attached carpets and other backings. One of the main impediments, she noted, is finding a building in which the property manager is interested in permitting the testing. Since replacements other than SBR-backed nylon carpets are rare in PWGSC-managed facilities, she has to keep her eyes and ears open. Tsuchiya expects to be involved in increasing levels of research related to emissions from carpet and pressed wood products. ***PF***

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## STANDARDS DEVELOPMENT

# Progress on ASTM Emission Standards

An array of standards on material emissions is being developed within ASTM's D-22 Committee on Sampling and Analysis of Atmospheres by the Related Factors Task Group of the Indoor Air Subcommittee (D-22.05.01). The Task Group is starting with guides and going through practices to test methods. The guides give good general advice, while the practices and test methods both define required steps. Only the test methods produce values that could be called up in codes. Test methods will be developed after practices have been in use for a few years, and when inter-laboratory comparisons confirm that consistent reports are being generated.

One guide, D5116-89 Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products, has been approved and published. A revision is in the works, and comments and suggestions are requested. It is likely that the next version will cover circulation within the chamber, including boundary-layer velocity control. The contact person is EPA's Bruce Tichenor.

Don Figley, a Saskatoon-based consultant, is drafting two small-chamber practices (still called test methods in most references) on caulks and sealants and on polyurethane foam, both based on CGSB standards activities. These standards are going out to subcommittee ballot this spring (May 11) or summer (August 3). Persons wishing to comment before the balloting should contact Don.

Yoshio Tsuchiya at the National Research Council is drafting a standard practice on VOC emissions from pressed-wood board products, using many common sections from Don Figley's practices. This standard will focus on non-formaldehyde emissions and may go out for the August 3 ballot, in order to get more input than has been available to date.

John Girman at EPA has sent out his standard on testing carpet emissions for subcommittee ballot and received enough comments to make a rewrite worthwhile. It will be rewritten as a practice on sampling without the analytical part, so that it can be published soon, and perhaps become a test method in the future.

Carl Meyer of Kapsa & Meyer has partly drafted a proposed guide for determining emissions from solid materials, but has not been able to work on it lately. The above three standards have taken into account what he has written. It may be possible to move the common parts of these practices into one document, to shorten them and ensure similarity, but that may have to wait for later.

The proposed guide or practice for emissions from architectural coatings and adhesives is not being actively worked on, but could come alive after the fall Symposium and the D-22 meeting in Phoenix.

Finally, Bob Lewis has proposed a guide for determining the recovery efficiencies of test chambers. Efficiencies may vary, depending on the compound being tested. No work has yet begun on this guide, but there is a fair bit of evidence to show that it is needed. Hopefully it will see daylight soon. ***JW***

*For further information, see the following article and table.*

## ASTM Standards Jargon

Standards can be referred to by many names. The following are some short-form definitions of the terminology used by ASTM.

- A "Guide" provides general advice that should be followed.
- A "Practice" provides a detailed procedure, but not a specific test result that could be used in a regulation.
- A "Test Method" provides test results that can be used for regulatory control.

# Status of Emission Test Standards

The following table lists some of the standards for emission testing which are currently in place or are being drafted. This listing is by no means complete, and we look forward to receiving information from readers on other standards. An updated listing will be printed in the next issue of *Healthy Materials*. *PF*

| NUMBER | NAME OF STANDARD | CONTACT/ TEL | STATUS |
|---|---|---|---|
| AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) | | | |
| D3614-90 | GUIDE FOR LABORATORIES ENGAGED IN SAMPLING AND ANALYSIS OF ATMOSPHERES AND EMISSIONS | | EXISTING |
| D3960 | STANDARD PRACTICE FOR DETERMINING VOLATILE ORGANIC COMPOUND CONTENT OF PAINTS AND RELATED COATINGS | | EXISTING |
| D5116-90 | GUIDE FOR SMALL-SCALE ENVIRONMENTAL CHAMBER DETERMINATIONS OF ORGANIC EMISSIONS FROM INDOOR MATERIALS/PRODUCTS | BRUCE TICHENOR (919) 541-2991 | EXISTING |
| E1330-90 | STANDARD TEST METHOD FOR DETERMINING FORMALDEHYDE LEVELS FROM PRESSED WOOD PRODUCTS UNDER DEFINED TEST CONDITIONS USING A LARGE CHAMBER | | EXISTING |
| Z2982Z | GUIDE FOR DETERMINATION OF EMISSIONS FROM SOLID MATERIALS IN ENVIRONMENTAL CHAMBERS | CARL MEYER (702) 366-9390 | EARLY DRAFT |
| Z3866Z or D1356-93A | TERMINOLOGY RELATING TO SAMPLING AND ANALYSIS OF INDOOR AIR | HAL LEVIN (408) 426-3946 | DRAFT |
| Z3869Z | STANDARD PRACTICE FOR DETERMINATION OF VOLATILE ORGANIC CHEMICAL EMISSIONS FROM CAULKS AND SEALANT PRODUCTS | DON FIGLEY (306) 374-8141 | DRAFT |
| Z3870Z | STANDARD PRACTICE FOR DETERMINATION OF VOLATILE ORGANIC CHEMICAL EMISSION FACTORS FROM SPRAY-APPLIED RIGID POLYURETHANE CELLULAR PLASTIC THERMAL INSULATION | DON FIGLEY (306) 374-8141 | DRAFT |
| Z3872Z | STANDARD PRACTICE FOR DETERMINATION OF VOLATILE ORGANIC CHEMICAL EMISSION RATES FROM PRESSED-WOOD BOARD PRODUCTS USING SMALL ENVIRON. CHAMBERS UNDER DEFINED TEST CONDITIONS | YOSHIO TSUCHIYA (613) 993-9777 | DRAFT |
| Z? | STANDARD PRACTICE FOR DETERMINATION OF VOC EMISSIONS FROM CARPET IN ENVIRONMENTAL CHAMBERS | JOHN GIRMAN (202) 233-9317 | OUT FOR COMMENT |
| Z? | METHOD FOR DETERMINATION OF VOC EMISSIONS FROM ARCHITECTURAL COATINGS IN SMALL ENVIRONMENTAL TEST CHAMBERS | BRUCE TICHENOR (919) 541-2991 | AWAITING EPA TEST RESULTS |
| Z? | GUIDE FOR DETERMINATION OF EMISSIONS FROM ADHESIVES IN ENVIRONMENTAL CHAMBERS | | |
| Z? | METHOD TO DETERMINE THE RECOVERY EFFICIENCIES OF TEST CHAMBERS | BOB LEWIS (919) 541-3065 | PROPOSED |
| Z? | PRACTICE FOR SCREENING AND SELECTING BUILDING MATERIALS AND PRODUCTS BASED ON EMISSIONS OF VOCS | HAL LEVIN (408) 426-3946 | NOTES AVAIL. |
| CANADIAN GENERAL STANDARDS BOARD (CGSB) | | | |
| CAN/CGSB-51.23-92 | SPRAY-APPLIED RIGID POLYURETHANE CELLULAR PLASTIC THERMAL INSULATION | | EXISTING |
| COMMISSION OF THE EUROPEAN COMMUNITY (CEC) | | | |
| EUR 13593 1991 | GUIDELINE FOR THE CHARACTERIZATION OF VOLATILE ORGANIC COMPOUNDS EMITTED FROM INDOOR MATERIALS AND PRODUCTS USING SMALL TEST CHAMBERS | M. DE BORTOLI CEC JOINT RES. CENTRE | EXISTING |
| EUR 12196 1989 | FORMALDEHYDE EMISSION FROM WOOD BASED MATERIALS: GUIDELINE FOR THE ESTABLISHMENT OF STEADY STATE CONC'S IN TEST CHAMBERS | | EXISTING |

## MATERIAL EMISSIONS TASK FORCE

# Task Force Reconvenes

After two and a half years of dormancy, the Task Force on Material Emissions (originally the Task Force on Material Emissions Standards) met again on January 27 in Ottawa. The re-invigorated group contains many new faces and is more broadly representative of the research community and the industry. Although all but one of the 36 attendees at the Ottawa meeting were Canadian, the Task Force has a large number of American and European associate members who participate through correspondence.

