

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 air pollution control at the municipal waste incinerator of IVRO, Roeselare, Belgium, using the REMEDIA™ D/F 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(I TEQ)/Nm³ at 11% O₂. 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 REMEDIA D/F filters to remove particles is demonstrated. In over 100 measurements, the clean gas dust concentrations were below 1 mg/Nm³, and often below the detection limit of 0.2 mg/Nm³. 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/Nm³. By installing GORE-TEX® membrane filter bags, the particulate emissions were reduced to less than 1 mg/Nm³. In 1996, new dioxin regulations were enacted, prompting IVRO to install a powdered activated carbon injection system (PAC), to reduce dioxin emissions below 0.1 ng(I TEQ)/Nm³. 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. The 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 4.5 million 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.

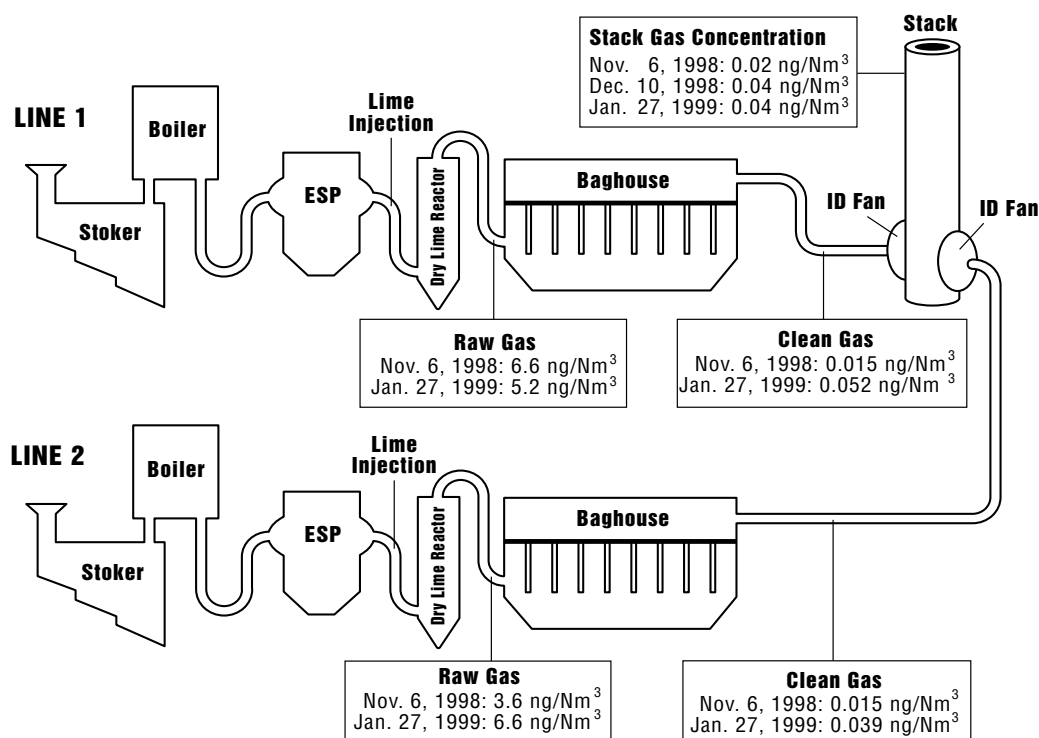


Figure 1 IVRO plant schematic diagram with current dioxin concentrations in the raw gas (before the baghouse), clean gas (after baghouse) and stack using the REMEDIA D/F catalytic filter system. All dioxin/furan emissions in (ITEQ) at 11% O₂.

Catalytic Filtration Product Information

REMEDIA D/F catalytic filter system is manufactured by W. L. Gore & Associates. 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 required for catalytic reaction is 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 REMEDIA D/F catalytic filter system was installed in March 1997 into a 1000 m³/h pilot baghouse. Full compartments of REMEDIA D/F filters

were installed in the main baghouse at IVRO in July 1997. After showing continued catalyst activity, the whole plant was equipped with REMEDIA D/F filters in October 1998. Today, IVRO has a total of more than 3 years experience with REMEDIA D/F 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 activated carbon. The measurement results are presented in Figure 1.

