Catalytic Dioxin/Furan Removal from Flue Gas Streams

Remedia™
CATALYTIC FILTER SYSTEM

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Abstract

In the first part of this paper, the need for particulate control in dioxin/furan emission reduction is discussed. Particulate and gas phase dioxin/furan measurements from operating plants are presented. In the second part, current dioxin/furan emissions of plants using the REMEDIA™ D/F catalytic filter system are shown.

The present investigation has shown it is not enough to reduce gas phase dioxins/furans, but that in most cases, the particulate outlet emissions cannot exceed 5 mg_{dust}/Nm^3, and in many cases, not even 1 mg_{dust}/Nm^3.

In addition, seven plants that have been operating with the REMEDIA D/F catalytic filter system had dioxin emissions below the 0.1 ng TEQ/Nm^3 regulatory limit consistently for up to three years.

Introduction

During combustion processes, PCDD/F are generated and can usually be found in the gas phase or adsorbed on aerosols and solids in the gas stream. Depending on the process, the input, and the operating conditions, the emissions and the isomer distribution can vary significantly, as well as the partitioning between gas and particulate phases[1].

A great amount of emphasis has been placed on the chemistry of dioxin formation[2,3]. The most prevalent control technology to date has been activated carbon injection[4]. However, dioxin-filled carbon may need to be treated so that once landfilled, dioxins are prevented from leaching into the environment[5,6].

There is literature available on current methods such as activated carbon injection and SCR systems[7]. Primary combustion optimization still plays an important role in reducing dioxins to a level where post-combustion methods can meet the stringent requirement of 0.1 ng TEQ/Nm^3. However, these methods (e.g., adsorption methods such as carbon injection and fixed bed processes, as well as catalytic honeycomb and fixed bed reactors) all require high to ultrahigh particulate removal to assure low outlet dioxin emissions[1]. A novel approach that combines ultrahigh particulate removal with catalytic destruction of dioxins is discussed. This approach can lead to significant reductions in the release of dioxins to the environment[5].

Catalytic Destruction/Filtration

In October 1999, after five years of testing, W. L. Gore & Associates, Inc. (Gore) introduced the REMEDIA D/F catalytic filter system. REMEDIA D/F catalytic filters consist of a GORE-TEX® membrane that is laminated to a catalytically active felt. Particles are captured on the membrane and dioxin/furans are catalytically destroyed within the felt. This filter is multifunctional. First, it is possible to remove virtually all dust components from the exhaust gas stream. Second, the catalyst enables dioxins and furans to be converted into environmentally acceptable substances. The REMEDIA D/F catalytic filter system has been in use in industrial applications since 1996 and enables dioxins and furans to be destroyed by more than 99%[5]. Figure 1 presents a schematic of the catalytic filter.

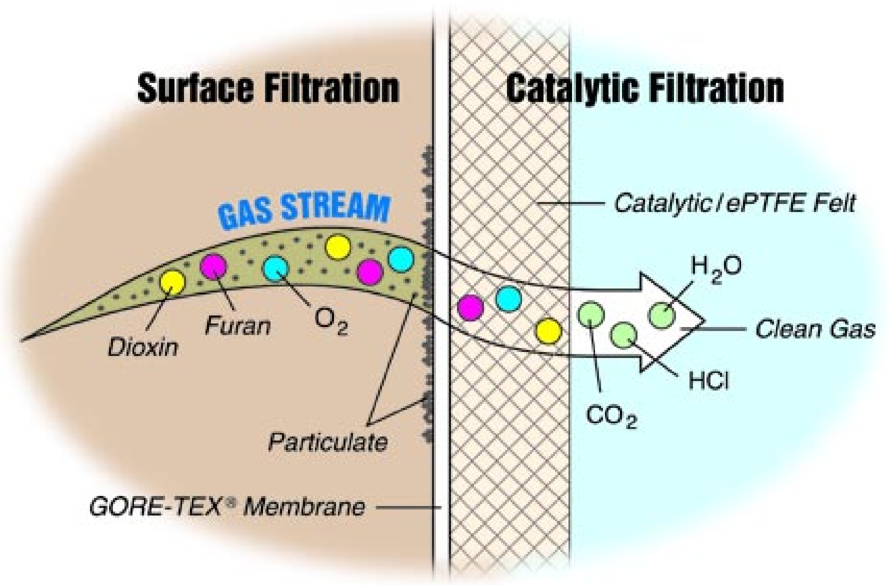

Figure 1. Schematic Diagram of the REMEDIA D/F Catalytic Filter System.