Task Force Chair Jim White from CMHC summarized the results of the 1991 meeting and outlined the possible areas of activity for the group. Task Force members adopted the following as a statement of purpose: "To promote cost-effective, safe, low-pollution, indoor environments." The Task Force intends to identify R&D needs, promote the development of emission standards and guidelines, develop a library of emissions data, and coordinate communications to the industry and public, while liaising with other groups on related issues such as setting health-based concentration limits for pollutants, establishing emission rate limits for products and developing ventilation standards.

### Current Emissions Research

The agenda for the morning and early afternoon was dominated by a series of presentations on current activities. White began by reviewing the current status of ASTM standards on emission test procedures and also provided a summary of CMHC's emission-related projects.

Dr. Jianshun Zhang from the Institute for Research in Construction at the National Research Council (NRC) gave an overview of NRC's emissions testing and modelling work, which aims to develop simple methods for predicting emission rates and contaminant levels. NRC is constructing an office-sized chamber with four air distribution designs to simulate real environments and to validate results from small-scale chamber tests. Modelling work is focusing on the effects of air movement: boundary layers, room flows and building interzonal flows. Dr. Yoshio Tsuchiya is developing a test standard on VOC emissions from pressed wood products, with funding support from CMHC.

Rein Otson summarized Health Canada's emissions research, which includes surveying residential concentrations of VOCs and SVOCs, developing monitoring methods, modelling, studying sink effects and determining source apportionment. Health Canada has established two databases, the Canadian Indoor Air Quality Database (CIAQ) and the Canadian Indoor Source Profile (CISP). Otson noted that their recent national survey found that the TVOC loading in typical Canadian homes is over 1 $mg/m^3$, which he regards as very high.

Saskatchewan Research Council's activities were presented by Dr. Don Figley. Past testing has focused on caulks and sealants. Current work is examining wood preservatives. Figley's standard on spray-in-place urethane foam emissions (CAN/CGSB-51.23) and draft CGSB standard on caulks and sealant emissions are being converted to ASTM format, with funding assistance from CMHC. Figley provided a good example of an emissions "horror story" by describing the problems at the University of Saskatchewan's Field House, where offgassing from a new polyurethane track floor resulted in losses of over $200,000.

Terry Robinson of Scanada Consultants Ltd. outlined CMHC's proposed newsletter on material emissions and sought input from the Task Force. The title "Healthy Materials: A Communiqué on Material Emission Testing and Standards Activities" was approved.

### Industry Activities

Mike Kronick of the Canadian Carpet Institute described the Indoor Air Quality Carpet Testing Program which was developed in the U.S by the Carpet and Rug Institute and EPA and which has been adopted in Canada. Dr. Ross Wallace of Domtar, representing the Canadian Particleboard Association, mentioned the voluntary certification program undertaken by the particleboard industry for the past several years. John Broniek of the Canadian Home Builders' Association outlined the emission standards proposed for the revised R-2000 Program. Broniek noted that the requirements are not onerous, but have been adopted to encourage builders to start thinking about their material choices. R-2000 builders must address two of six categories, with criteria specified for each.

**Table 5. R-2000 Emission Criteria**

| Product Category | New R-2000 Criteria |
|---|---|
| Carpeting | Wool, cotton, or latex-free backings with no underpad or adhesives; <u>or</u> carpet limited to 50% of total floor area |
| Air Filtration | Minimum 10% average dust spot efficiency |
| Paints and Varnishes | Water-based or Ecologo |
| Flooring Adhesives | Water-dispersion, low-toxicity or pre-adhesive types |
| Cabinets | Solid wood; formaldehyde-free fibre board; <u>or</u> particleboard meeting European E-1 or American HUD standard or having all surfaces sealed |
| Wood Floor Coatings | Ecologo |

## Materials Guide

Also discussed was CMHC's proposed guide to healthy building materials, which was presented by Dr. Virginia Salares. Due to the lack of detailed emissions data and documented health effects, the publication includes the experiences and observations of persons involved in housing the environmentally hypersensitive. This approach sparked reaction from some of the industry representatives. Dr. Ross Wallace articulated the official position of the Canadian Particleboard Association that the release of CMHC's publication should be delayed. CMHC's Senior Researcher Jim Robar stressed the need that the environmentally hypersensitive have for this guide and that CMHC intends to proceed with its publication. He acknowledged the value of industry's contributions. Among the revisions planned are changes to the title and introduction to clearly establish that the document is intended for the environmentally hypersensitive and those that build housing for them.

## Issues and Priorities

Much of the afternoon was devoted to a lively exchange among participants. The highlights are as follows:

- Contractors need to benchmark pollutant levels in buildings prior to turnover, since they can't control occupant-related activities and furnishings.
- The time factor needs to be considered in emissions testing, since many products have greatly reduced emissions a few days after installation.
- Obtaining definitive health data on individual chemicals may take another 20 years. The task of assessing the entire "chemical soup" in the indoor air is even more challenging and may not be well understood for a very long time.
- Practitioners (ie. builders and designers) need advice now and can't wait for all the research to be completed.
- Formaldehyde remains controversial. New Canadian housing typically exceeds Health Canada's recommended formaldehyde levels, and many feel it should be a priority for reduction. However, the particleboard industry maintains that there is insufficient toxicological evidence of health effects at low levels.
- Material emissions cannot be regulated without first determining what needs to be measured and how to measure it; the industry needs to be assured of reliable results.

## Working Groups Formed

The meeting concluded with the establishment of 7 Working Groups to carry on the detailed work of the Task Force.

**Health Data**: finding out what is known about health effects and exposure limits. Chair: Dr. John Molot. Tel: (613) 235-6734.

**International Activities**: identifying emission testing and standards activities being undertaken internationally. Chair: Dr. John Shaw, National Research Council. Tel: (613) 993-9702. Fax: 954-3733.

**Test Methods:** reviewing existing and proposed standards and identifying priorities. Chair: Dr. Jianshun Zhang, National Research Council. Tel: (613) 993-9538. Fax: 954-3733.

**Interpretation of Data**: reporting on current emission levels in buildings and advising on what emissions data mean and how they can be used. Chair: Dr. Gemma Kerr, Public Works and Government Services Canada. Tel: (613) 736-2135 Fax: 736-2826.

