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A N A L Y T I C A L R E P O R T

No. K 12 303

Re: Flue Gas Emissions in Wood Burning Stoves

Applicant: WIFI-Vienna, Dr. Heinisch

Address: Wahringer Gurtel 97, 1181 Wien

Date of Request: **11/11/85**

Request Received: **11/13/85** **Sign** of Request: **he/fb**

TGM Number: **68/86** Testing Materials **Rec'd:**

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Authorized by regulation **BMfBuT ZI. 41477/3-iv/1/75**
Investigation (and evaluation) of all macromolecular polymers (plastomere, duromere, elastomere) including technologies for production, use, analysis, structural enumeration, mechanical thermal, optical and chemical reactions, combinations, stability, changes, burn reactions, technological and reuse characteristics. Investigation of utility of synthetics in technology, agriculture, medicine, packaging, households and offices. Investigation (and evaluation) of raw and other materials used in manufacturing and use of synthetics. Problems of corrosion and its prevention including galvanization, lacquers and paints. Investigation of related issues of environmental hygiene and protection as well **as** possibilities of recycling of macromolecular polymers.

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1. The results of testing pertaining to this report is based entirely on the testing materials described.
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The applicant requested an investigation of gaseous emissions from burning wood, with emphasis on aromatic carbon hydroxides.

The investigators were provided with a basic tile stove and a stove insert. The testing took place at the site of the tile stove association at 1100 Vienna.

1. Description of Investiaation:

I.1 Methods of Investigation

The dimensions of the stove made it impossible to obtain samples of the entire flue emissions, therefore a partial sample was used.

This sample was taken from the approximate middle of the flue pipe - the exact location is made clear in the attached diagram.

The gas samples were passed through a cooling trap in order to extract the aromatic compounds in the benzene. Analysis of a blank sample showed that aromatic compounds were below the detection limit. Therefore, absorption of aromatics into the extraction fluid can, under the circumstances of the experiment, be assumed to be complete.

The prepared emission samples were then examined for aromatic content by a gas chromatograph.

The sample preparation described were necessary because of problems with condensation of higher aromatics as well as contamination and loss via soot and dust.

Similar procedures are described several times in scientific literature: this investigation therefore does not contain extensive detail of methods and their relative shortcomings but emphasizes the detection and analysis of particle loss and emissions.

1.2 Instruments and Chemicals;

Gas Chromatograph: Carlo Erba, Fractocap 4200

Detector: FID and ECD

Injector: Split/Splitless

Gas: Hydrogen (4.5 Messer Griesheim)

Nitrogen (5.5 Messer Griesheim)

Synthetic Air (kw-free Messer Griesheim)

Temperature Programmer

Integrator Shimadzu C1R

X.Y. Writer

GC Pillar Durabond DB5 30 m: ID 32 mm

Film thickness .25 jun

Pump (Production 2.6 m3/h at 1 bar)

Washing Bottle (Glass 20 ml)

Suction Probe (Glass)

Fill-Body for Washing Bottles

Measuring Cylinders

5 µl syringe for gc

10 µl syringe for gc

5 ml gas-tight syringe

Hose Connections

n-Heptane (gc pure Merck)

Benzene (gc pure Riedl de Haen)

Toluene (gc pure Merck)

Formaldehyde was found only in the stove insert and only during the first 2 minutes of burning, when the stove temp, was at 18°C.

Its concentration was 60 ppm 30 seconds after the start of the fire and decreased thereafter. The sum concentration of the carbon hydroxides can be seen in table 1.

In comparison, a cigarette (brand Jonny Filter) was sucked through the sample hose ("smoked") and its total emissions were absorbed by the cooling trap fluid. Results of the analysis were qualitatively similar to those obtained from the stove insert (numerous polycyclical aromatics detected). Quantitatively, the aromatics content is approximately one factor 10 higher than in the tests with the basic tile stove. See Table 9.

Conclusions

Based on the results obtained, the following statements can be made. The content of unburned carbonhydroxides in the tile stove tested with beach or birch wood is below 100 mg/Nm3. The percentage of polycyclical aromatic carbonhydroxidesin the flue gases under optimal burn conditions, with 20 µg/m³, can be considered particularly low.

