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PERFORMANCE OF SYNTHETIC FIREPLACE LOGS IN A NON-AIRTIGHT, FIREPLACE-TYPE, WOOD STOVE

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ABSTRACT

This paper discusses the relative combustion performance of synthetic fireplace logs in a fireplace-type, wood stove using dry, hardwood maple as a reference fuel. The test procedure employed was developed at the Canadian Combustion Research Laboratory and is the procedure recommended by the Canadian Wood Institute for evaluating the performance of wood-burning appliances.

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INTRODUCTION

At the request of Burnco Industries Ltd, the Canadian Combustion Research Laboratory (CCRL) conducted a series of combustion trials to measure the combustion performance and emissions of synthetic fireplace logs in a fireplace environment. Dry, hardwood maple logs, the standard reference fuel for wood burning performance, was used to provide a baseline against which the synthetic logs were compared.

This paper describes results of four combustion trials in a non-airtight fireplace-type, wood stove under a range of operating conditions including different chimney drafts.

FUEL ANALYSIS

The synthetic fireplace logs contained about 60% parafin, 2.6% moisture and about 37% sawdust. The maple wood had been air-dried for about 2 years and had about 15% moisture on a wet basis. On a weight basis, the synthetic logs at 37,276 KJ/kg had nearly twice the calorific value of the maple wood at 19,306 KJ/kg. The ultimate analyses of the synthetic logs and the maple wood are given in Tables 1 and 2 respectively.

Both analyses were performed by the Solid Fuels Analyis Laboratory Energy Research Laboratories, CANMET.

TEST FIREPLACE

The non-airtight, fireplace-type wood stove used in these trials was made of cast iron and is generally called a Franklin fireplace. It has folding doors across the front which can be opened for operation as a fireplace or they can be closed for operation as a box stove. However, even with the doors shut and the combustion air control completely closed off, there is a large amount of air leakage into the combustion zone. A schematic of this stove is given in Figure 1.

TEST PROCEDURE AND RESULTS

The method used to evaluate the performance was instantaneous heat loss method (1). All of the components in the exhaust stream, as well as the weight change of the fuel are measured and recorded simultaneously on magnetic tape throughout the burning cycle. Afterwards analyses of the data are carried out on the computer for each instant of time, and the profiles throughout the burning cycle are plotted. Flue gas components measured and the technique used for each are given in Table 3.

Each test, which was done in duplicate, was started immediately after ignition of the log as instructed on the log wrapper. Four tests under various combustion conditions were conducted and the results are summarized in Tables 4 and 5.

Emissions from fireplaces are normally reported in terms of grams of solids per kilogram of fuel or grams of solids per megajoule input. The emissions from the synthetic logs ; Table 5, were 5 to 10 times higher than dry maple on a fuel weight basis and 2.7 to 5 higher than dry maple on a heat input basis. However, the mass of emissions per unit of time or per unit of flue gas volume from the synthetic logs was comparable to the dry maple because of differences in burning rate and excess combustion air.

In work reported recently by Butcher and Sorenson (2), air-dried oak in an air-tight, wood stove generated emissions of 24.4 g/kg fuel at low draft and between 2.3 and 13.3 g/kg fuel at high draft. This trend was also evident in the burns with the synthetic fireplace logs where emissions per weight of fuel input decreased as the draft was increased.

Typically, most wood-fired heating appliances generate emissions of between 1 and 15 g/kg fuel input; in the case of the fireplace logs these values would be equivalent to between 2 and 30 g/kg of fuel when credit is given for the calorific value of the synthetic logs which are about twice as high as most wood species after air drying.

Figures 2 to 4 show the cycle results for stack temperature and burning rate using the synthetic logs, while Figure 5 shows the same variables with the dried maple as fuel. Even when the fireplace-type stove was run with the doors closed, and the combustion air controls almost shut, the flue gas temperatures, which peaked at about 110°C, did not change significantly from when the doors were open. Excess air levels in all tests which were typical of most open fireplaces.

were very high (>4000% with CO_2 levels ranging from 0.1% and 0.8%); CO and gas-phase hydrocarbons and volumetric basis were barely detectable because of the missive air infiltration. Maximum metal temperatures in the fireplace reached 140°C with the synthetic logs compared with 290°C with the maple.