**Manufacturing Industry Response**: voluntary standards, model programs and product development. Chair: John Burrows, Canadian Wood Council. Tel: (613) 731-7800. Fax: 731-7899.

**Builder Update**: reporting on home builder needs and activities. Chair:John Broniek, Canadian Home Builders' Association. Tel: (613) 230-3060. Fax: 232-8214.

**Communications Vehicles**: reporting on what is available and identifying needs for the public and for industry. Chair: Jim Robar, CMHC Research Divn. Tel: (613) 748-2316 Fax: 748-2402

The next meeting of the Task Force on Material Emissions is tentatively scheduled for October 13 in Ottawa. The meeting will feature presentations by Working Groups and an overview of the ASTM Symposium. ***TR***

*Minutes of the Task Force meeting are available from the Secretariat:*
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FUTURE DIRECTIONS

# Survey Identifies Emission Priorities

What are the priorities in emissions work? Where should limited research funds be directed? Which building materials should be tested first? What are the most pressing communication needs?

A recent survey conducted of those active in the emissions field has shed some light on these questions. Members and associates of the Task Force on Material Emissions were mailed a questionnaire as a follow-up to the January 27 meeting. The questionnaire sought input on priorities for standards development and emission testing research. Over 50 responses were received, with a broad representation from Canadian and international researchers, testing labs, the construction industry, regulatory agencies, health professionals and IAQ consultants.

## Standardized Test Methods

By far the number one priority identified is the need for standardized emission testing methods. Agreement is needed on the environmental conditions, sampling procedures and analytical methods, both for small chambers and room-sized chambers. Some are calling for simplified procedures to reduce costs and time delays; one suggestion is for a mass balance test for TVOCs. Some recommend comparisons and accreditation of labs. Testing-related research needs include: determining the effects of sinks, environmental conditions, time, local airflow and ventilation strategies on emission rates; developing methods for measuring true emission factors for semi-volatile organics (SVOCs) which are fixed to surfaces and particles; and developing special methods for determining the acceptability of materials for the environmentally hypersensitive.

## Priority Substances and Materials

Another high priority is the need to set priorities! Both researchers and practitioners feel there is a need to identify which VOCs are the most hazardous and which materials should be the focus of testing. One suggestion is to start with those compounds which typically exceed 1% of OSHA or other workplace standards. Materials regarded as priorities for testing include pressed wood products, carpets and other floor coverings. Some recommended that particulate emissions, especially man-made mineral fibres (MMMF) be addressed.

## Standards and Guidelines

Many would like to see acceptable concentrations for TVOCs and specific VOCs established for non-industrial environments, based on the best toxicological data available. However, setting emission standards for construction products is still regarded by some as premature.

## Sharing of Data and Info

Many wish to see an improved flow of information within the research community, calling for data banks of emissions test results to be established and for information on international emission standards, emission testing, typical concentrations and related health data to be assembled. One respondent *(Laura Hurst, Bovar-Concord Environmental, tel: (613) 745-4644, fax: 745-1290)* has asked ***Healthy Materials*** to appeal to manufacturers to make their emission test data available.

## Modelling and Other Research

The need for increased modelling research, leading to the development of better extrapolations between chamber tests, field conditions and indoor concentrations, is also noted. Other interesting research issues put forward include post-fire conditions and problems with odour-masking agents.

## Communications to Designers and Contractors

Although the intent of the questionnaire was to identify priorities for research and standards, a large number of respondents raised the issue of communications as a priority. Many feel there is a need to communicate what is known to design professionals and contractors. Suggestions include the development of design tools for material selection, model accommodation requirements, "eco-labelling" of building materials, a builders' advisory document on handling materials and low-emission alternatives, product emission publications modelled after consumer magazines, and widespread distribution of CMHC's proposed materials guide.

# Priority Substances Reports

In 1989, Environment Canada published a Priority Substances List (PSL) to identify chemicals for priority assessment under the Canadian Environmental Protection Act. Assessments have now been completed for all of the 44 substances. Such assessments may be of considerable benefit to researchers needing information on the health and environmental toxicity of various chemicals in order to better target emissions research and testing.

The following table lists the 34 PSL reports currently available. The Chemical Abstracts Service Registry numbers (CASR#) provide unique identification. The toxicity evaluations refer to the environment, the food chain and human health, essentially in indoor air. Substances are classified as toxic (T) or non-toxic (N). In some cases, insufficient information (I) is available to make a determination. *JW*

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*To order copies of the reports:*
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*Environmental Health Centre*
*Tunney's Pasture*
*Ottawa, Ontario K1A 0L2*
*Tel: (613) 957-3143*
*Fax: (613) 954-2486*

**Table 6. Priority Substance List Toxicity Status**

| Substance Name | CASR # | Assessed as Toxic to | | |
|---|---|---|---|---|
| | | Envir | Food | Human |
| **Group 1** | | | | |
| Arsenic and its compounds | 7440-38-2 | T | N | T |
| Benzene | 71-43-2 | N | N | T |
| Effluents from pulp mills using bleaching | | T | - | - |
| Hexachlorobenzene | 118-74-1 | T | N | T |
| Methyl tertiary-butyl ether | 1634-04-4 | N | N | N |
| Polychlorinated dibenzodioxins | | T | T | T |
| Polychlorinated dibenzofurans | | T | T | T |
| **Group 2** | | | | |
| Chlorinated wastewater effluents | | T | I | I |
| Chlorobenzene | 108-90-7 | N | N | N |
| Creosote-impregnated waste materials | | I | I | I |
| sites | | T | I | I |
| Dibutyl phthalate | 84-74-2 | N | N | N |
| 1,2-Dichlorobenzene | 95-50-1 | I | N | N |
| 1,4-Dichlorobenzene | 106-46-7 | I | N | N |
| 1,2-Dichloroethane | 107-06-2 | N | N | T |
| Dichloromethane | 75-09-2 | T | N | T |
| Di-n-octyl phthalate | 117-84-0 | N | N | I |
| Pentachlorobenzene | 608-93-5 | I | N | N |
| Styrene | 100-42-5 | I | N | N |
| Tetrachlorobenzenes | | I | N | N |
| Tetrachloroethylene | 127-18-4 | T | N | N |
| Toluene | 108-88-3 | N | N | N |
| Trichlorobenzenes | | I | N | N |
| Trichloroethylene | 79-01-6 | T | N | T |
| Xylenes | 1330-20-7 | N | N | N |
| **Group 3** | | | | |
| Analine | 62-53-3 | N | N | I |
| Benzidene | 92-87-5 | N | N | T |
| Chlorinated paraffin waxes: short chain | 63449-39-8 | I | N | T |
| med. chain | | I | N | I |
| long chain | | I | N | I |
| bis(2-Chloroethyl) ether | 111-44-4 | N | N | I |
| bis(Chloromethyl) ether | 542-88-1 | N | N | T |
| Chloromethyl methyl ether | 107-30-2 | N | N | T |
| 3,3-Dichlorobenzidene | 91-94-1 | N | N | T |
| 3,50Dimethylanaline | 108-69-0 | N | N | I |
| Methyl methacrylate | 80-62-6 | N | N | N |
| Organotin compounds (non-pesticide) | | N | N | I |

MATERIAL LABELLING

# Particleboard Program Enters 2nd Decade

*Healthy Materials appreciates the help provided by the Canadian Particleboard Association and Forintek Canada Corporation who assisted in the preparation of this article.*

Particleboard, which enjoys widespread application in the furniture and cabinet industry, is widely recognized as a valuable engineered wood panel product. However, particleboard has been targeted as a major source of indoor pollutants due to its formaldehyde emissions. The health impacts of formaldehyde remain controversial. Some jurisdictions regard it as a suspected carcinogen, while others do not. Canada's "Exposure Guidelines for Residential Indoor Air Quality" refer to the "possible carcinogenicity" of formaldehyde, and recommend an action level of 120 $\mu g/m^3$ (0.1 ppm) and a target level of 60 $\mu g/m^3$ (0.05 ppm). The national airtightness survey undertaken in 1989 by CMHC, NRC and Energy Mines and Resources Canada (now Natural Resources Canada) found that the average new Canadian home exceeds this target level.