Full Scale Municipal Waste Incinerator Results over 35 Months

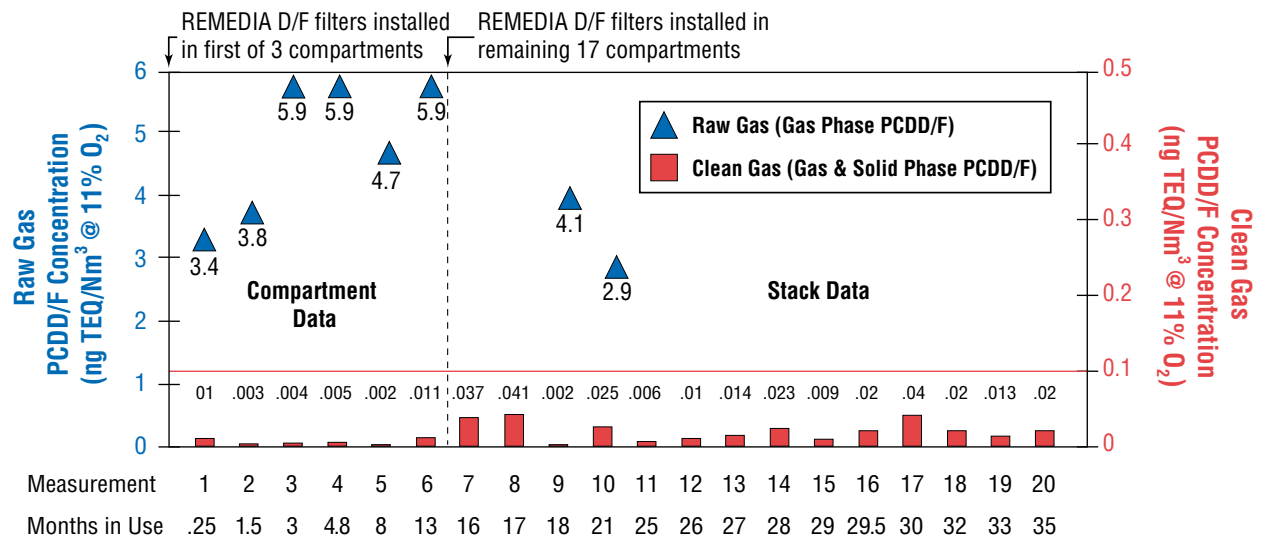


Figure 2 Dioxin concentration of the raw and clean gas, using REMEDIA D/F catalytic filter system to demonstrate continued dioxin destruction performance during incinerator operation at temperatures of 200°C to 230°C. All measurements were conducted according to the Euro Norm EN 1648. After destruction efficiency was quantified, raw gas readings were discontinued. "Compartment Data" represent 3-hour measurements directly before the baghouse (raw gas) and after the baghouse compartment (clean gas). "Stack Data" represent measurements in the stack (clean gas).

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 July 1997, these select few were then installed into several baghouse compartments of the IVRO municipal waste combustor, and their dioxin destruction performance was monitored. Then, in October 1998, REMEDIA D/F filters were installed in all baghouse compartments. The raw and clean gas dioxin concentrations of one specific compartment and the entire plant 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 0.01 ng(ITEQ)/Nm³.

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/Nm³ 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/Nm³ at 11% O₂. To evaluate the total release of dioxins into the environment, a comparison was made between the PAC and the REMEDIA D/F catalytic filter system. To do this, gas and solid phase PCDD/F emissions were tested.

Part 5 – Total Release of Dioxins into the Environment

In January 1998, the gaseous dioxin emissions were 0.07 ng/Nm³ with the PAC system. In January 1999, the gaseous PCDD/F emissions were 0.04 ng/Nm³ (see Figure 1) utilizing the REMEDIA D/F catalytic filter system, without the injection of carbon. To determine the amount of dioxins released into the environment before and after installation of the REMEDIA D/F filters, the gas and particulate phase dioxin emissions needed to be evaluated.