CONCLUSIONS

1. Each synthetic log burned for about 3 hours. They ignited and burned readily with flue gas temperatures decreasing gradually over the burn period from about 120°C to 50°C.
2. Particulate emissions from the synthetic logs, which consisted mostly of smoke, ranged from 18.6 to 36.1 g/kgm of fuel. These values were more than 5 times higher than dry maple, but fall within the upper range of emissions from typical wood-burning appliances when the weight of fuel is adjusted to compensate for the higher calorific value of the synthetic logs.
3. The synthetic logs, because of their lower burning rate, produced emissions on a time basis that were comparable to maple wood.
4. The very high excess combustion air levels, typical of open fireplace operation, resulted in CO_2 values below 1% whereas CO and gas-phase hydrocarbons at <25 ppm and <0.05 ppm were barely detectable on a volumetric basis. These high excess combustion air levels, resulted in the emissions from the synthetic logs on a volumetric basis being lower than for the maple wood.
5. Non-airtight fireplaces or stoves are capable of burning single synthetic logs of the type used without risk of overheating or of producing excessive pollution relative to wood.

REFERENCES

1. Hayden, A.C.S. "Efficiency of wood-fired appliances"; Division Report ERP/ERL 78-82 (TR)(OP);CANMET, Energy, Mines and Resources Canada;1978.
2. Butcher, S.S. and Sorsenson, E.M. "A study of wood stove particulate emissions";J Air Pollut Control Assoc;Vol 29, No. 7, 724-728;July 1979.

Table 1 - Synthetic fireplace log

ULTIMATE ANALYSIS
(dry basis)

Carbon:	69.91%
Hydrogen:	11.06%
Sulphur:	0.13%
Nitrogen:	0.08%
Ash:	0.29%
Oxygen:	18.53%

Gross Calorific or Higher Heating Value: 37,276 kJ/kg (16,026 Btu/lb)

As-fired Moisture: 2.61%

Table 2 - Sugar Maple

ULTIMATE ANALYSIS

(dry basis)

Carbon:	49.6%
Hydrogen:	5.2%
Sulphur:	0.1%
Nitrogen:	0.2%
Ash:	2.0%
Oxygen:	43.0%

Gross Calorific or Higher Heating Value: 19,306 kJ/kg (8,300 Btu/lb)

As-fired Moisture: 15%

Table 3 - Measurements for instantaneous heat loss method

COMPONENT MEASURED		TECHNIQUE
Carbon Dioxide	in Flue Gas	Infrared Analyzer
Carbon Monoxide	" " "	Infrared Analyzer
Oxygen in Flue Gas	" " "	Paramagnetic Analyzer
Ambient Hydrocarbons	" " "	Infrared Analyzer
200°C Hydrocarbons	" " "	Flame Ionization Detector
Water-condensed Hydrocarbons	" " "	Mass Spectrometer
Water	" " "	Dew Cell
Equivalent Oxygen	" " "	Fuel Cell
Temperatures		Thermocouples
Soot		Dust Sampling Train
Fuel Weight		Continuous Digital Scale
Nitrogen Oxides		Chemiluminescent Analyzer

Table 4 - Combustion performance data

Test No.	Fuel	Draft mm WC	Fireplace Doors	Fuel Load kg	Burn Time h	Heat Rate MJ/h	Excess Combustion Air, %
1*	Synthetic Firelogs	0.5	open	1.4	3.3	15.8	4100
2***		2.5	open	3.4	6.0	20.5	>4100
3**	"	1.5	closed	3.1	5.3	21.9	>4100
4*	Dry Maple	0.5	open	27.7	7.5	71.3	1050