The Canadian Particleboard Association (CPA), which represents all 12 particleboard manufacturers in Canada, recognizes that high concentrations of formaldehyde pose an acute hazard, but is concerned that there is an over-reaction to the effects of exposure to low levels of formaldehyde. The CPA brochure "Studies on Formaldehyde" claims that "of the many scientific studies conducted on the health effects of formaldehyde, none concludes that humans develop respiratory illness or cancer from exposure to formaldehyde". At the January meeting of the Task Force on Material Emissions, the CPA spokesperson stated that the Association welcomes Health Canada's review of the possible human health impact of exposure to formaldehyde emissions.

In the late 1970s, concern arose regarding formaldehyde emissions from urea formaldehyde foam insulation used in cavity walls and from pressed wood panel products increasingly installed as floor decking in mobile homes and in manufactured housing. The US Housing and Urban Development agency (HUD) established a regulation limiting formaldehyde emissions from particleboard. In response to these air quality concerns and recognizing that formaldehyde is a sensory irritant, the Canadian industry, through the CPA, developed a voluntary testing and monitoring program to control the level of emissions. The program was initiated in 1981-82 in cooperation with the Canadian Chemical Producers' Association, the Formaldehyde Council of Canada, and Consumer and Corporate Affairs Canada. Producers reduced emission levels and reported progress to the government twice yearly using dessicator testing. This evolved into a voluntary certification program in 1988-89, adding large scale chamber testing (LSCT). This program was modeled on the U.S. National Particleboard Association's program which addresses the HUD standard for manufactured housing.

The CPA is the certification agency which engages an independent, third part laboratory to provide the monitoring and testing service. Forintek Canada Corporation provides this service to most CPA member companies. Two types of testing are undertaken: (1) At the mills, daily quality control tests are performed by the manufacturers, using the Canadian Two-Hour Desiccator Test Method. This involves placing 7 x 12.5 cm samples in a standard chemistry desiccator with a dish of water, sealing the desiccator, and then analyzing the formaldehyde content of the water.
(2) On a quarterly basis, all product lines undergo testing at Forintek's labs. 24-hour testing in a 28.32 $m^3$ (1000 cu.ft.) dynamic chamber follows the ASTM E1333-90 standard. The loading factor is approximately 0.427 $m^2/m^3$, which simulates the use of particleboard decking or underlayment over the entire floor of a structure with a ceiling height of 2.3-2.4 m. The air exchange rate during the test is 0.5 air changes per hour and the maximum allowable chamber concentration is 0.3 ppm.

For initial product certification and for on-going third party independent verification of compliance, the LSCT is used. Conformance to standard on a daily basis is assured by the plant desiccator tests, which are reported to Forintek. Products which comply can use the CPA grademark. All test results are provided to CPA, Industry Canada and the manufacturer. Products that do not meet the standard cannot use the CPA grademark, and must be treated or used for other applications. To date, no products have failed. A 1987 study by Consumer and Corporate Affairs Canada concluded that there had been a significant decrease in formaldehyde release from particleboards since the initiation of the CPA program. Following this initial dramatic decrease, emissions have levelled off, with most mills currently producing in the 0.2 - 0.3 ppm range.

The new ANSI Standard A208.1, adopted in late 1993, specifies a lower limit of 0.2 ppm for flooring materials and underlay used in manufactured housing where the raw particleboard may not be overlaid or sealed in the site application. Recognizing the effectiveness of decorative overlays, for example thermofused melamine, to provide a barrier to formaldehyde emissions, the 0.3 ppm regulation was retained for all other grades of particleboard which are overlaid or sealed in use.

While the industry is generally quite satisfied with their program, ***Healthy Materials*** notes that there would appear to be three areas where improvement is desirable.

**The Need for Emission Rate Data**: Test results are reported as chamber concentrations or desiccator water concentrations. While these are well suited to quality control checks, they do not provide useful information to researchers or practitioners in terms of actual emission rates. Particleboard is only one source of formaldehyde emissions. Carpeting, various finishes, drapery, upholstery, smoking and paper products are among the other contributors. A designer or researcher has no way of predicting concentrations or exposures without knowing emission rates. While emission rates can be calculated from the LSCT data, these rates correspond only to the conditions specific to the test methods. This same issue has arisen in the U.S. and has been covered exhaustively in past issues of Indoor Air BULLETIN.

*Industry Response: "The CPA notes that there are many sources of indoor formaldehyde including smoking, cooking, curtains, carpets, paints and adhesives. In some instances, these emissions decrease over time, rendering initial emission rate data of limited use. Indeed, a 1990 study of raw particleboard (ie. board which is not sealed or overlaid with a barrier to formaldehyde emissions) showed a rapid decrease in the degree of off-gassing - typically a 25% reduction in emissions within 38 days and a 50% reduction in 216 days. Furthermore, in view of ongoing U.S. studies (EPA's Home Study and Washington State East Campus Plus Program) regarding indoor air quality, including formaldehyde emission, the CPA believes it is premature to embark on a program to report emission rates. These studies have been designed to improve the understanding of off-gassing of VOCs and formaldehyde in actual occupancy spaces. Through its membership in the U.S. National Particleboard Association, the CPA supports the Home Study and will be closely monitoring the findings."*

**The Need for Product Comparisons**: The current program does not contribute to an "informed marketplace". Since product certification is on a pass-fail basis, buyers and specifiers are given no information upon which to choose a lower-emission product. This creates frustration, particularly for those designing or building for allergic or chemically sensitive clients.

*Industry Response: "The CPA disputes the need and the practicality of product emission comparisons. In view of the normal process variation and the low 0.2-0.3 ppm emission level standards, it is not feasible to differentiate products from a practical perspective."*

**The Need to Mark the Product**: Since the grademark is applied to the shipping label and not to the product itself, a builder or contractor examining a product at the supplier's yard or on the jobsite has no way of knowing if it meets any standard. There is no control on off-shore imports.

