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Residential Combustion Spillage Monitoring

The research described in this Highlight was first published in 1987, but it has never been released in a summary form. This Highlight has been written for distribution now because the findings of the research project are still valid and can still contribute to the understanding of the residential combustion spillage issue.

INTRODUCTION

In research activities conducted in the mid-80s, CMHC had simple monitors installed in approximately 900 houses to detect spillage of combustion products from fuel-fired furnaces and hot water heaters (see Research Highlights 03-125, *Residential Combustion Venting Failure*). In that study, CMHC found that a significant percentage of houses did have occurrences of combustion product spillage. The purpose of this study was to carry out a more detailed monitoring program on some houses that had experienced incidents of combustion spillage.

RESEARCH PROGRAM

Monitoring activities were carried out in a total of 16 houses: 9 in Ottawa and 7 in Winnipeg. Three of the Ottawa houses were oil-heated; the others were heated by natural gas. Monitoring was done over a period of 14 to 35 days on individual houses; a total of 322 days of usable monitoring data was gathered.

A data acquisition system was used to record when combustion appliances were on or off, whether spillage was occurring, whether windows and doors were open, if exhaust fans were operating and if the fireplace was in use. Thermisters were used to determine furnace and water heater status, as well as to indicate a spillage condition.

Fan status was determined using FM intercom transmitters wired in parallel to the fan. This novel approach eliminated the need for any internal wiring in the house. Door and window status was monitored using magnetic switches with external wiring. Fireplace status was measured with a thermostatic switch. The monitoring software, written in BASIC, scanned all eight input signals and the clock on a continuous basis.

Air sampling was carried out at the start of each monitoring period when the data acquisition system was installed. Absorption tubes were used to check for the presence of NO_2, NOx and in some cases SO_2, in the basement near the furnace and in the living space, usually in the master bedroom. Samples were first taken when spillage was intentionally provoked (by using a blower door fan or by blocking the flue). Where detectable quantities of contaminants were found during the forced spillage tests, additional tube samples were carried out and air samples were also collected a few minutes after the forced spillage was stopped. Gas chromatography analysis was used on these samples to determine concentrations of CO, CO_2, methane (CH_4) and non-methane hydrocarbons (HC).

On houses that showed significant spillage occurring within the first two weeks of monitoring, further work was undertaken to determine the effects of spillage on indoor air quality during normal house occupancy.

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Conventional aquarium pumps controlled by the monitoring software were installed to draw air samples into Mylar® sample bags. One pump was activated when a significant spillage event occurred; the other was on a regular timed cycle so that "average" indoor contaminant levels could be determined. These samples were analyzed for CO, CO_2 and volatile organic compounds (VOCs). A selected number of samples also underwent mass spectrography for a more complete analysis of the VOCs.

Two other procedures were carried out to provide support data for the spillage monitoring and air quality monitoring activities. Each house was subjected to a fan depressurization test to determine the equivalent leakage area of the building envelope. A time-averaged tracer gas procedure was also used to establish the actual air change rate during the monitoring period. In this procedure, two sources of a perfluorocarbon tracer gas were located in the basement and in the master bedroom. The sources emit different tracer gases so that inter-zone mixing can be determined. A sampler that absorbs the tracer gases was mounted in the same rooms as the sources and left in place during the entire air quality-monitoring period. These samplers are analyzed by a thermal desorption/mass spectrographic process, from which a time-averaged air change rate and inter-zone mixing can be calculated.

RESEARCH RESULTS

The results of the testing are summarized in Table 1.

Considering that the houses monitored were pre-selected to be those in which spillage incidents were thought to have occurred, remarkably few actually had significant spillage events. Of the sample 16 houses, 9 showed no spillage activity during the monitoring period. Two houses, which were oil-heated, had brief, infrequent periods where spillage was detected, consistent with the "startup puffs" expected with a powered burner. Five gas-heated houses indicated significant spillage incidences (a significant spillage event was defined as 10 seconds of spillage for a gas-heated house and 5 seconds for an oil-heated house). In one gas-heated house, the spillage was almost exclusively driven by the fireplace. In another, the spillage seemed driven by other exhaust appliances, notably exhaust fans.

In the remaining three gas-heated houses, spillage occurred regularly even in the absence of aggravating conditions.

In the forced spillage tests, a fairly high reading of some contaminants, particularly CO_2 and SO_2,were recorded. However, where naturally occurring spillage was monitored, contaminant levels would not be considered hazardous. Interestingly, many houses with the highest CO_2 levels during "forced" spillage did not spill during monitoring. The results of the three samples, which underwent mass spectrographic analysis, showed that levels of all VOCs were in the sub-parts per billion range and no "concern" levels of any compound were found.

The airtightness and air change testing data was collected to allow analysis of the effects of temperature and wind. However, no direct correlation to wind and temperature was discernible, probably because other factors overwhelmed the weather factors; therefore, there was no attempt at employing the airtightness and air change testing results in correlations.

IMPLICATIONS FOR THE HOUSING INDUSTRY

While forced spillage indicates the potential for unacceptably high levels of some hazardous contaminants, particularly CO_2 and SO_2, the monitoring results indicate that the combinations of environmental and house operation characteristics that are most conducive to spillage of combustion gases are relatively rare. Appliance and venting system configuration and the effect of exhausting appliances are more strongly related to spillage incidents than the effects of outside temperature and wind. Further, since spillage occurred in three cases even when exhausting appliances were off, poor chimney performance is likely the most important contributing factor. Therefore, emphasis should be placed on improved chimney performance to prevent hazardous spillage occurrences.

House No.	Heating Fuel	Spillage Occurrence	Spillage Condition	CO	CO_2	CH_4	HC
O1	Gas	No	Forced	1.1	750	4.4	0.9
O2	Gas	Yes	Forced Natural	1.2 2.9-3.7	1,826 697-1,045	2.5 1.9-2.2	1.7 1.5-2.1
O3	Gas	Yes	Forced Natural	N/a 0.8-2.8	N/a 621-968	N/a 1.6-4.6	N/a 1.4-6.0
O4	Oil	No	Forced	1.6	1,904	1.1	0.9
O5	Oil	Yes	Forced Natural	1.6 1.0	528 462	1.5 1.6	0.9 2.1
O6	Gas	Yes	Forced Natural	0.8 1.1-2.4	838 702-827	4.4 8.5-12.9	1.2 1.4-1.5
O7	Oil	Yes	Forced Natural	N/a N/a	N/a N/a	N/a N/a	N/a N/a
O8	Gas	No	Forced	Not detected	>6,634	1.4	1.2
O9	Gas	No	Forced	Trace	>2,594	2.2	1.7
W1	Gas	Yes	Forced Natural	0.1 0.8	503 646	2.8 2.5	2.9 2.7
W2	Gas	No	Forced	0.5	963	1.8	1.5
W3	Gas	No	Forced	1.1	1,268	2.7	2.1
W4	Gas	Yes	Forced Natural	5.3 0.5	1,998 570-1,590	2.9 1.7-3.8	1.4 1.5-1.9
W5	Gas	No	Forced	0.8	3,568	1.5	2.0
W6	Gas	No	Forced	3.6	2,592	3.3	2.0
W7	Gas	No	Forced	1.0	535	3.8	2.7

Table 1: Summary of Test Results

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and SRO Engineering Ltd.

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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