The catalyst fiber, which makes up the support felt, promotes the oxidation of dioxins and furans to form CO_2, H_2O, and HCl, while the gas passes through the felt. Since the concentration of dioxins and furans is typically nanogram level, the amount of HCl formed is insignificant for the total emission. On passing through the felt, the gas (unlike in a honeycomb reactor) is continuously deflected through catalytic fibers, thereby improving the diffusion of dioxins and furans from the gas phase to the surface of the catalyst. In typical industrial facilities, the system is currently operated at temperatures of 180°C to 250°C. The filter velocity is approximately 1 m^3/m^2/min, which is the usual range for cloth filters so that on passing through the filter, there is sufficient residence time for the reactions.

Materials and Methods

Since the end of 1994, analyses were carried out on more than 200 PCDD/F measurements at various plants using the catalytic filter system. Measurements were taken in four types of industries: namely, incinerators (140 measurements), crematoria (20 measurements), metals plants (30 measurements), and cement plants (15 measurements). The purpose of these measurements was to fundamentally understand the PCDD/F removal process and to understand whether these plants met the current environmental regulations.

In measurements described in this paper, the dioxin concentrations in the gas and particulate phases were investigated by separately analyzing the particle filters and the condensate/XAD fraction of the measurement. All raw gas and stack measurements were conducted according to the Euro Norm EN 1648, with sampling times of at least three hours. A few datapoints were added in which the baghouse hopper dust was analyzed.

Results and Discussion

In total, dioxin levels in the gas and solid phase were collected from 14 plants overall (3 crematorium, 7 incinerator, and 4 metals plants). These plants are located in Europe, Japan, and the USA. Baghouse temperatures varied between 180°C to 240°C. Figure 2 presents the maximum allowable clean gas dust emissions from these 14 plants.

Allowable Clean Gas Particulate Emission

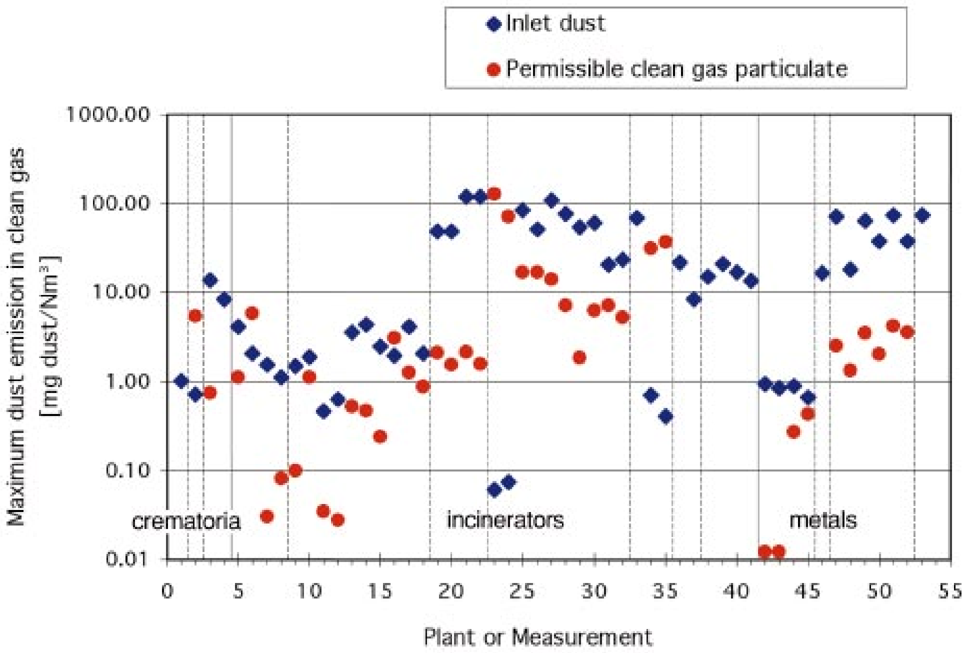

Figure 2. This graph illustrates the maximum dust emissions that a plant can safely emit while meeting the required emission of 0.1 ng TEQ/Nm^3. Solid vertical lines separate market segments (crematorium, incinerator, and metals plants), while dashed vertical lines separate each segment into individual plants.