*Industry Response: "The CPA is proud of the success of the Formaldehyde Certification Program, noting that it was voluntarily developed in a spirit of cooperation with governments without the need for regulations. While all Canadian producers are involved in the certification program, the CPA recognizes that there is no assurance given the consumer regarding off-shore imports. The CPA acknowledges there may be a need to stamp conforming product, however there are practical concerns in doing so due to the decorative nature of the the panel products."*

Some or all of the above recommendations for improvement also apply to other product labelling programs. ***Healthy Materials*** welcomes the views of practitioners, researchers and the industry on any of these issues. ***TR***

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# Low-Emission Applications

*In addition to reporting on new developments in emission testing and standards,* ***Healthy Materials*** *will also report periodically on the application of low-emission materials. This first issue focuses on the material selection process in some recent Canadian residential demonstrations. Future issues will cover other building types.*

## Low-Cost Multiple Housing for the Hypersensitive

*by Phillip Sharp, Phillip Sharp Architect Ltd*

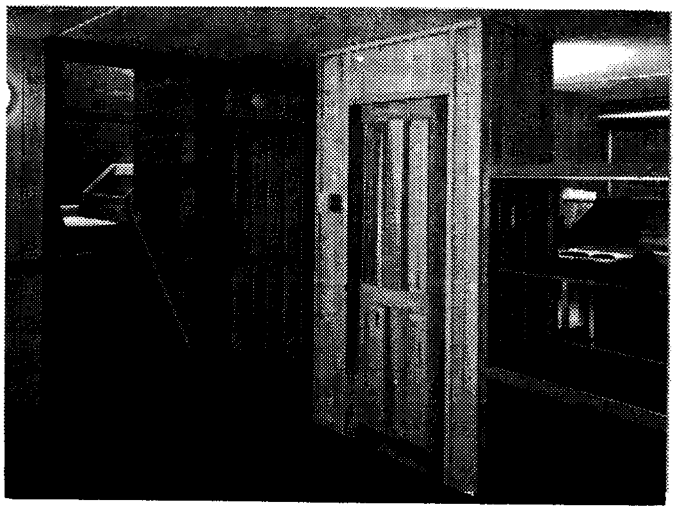
Most people suffering from "environmental hypersensitivity" can benefit greatly from home environments that provide a respite from constant exposure to irritants. Phillip Sharp Architect, in association with consultants Buchan Lawton Parent and Drerup Armstrong, recently completed a prototypical "healthy building" incorporating 7 rowhouse and stacked dwellings in Nepean, a suburb of Ottawa. The project was sponsored by the Barrhaven United Church and funded by the Ontario Ministry of Housing.

Existing publications and buildings were reviewed to identify medical disorders and sources of toxic or irritant chemical emissions, moulds and particulates. Rigorous objective selection criteria are hampered by a number of factors. However, through precedent and from published results of subjective testing, some broad categories of toxins and irritants have been identified, including moulds, particulates, inorganic gases and VOCs.

This led to the potential rejection of the following: all petrochemical products; soft plastics, including floor coverings and polyethylene films; oil-, latex- or solvent-based paints and sealants; caulking and adhesives; insecticides, herbicides, fungicides and fire-retardants; softwoods; and products containing urea formaldehyde, including insulation, building papers, chip-board, particleboard, plywood and pressed board products, furnishings and carpeting. Plywoods and particleboards containing phenyl formaldehyde proved less volatile than those with urea formaldehyde, but some subjects still reacted badly. Gypsum wallboard evoked adverse reactions in some tests, possibly because paper coverings contained recycled materials or fungicide. Although special applications are available to retard emissions, it is preferable to eliminate them at source. All carpets harbour dust and are potential sources of irritant particulates.

A minimum number of materials were exposed to the interior and where possible, single-material assemblies were employed. Where undesirable materials were used in exterior assemblies, they were isolated from the interior.

Concrete products devoid of additives (e.g., detergent for air entrainment, plasticisers, curing agents) form the major structural elements. Foundations and slab-on-grade (which isolates a polyethylene moisture/soil gas barrier and expanded polystyrene insulation from the interior) were poured in-situ. Second floor precast concrete slabs were formed using non-allergenic soap as a release agent. Floor slabs were polished to reveal their aggregate and were sealed with a penetrating sodium silicate water repellent which hardens the surface and prevents dusting.



Fair-faced concrete blocks, with grout-filled cores and shale-based mortar, were used for all fire-rated, sound-attenuating, load-bearing and demising walls, and were sealed as described for the floor slabs. Load-bearing exterior block walls are clad on the outside with a polyethylene vapour barrier, stud framing, additive-free rock wool insulation restrained by a woven olefin fabric, and prefinished hardboard siding. Non-bearing gable end walls are clad and insulated in a similar manner, but use 200 mm wood stud framing. The gable end interior sheathing is 16 mm fire-rated gypsum board with aluminum foil backing exposed to the inside as a vapour and isolation barrier, sealed with aluminum tape and lined with basswood, which is a relatively inexpensive hardwood free of the volatile resins and acids associated with softwood.

Windows are double-glazed, with baked enamel aluminum frames. Junctions are sealed with aluminum tape and a limited amount of full-cure silicone caulking. Low-emissivity glazing units incorporating metallic foils were rejected to provide a wider spectrum of natural daylight. The roof assembly consists of pre-finished sheet steel fixed to softwood purlins and trusses, with rock wool insulation and fire-rated ceiling membranes of 16 mm gypsum board isolated by aluminum foil backing, lined with basswood.

Partitions are vertical 50 x 150 mm tongue and groove basswood planks in rebated top and bottom plates. Doors are framed and panelled in poplar. Staircases, cabinets, kitchen fittings and counters are solid red maple. Wood assemblies employ white glue only. Wood surfaces subject to wear are sealed with water-based urethane. Plumbing is copper or bronze plated, except for ABS stacks and vents in the negatively pressurized mechanical rooms. Metals were finished off-site with baked enamel. Metal roofing, aluminum vapour barriers, drywall screws, and galvanized air ducts were washed to remove oil residues.

In addition to minimizing material emissions, the design addressed other factors impacting the indoor environment, such as the elimination of basements, crawlspaces and wall and floor cavities; ventilation and air filtering systems; exhaust from storage and service spaces; and glazed fume cabinets for off-gassing, dust-burning appliances.

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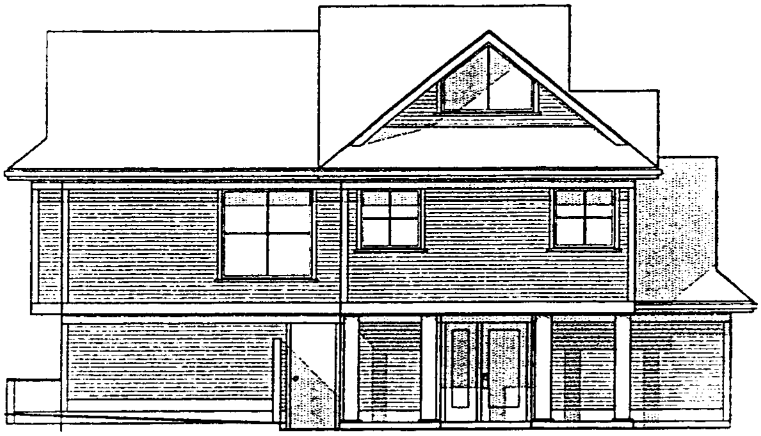
## Vancouver's Healthy House

*by David Rousseau, Archemy Consulting Ltd*

In the absence of adequate emission standards and research results, some form of interim material selection method is necessary for healthy building practice. This is the dilemma that many builders and consultants find themselves in, and it has been one of the challenges of the CMHC-sponsored Healthy Housing initiative. Indoor air quality through source control was one of several material selection considerations for the CMHC Vancouver Healthy House, a demonstration opened during the Innovative Housing 1993 Conference. Materials also demonstrate resource efficiency, durability, recycled content and energy efficiency.



