

11650

Ser  
TH1  
N21d

no. 1204  
c. 2  
BLDG



National Research  
Council Canada

Conseil national  
de recherches Canada

**PROBLEMS WITH UREA-FORMALDEHYDE FOAM  
INSULATION**

by C.B. Crawford and C.J. Shirliffe

**ANALYZED**

Reprinted from  
CIB 83  
The 9th. CIB Congress, Stockholm, Sweden  
Building Materials and Components, Vol. 4  
p. 517 - 527

DBR Paper No. 1204  
Division of Building Research

NRC - CISTI  
BLDG. RES.  
LIBRARY

84- 06- 2 F

BIBLIOTHÈQUE  
Rech. Bâtiment

Price \$1.00

OTTAWA

NRCC 23440

**Canada**

4608699

CISTI/ICIST



3 1809 00210 2652

This paper, while being distributed in  
reprint  
Research  
original  
repro  
permi

A 14  
the  
the  
Bui  
Cou  
K1A

**Title of the paper** PROBLEMS WITH UREA-FORMALDEHYDE FOAM INSULATION

**Author** Carl B. Crawford and C.J. Shirliff

**Organization/Enterprise** Division of Building Research,  
National Research Council Canada

**Key words** Energy in Buildings, Insulation, Urea formaldehyde foam

### Summary

The urgent need to conserve energy in buildings has increased the use of non-conventional insulating materials such as urea formaldehyde foam insulation (UFFI) in Canadian buildings. Although UFFI is not a particularly good insulating material because of its high initial water content and therefore its high volumetric shrinkage and known deterioration with age, it was installed in more than 80 000 Canadian homes before December 1980 when its use was banned under the Hazardous Products Act. The ban was based on an investigation by an Expert Advisory Committee set up by the Department of Health and Welfare Canada. Subsequent studies in the laboratory and in the field have indicated that gases and/or particulates given off by UFFI cause illness in some people. The nature of the problem and some of the studies carried out in Canada to improve understanding and develop methods of reducing exposure to the substances given off by UFFI are described.

**Titre du texte** LA MOUSSE D'URÉE-FORMALDÉHYDE ET SES PROBLÈMES

**Auteur** Carl B. Crawford et C.J. Shirliffé

**Organisation/Entreprise** Division des recherches en bâtiment,  
Conseil national de recherches Canada

**Mots-clés** énergie dans les bâtiments, isolation, mousse d'urée-formaldéhyde

### Sommaire

Le besoin urgent de conserver l'énergie dans les bâtiments au Canada a entraîné une consommation accrue de matériaux d'isolation nouveaux comme la mousse d'urée-formaldéhyde (MIUF). Bien que cette mousse ne soit pas un excellent matériau d'isolation à cause de sa forte teneur initiale en eau occasionnant un important retrait et qu'elle se détériore en vieillissant, elle a été utilisée dans plus de 80 000 maisons canadiennes jusqu'en décembre 1980, date à laquelle son usage a été interdit par la Loi sur les produits dangereux. L'interdiction est survenue à la suite d'une enquête effectuée par un comité d'experts formé par le ministère de la Santé et du Bien-être. Des études ultérieures en laboratoire et in-situ ont indiqué que les gaz et/ou les particules émises par la MIUF provoquaient des maladies chez certaines personnes. Dans cette note, on présente le problème et on décrit les études entreprises au Canada pour améliorer la connaissance des substances qui se dégagent de la MIUF et pour élaborer des méthodes afin de réduire les risques d'exposition à ces substances.

## PROBLEMS WITH UREA-FORMALDEHYDE FOAM INSULATION

C.B. Crawford and C.J. Shirtliffe, Canada

Urea Formaldehyde Foam Insulation (UFFI) had been installed in an estimated 80 000 Canadian homes, mostly wood-frame, before it was banned under the Hazardous Products Act in December 1980. The ban was based on the advice of an Expert Advisory Committee set up by the Department of Health and Welfare Canada. A year later, in December 1981, the Canadian Government announced a \$110 million assistance program for UFFI homeowners to cover free testing, technical advice, and up to \$5000 tax-free assistance for removal of the foam or other remedial action. Later, additional funds were made available to low income families.