Table 5 - Particulate matter emissions

Test No.	Fuel	Draft mm WC	$\frac{g}{\text{kg Fuel}}$	$\frac{g}{\text{MJ Input}}$	$\frac{g}{h}$	$\frac{g}{Nm^3}$
1*	Synthetic Firelogs	0.5	36.1	0.97	15.3	0.099
2***	"	2.5	18.6	0.52	10.6	0.048
3**	"	1.5	27.3	0.95	16.0	0.089
4*	Dry Maple	0.5	3.6	0.19	13.2	0.128

*Low draft
**Moderate draft
***High draft

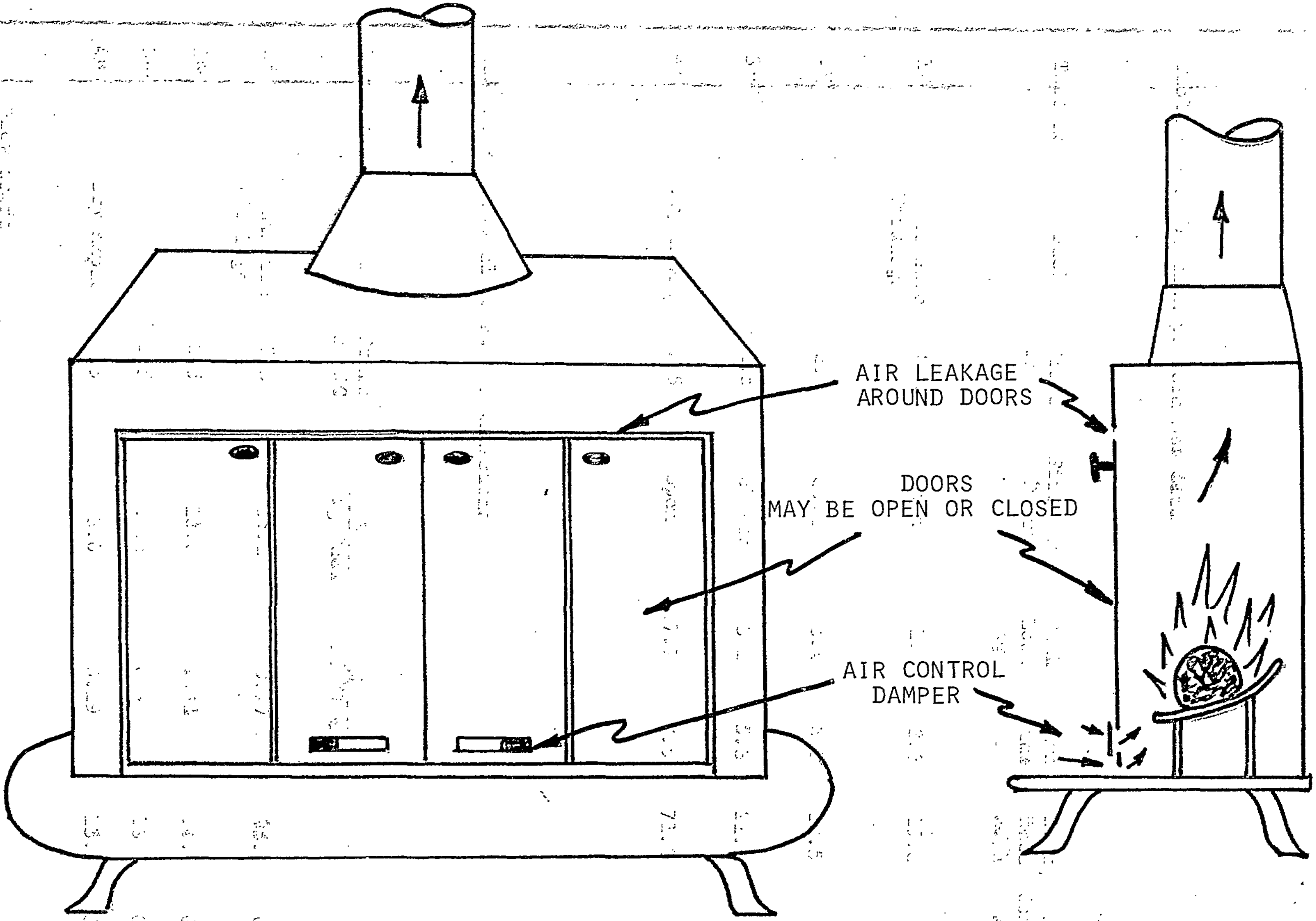

Fig. 1 - Non-airtight, fireplace-type wood stove

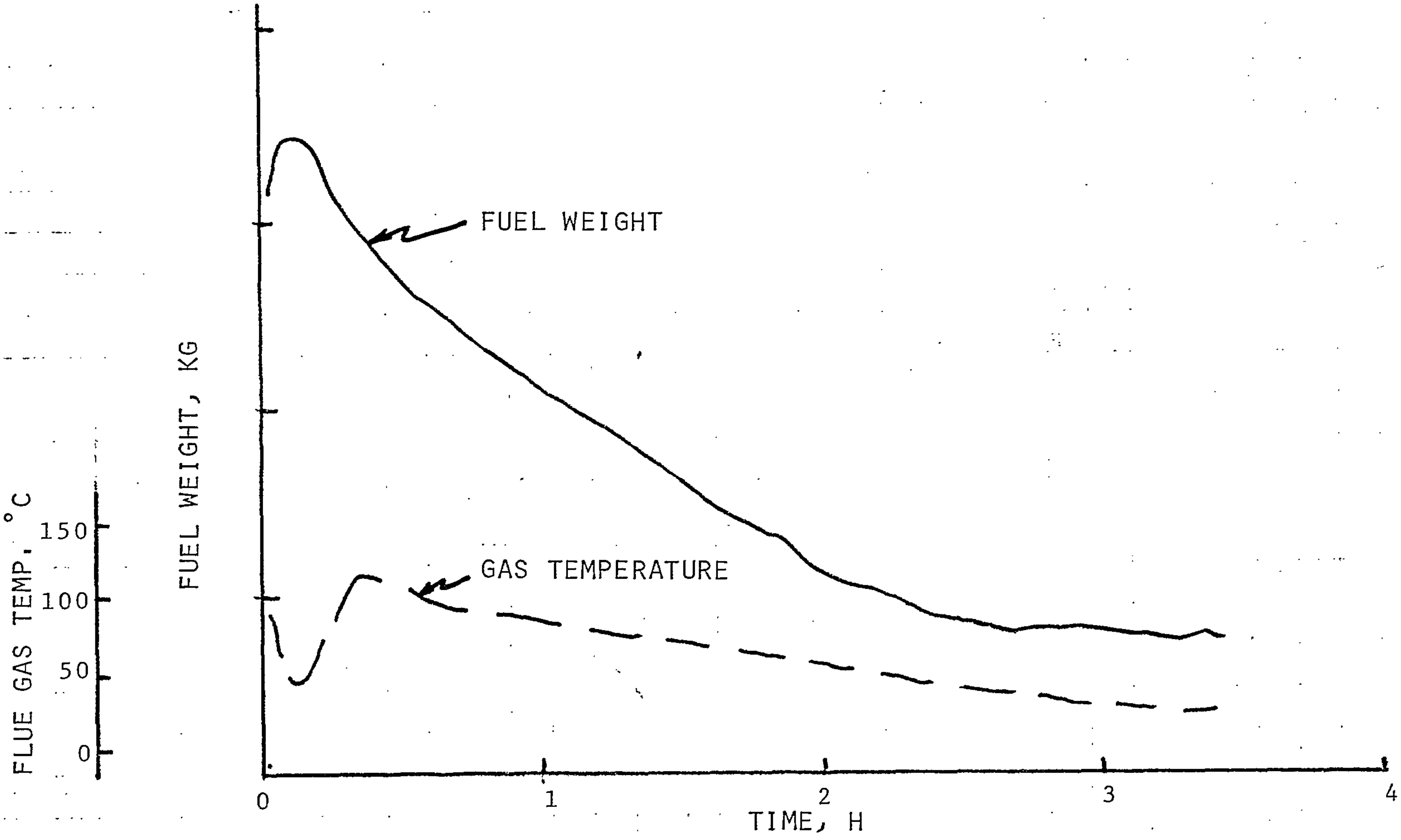

Fig. 2 - Test No. 1 with a synthetic firelog at 0.5 mm draft; doors open