In selecting materials for the Vancouver Healthy House, maintenance and replacement was added as part of a "life-cycle air quality" evaluation because many materials require in-situ finishing, cleaning and repair throughout their useful lifetime, which introduces a wide range of other air pollutants. In addition to volatile emissions, fibre release from materials was also considered.

The following were some of the key points considered: **Quantity**: How much of the material will be exposed to indoor air? **Location**: How close will the material be installed to occupants, air ducts etc? **Duration**: How long are emissions expected to continue and will the building be occupied at that time? **Emissions and sinks**: What compounds are likely to be emitted into the air from the product during installation and in use? And to what extent will it adsorb and desorb odours and trap soil over time? **Toxicity**: What hazard level is presented by the gases and particulates emitted? **Durability**: How much is the material likely to break down during its service life? **Maintenance requirements**: How much cleaning, waxing, stain resistance treatment and other high impact maintenance will it require?

These considerations led to a "most significant contributors" list. A brief list, roughly in order of priority, is: (1) floor coverings, underlayments and fastening systems; (2) cabinets and furniture; (3) wall and ceiling coverings, paints and other liquid finishes; and (4) insulation.

A review of materials emission testing literature and indoor air sampling results helps to eliminate those classes of material which are most likely to be problem sources.

Manufacturers' literature and material safety data sheets (MSDS) were then checked for the specific candidate materials. Extensive empirical and anecdotal experience with reactions to materials by hypersensitive individuals was also helpful. Though this is an imperfect procedure and is hardly quantifiable, it is pragmatic.

For the majority of floor areas a pre-finished hardwood plank was selected. The finish is a polyurethane which is ultraviolet-cured and therefore stabilized at the factory. The underlayment is a fibre gypsum panel. All fastening is done by nailing. Linseed oil linoleum was selected for the kitchen, baths and entry. Larger areas are glued to the gypsum underlayment or concrete slab with a low emission European adhesive. Small areas are laid dry. Though the linoleum has a prolonged linseed oil odour, this is not considered a health risk. A small area has a wool carpet and cotton/polyester fibre underpad. The carpet is untreated, undyed, contains no mothproofing and is fastened with tack strips. The backing contains no synthetic latex (SBR).

Cabinet frames are made with a polyurea bonded fibreboard (MDF) with minimal formaldehyde content. The trims and some panels are solid birch or birch veneer. Some European water-dispersed contact adhesive and water-dispersed polymer finish were used. Walls and ceilings are gypsum board with a low emission acrylic sealer and very-low-volatiles water-dispersed paint in an eggshell finish. Very little tint was used. The sashwork was finished with a linseed-oil-based clear coating containing citrus solvents and odour-free isoparaffinics. The insulation is cellulose fibre blown-in-batt. Though it contains an irritating borate flame retardant, it is well contained by the air barrier system and is considered less risky than mineral fibres.

Some preliminary air quality sampling results show that formaldehyde is below 0.04 ppm., particulates are less than 10 $\mu g/m^3$, xylenes are 0.04 $mg/m^3$ and benzene is 0.01 $mg/m^3$. These are all low in comparison to typical new housing. However, total volatile organics are 0.57 $mg/m^3$, mostly comprised of aliphatics. Though this is about half of typical new housing, it is still higher than expected. The possibility that outdoor sources are contributing (the house is in a busy urban area) or that one or more indoor materials are involved will be investigated.

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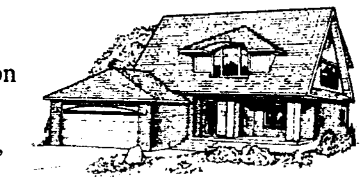
## Advanced Houses

Low-emission products were featured in several of the ten demonstration houses built across Canada as part of the Advanced Houses Program sponsored by Natural Resources Canada (NRCan) and developed in collaboration with the Canadian Home Builders' Association (CHBA). The Advanced Houses were selected in a national competition held in 1991-92, with construction of most of the units completed by mid-1993.



INNOVA HOUSE

While the primary focus is on energy efficiency and environmental responsibility, the Technical Requirements for the Advanced Houses Program also place considerable emphasis on the quality of the indoor environment. In addition to provisions for continuous mechanical ventilation and the proper venting of combustion products, three specific emission requirements are listed:

- incorporation of low-offgassing building products;
- no use of products with urea-formaldehyde-based resin glues, unless indoor formaldehyde levels can be maintained below 0.05 ppm at normal ventilation rates;
- meeting pollutant concentration levels as per the "Exposure Guidelines to Residential Indoor Air Quality" developed by the Federal-Provincial Advisory Committee

NRCan's Robin Sinha provided ***Healthy Materials*** with an update on how the Advanced Houses are dealing with the issue of material emissions.

To avoid wood products with urea formaldehyde glues, a range of alternative flooring and cabinet materials are being demonstrated. The product which has impressed Sinha the most is a new high-density fibreboard which is completely free of urea formaldehyde and toxic solvents. This material is used in the cabinetry in the BC Advanced House and is manufactured in the U.S. The Hamilton NEAT Home uses coated plywood cupboards. The cabinets in the Manitoba Advanced House are built of solid wood, while the Saskatchewan Advanced House employs both solid wood and plywood. The Nova Scotia EnviroHome, the Innova House in Ottawa and the Saskatchewan unit also made attempts to seal contaminants into particleboard products with various coatings, based on testing undertaken by the Saskatchewan Research Council.

Three Advanced Houses - Waterloo, Hamilton and BC - installed low-emission carpeting. Others used a new form of carpeting made from recycled pop bottles, which has been tested by the Build Green Program at Ortech Corporation in Toronto and found to emit fewer VOCs than conventional carpets.

All ten of the Advanced Houses have used "Ecologo" finishes, primarily latex paints and water-based varnishes, which conform to Environment Canada's TVOC standards. Silicone caulkings were often chosen over other types of sealants. Several design teams consciously avoided synthetic materials to reduce VOC emissions, choosing paper wall coverings over vinyl, hardwood and tile flooring over carpets, drapes made of cotton, and furniture made of natural fabrics and solid wood.

B.C ADVANCED HOUSE

NRCan is undertaking IAQ monitoring to verify the approaches used. Sinha indicates that initial testing has shown all houses have been successful in meeting Canada's "Exposure Guidelines". The Advanced Houses project has also underlined the current lack of information on emissions. Sinha notes that NRCan staff experienced considerable frustration in trying to find reliable sources of product emissions data for Advanced House design teams. ***TR***

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## CMHC's Modular "Clean Suite"

*by Dr. Virginia Salares, CMHC Research Division*

In May, Canada Mortgage and Housing Corporation opened a prototype manufactured house for the environmentally hypersensitive. Three priorities guided the design and construction process: (a) meeting the indoor air quality requirements of most environmentally hypersensitive individuals; (b) energy efficiency; and (c) affordability.