## WHAT IS UFFI

Urea Formaldehyde Foam Insulation is a thermosetting organic polymer manufactured at the job site by mixing urea formaldehyde resin with a foaming agent containing an acid catalyst and a propellant such as compressed air or nitrogen. The fresh foam, having a consistency of shaving cream, sets within a few seconds to a semi-rigid foam with an initial wet density of 40 to 48 kg/m<sup>3</sup>. Over a period of weeks to years it dries to a shrunken, open-celled, friable, structurally weak material having a dry density of 9.5 to 13 kg/m<sup>3</sup>.

The most attractive feature claimed for UFFI was that it could be installed in an existing wall cavity at high rates through a small hole. The quality of the foam was unfortunately highly dependent on the installer, who seldom had any understanding of the process. Once installed, the foam deteriorates at a rate depending on the formulation, the absolute humidity, and the temperature in the wall cavity. In the worst case it can end up as a powder at the bottom of the stud space after a few months, but little information is available on the average time it takes to reach this condition. While crumbling, the particulate material can be carried from the cavity in air currents. Excessive drying time in the wall cavity can also lead to fungal growth in the foam and on the surfaces of surrounding materials. Capillary action may also cause these surfaces to become impregnated with water, acid, and fractions of the foam.

## DEVELOPMENT OF A STANDARD FOR UFFI

In 1970 the Canadian Government Specifications Board (now called the Canadian General Standards Board, CGSB) was asked to develop a standard for UFFI. A committee of producers, consumers, contractors and government representatives

was established, but four years later it was still not satisfied that it had sufficient knowledge of the material to prepare a standard. Reservations about UFFI as an insulator included the following (1):

- difficulty of ensuring that the foam will be properly applied,
- possible corrosiveness of UF foam,
- possible damage caused by water during the drying period,
- possible collapse due to vibrations,
- possible susceptibility to hydrolysis,
- long-term physical stability,
- possibility of formaldehyde odour problems,
- thermal effectiveness.

The committee set up three working groups to address these problems. Literature describing experiences in several other countries was reviewed and many walls containing UFFI were opened. An early conclusion was that the thermal resistance of the foam is greatly reduced by shrinkage. Although linear shrinkage was reported to vary widely and uncontrollably, "it was decided to accept an effective thermal resistance of 60 percent of the thermal resistance values measured on the guarded hot plate or heat flow meter, assuming that UF foams would stabilize at a linear shrinkage of 7 percent" (1).

Another important finding, resulting from opening of walls, was that the foam seldom filled the space to be insulated. The committee decided, therefore, to write two standards: one governing the performance characteristics of the product when applied correctly, and a second describing how the foam should be installed. A provisional product standard was issued in May 1977, and in December 1977 CGSB 51-GP-24M, "Thermal Insulation, Urea Based, Foamed In-situ," was published. During 1977 the manufacturers improved their training courses for applicators and in December 1977 a provisional standard for the installation of UFFI was issued as CGSB 51-GP-22MP. In July 1980 CGSB published 51-GP-43MP, "Manual For: Installers of Urea Formaldehyde Foam Thermal Insulation."

Both the product and installation standards were urgently required by the industry in order to qualify UFFI under the Canadian Home Insulation Program (CHIP). The CHIP program, introduced by the Canadian Government in September 1977 as a means of encouraging energy conservation, provided financial assistance to homeowners for the thermal upgrading of older houses.

#### EMERGENCE OF PROBLEMS

The inadequacies of the foam as a thermal insulator began to fade in significance when health problems attributed to formaldehyde gas in UFFI-insulated homes emerged. At the request of the CGSB committee the Department

of Health and Welfare advised that the upper level of formaldehyde gas in homes should be set at 0.1 ppm in the CGSB product standard. The industry requested that the level be set at least twice as high. When it became clear that there was no way to predict or control the emissions from the product and the resulting levels in buildings, the CGSB committee refused to include this in the standard. The Department of Health and Welfare in turn suggested that use of the product in the CHIP program be discontinued, and established the Expert Advisory Committee that subsequently recommended the ban.

Once the ban was publicized and a reporting mechanism was established, many of the occupants of UFFI homes reported illnesses of various kinds and subsequently the market value of UFFI-insulated homes dropped dramatically. The influence of UFFI on health was generally attributed to its emission of formaldehyde, although the contributions of other gases and particulates are still under investigation. The problem is complicated by the great variation in human sensitivities and by changes in sensitivity with exposure and time (2). Symptoms of exposure include eye, nasal, and respiratory tract irritation, sore throat, headache and nosebleeds. Recovery is generally rapid when exposure is terminated. The non-specific nature of the symptoms combined with the impossibility of establishing levels of previous exposure resulting from UFFI while aging under daily and seasonal moisture and wind fluctuations make it impossible to quantify the contribution of UFFI to the health problem.