The concentrations of CO and SO_2 are in the normal range for a mostly complete burn and otherwise in the .01 percentile range because of the lows-content of the wood.

The results obtained with the stove inserts were in part much higher than those of the masonry tile stove. Using beach wood (15 kg) and 10 Pa draft resulted in concentrations pf polycyclical aromatics 100 times higher (2000 ug) than those found in the masonry tile stove, with a total content of carbonhydroxides at 1400 mg/Nm3.

Results of a comparison test with a cigarette showed aromatics contents on the average to be 10 times higher than those of the basic tile stove.

Under the test conditions selected, chlorinated aromatic hydroxides were practically undetectable, assuming a detection limit of approx. 1 µg/m.

Xylene (for analysis Merck)

Standard for Polycyclical Aromatics

Standard for Formaldehyde

Measuring Instruments for

CO determination

CO_2 determination

SO_2 determination

Scale for Collecting Burned Material

Negative Pressure Manometer for Pressure Measurement

Thermal Probes for Determining Temperature of Fire Box, Flue and Room

Various Small Instruments, Chemicals and Filters for the GC and the **other Instruments**

1.3 Results:

During each test, the stove used would be filled with the wood and measurements would begin at the first appearance of flames. The sample was sucked through 10 ml benzes, and the benzes were changed after 15, 30 and 90 minutes. The samples thus obtained were cooled to room temperature and injected into the gc. During this time, measurements were taken for concentrations of CO, CO_2 , SO_2 , the temperature of the fire box, the room and the flue emissions, and the draft (negative pressure).

Gaschromatosranhv:

Injection: 2 µl sample + 2 µl methanol
1 min. splitless

Temperatures:

Injector: 60' C

Stove: 4 min. isotherm 55' C

to **310' C, 4 degrees/min.**
310' C 5 min. isotherm

Detector: 320' C

Gases:

Carrier Gas: Hydrogen 40 cm/sec

Detector: Hydrogen 1 kp/cm²
Nitrogen .5 kp/cm²
Air .7 kp/cm²
FID

The identification and determination of concentrations were done by standard. over retention time and - temperature as well as the length of the peaks.

The results can be seen in the attached tables and diagrams.

Detection limit (approx. 5 µg/m³)

1.4 Testina of Stove Insert

Some gas samples were taken directly from the cooling trap to detect losses.

The concentrations in these were below the detection limit.

Samples were examined for chlorine compounds under the same conditions described in 1.3.

No chlorine-containing carbonhydroxides could be detected (detector: ECD).

Some gas samples were measured for formaldehyde content and total concentration of carbon hydroxides.

Pillar: Poropac Q

2m / ID 4mm

Injection amount: 1 ml gas at 20°C

Stove temperature: 80°C

Detector: 200'C FID

Standard: Formaldehyde; n-hexane

Table 1

stove: Tile stove

Amounts burned: 20 kg beech wood

Draft pressure: 20 PA

77 mg/m³ total CO2

Burn time	Amount burned	Room temp	Fire box temp	Flue gas temp	Carbon monoxide content	CO content	CO_2 content	SO_2 content	
0	20	23	165	160				Acenaphthylene	110 µg/m³
5								Acenaphthene	24 µg/m³
10								Fluorene	51 µg/m³
								Rnthracene	180 µg/m³
								Pyrene	30 µg/m³
15	16	24	758	276	2,9	3,4	7,6	Single ring aromatics	120 µg/m³
20								Benzofluoranthene	9 µg/m³
25								Other POA	10 µg/m³
30	8,5	24	879	328	1,3	7,3	2,9	Single ring aromatics	40 µg/m³
45	8,5	23	800	355	0,05	1,6	1,7	Polycyclical aromatics	10 µg/m³
60	2,0	23	639	337	0,15	5,8	1,5	Single ring aromatics	15 µg/m³
75	1,0	23	634	311	0,3	3,3	1,5		
105	0	23	446	287	0,35	2,9	1,2		
120	0	22	389	270	0,35	2,9	1,2		