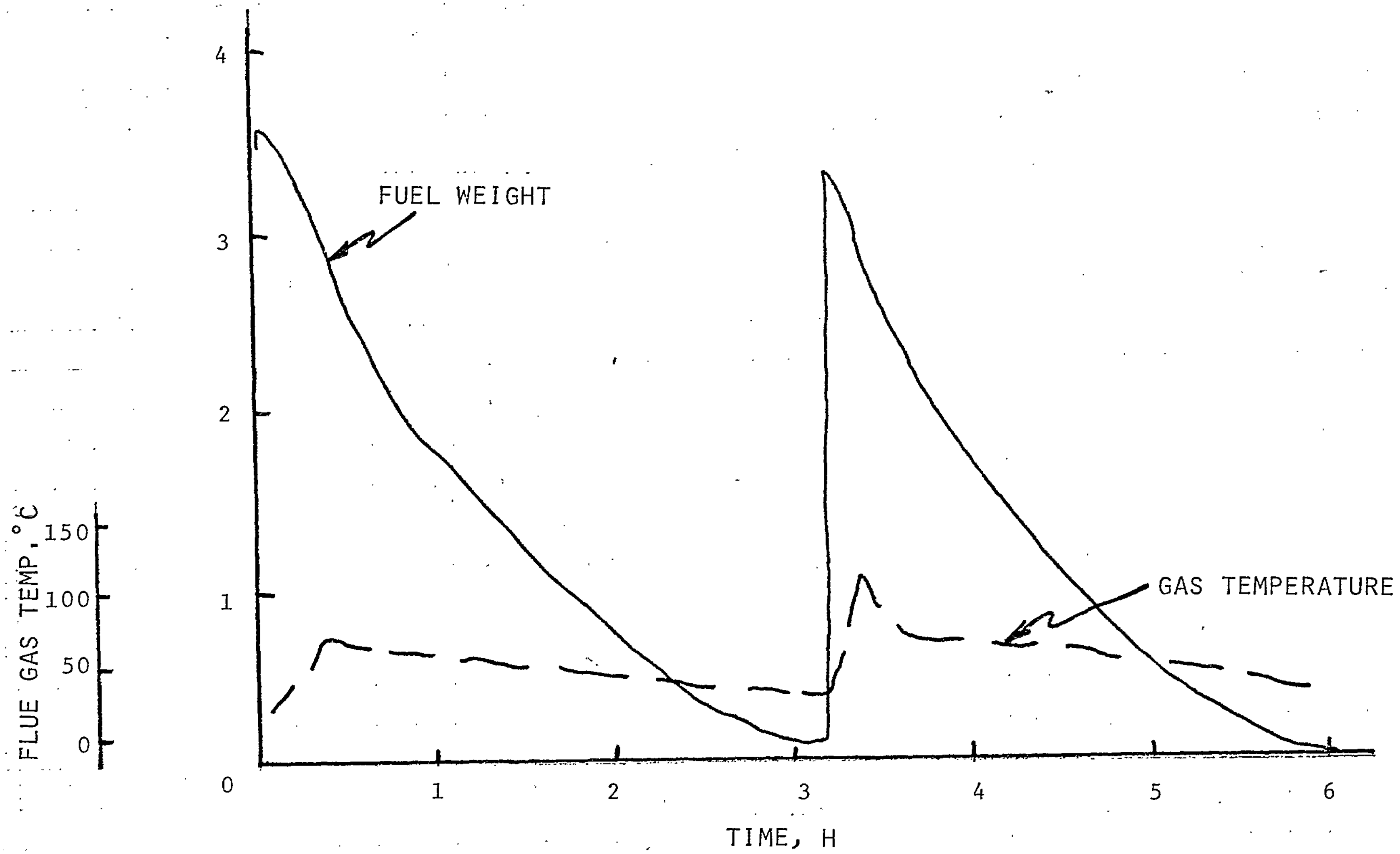

Fig. 3 - Test No. 2 with a synthetic firelog at 2.5 mm draft; doors open

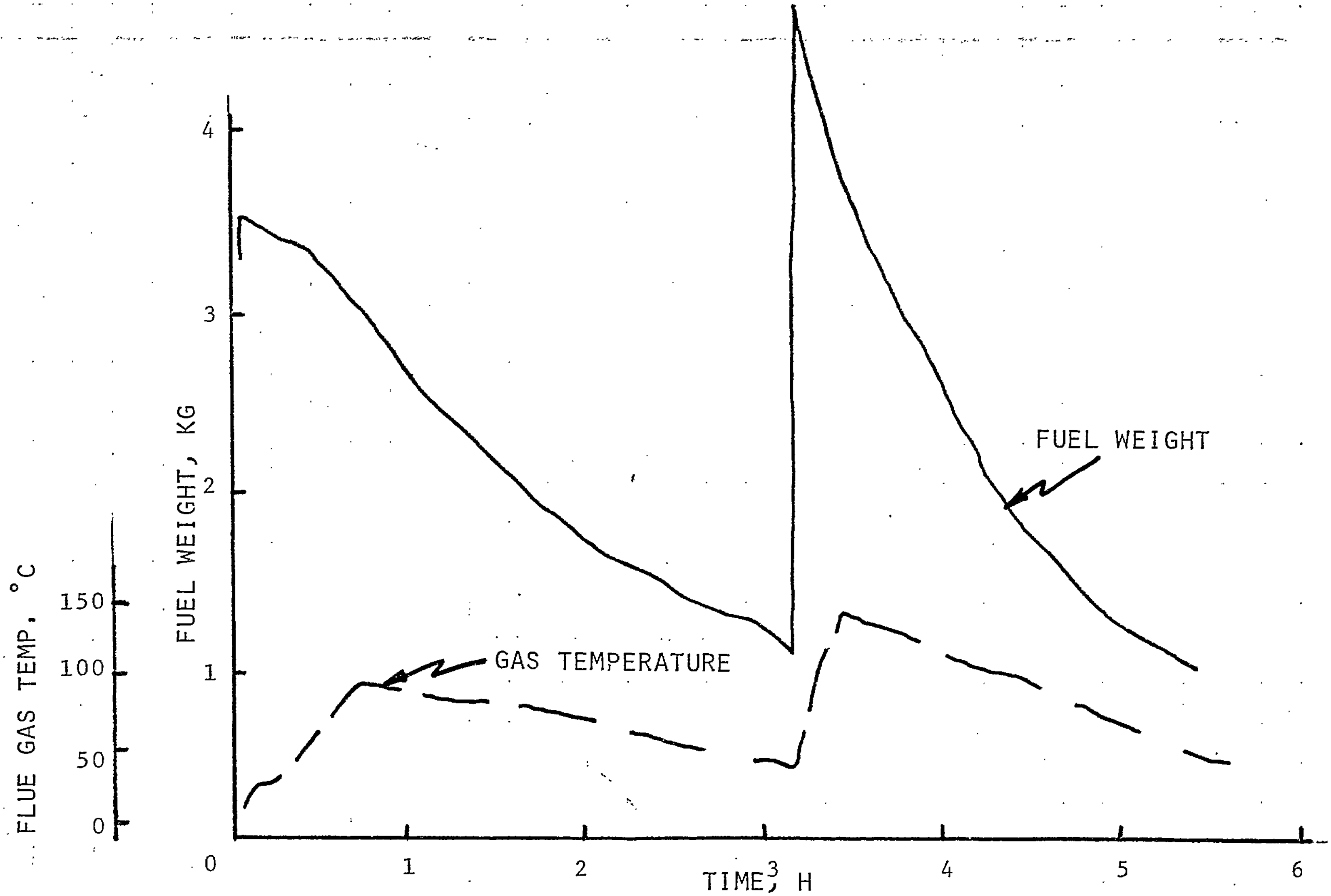

