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### Characterization of Fires in Residential Buildings

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<b>Project Leader:</b>	Jim Mehaffey, Building Systems Department, Fire Research Group, Ottawa Laboratory		
<b>Program Area:</b>	Building Systems	<b>Start Date:</b>	April 2005
<b>Program Goal:</b>	BF	<b>Completion Date:</b>	March 2010
<b>Project No.:</b>	4918	<b>Date of Last Update:</b>	March 31, 2009
<b>Project Liaison(s):</b>	Rodney McPhee, Canadian Wood Council; Claude Lamothe, Abitibi-Consolidated; Bill Love, Tembec		

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#### Long Term Goals / Strategies

- Focus on members' customers and product end-use performance by conducting empirical fire tests and numerical simulations which quantify fires originating within the living spaces of Canadian residential structures, in order to characterize typical fires in those structures and thereby identify appropriate design-fire scenarios and design fires for Canadian building code purposes.
- Increase value of research through alliances with the National Research Council of Canada (NRC) and the other government and industry partners in this collaborative project.

#### Key Objectives

- Participate in a collaborative NRC-led research project involving fire experiments that quantify fires originating in living spaces within multi-family dwellings and numerical simulations of various fire scenarios that determine the characteristics of fires in the living spaces of residential buildings.

#### Key Actions and Deliverables

Deliverables	Expected Delivery Date Completed Item ✓
A collaborative research agreement with NRC and CWC for the first phase of a research program to be carried out primarily by researchers at NRC to characterize fires in the living spaces of residential buildings in Canada	April 2005 ✓
Reports and electronic data files describing the results of fire experiments and numerical simulations that quantify fires originating in the living spaces within multi-family dwellings	March 2009
Characterization of design-fire scenarios and design fires in living spaces of multi-family dwellings	September 2010

#### Status

This project was initiated in April 2005 in order to facilitate participation in a collaborative research project that NRC was to carry out in response to directions from the Canadian Commission on Building and Fire Codes (CCBFC). The research is intended to provide information to assist with implementation of objective-based codes in Canada and to assist in establishing fire-safety objectives for future editions of the National Building Code of Canada. As a member of a Consortium, Forintek has ample opportunity to provide input into the research being undertaken, to vote on all decisions made regarding the direction of the research and on all reports describing the results of the research and the conclusions reached. In mid-June 2005, officials of NRC disclosed that they were having difficulty attracting other partners for this project so the research could not commence until 2006/2007.

The first meeting of the Consortium was held on October 27, 2006. Consortium members included: Canadian Concrete Masonry Producers Association, Masonry Worx, La Régie du Bâtiment du Québec, Forintek Canada

Corp., Canadian Automatic Sprinkler Association, Canadian Wood Council, NRC Fire Research Program, and NRC Canadian Codes Centre. The study was originally to focus on fires in kitchens, living rooms and bedrooms. However, CCBFC requested that “secondary residential suites” and “residential care facilities” be included. NRC proposed to begin a literature review of fire models, fire loads and fire test data; a survey of floor plans; and a survey of fire loads for all five room-types.

The second meeting of the Consortium was held on June 19, 2007. Since the first meeting, the Ontario Ministry of Municipal Affairs and Housing, the City of Calgary and the Gypsum Association had joined the Consortium. NRC had initiated a search of realtors’ web-sites in order to build up a database of the sizes, layouts and fuel loads in multi-family dwellings units. It was agreed that, before commencing full-scale tests, a series of “medium-scale” tests would be conducted on fuel packages in 16-m<sup>2</sup> rooms. Enough furnishings were to be purchased by NRC to carry out the tests. The rate of heat release, calorific values and gas yields will be measured as a function of ventilation conditions. Computer zone models were also to be used to predict the burning behaviour for other compartment and ventilation scenarios.

By the end of 2007, NRC had completed the residential fire load survey and construction of the medium-scale test was nearing completion. The next Consortium meeting will be convened in early 2008 in order to finalise the plans for the medium-scale testing.

### **Partners**

Canadian Wood Council  
National Research Council Canada

### **Rationale and Potential Impact**

Canadian fire statistics demonstrate that about 40% of the total number of fires and 74% of the total number of fire fatalities in Canada in 2000 occurred in residential buildings<sup>1</sup>. Statistics such as these clearly demonstrate the need for engineered fire-safety-design solutions for residential buildings in Canada, and since these structures are primarily of wood-frame construction, the importance of being involved in this collaborative project, on behalf of the wood industry, is obvious. While the initial phase of the research will focus primarily on fires originating within the living spaces of multi-family wood-frame structures, the results will also be applicable to single-family dwellings.

An analysis of fire loss statistics indicates that more than 70% of all fires in residential buildings commence with the ignition of one or more items of furnishing and/or contents within the living spaces of the buildings, and that less than 10% commence with the ignition of the building’s structural members. However, the severity of the fires within the living spaces has a significant impact on the performance of those structural members and on the amount of protection that must be provided to them. Therefore, it is of critical importance that the threats to the major structural components of residential structures be quantified in order for the CCBFC to establish appropriate fire safety objectives for the structural elements in those assemblies

### **Proposed Approach**

NRC has established a collaborative research agreement with Forintek (and other partners) to characterize fires in the living spaces of residential buildings in Canada. During 2008-2009, with guidance from its partners, NRC was to undertake empirical fire tests and numerical simulations to quantify fires originating in residential structures as a first step in identifying appropriate design fires and design-fire scenarios for Canadian building code purposes.

