Catalytic Filtration: Dioxin/Furan Destruction in the Baghouse

Experiences at the IVRO Municipal Waste Incinerator in Roeselare, Belgium

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ABSTRACT
This paper describes the current status of pollution control at the municipal waste incinerator of IVRO, Roeselare, Belgium, using a catalytic filter system for dioxin/furan destruction and particulate control. Several catalytic filters were first installed in the baghouse in October 1996, to investigate catalyst activity. Pilot scale tests were then conducted from March 1997 to July 1998, to evaluate the dioxin destruction efficiency of various catalysts. In October 1998, the full installation of the plant was completed.
This paper is divided into five parts. Part 1 focuses on the current dioxin/furan emissions to show that the catalytic filter system destroys dioxin/furans below the regulatory limit of 0.1 ng/Nm^3 I-TEQ at 11%O_2. In Part 2, catalyst durability is demonstrated. For three years a consistent destruction of dioxins and furans has been observed. Part 3 focuses on the quality of dioxin/furan concentration measurements. Several measurement companies have been evaluated showing measurement accuracy of ±15% within one company. In Part 4, the ability of the filter system to remove particles is demonstrated. In over 100 measurements, the clean gas dust concentrations were below 1 mg/Nm^3, and often below the detection limit of 0.2 mg/Nm^3. In Part 5, the total release of dioxins into the environment is evaluated. When comparing the catalytic filter system with an activated carbon injection system, the catalyst filter system not only decreased the gaseous dioxin/furan emissions by more than 99%, but also decreased the particulate phase dioxin/furan emissions by more than 93%.

BACKGROUND

Plant Information

The IVRO municipal waste incinerator is located in Roeselare, Belgium. As shown in Figure 1, the plant consists of a Stoker – Boiler – ESP – dry lime injection – fabric filter baghouse. The baghouse operating temperature varies between 200°C and 230°C.

Plant History:

The plant was built in 1976 and consisted of two lines, each having a stoker, an air cooler and an electrostatic precipitator (ESP). In 1985, IVRO installed a dry gas cleaning system and increased the capacity from 3.2 t/h to 4 t/h per line. Including further optimization steps, the total investment for the plant at that time was approximately 14 million euro.
In 1990, IVRO switched from dry lime to Spongiacal, an expanded lime, to reduce emissions of chlorines to approximately 10 mg/Nm^3. By installing GORE-TEX® membrane filter bags, the particulate emissions were reduced to less than 1 mg/Nm^3. In 1996, new dioxin regulations were

enacted, prompting IVRO to install a powdered actived carbon injection system (PAC), to reduce dioxin emissions below 0.1 ng/Nm^3 I-TEQ. The PAC system was used at high temperatures of 200–230°C. At these temperatures corrosion is kept to a minimum, and Spongiacal can be added with screw conveyers.. However, the disadvantage of using PAC at high temperatures is the danger of fires in the baghouse. Burning carbon-rich fly ash not only damages the filter bags, but also the dust evacuation equipment. To avoid a subsequent plant shutdown, IVRO began looking for alternative technologies for dioxin and particulate control. In 1998, IVRO invested an additional 4.5million euros to renovate the stokers and ESP, and install new de-ashing, and electrical control systems. The catalytic filter system was installed in the existing baghouse without any changes to the operation. Today the plant can be operated to be within compliance with all European environmental regulations.

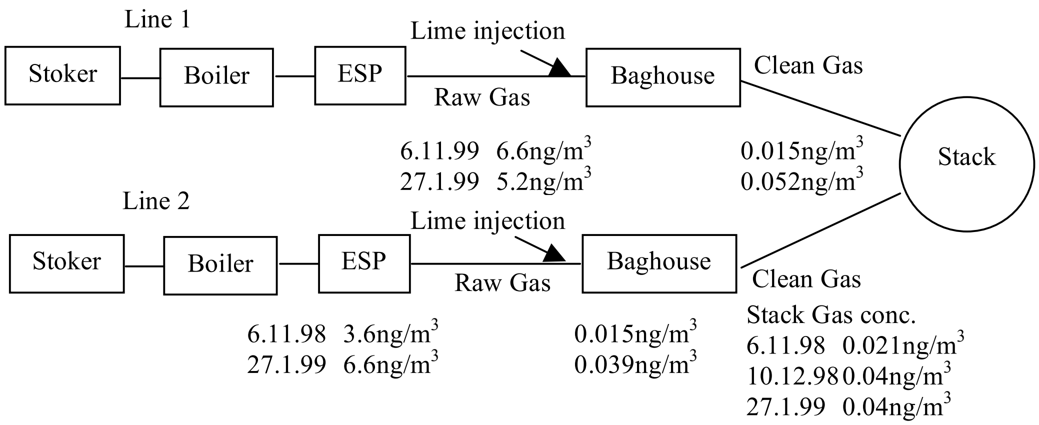

Figure 1. IVRO Plant schematic with current dioxin concentrations in raw gas (before the baghouse), clean gas (after baghouse) and stack using catalyst filters. All dioxin/furan emissions in ITEQ at 11% O_2.

