



## EMISSION OF DIOXINS FROM DANISH WOOD-STOVES

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### Abstract

The main purpose of the investigation was to estimate the annual dioxin emission from Danish wood-stoves. 4 stoves of different designs and 3 types of fuel were tested in 2 operating conditions. Sampling was carried out in a dilution tunnel, making reproducible sampling possible. The dioxin emission was found to depend significantly on the type of stove, the type of fuel and the operating conditions. The average emission was 0.18 ng TEQ/Nm<sup>3</sup> (Nordic) in fluegas, or 1.9 ng TEQ/kg fuel. The annual emission in Denmark was estimated to 0.40 g TEQ/year, roughly 100 times lower than the emission from incinerators previously reported.

### Introduction

These studies, initiated and funded by the Danish government, represent the final investigations in the Danish Incinerator Dioxin Program. In a preliminary study of different wood-stoves and fuels<sup>1</sup>, very high emission of dioxins were found, implying that the annual emission in Denmark of dioxins from this source would be of the same order of magnitude as the emission from incinerators. A follow-up study was subsequently carried out, involving new experiments at another test site at the Danish Technological Institute (DTI), as well as method development and validation studies at the National Environmental Research Institute (NERI)<sup>2</sup>. However, the follow-up study failed to confirm the previously found high emissions. A possible theory for these high values could be carry-over which had occurred at the test site during experiments with extremely high dioxin emission. The present investigation is a complete re-evaluation making use of improved testing, sampling, and analytical methods.

### Objectives

The primary goal is to estimate the annual emission of dioxins from wood-stoves in Denmark. Secondary goals are to study the influence of stove design, type of fuel, and operating condition on the dioxin emission. The aim of this is to make a decision ground for reducing the dioxin emission from this source as far as possible, and to make a basis for instructions for users and manufacturers of wood-stoves.

## Experimental

The wood-stove experiments were performed at DTI at a special test facility. 4 types of stoves, 3 types of fuels (all pure wood), and 2 operating conditions were investigated.

In the experimental setup, shown in Fig. 1, the stove was connected to a chimney followed by a dilution tunnel system which diluted the total stream of fluegas about 1 to 10. The tunnel was developed by DTI for these experiments, since the preliminary study<sup>1</sup> had shown a poor correspondence between parallel samples taken in the chimney. The low linear velocity in the chimney, 0.1 to 0.3 m/sec, makes isokinetic conditions difficult to obtain, whereas the velocity in the tunnel is constant 3 m/sec. A data logging system registered CO<sub>2</sub>, CO, temperatures in chimney and tunnel, draught and flow. Hydrocarbons were measured by FID, chloride sampled in NaOH and analyzed by ion-chromatography.

To minimize carry-over in the system, no experiments with fuels known to be high emitters such as impregnated or painted wood were performed.

### Stoves

The stoves were designed for additional heating of single rooms, a widely used practice in Denmark. No. 1 and no. 2 were included in the previous studies<sup>1</sup> and are both widely used in Denmark, no. 3 was an improved version of no. 2. Stove no. 1 to no. 3 are commercial models, whereas stove no. 4 is an experimental prototype designed by DTI. The combustion chambers of all the stoves were lined with refractory bricks or plates 2 to 3 cm thick. The most important technical data for the stoves are summarized in Table 1.

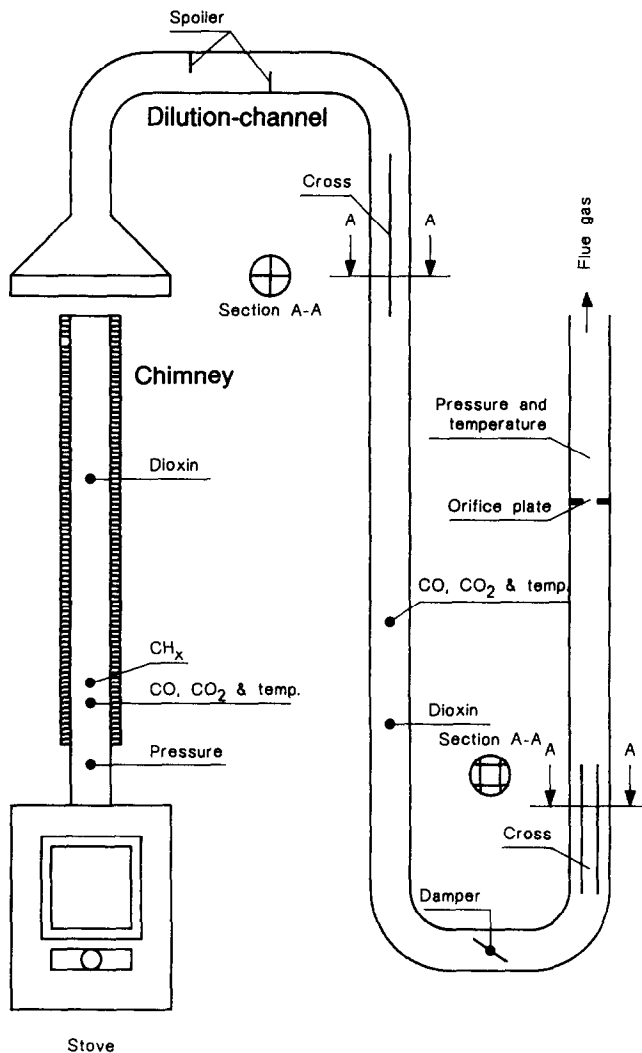


Fig. 1. Experimental setup with dilution tunnel.

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