Exceptionally good indoor air quality requires, above all, the elimination of sources of contaminants. The building materials were selected partly on the basis of previously known experiences of hypersensitive individuals. These experiences and observations are compiled in CMHC's forthcoming publication "Building Materials for the Environmentally Hypersensitive".

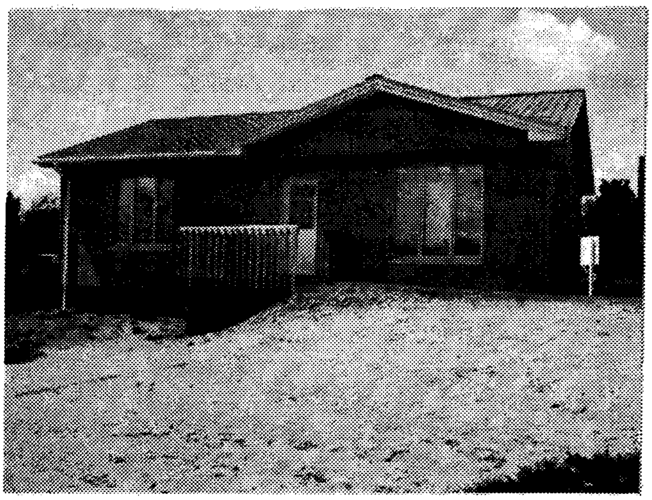
Most low-emitting building materials cost more, and since affordability is a key element in making this type of housing accessible, some creative solutions were nèeded. A panel of hypersensitive individuals from the Ottawa area was asked to test prepared samples of materials, including adhesives, paints, sealants, solid wood, manufactured wood products (coated and uncoated), and interior wall finishes. Based on the test results, materials were assigned to three categories: (1) unacceptable; (2) tolerability varies with individuals; and (3) acceptable to most of the panel members.

Prefinished wood hardboard was chosen for the exterior siding because of its low maintenance and affordability. Kiln-dried spruce was used as the framing material. Rock wool batts were selected over loose-fill glass fibre or cellulose or glass fibre batts. Polyethylene is used as the air/vapour barrier.

All composite wood panel products were found to be unacceptable to the panel, and the degree of unacceptability was reported to correlate with odour levels. The panel's preference was not to use these products. However, the less odorous composite woods were considered for applications outside the indoor space or if thoroughly sealed to encapsulate the odours. An example is construction plywood (softwood), which was found by the panel to be acceptable after being sealed with a low-toxicity sealant. The sealant, an odourless water-based acrylic, dries quickly and leaves a clear invisible film.

Birch and maple were found to be more acceptable than most other woods, with basswood an affordable alternative. Pine and cedar were less acceptable to the panel members, consistent with the known aromatic resin content of these woods. Kitchen cabinets and vanities were built of BC fir plywood. Countertops and shelves were laminated and all cut surfaces and edges were sealed with four coats of the low-toxicity sealer. The laminates were applied using a water-based contact cement. Cabinet doors were solid birch or glass with birch frames. Interior doors were hollow-core birch, sealed with four coats of the low-tox sealer. Basswood trim was used. A work station was constructed with a laminated, formaldehyde-free fibreboard. Emissions from a computer, printer or television are vented directly to the outdoors through the house ventilation system.

Unpainted veneer plaster was used as the wall finish. The mechanical/utility room uses standard gypsum wallboard, jointed with a dry mix and painted with a water-based, low-VOC paint. Ceramic tiles were installed using a thin-set mortar on a cement fibreboard over a radiant floor assembly. The cavity walls are slightly depressurized to prevent infiltration of any emissions from materials in the building envelope.



Windows were argon-filled, triple-pane clear glass in extruded fibreglass frames. An enamel coating on the frames seals off any emissions from the fibreglass and renders the windows low-maintenance. Testing of clear and low-emissivity glazings by the panel resulted in the selection of clear glass. Furnishings for the house were selected with the same care as the building materials. Solid hardwoods, some well aged, and natural fabrics without soil- and stain-repellent chemicals were chosen. Cotton felt without any chemical treatment was used for upholstery. Light fixtures are made of glass, ceramic or metal, and are fitted with ceramic instead of hard plastic sockets.

The heating and ventilation systems were also specifically designed for enhanced indoor air quality and thermal comfort. CMHC's modular house will remain open to the public for approximately one year and will also be used for research purposes.

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## TECH TRANSFER

*While emissions research continues to raise more questions needing long-term study, it is essential that the short-term needs of practitioners not be neglected. The following provides brief reviews of two recent publications on environmental issues which contain significant sections on low-emission products.*

## Environmental By Design

### Volume 1: Interiors
### A Sourcebook of Environmentally Aware Material Choices

*Kim Leclair and David Rousseau*
*H&M Publishers, Point Roberts, Washington and Vancouver, BC, 1992. ISBN 0-88179-085-0*

While media coverage of "sick" buildings has successfully raised the awareness of the importance of indoor air quality and the need to select low-offgassing materials, attempts to specify alternate materials are often frustrated by a lack of information. Kim Leclair and David Rousseau have attempted to fill this need with a well-structured sourcebook on material choices. Rousseau is well known for his consulting and teaching work in environmental design and healthy indoor environments, and has co-authored "Your Home, Your Health and Well-Being". Leclair is an interior designer, an advocate of alternative materials and a senior editor for the Interior Design Institute.

Volume 1 of *Environmental By Design* focuses on interiors, analyzing the range of environmental impacts associated with material selections, including implications for the global environment, the indoor environment and social and ethical issues. "In-use emissions" is one of the characteristics evaluated. Credit is given to products which are made from chemically stable materials or which are specially formulated, stabilized or coated to reduce volatile emissions and dust. One of the criteria used by the authors is a half-life period for total volatile emissions of one week or less, after initial curing.

*Environmental By Design* addresses eight categories of materials: thermal insulation, interior construction panels (including ceiling tile), carpeting, flooring, installation materials (caulking, joint compounds, mortar, grout, adhesives), wall coverings, finishes and furniture and accessories. Each section begins with a well-researched overview of the properties and manufacturing processes of generic materials and the key environmental issues involved. This is then followed by a series of one-page product reports which provide information on specific products and manufacturers, statements by the manufacturers and graphic ratings of the environmental impacts. A large percentage of the 150 products listed are rated as "low toxic emissions in use". Included are many innovative products which mainstream designers and builders may not be aware of.