#### NATIONAL TESTING SURVEY OF CANADIAN HOMES

As a consequence of the ban, government agencies were deluged with telephone calls and letters from homeowners worried about their health or the market value of their homes. In order to deal with these demands the Department of Consumer and Corporate Affairs Canada established, in June 1981, a Urea Formaldehyde Foam Insulation Information and Coordination Centre, which was soon receiving up to 400 telephone inquiries a day. Shortly afterwards, the Centre launched a comprehensive national testing survey to determine ambient formaldehyde levels for both indoor and outdoor air and to look for any other factors that might be influencing health problems in the affected homes. Formaldehyde levels were measured in 2275 homes, including (a) 378 control houses without UFFI; (b) 100 "problem" UFFI houses where serious health problems or concerns had been reported; (c) 651 houses chosen from UFFI Centre files; and (d) 1146 houses selected from CHIP files. The average outdoor formaldehyde levels measured over 2 h during the daytime ranged from 0.007 to 0.009 ppm. In group (a), control houses, 2.6 percent had formaldehyde levels greater than 0.1 ppm, measured over the same 2 h at two locations. In

group (b), problem houses, 47 percent exceeded 0.1 ppm, and in (c) and (d) 5.1 and 10.2 percent, respectively, exceeded this level.

Most inside measurements were made over the 2-h period after the home had been closed for 18 h and after occupant-related sources of formaldehyde had been eliminated or reduced. Average levels for the following seven days, without such reductions, were measured at the same locations in over 750 homes. Large discrepancies were disclosed between 2-h and seven-day measurements for given houses, the average seven-day readings being close to 50 percent higher. An extensive analysis of the results of the survey will be released in early 1983.

#### REPORT OF HAZARDOUS PRODUCT BOARD OF REVIEW ON UFFI

On 24 April 1981 the Minister of Consumer and Corporate Affairs, in accordance with the provisions of the Hazardous Products Act and at the request of one of the distributors of the banned product, authorized a three member Board of Review on UFFI. The Board held public hearings at seven cities from coast to coast between 28 June 1981 and 6 January 1982, at a cost of nearly \$2 million. During the process, one of the most complete collections of scientific and medical information was amassed, analysed and debated by experts from the U.S. and Canada. On 5 October 1982 the Board submitted its report (3).

The Board was not impressed with the quality control or with the effectiveness of UFFI as an insulating material. It concluded that "no feasible standard would adequately protect the public from the risk of injury associated with the product, nor would it be feasible to eliminate or reduce the level of formaldehyde off-gassing from the product. The reports, tests and testimonies show us that the urea-formaldehyde foam insulation production and use cannot be adequately controlled or predicted."

The Board quoted the U.S. National Academy of Sciences Committee on Toxicology as follows: "There is no population threshold for the irritant effects of formaldehyde in humans. Information from controlled human studies and complaint-related investigations suggests that, even at extremely low airborne concentrations, a proportion of the population will respond with some irritation."

Sensationalism in the media, the sudden banning of the material without warning, and exaggeration of the health problem by some consumers associations were blamed by the Board for the loss of value of UFFI-insulated houses. Nevertheless, the Board concluded that the possible risks to health from exposure to UFFI are sufficient to warrant a continuation of the ban on its use and that it apply to all buildings.

## REPORT OF PARLIAMENTARY COMMITTEE ON UFFI

On 26 July 1982 the Standing Committee on Health, Welfare and Social Affairs was authorized by the government to investigate various questions with respect to UFFI. On the basis of testimony by many witnesses, written submissions, and other investigations, it issued its final report in December 1982 (4). The report made a number of suggestions aimed at reducing the risk of similar problems in the future. It also recommended that the ban be continued, although it recognized that "the degree of health risk associated with UFFI remains undetermined and subject to an ongoing debate within the health field."

The Committee advocated a number of actions including the following:

- a comprehensive epidemiological study, similar to a proposal of the World Health Organization, to determine whether there is any relation between formaldehyde exposure and nasal cancer in humans,
- a comprehensive study of indoor air pollutants and their potential health effects,
- development of a clear and effective policy on formaldehyde exposure to the public, since this chemical is emitted not only by UFFI but is essentially ubiquitous in the environment,
- identification of other gases emitted by UFFI in order to measure their concentrations and establish, if possible, their effects on human health,
- development of more efficient and less expensive methods of removing UFFI from all types of buildings,
- development of a methodology for the detection and measurement of formaldehyde and other gases.