Measurement Number	Date	PCDD/F in Hopper Dust Using PAC [ng ITEQ/kg dust]	Date	PCDD/F in Hopper Dust Using REMEDIA D/F Filters [ng(ITEQ)/kg dust]
1	January 1, 1998	7490		
2	January 15, 1998	2240	January 28, 1999	319
3	January 15, 1998	1247	January 28, 1999	248
Total Average		3659		283

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

In January 1998, the total amount of particulate entering the baghouse was 2.5 g/Nm³ (0.1 g/Nm³ fly ash + 0.15 g/Nm³ PAC + 2.25 g/Nm³ Spongiacal) during PAC injection. In January 1999, 2.1 g/Nm³ (0.25 g/Nm³ fly ash + 1.85 g/Nm³ Spongiacal) of particulate entered the baghouse after installation of the REMEDIA D/F filters. 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.

The total dioxin/furan emissions reduction with the REMEDIA D/F catalytic filter system can be calculated as follows:

$$\begin{array}{r}
 \text{Particulate phase PCDD/F emissions from baghouse} \\
 + \\
 \text{Gas phase PCDD/F emissions from stack} \\
 \hline
 \text{Total PCDD/F emissions}
 \end{array}$$

$$\begin{array}{r}
 \text{Amount of filter dust from baghouse hopper} \\
 \times \\
 \text{PCDD/F concentration in hopper dust} \\
 \hline
 \text{Particulate phase PCDD/F emissions from baghouse}
 \end{array}$$

Therefore, the total PCDD/F emissions using:
GORE-TEX membrane filter and PAC (Jan.'98):

$$\begin{array}{r}
 0.07 \text{ ng/Nm}^3 + 2.5 \text{ g/Nm}^3 \\
 \times \\
 3659 \text{ ng/kg} \\
 \hline
 9.22 \text{ ng(ITEQ)/Nm}^3
 \end{array}$$

REMEDIA D/F catalytic filter system (Jan.'99):

$$\begin{array}{r}
 0.04 \text{ ng/Nm}^3 + 2.1 \text{ g/Nm}^3 \\
 \times \\
 283 \text{ ng/kg} \\
 \hline
 0.63 \text{ ng(ITEQ)/Nm}^3
 \end{array}$$

The total reduction of dioxin/furan emissions into the environment using the REMEDIA D/F catalytic filter system exceeds 93% when compared to PAC injection. At a total flow rate of 60,000 Nm³/h (both lines), the total amount of dioxin/furans destroyed each year is equal to about 4 g (ITEQ).

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

Using powder activated carbon: 69 µg/ton of municipal waste

Using the catalytic filter system: 4.7 µg/ton of municipal waste

Discussion

It was demonstrated that the REMEDIA D/F 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 indicate 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/Nm³ at 11% O₂ was achieved.

The total amount of PCDD/F released into the environment was reduced by more than 8 ng(ITEQ)/Nm³ 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/Fs 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 baghouse solid residue.

Conclusion

The emissions of PCDD/F from the IVRO municipal waste incinerator in Roeselare, Belgium, are significantly below 0.1 ng(ITEQ)/Nm³ at 11% O₂ using the REMEDIA D/F catalytic filter system. REMEDIA D/F catalytic filters that were installed three years ago remain active, and still reduce emissions below 0.1 ng(ITEQ)/Nm³ at 11% O₂. Several reliability measurements have been conducted, all indicating that the chosen measurement company is capable of reliably measuring dioxin/furan emissions (within 15%) for concentrations as low as 0.01 ng(ITEQ)/Nm³ at 11% O₂. Lastly, in over 100 measurements, the clean gas dust concentrations were below 1 mg/Nm³ (at 11% O₂), often below the detection limit of 0.2 mg/Nm³ (at 11% O₂).

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 REMEDIA D/F catalytic filter system. In order to verify the performance of the REMEDIA D/F catalytic filter system, 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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