To meet the ongoing need of the building industry for up-to-date data, a "Professional Edition" of *Environmental by Design* is also available, which comes in a looseleaf binder format and includes semi-annual updates, a manufacturer and supplier index, information bulletins and summaries of material properties. Manufacturers and suppliers are invited to submit products for inclusion in the Professional Edition updates and in future editions of the publication. ***TR***

*Environmental by Design retails for $24.95 ($19.95 US). The Professional Edition costs $50 ($40 US), with a subsequent yearly subscription fee of $30 ($25 US). An information package for manufacturers wishing to submit products is available for a $12 ($10 US) handling fee.*

*Environmental By Design*
*P.O. Box 34493, Station D, Vancouver, British Columbia V6J 4W4*

## Environmental Choices for Home Builders and Renovators

*Prepared by Energy Pathways Inc for the Canadian Home Builders' Association, the Ontario New Home Warranty Program and Canada Mortgage and Housing Corp., 1994.*

*Environmental Choices for Home Builders and Renovators* addresses a complete range of environmental issues, including indoor air quality. The focus of the publication is low-rise housing, where it is often the builder or renovator who is faced with the final choices regarding design and material selection. *Environmental Choices* stresses the role the contractor can play in influencing consumer attitudes and in transforming research findings into practical alternatives. Since mainstream contractors are the target audience, the recommended options tend to be commercially available products and may still have emissions, but at reduced levels. A note cautions readers that the recommended materials may not be adequate for "at-risk" individuals, such as those with chemical sensitivities.

Where standards exist, "environmentally preferred" choices are given. This applies to many paints and finishes, where limitations are placed on the maximum VOC content of the product formulation, in accordance with Canada's Ecologo standards. Where there are as yet no specific material standards, "environmental options" are given for such items as carpeting, sheet flooring, wood composite panels, glues and adhesives, and caulking and sealants. *Environmental Choices* also contains a resource list of programs and publications for those wishing more detailed information.

This joint publication by industry and government signals a new era in the entry of environmental issues into mainstream housing, and reflects the growing acceptance within the industry of the principle of source control. ***TR***

*Environmental Choices for Home Builders and Renovators is available from CHBA for $34.*

*John Broniek, Canadian Home Builders' Association*
*150 Laurier Avenue West, Suite 200, Ottawa, Ontario K1P 5J4*
*Tel: (613) 230-3060 Fax: (613) 232-8214*

## *Call for Submissions*

***Healthy Materials*** invites the submission of articles on building material emissions, particularly regarding current activities in standards development, research, testing, labelling programs and the development and application of low-emission materials. Longer articles should be submitted on diskette in WordPerfect, if possible. Photos, drawings and other graphic materials are encouraged. News briefs, announcements, research summaries and personal viewpoints are also welcomed.

***Healthy Materials*** wishes to complement, rather than compete with, existing publications. Therefore, articles on broader issues of indoor air quality should be directed to newsletters such as *Indoor Air BULLETIN* and *Indoor Air Quality Update*, and technical papers should be directed to journals such as *Indoor Air*, *Indoor Environment*, *ASHRAE Journal*, and *Air and Waste*.

# COMING EVENTS

## Calendar for 1994

Aug 22-25. **Healthy Buildings '94**. Budapest, Hungary. Sponsored by CIB, ISIAQ and Hungarian Academy of Sciences. Contact Professor László Bánhidi, Technical University of Budapest, H. 1521 Budapest, Pf 91, Hungary, tel: +36 1 1812 960, fax: +36 1 1666 808.

Sept 25-28. **Symposium: Methods for Characterizing Indoor Sources and Sinks**. Washington, DC. Sponsored by ASTM Subcommittee D22.05 on Indoor Air. Contact: Symposium Chair Dr. Bruce Tichenor, US EPA, Air and Energy Engineering Research Laboratory, Indoor Air Branch, MD-54, Research Triangle Park, NC 97711, tel: (919) 541-2991, fax: (919) 541-2157; or Symposium Coordinator Dorothy Savini, ASTM, 1916 Race Street, Philadelphia, PA 19103, tel: (215) 299-5413 (see "News and Announcements" for more details).

Oct 5-7. **Indoor Air Pollution**. Ulm, Germany. Sponsored by Indoor Air International. Contact: Dr. Lothar Weber, Institute of Occupational and Social Medicine, University of Ulm, Albert-Einstein-Allee 11, D-89081 Ulm, Germany, tel: +49 731 502 3395, fax: +49 731 502 3415.

Oct 13 (tentative). **Task Force on Material Emissions**, 3rd Meeting. Ottawa, Ontario. Hosted by Canada Mortgage and Housing Corporation. Contact: Chair: Jim White, CMHC, 700 Montreal Road, Ottawa, Ontario K1A 0P7, tel: (613) 748-2309, fax: (613) 748-2402; or Secretariat: Terry Robinson, Scanada Consultants Ltd, 436 MacLaren Street, Ottawa, Ontario K2P 0M8, tel: (613) 236-7179, fax: (613) 236-7202.

Oct 18-20. **Indoor Air Quality in Asia**, 2nd Conference. Beijing International Convention Centre, Beijing, China. Sponsored by Indoor Air International and Chinese Academy of Preventative Medicine. Contact: Conference Secretariat, IAQ in Asia, Unit 179, 2 Old Brompton Road, London SW7 3DQ, UK, tel: +44 767 313 929, fax: +44 71 823 9401.

Oct 23-28. **Clean Air '94**, 12th International Conference. Perth, Australia. Sponsored by The Clean Air Society of Australia and New Zealand. Contact: Promaco Conventions Pty Ltd, Unit 9A, 890-892 Canning Highway, Applecross 6153, Western Australia, tel: +61 9 364 8311, fax: +61 9 316 1453.

Oct 30-Nov 2. **IAQ'94: Engineering Indoor Environments**. St. Louis, Missouri. Sponsored by ASHRAE. Contact: ASHRAE, 179 Tullie Circle N.E., Atlanta GA 30329, tel: (404) 636-8400, fax: (404) 321-5478.

Nov 27-Dec 1. **Indoor Air: An Integrated Approach**. Gold Coast, Australia. Contact: Lidia Morawska, Queensland University of Technology, Brisbane, Australia.

## Calendar for 1995

May 10-12. **Indoor Air Quality, Ventilation and Energy Conservation in Buildings**, 2nd International Conference. Montreal, Quebec. Organized by Concordia University's Center for Building Studies, with sponsorship from various Canadian government agencies. Abstracts due June 1. Contact: Dr. Fariborz Haghighat, Centre for Building Studies, Concordia University, 1455 de Maisonneuve Blvd W, Montreal, Quebec H3G 1M8, tel: (514) 848-3200, fax: (514) 848-7965 (see "News and Announcements" for more details).

Sept 11-14. **Healthy Buildings '95**. Milan, Italy. Contact: Prof. Marco Maroni, Universita de Milano, Via S. Barnaba 8, 20122 Milano, Italy, tel: +39 2 5518 1723, fax: +39 2 5518 7172.

## Calendar for 1996

July 21-26. **Indoor Air '96**, The 7th International Conference on Indoor Air Quality and Climate. Nagoya, Japan. Contact: Prof. Susumu Yoshizawa, Science University of Tokyo,1-3, Kagurazaka, Shinjuku-ku, Tokyo, Japan 162, fax: +81 3 3260 4294.

*Healthy Materials* is published by Canada Mortgage and Housing Corporation, Canada's federal housing agency. It is distributed in French under the title *Matériaux sains*. Its purpose is to facilitate collaboration and information exchange on material emission testing and standards development, in order to foster the coordinated development of test procedures and standards, encourage the availability of low-emission products and create an informed marketplace. *Healthy Materials* invites comments and articles from readers.

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