## WHAT CAN THE HOMEOWNER DO?

Formaldehyde and perhaps other gases given off by UFFI may cause respiratory difficulties and other discomforts. The Board of Review noted that "Removal of the individual from exposure usually results in a prompt cessation or remission of symptoms, while return to exposure results in the return of symptoms." A small proportion of the population, perhaps 10 percent, is bothered by very low concentrations of formaldehyde.

The homeowner must first be made aware that formaldehyde is generated at appreciable levels by many products commonly found in houses and by many household activities. These products and activities include some plywoods, most particle boards, veneer furniture, paint, some carpets, cooking, and cigarette smoking. Secondary sources are created when formaldehyde is adsorbed on fabrics, painted surfaces and carpets while levels are high, then desorbed when emissions from primary sources decrease. The solution is to

remove the primary sources and to discharge the secondary sources. Where the primary source is in wall cavities, as with UFFI, pressurizing the living space will prevent contaminated air from flowing into it and thereby remove the source. Pressurization should be reduced in winter (when the dehydrated and discharged foam emits little gas) to prevent condensation in the wall. Sealing leaks in the inner skin of the wall will similarly eliminate the source as well as the potential for problems with outward flow of air. Continuous ventilation reduces peak concentrations as well as average values, but it is effective only if it rapidly depletes the sources. Air cleaners and scrubbers can provide added protection, but as yet their performance and effect on occupants are not predictable.

One way to remove the source from wall cavities is to open the walls and take out the UFFI and any contaminated materials that can be removed, and to neutralize contaminants in remaining materials. Contaminated surfaces generally emit at levels similar to those of the foam, and often at greater rates. Contamination of wood products is more severe than that in masonry materials.

In April 1981 the National Research Council Canada issued Building Practice Note 19, Urea Formaldehyde Foam Insulation (5), to explain what UFFI is, how to determine whether a problem exists, and what to do about it. In August 1981 NRCC issued Building Practice Note 23, Urea Formaldehyde Foam Insulation: Problem Identification and Remedial Measures for Wood Frame Construction (6). This Note assembled and summarized all the technical knowledge available on the UFFI problem in houses and gave extensive guidance on problem identification and remedial and preventive measures. More than 50 000 copies of this note have been distributed. A companion note dealing with masonry construction is expected to be issued early in 1983.

These documents have been used as a basis for training manuals for contractors and homeowners performing remedial measures. Certification by the UFFI Centre is now required for contractors carrying out subsidized removal of UFFI, and government inspectors provide advice and monitoring services to the homeowner. A preliminary survey has shown that these actions have greatly reduced post-removal health complaints, although they do not always reduce formaldehyde levels.

#### CURRENT ASSESSMENT OF THE PROBLEM

The UFFI problem is interwoven with factors that are causing the "sick building syndrome" now recognized internationally. This syndrome is probably caused by the proliferation of sources of contamination as well as decrease in ventilation rates arising from energy conservation efforts. Several national and international organizations are giving it their attention. The problem of

air quality is complex and is associated with such things as tobacco smoking, unventilated combustion, and various building materials and consumer products that give off a variety of gases and respirable suspended particulates.

A multi-disciplinary task force of experts set up within NRCC has identified the following urgent areas for study of UFFI:

- Characterize the material itself in order to be able to assess its performance in service and its stability, and thus be able to anticipate the kinds of compounds that may be given off at various times due to aging of the material.
- Measure accurately the compounds given off.
- Develop ways of reducing emissions or excluding these compounds from occupied space.
- Develop ways of reducing the concentration of products, for example, by pressurizing the space, ventilating it, or cleaning the air mechanically or chemically.
- Develop effective ways of removing UFFI foam, when necessary, and of neutralizing the space it occupied.
- Relate the potential for health problems to the presence of compounds associated with various formulations of UFFI.
- Develop techniques for reconstructing energy-efficient walls.

