Technical Series
90-221

That Nice "Woodsy" Smell: Combustion Spillage from Residential Wood Heating Systems

Introduction

The distinctive smell of wood smoke is often regarded as one of the advantages of a wood heating system. However, wood smoke contains a number of known and suspected carcinogens. Because the smell of smoke in the home results from combustion products spilling from a wood heating appliance, it is also an indication that the appliance is not operating properly.

To help reduce the risk of combustion spillage, CMHC commissioned a research project to learn more about residential wood heating systems. The objectives of the project were:

- to determine the frequency and severity of spillage;
- to learn what design, installation and operation factors affected spillage; and
- to develop effective ways of preventing spillage in new and existing installations.

Research Program

The study consisted of three parts. Wood heating system owners across Canada were interviewed and their appliances inspected by qualified technicians. Several systems were field tested and a number of remedial measures were developed and tested on these systems. Laboratory testing was also carried out to assess the degree to which appliance design affects sensitivity to spillage.

Findings

Although virtually all systems had some history of spillage, most episodes were minor and could easily be controlled by the user. The most common form of spillage occurs when the appliance door is opened at start-up or for reloading. Closed door spillage, which is considered more serious, was reported by just under a third of the users that were interviewed. About one in ten systems experienced severe and persistent spillage problems.

The remedial measures that were developed and tested were designed to achieve two objectives: reducing restrictions or other factors preventing the flow of combustion gases, or raising the average flue gas temperature throughout the system. Most of the remedial measures were highly successful and spillage was eliminated completely.

Appliances that meet United States Environmental Protection Agency (EPA) emissions standards appear less likely to spill than conventional appliances because of their ability to maintain stable flue gas temperatures.

Conclusions

The research demonstrated that spillage can be prevented through good system design, component selection and proper appliance operation and maintenance.

The study identified a number of design, installation and operation factors affecting spillage. These are summarized in Table I.

Simple remedial measures can reduce or eliminate many of the causes of spillage. Table 2 shows some typical problems and effective remedial strategies.

A significant finding of the study is that the actions of the user are the most important element in the proper operation of a wood heating system. Even a system whose design makes it resistant to spillage can be operated in a way that causes it to spill, while systems which are highly susceptible to spillage can be spill-free if controlled by a careful and knowledgeable operator. Accordingly, the study developed instructions for users on ways to reduce or prevent spillage. These are listed below.

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Research Report: That Nice "Woodsy" Smell: Combustion Spillage from Residential Wood Heating Systems (1991)

Research Consultant: John Gulland, Performance Woodburning and Charles Lemay, IRTA Laboratories

A full report on this research project is available from the Canadian Housing Information Centre (CHIC) at the address below.

The findings of this report have been incorporated into A Guide to Residential Wood Heating (NH.4 5178), published jointly by CMHC and Natural Resources Canada, and available from CHIC.

Anti-Spillage Instructions for Users

Once any design or mechanical causes of spillage have been identified and corrected (see Table 2), it is up to the user to ensure that a wood heating appliance is operated in a manner that effectively prevents spillage.

The following techniques, which were found to be effective in this study, are organized into three categories: understanding and correcting a cold backdraft, techniques to raise the flue gas temperature, and maintenance required to prevent restrictions and to keep the appliance operating properly.

Cold Backdraft

Cold backdraft occurs when cold outdoor air is drawn down the chimney into the house. If there is no fire in the system, the user may detect the smell of creosote. If the system is in use, the combustion products will spill into the room.

Cold backdraft is usually the result of stack effect, especially when the chimney is outside the house and the appliance is installed in the basement. It may also be caused by adverse pressure conditions, such as house depressurization caused by a powerful exhaust ventilator.

Table 1: System features that affect spillage

	Promotes Spillage	Resists Spillage
Appliance	**Too large for space heat loss**	Proper size for space heat loss
	Unlined combustion chamber	Lined or insulated combustion chamber
	No combustion system	EPA certified combustion system
	Large door opening area	Moderate to small door opening
	Leaky construction	Sealed construction
	Large heat exchanger	Moderate to small heat exchanger
	Firebox exhaust lower than door opening	Firebox exhaust higher than door opening
	Solid doors	Glass doors with air wash system
Flue Pipe	Different size from appliance flue collar	Size matches appliance flue collar
	Assembly includes elbows	Assembly straight to chimney
	More than 2 metres in length	Less than 2 metres in length
	Assembly has key damper	No key damper or other restrictions to flow
	Assembly loose and leaky	Assembly reasonably well sealed
Chimney	Chimney flue is not insulated	Chimney flue is insulated
	Located on outside wall	Located inside house envelope
	Flue size different from flue collar	Flue size matches flue collar
	Flue has offsets	Flue is straight
	Total system height less than 4.5 metres	Total system height more than 4.5 metres
	Chimney height below code requirements	Chimney height exceeds code requirements
	Chimney not clear of roof	Chimney clears top of roof
	Chimney leaks	Chimney is well-sealed
House/Setting	Has high-volume exhaust ventilators	No high-volume exhaust ventilators
	Appliance is located below neutral plane	Appliance is located above neutral plane
	House set low compared to nearby features	House is clear of wind obstructions
Appliance Operator	Tolerant to wood smoke smell	Intolerant to wood smoke
	Allows appliance to smoulder	Avoids smouldering
	Misuses flue pipe key damper	Takes care in use of flue pipe key damper
	Inexperienced wood burner	Experienced wood burner

To correct a cold backdraft without causing ***spillage:*** open a basement window to relieve pressure before lighting a fire, or use a hair drier in the chimney cleanout.