Fig. 4 - Test No. 3 with a synthetic firelog at 1.5 mm draft; doors closed

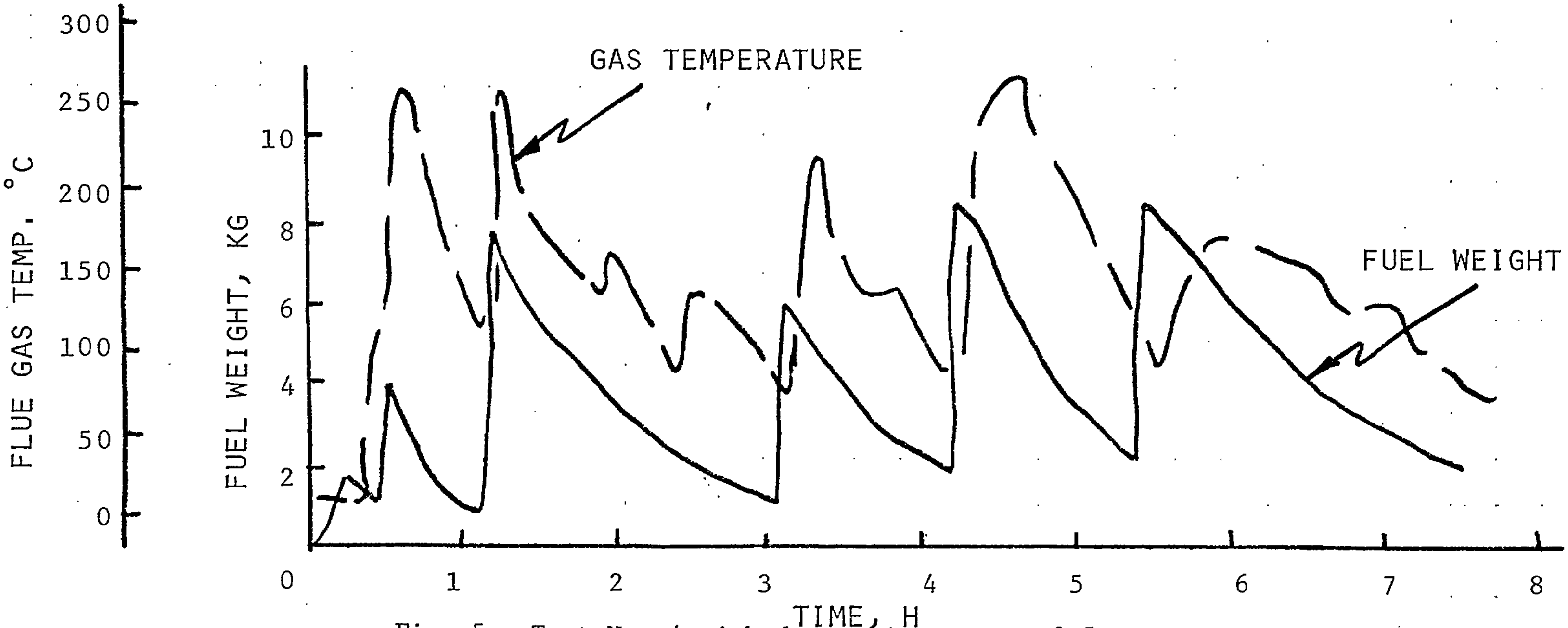

Fig. 5 - Test No. 4 with dry maple wood at 0.5 mm draft; doors open