Catalytic Filtration Product Information

The catalytic filter system is manufactured by W. L. Gore & Associates, Inc. (Gore). This new system consists of a GORE-TEX® membrane laminated to a catalytically active felt. The felt is composed of chemically active fibers containing a variety of specially produced catalysts. As gases pass through the felt, a catalytic reaction is induced and dioxins/furans are decomposed into harmless gaseous components. The new fiber provides the GORE-TEX membrane filter bag with multifunctional filtration capabilities. The GORE-TEX membrane provides particulate collection, while the catalytic substrate will destroy highly toxic gaseous pollutants. The temperature range in order for the catalytic reaction to occur varies from as low as 140°C to 260°C. A minimum temperature of 180°C is preferred.

EXPERIMENTAL PROCEDURE

Filter Installation Dates

Deactivation studies with catalytic materials in the main baghouse at IVRO and other combustion plants started in October 1995. The first complete catalyst filter system was installed in March 1997, into a 1000m^3/h pilot baghouse. Full compartments of catalyst filters were installed in the main baghouse at IVRO in August 1997. After showing continued catalyst activity, the whole plant was equipped with catalytic filters in October 1998. Today, IVRO has a total of more than 3 years experience with catalytic filters in real gas conditions. In the process, more than seven catalysts were tested for dioxin/furan destruction, reaction by-product generation, and continued catalyst activity.

Dioxin Measurement Procedure

All stack measurements at IVRO were conducted according to the Euro Norm EN 1648. All other measurements of raw gas (before the baghouse) and clean gas (after the baghouse) were conducted according to the same method, but with sampling times of three hours (see Figure 1).

RESULTS

Part 1 - Current Dioxin/Furan Emissions at IVRO

All measurements at the baghouse inlet and outlet for lines 1 and 2, as well as the stack measurements, were conducted simultaneously. All tests were conducted without the injection of carbon. The measurement results are presented in Figure 1.

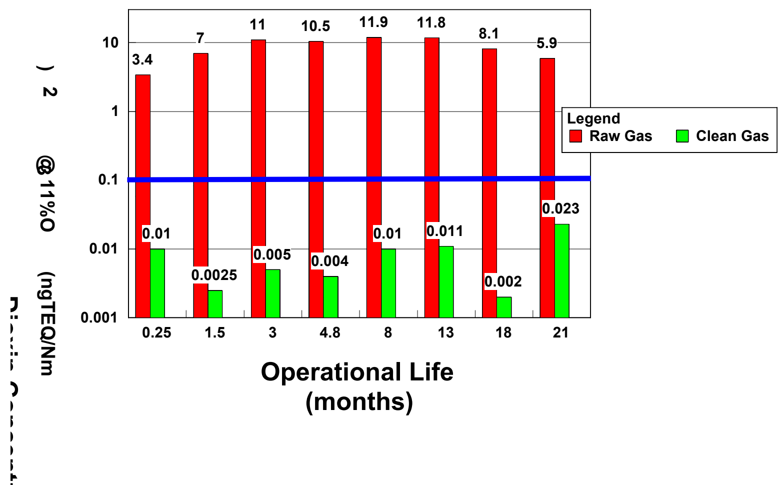

Figure 2. Total dioxin concentration of the raw and clean gas, using the catalytic filter system to demonstrate continued catalyst performance during incinerator operation at temperatures of 200°C to 230°C (one compartment).

Part 2 - Catalyst Life

Over a three year period, laboratory activity tests were conducted on several commercial and non-commercial catalysts after they were exposed to the actual flue gas conditions. After an extensive evaluation, only a select few catalysts maintained their original activity. In August 1997, these select few were then installed into several baghouse compartments of the IVRO municipal waste combustor, and their dioxin destruction performance was monitored over the last two years. The raw and clean gas dioxin concentrations of one specific compartment are shown in Figure 2.

Part 3 - Quality of the Measured Dioxin/Furan Emissions
More than 100 dioxin/furan measurements were conducted at IVRO. An extensive measurement accuracy program concluded that the measurement company (MPU, Germany) was able to accurately measure dioxin /furan emissions within ±15%. This accuracy was achieved at dioxin concentrations as low as 0.01ng/m^3I-TEQ. Details will be provided at the conference presentation.

Part 4 - Particulate Control
More than 100 dust concentration measurements were completed at the IVRO incinerator. The clean gas dust concentration did not exceed the 1 mg/Nm^3 level. In most cases, for sampling times of 3 hours, the dust level was at or below the dust detection level of 0.2 mg/Nm^3 at 11%O_2.
To evaluate the total release of dioxins into the environment, a comparison was made between the PAC and catalyst filter system. To do this, gas and solid phase PCDD/F emissions were tested.