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<sup>1</sup> Fire Losses in Canada – Annual Report 2000, published by Council of Canadian Fire Marshals and Fire Commissioners



### Work Completed this Fiscal Year

A Consortium of thirteen interested parties has been assembled by NRC to participate in planning (and funding) of this NRC Collaborative Project on Characterization of Fires in Multi-suite Residential Dwellings (CFMRD). The Consortium members now include: Canadian Automatic Sprinkler Association, Canadian Concrete Masonry Producers Association, Masonry Worx, Canadian Furniture Manufacturers Association, Canadian Wood Council, City of Calgary, FPInnovations - Forintek Division, Gypsum Association, Ontario Ministry of Municipal Affairs and Housing, Régie du Bâtiment du Québec, NRC-IRC Canadian Codes Centre, Health Canada (Invited observers) and Ontario Ministry of Community Safety and Correctional Services (Office of the Fire Marshal).

The Consortium met March 25, 2008 (at the end of the last fiscal year) to plan the work for 2008-2009. Changes in the original work plan, in particular the decision to run medium-scale tests before full-scale tests, put this project significantly behind schedule. The Consortium met again on December 3, 2008 to review progress and plan the work for 2009-2010. Forintek scientists participated in both meetings. A summary of the progress during 2008-2009 follows:

- NRC has completed numerous small-scale (cone calorimeter tests) on various floor coverings (Carpets, vinyl, OSB subfloor, etc), hard furniture materials (particle board and MDF), and components of mattresses and upholstered chairs (particularly polyurethanes foam and cross-sections of top layers). The data measured (rate of heat release, rate of generation of toxic gases and rate of generation of soot) will subsequently be used as input to computer modelling of the medium-scale and full-scale experiments.
- NRC has completed 28 medium-scale tests on upholstered chairs, mattresses (with and without bedclothes) and other combustible contents (clothes in a wardrobe, books on a book shelf, etc). The medium-scale test facility is a room 3.8 m wide, 4.2 m deep and 2.4 m in height with a window 1.5 m by 1.5 m in an end wall. This room represents the mean area (16 m<sup>2</sup>) of living rooms and master bedrooms as determined in NRC's survey. The window is also of typical size. The primary measurements taken were the rate of heat release, rate of generation of toxic gases and rate of generation of soot. On the basis of these tests, a specific upholstered chair as well as two mattresses plus bedclothes arrangements have been selected for the full-scale tests.
- Plans have been finalised for up to 16 full-scale tests that will be run. A one-storey three-room facility was chosen for the full-scale tests. The facility will be sufficiently flexible that various ventilation conditions can be explored. Fire will be initiated in one room (e.g. a bedroom decorated as found in the survey), but conditions monitored in all three rooms. Construction of the facility will commence shortly with testing to commence in the spring of 2009. NRC intends to call another meeting of the Consortium in the spring to witness one of the early full-scale tests and to finalise plans for the rest of the full-scale tests.
- Computer modelling was found to successfully simulate the results of the first medium-scale mattress test. Similar computer simulations will be run for each full-scale test. If the computer simulations prove to give accurate predictions, numerous simulations can be run to assess the influences of minor or major variations in the fire scenario.
- The ultimate goal is to devise design fires (rate of heat release, rate of generation of toxic gases and rate of generation of soot) for use in engineering analyses of fires in multi-family residential suites.

NRC established a members' website and posted several reports there during 2008/09. A brief summary of the reports follows:

- NRC scientists published the results of experiments and computer simulations of sofa fires in a room that studied the effects of varying the location of the sofa, and the locations and sizes of ventilation openings.
- NRC scientists published the results of a survey in which they examined floor plans and photographs of 60 multi-family dwelling units that had been posted on the internet by realtors. In addition to fuel load data, the survey provided information on typical layouts of suites as well as typical window and door sizes.
- NRC scientists published a description of the medium-scale test facility as well as the results of the first tests conducted in the facility.

**Publications**

- Saber, H.H.; Kashef, A.; Bwalya, A.C.; Lougheed, G.D. 2008. Analyses of Post-Flashover Fires in a Medium-Sized Residential Room under Different Ventilation Conditions. IRC-RR-264, Institute for Research in Construction, National Research Council Canada.
- Saber, H.H.; Kashef, A.; Bwalya, A.C. 2008. Post-flashover compartment fire for different fire ventilation settings in a medium-sized residential room," ASME International Mechanical Engineering Congress and Exposition (Boston, Mass. November 02, 2008),
- Bwalya, A.C.; Lougheed, J.D.; Kashef, A.; Saber, H.H. 2008. Survey Results of Combustible Contents and Floor Areas in Multi-Family Dwellings. IRC-RR-253, Institute for Research in Construction, National Research Council Canada, pp. 42.
- Bwalya, A.C.; Gibbs, E.; Lougheed, J.D.; Kashef, A.; Saber, H.H. 2008. Design of a Single-Room Heat Release Rate Calorimeter for the Characterization of Fires in Multi-Suite Residential Dwellings Project. IRC-RR-267. Institute for Research in Construction, National Research Council Canada.
- Bwalya, A.C. 2008. Characterization of Fires in Multi-Suite Residential Dwellings (CFMRD). Progress Report No. 1. Institute for Research in Construction, National Research Council Canada.
- Bwalya, A.C. 2008. An Overview of design fires for building compartments. *Fire Technology*, Volume 44, pp. 167-184.