Table 2

Stove: Tile stove
Amount burned: 10 kg beech wood
Draft pressure: 20 Pa

Burn time	Amount burned	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content			
0	10	22	63	58				Fluorene	18,5	µg/m³
								Anthracene	57	µg/m³
5	9	22	505	135	0,6	10	0,05	Pyrene	4	µg/m³
10	7,5	22	655	184	0,45	15	0,05	Single ring aromatics	60	µg/m³
15	5,5	22	615	217	0,35	15	0,05			
20	4	21	550	217	0,3	11,5	0,05	Acenaphthylene	24	µg/m³
25	3	22	533	213	0,3	8,7	0,05	Single ring aromatics	20	µg/m³
30	2	22	505	214	0,2	7,7	0,05			
45	0,5	22	445	201	0,15	4,0	0,05	Polycyclical aromatics	10	µg/m³
60	0	22	340	179	0,35	2,5	0,05			
90	0	22	240	155	0,1	1,2	0	Single ring aromatics	10	µg/m³

Table 3

Stove: Tile stove

Amount burned: 20 kg beech wood

Draft pressure: 10 Pa

80 mg/m³ total CO2

0	20	22	80	51				Anthracene 212 µg/m³
								Pyrene 26 µg/m³
12	17,5	22	655	277	0,7	17,7	1,2	Chrysene 24 µg/m³
								Benzopyrene 58 µg/m³
								Benzofluoranthene 69 µg/m³
								Benzoperylene 16 µg/m³
								Dibenzathracene 28 µg/m³
								Single ring aromatics 150 µg/m³
20	11	22	781	249	1,9	8,7	5	Anthracene 104 µg/m³
								Pyrene 10 µg/m³
33	65	22	702	260	0,28	15	1,8	Chrysene 7 µg/m³
								Benzofluoranthene 34 µg/m³
								Single ring aromatics 75 µg/m³
53	3	22	601	26	7	0,1	7	2	Anthracene 17 µg/m³
67	2	23	575	5	8	0,2	6	2	
77	1,5	23	515	4	9	0,3	4,5	1,5	Single ring aromatics 20 µg/m³
97	0,5	23	453	22	8	0,3	3	1,5	
120	0,5	22	430	2	3	0,25	3,5	1,5	

Table 4

Stove: Tile stove

Amount burned: 10 kg beech wood

Draft pressure: 20 PA

Burn time	Amount burned	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content		
0	10	23	105	99				Polycyclical aromatics	20 µg/m³
5	8,5	23	508	184	0,08	12,5	),4	Single ring aromatics	30 µg/m³
10	7,5	23	588	198	0,1	15	),1		
15	6	23	670	210	0,08	14,5	),1		
20	4,5	23	683	220	0,05	14	),1	Polycyclical aromatics	10 µg/m³
25	3,5	23	630	220	0,05	12,5	),1	Single aromatics	10 µg/m³
30	2,5	23	605	221	0,9	11,3	),1		
45	1	23	530	219	0,2	6	),1	Polycyclical aromatics	10 µg/m³
60	0	23						Single ring aromatics	10 µg/m³
90									

Table 5

Stwe : Tile oven

Amount burned: 20 kg birch wood

Draft **pressure:** 20 Pa

Burn time	Amount burned	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content
0	18,5	18	100	60			
5	16	18	643	160	1,5	15	0,1
10	13,5	18	700	192	2,7	17,9	0,1
15	11,5	18	720	209	2,7	17,5	5,8
20	9	18	732	224	2,6	17	5
25	6	18	760	249	0,4	17	2
30	5	18	700	252	0,2	15,5	0
45	2,5	20	590	250	0,1	8,5	0
70	1	27	480	236	0,4	4,7	0
85	0,5	28	410	218	0,3	2,7	0