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Part 5 – Total Release of Dioxins into the Environment
In January 1998, the gaseous dioxin emissions were 0.07 ng/m^3 with the PAC system. In January 1999, the gaseous PCDD/F emissions were 0.04 ng/m^3 (see Figure 1) utilizing the catalyst filter system, without the injection of carbon. To determine the amount of dioxins released into the environment before and after installation of the catalytic filter system, the gas and particulate phase dioxin emissions need to be evaluated:
In January 1998, the total amount of particulate entering the baghouse was 2.5 g/Nm^3 (0.1 g/Nm^3 fly ash + 0.15 g/Nm^3 PAC + 2.25 g/Nm^3 Spongiacal) during PAC injection, and in January 1999, 2.1 g/Nm^3 (0.25 g/Nm^3 fly ash + 1.85 g/Nm^3 Spongiacal) after installation of the catalyst filter. The particulate phase PCDD/F emissions from the stack are not included in this calculation because they are considered negligible due to the very low particulate emissions (see Part 4 above).
Table 1 shows the measured dioxin concentrations of the dust released. In January 1998, powdered activated carbon and lime were injected into the baghouse.

Measurement Number	Date	PCDD/F in Hopper Dust Using PAC [ng I-TEQ/kg dust]	Date	PCDD/F in Hopper Dust Using Catalyst Filter [ng I-TEQ/kg dust]
1	January 1, '98	7490		
2	January 15, '98	2240	January 28, '99	319
3	January 15, '98	1247	January 28, '99	248
Total Average		3659		283

Table 1. Comparison of dioxin concentrations in the baghouse hopper dust.

The total dioxin/furan emissions reduction with the catalytic filters system can be calculated as follows:

Total PCDD/F emission = (PCDD/F amount of gas phase stack emissions)
+ (PCDD/F amount of particulate phase emissions from baghouse)

PCDD/F amount of particulate phase emissions from baghouse = (amount of filter dust from hopper) * (PCDD/F concentration in hopper dust)

Therefore, the total PCDD/F emissions using:

membrane filter + PAC (Jan. 98):	0.07 ng/Nm^3 + 2.5 g/Nm^3 * 3659 ng/kg	= 9.22 ng/Nm^3 I-TEQ
catalytic filter system (Jan. 99):	0.04 ng/Nm^3 + 2.1 g/Nm3 * 283 ng/kg	= 0.63 ng/Nm^3 I-TEQ

The total reduction of dioxin/furan emissions into the environment exceeds 93%. At a total flow rate of 60000 Nm^3/h (both lines), the total amount of dioxin/furans destroyed each year is equal to about 4 g I-TEQ.

When comparing the total release of PCDD/F from the baghouse into the environment per ton of municipal waste burned:

	using PAC:	69 μg/ton of municipal waste
	using the catalytic filter system:	4.7 μg/ton of municipal waste

DISCUSSION

It was demonstrated that the catalytic filter system can destroy dioxins and furans to levels significantly below the regulatory limits. The expected life of the filter is in excess of five years according to long duration tests. Laboratory examinations of the catalysts have shown no statistically significant decrease in catalyst activity. This data confirms the findings of many catalyst companies, which indicates that catalytic honeycomb systems exceed three-year lifetimes, if not exposed to incinerator dust.

High particulate removal with the GORE-TEX membrane was also demonstrated. In all cases a clean gas dust concentration of below 1 mg/Nm^3 at 11% O_2 can be achieved.

The total destruction of PCDD/F into the environment was reduced by more than 8 ng I-TEQ /Nm^3 flue gas. When comparing the raw gas and filter material PCDD/F concentrations during PAC and catalytic filter use, it is found that the PCDD/F's were destroyed and not simply adsorbed onto the filter material. The demonstrated overall lower dioxin release into the environment is, therefore, mostly due to the absence of carbon in the flue gas.

CONCLUSION

The emissions of PCDD/F from the IVRO municipal waste incinerator in Roeselare, Belgium are significantly below 0.1 ng/m^3 (ITEQ at 11% O_2) using the catalytic filter system. Filters that were installed three years ago remain active and still reduce emissions below 0.1 ng/m^3 (ITEQ at 11% O_2). Several reliability measurements have been conducted, all indicating that the chosen measurement company is capable of reliably measuring dioxin/furan emissions (±15%) for concentrations as low as 0.01 ng/m^3 (ITEQ at 11% O_2). Lastly, in over 100 measurements the clean gas dust concentrations were below 1 mg/Nm^3 (at 11% O_2), often below the detection limit of 0.2 mg/Nm^3 (at 11% O_2).

The total amount of dust removed from the baghouse hoppers has decreased since the PAC injection system was turned off. In addition, the contamination of the fly ash with dioxins and furans decreased because the dioxins and furans are destroyed by the catalytic filter system. In order to verify the performance of the catalytic filter system, three stack tests and an additional 100 PCDD/F measurements within the system have been conducted.

Most importantly, the total PCDD/F emissions of the plant including gaseous stack emissions and hopper dust emissions were reduced by more than 93% from levels associated with using PAC. This reduction is due to a minimization of the amount of additives (PAC) and subsequent reduction of baghouse dust toxicity.

Acknowledgement
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