Figure 2 has been obtained by extrapolating the permissible clean gas dust emissions of a plant that has to follow the regulation of 0.1 ng TEQ/Nm^3. Datapoints were obtained from the measured particulate and gas phase dioxin concentrations in raw and clean gas in every plant. The calculation shows the relatively high degree of dust control that is required from a plant to meet the guidelines. If the regulation of 0.1 ng TEQ/Nm^3 is to be achieved, in 8 of 14 (or 60%) of all measured plants, the clean gas dust emission must be at or below 1 mg_{dust}/m^3. In 10 of 14 (or 70%) of all plants, the permissible dust level must be below 2 mg_{dust}/m^3 and in 11 of 14 (or 80%) a limit of 10 mg_{dust}/m^3 is required.

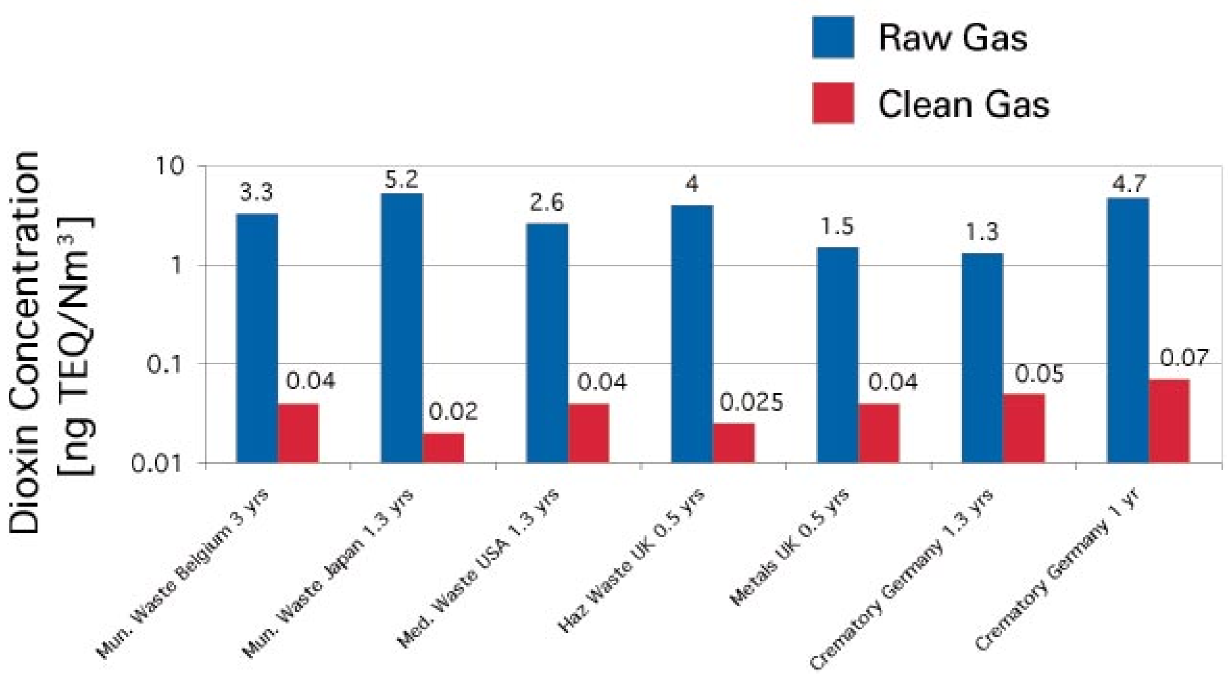

Figure 3. This graph shows the current dioxin levels of seven plants in raw and clean gas.

Figure 3 shows the current dioxin emissions of seven plants that have been using the REMEDIA D/F catalytic filter system. During up to three years of operation, dioxin levels never exceeded 0.1 ng TEQ/Nm^3. Laboratory studies have demonstrated that the dioxins are indeed destroyed, and not just adsorbed on the dust cake or the catalyst.

Conclusions

This paper demonstrates the need for high efficiency dust particle filtration in industrial processes where a dioxin outlet emission of 0.1 ng TEQ/Nm^3 or less is required. In almost 60% of the examined plants, dust emissions in the clean gas cannot exceed 1mg/Nm^3.

Seven plants that have been operating with the REMEDIA D/F catalytic filter system for up to three years in municipal, medical, and hazardous waste incinerators as well as in metals plants and crematories have had dioxin emissions of below 0.1 ng TEQ/Nm^3.

Acknowledgments

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