To correct a backdraft but risk some spillage: burn some newspaper in the appliance or the chimney cleanout.

Raising Flue Gas Temperature

Combustion spillage is least likely to occur when the temperature of the gases in the flue remains high. There are a number of simple ways to achieve this.

- Use plenty of newspaper when lighting a fire; 6 - 10 sheets crumpled.
- Use plenty of small pieces of dry kindling.
- When starting a fire, set the air controls fully open.
- Once kindling is charred and flaming brightly, add a few pieces of intermediate kindling. Do not smother the kindling fire.
- Never add just one piece of wood at a time.
- Never reload the appliance until the room or house temperature has begun to fall.
- Operate the appliance in cycles. One cycle is the time between loading wood on a coal bed and its burning down to a coal bed of the same size.
- When loading wood on a coal bed, always add at least three pieces, and preferably six or seven.
- If you want to produce less heat, use smaller pieces, not fewer pieces.

Table 2: Remedial strategies for common spillage problems

	Type of Problem	Possible Remedial Action
Chimney Top Temperature	**Chimney on outside of house is being chilled**	**Enclose in chase**
		Reline and insulate
		Install indoor chimney
	Chimney flue over- or under-sized	Reline to correct size
		Replace with chimney of correct size
	Excessive flue pipe heat loss	Replace with sealed double-wall pipe
		Relocate appliance or chimney to shorten flue pipe run
		Replace 9Q0 elbows with 450 elbows
	Low flue gas temperature from appliance	Build hotter fires; avoid smouldering
		Adjust bi-metallic operator
		Use smaller and dryer pieces of wood
		Replace oversized appliance with a smaller one
		Replace conventional appliance with advanced design
Flow Restrictions	Elbows in flue pipes	Replace 9Q0 elbows with 450 elbows
	Flue pipe key dampers	Remove key damper
		Use key damper properly
	Creosote build-up or blocked breech	Clean chimney or reconstruct breech
	Appliance bypass damper	Use bypass damper properly
External Influences	Chimney top affected by wind and nearby wind obstacles	Increase chimney height
		Remove obstacles
		Try a specialized chimney cap
	Adverse air pressure	Eliminate competing exhaust ventilator
		Install make-up air supply
		Avoid operating competing exhaust ventilators when appliance is in use

- To take the chill off the house in spring and fall, use the flash fire technique: several smallish pieces criss-crossed.
- For a longer cycle, such as overnight, use larger pieces placed compactly.
- Never allow excess ash to build up in the firebox - many stoves should have some ash removed each morning.
- Install a flue pipe thermometer about *450* mm (18") above the flue collar and use it to ensure that the system operates above the minimum operating temperature. This is the level at which the appliance sustains flaming combustion while operating at the lowest firing rate. Never allow the temperature to fall below this level until the fire reaches the coal bed phase.
- Fire each new load for 20 to *45* minutes at full output, until the wood is flaming brightly and is well charred.

Here's what users will see if the appliance is operating properly:

- The wood should be flaming until only charcoal remains. If there are no flames, something is wrong.
- If there are firebricks in the appliance firebox, they should be tan in colour, not black.
- Steel parts of the firebox should be light to dark brown, not black and shiny.
- New loads of wood should ignite almost instantly. The bottom pieces should be flaming by the time the door is closed.
- If the stove has a glass door with airwash it should be clear.
- If the stove has a glass door without airwash, it will be hazy, but should never be totally black.
- The exhaust coming from the top of the chimney should be clear or white. Blue or grey smoke indicates smouldering and probably low system operating temperatures.

Maintenance

Regular maintenance is necessary to prevent the development of conditions that can lead to spillage.

- Inspect the appliance, flue pipes and chimney regularly to monitor ash, soot and creosote build-up, and clean as necessary to prevent restrictions.
- Check the internal passages of the appliance to ensure that components such as insulation have not shifted.
- Check and clean catalytic combustors regularly; use a vacuum to remove ash.
- Check door, glass and cleanout gaskets to be sure they are sealing properly. The objective is not to keep the unit as airtight as possible, but to ensure that combustion air enters only where it is intended to enter.

Housing Research at CMHC

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This factsheet is one of a series intended to inform you of the nature and scope of CMHC's technical research program.

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For a complete list of Research and Development Highlights, or for more information on CMHC housing research and information, please contact:

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