All these questions have proved to be extremely complex and difficult. It is impossible, for example, to correlate the magnitude of a particular problem with individual reaction because of variations in human sensitivities. There is great variation in the character of the foam from house to house and even within a single house owing to the manipulation of chemical quantities by individual installers, modifications to the formulation by distributors, and age and uniformity of the basic components being used. The off-gassing of UFFI is a function of age, structure, pH, and moisture content of the foam, as well as absolute humidity, temperature gradients and fluctuations in the foam, and speed of the air flowing through and around it. Indications are that storage of formaldehyde in the foam can be a function of the weather during the previous several weeks. Levels of concentration in occupied space vary from hour to hour and are therefore misleading if carried out over a short period of time or at a particular season of the year. Finally, it is extremely difficult to measure minute quantities of unknown gases; some well-known measurement techniques that had been accepted virtually as standards for occupational exposures have been found to give incorrect values in the lower ranges.

## RESEARCH ACTIVITIES

The basic research effort needed to guide a more extensive program is being carried out in-house by the National Research Council Canada. In addition, approximately \$3 million has been spent for contract research under NRCC guidance. Some 45 contracts are currently under way. The contract research includes the following:

- Observations of circumstances in specific problem houses and field monitoring of remedial measures.
- Comparison of formaldehyde levels in wall spaces and adjacent living spaces.
- Identification of particulates and gases other than formaldehyde given off by UFFI.
- Investigation of new gas detection techniques.
- Development of a set of dosimeters for low-cost monitoring of formaldehyde and other gases.
- Improved laboratory analyses of exposed dosimeters and assessment of the reliability of the results.
- Development of calibration facilities for instruments and dosimeters.
- Investigation of methods of neutralizing contaminated materials following UFFI removal.
- Laboratory and field evaluation of effectiveness of remedial measures.
- Investigation of the effects of UFFI on the structure and services in buildings.
- Investigation of the applicability of air filters and scrubbers in the cleaning of contaminated air.
- Development of techniques to identify the number of hazardous compounds in emissions and to categorize the formulations and field specimens by biological damage.

Much has been achieved both in-house and under contract in furthering understanding of the nature of the problem in individual houses. In particular, techniques for measuring gases given off by UFFI have been evaluated, reliability and sensitivity have been greatly improved, and costs have been reduced from several hundred to a few dollars for each measurement. Under the pressure of events many individuals and organizations in Canada have developed expertise that will be useful in carrying out the corrective measures required for the future.

The UFFI problem has drawn attention to one aspect of the much broader problem of air quality in buildings. It has illustrated the many uncertainties of assessing health hazards on the basis of a few simple measurements of gas concentration. Factors such as the daily profile of exposure, including duration of exposure-free periods, may influence the

ability of the body to flush out contaminants and lower its susceptibility to illnesses. Extrapolations from occupational exposure and rules of thumb have not been adequate for evaluating the acceptability of the environment. Several avenues of research are, however, showing some success.

One technique being applied to UFFI involves the exposure of a number of simple biological organisms to various concentrations of gases, particulates or water extracts of the material and measurement of their response. The response to these specific mixtures of chemicals is then compared with the response to known materials to determine unacceptable or suspect levels of exposure. As well, the identification of the more harmful components in the gas and particulate emissions from UFFI is continuing, and comparisons of foam from "sick" and normal buildings are giving useful information.

UFFI is just one of many modern materials that emit compounds to which individuals may react. The characterization and the identification and quantification of these compounds are essential in achieving a satisfactory environment in buildings. Clearly this is a problem of the highest priority for building research.

#### REFERENCES

1. BOWLES, A.M., and SHIRTLIFFE, C.J. Development of a Canadian Standard for Urea Formaldehyde Thermal Wall Insulation, In Thermal Insulation Performance. American Society for Testing and Materials, STP 718, 1980, pp. 361-394.
2. SMALL, B.M. Chemical Susceptibility and Urea-Formaldehyde Foam Insulation. Deco-Plan Inc. (Box 3000; Cornwall, Ont., Canada K6H 5R8), 1982.
3. Report of the Hazardous Product Board of Review on Urea Formaldehyde Foam Insulation. Consumer and Corporate Affairs Canada, 1982, 127 p.
4. Report on Urea Formaldehyde Foam Insulation of the Standing Committee on Health, Welfare and Social Affairs. Supply and Services Canada, December 1982.
5. CHOWN, G.A., BOWEN, R.P., and SHIRTLIFFE, C.J. Urea Formaldehyde Foam Insulation. National Research Council Canada, Division of Building Research, Building Practice Note 19, April 1981.
6. BOWEN, R.P., SHIRTLIFFE, C.J., and CHOWN, G.A. Urea Formaldehyde Foam Insulation: Problem Identification and Remedial Measures for Wood-Frame Construction. National Research Council Canada, Division of Building Research, Building Practice Note 23, August 1981.