Single ring aromatics	**3,5**	**mg/m³**
Acenaphthylene	77	**µg/m³**
Acenaphthene	102	**µg/m³**
Fluorene	26	**µg/m³**
Anthracene	40	**µg/m³**
Benzopyrene	350	**µg/m³**
Benzofluoranthene	623	**µg/m³**
Dibenzoanthracene	70	**µg/m³**
Other POA	300	**µg/m³**
Single ring aromatics	5	**mg/m³**
Polycyclical aromatics	50	**µg/m³**

Table 6

Stove: Tile Stove

Amount **burned:** 10 kg birch wood

Draft pressure: 20 Pa

Burn time	Amount burned	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content
0	10	19	30	30			
5	9	19	569	107	0,1	10,8	0
10	7,5	19	512	113	0,1	11,5	
15	6,5	19	523	150	0,1	113.5	
20	4,0	19	515	160	0,85	9,3	
25	2,5	20	465	115	0,2	7,3	
50	1,5	20	400	114	0,3	4,5	0

Single ring aromatics	2,9 mg/m³
Acenaphthylene	800 µg/m³
Anthracene	24 µg/m³
other POA	250 µg/m³

Single ring aromatics	3.0 mg/m³
Polycyclical aromatics	25 µg/m³

Table 7

Stove: stove insert (Kaschutz)

Amount burned: 15 kg beech wood
1400 mg/m³ total CO^2

Burn time	Draft pressure	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content		
0	11	25	57	50				Single ring aromatics	4 mg/m³
								Acenaphthylene	241 µg/m³
5	15	20	520	220	38	13	7	Acenaphthene	73 µg/m³
								Fluorene	41 µg/m³
10	17	26	550	300	6	18	12	Anthracene	278 µg/m³
15	17	27	590	320	7	18	16	Benzoanthracene	090 µg/m³
								Benzofluoranthene	210 µg/m³
20	17	28	772	363	6,2	18	14	Other POA	600 µg/m³
25	20	30	760	377	5,6	12,7	12,5		
30	20	32'	660	410	4.7	17	9	Single ring aromatics	1,5 mg/m³
								Acenaphthylene	255 µg/m³
								Acenaphthene	168 µg/m³
								Fluorene	16 µg/m³
								Anthracene	194 µg/m³
								Fluoranthene	188 µg/m³
								Benzofluoranthene	433 µg/m³
								Other POA	300 µg/m³

Table 8

Stove: stove insert (brand **Kaschutz**)

Amount burned: 10 kg beech wood

1300 **mg** total CO_2

Burn time	Draft pressure	Room temp	Fire box temp	Flue gas temp	CO content	CO_2 content	SO_2 content
0	5	22	293	28,7			
5	5	22	145	85	0,5	3	0
10	10	22	645	343	2,2	14,4	4,0
15	12	24	785	416	3,25	18,6	5,8
20	12	25	770	437	3,2	19	4,5
25	12	27	705	483	3,25	19	3
30	12	25	679	415	3,2	15,2	1,0

Single ring aromatics	6 mg/m³
Acenaphthylene	100 µg/m³
Acenaphthene	132 µg/m³
Fluorene	31 µg/m³
Anthracene	7 µg/m³
Fluoranthene	7.5 µg/m³
Pyrene	13 µg/m³
Chrysene	403 µg/m³
Other POA	400 µg/m³

Single ring aromatics	4 mg/m³
Acenaphthene	150 µg/m³
Pyrene	7 µg/m³
Chrysene	15 µg/m³
Other	250 µg/m³

Table 9

Cigarette

Naphtaline	
Acenaphthene	
Anthracene	
Fluoranthene	
Benzoanthracene	
Benzoperylene	
Single ring aromatics	approx. 900 µg/m^3

Explanation of Table Terms

Amount burned: kg of wood

Draft pressure: Pa negative pressure

Total CH_2: carbon hydroxides in mg (CH_2 n/m^3)

Burn time: minutes

Boom temp: • C

Fire box temp and flue gas temp: •C

CO content: vol.-%

CO_2 content: vol.-%

SO2 content: 10-2 vol.-%

m^3: normal m^3 at 20 • C

This analytical report (exclusive of cover page)

contains 15 pages 9 tables no graphics no photos no additions.

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