

Influence of start-up on PCDD/F emission of incinerators

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Received 26 May 2006; received in revised form 10 October 2006; accepted 19 October 2006

Available online 8 January 2007

Abstract

This study aims to evaluate the influence of start-up on polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs) concentration in the stack flue gas of incinerators and its contributing PCDD/F emission. The PCDD/F emission of the first sample among three consecutive stack flue gas samples of five intermittent incinerators, which sampled at a stable combustion condition after start-up, is 2–3 times higher than the mean of the others. For verifying the PCDD/F characteristics of incinerators during start-up, one continuous MSWI was investigated for two years. The elevated PCDD/F emissions of the MSWI during start-up could reach 96.9 ng I-TEQ N m⁻³ and still maintained a high PCDD/F emission (40 times higher than the Taiwan emission limit) even 18 h after the injection of activated carbon, indicating the memory effect. Taking the MSWI for example, which consists of four incinerators, the estimated annual PCDD/F emission from normal operational conditions was 0.112 g I-TEQ. However, one start-up procedure can generate ~60% of the PCDD/F emissions for one whole year of normal operations. And the PCDD/F emission, which is the result of the start-ups of four incinerators, was at least two times larger than that of a whole year's normal operations, without consideration for the PCDD/F emission contributed by the long lasting memory effect.

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Keywords: PCDD/Fs; Start-up; Incinerator; Memory effect

1. Introduction

After polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were discovered in the flue gases and fly ash of municipal solid waste incinerators (MSWIs) in 1977 (Olie et al., 1977), PCDD/Fs have become a serious issue in many countries because of their toxicological effects and associated adverse health implications.

Most research investigated the PCDD/F characteristics and the induced hazardous effect of incinerators during

normal operations. Till recently, several studies (Gass et al., 2002; Löthgren and van Bavel, 2005; Neuer-Etscheidt et al., 2006) have focused on the high PCDD/F emission during the start-up of incinerators. The start-up of continuous MSWIs is usually a cold start-up, which occurs after a plant revision and consists of the following procedures: (1) Oil burning with a maximum fuel feed rate until the suitable temperature for incineration (850 °C) is reached. (2) Start of waste feeding and increasing feed rate until design load is reached (Gass et al., 2002). However, for intermittent incinerators, the start-up procedure is a warm start-up, which can be characterized by the furnace's remaining temperature when it is started up again the next day.

Löthgren and van Bavel (2005) measured the PCDD/F levels after a polishing wet scrubber continuously for

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18 months using long-time sampling equipment at a hazardous waste incineration facility in Sweden. Each sampling period lasted two weeks. Two dramatic risings of TEQ levels were observed, both in the period just after a maintenance stop of the plant, from 0.02 to 0.25 ng TEQ m⁻³ and from 0.03 to 0.15 ng TEQ m⁻³. Gass et al. (2002) reported raw flue gas PCDD/F concentrations during the start-up of a MSWI of up to 250 ng I-TEQ m⁻³ in the heat-up phase. In contrast, Neuer-Etscheidt et al. (2006) reported that PCDD/F I-TEQ crude gas concentrations during the heat-up period were a little lower than those during normal operations with waste as the fuel. One reason for this difference may be the state of cleaning of the boiler section. Immediately after waste was fed, PCDD/F concentrations (46 ng I-TEQ m⁻³) in the crude gas increased by one order of magnitude compared to normal operating conditions (3–4 ng I-TEQ m⁻³). Even for a ship's main engine, the highest PCDD/F emissions have been measured for the start-up samples (0.1–0.4 ng WHO-TEQ kW h⁻¹ vs 0.03–0.1 ng WHO-TEQ kW h⁻¹ during normal operations), which are characterized by relatively poor combustion conditions (also high CO emissions) (Cooper, 2005). However, still little research estimated the generated PCDD/Fs during start-up to what extent. Consequently, it is not yet possible to evaluate the exposures and potential health risks during these conditions (Mckone and Hammond, 2000).

In this study, five intermittently operating incinerators, including one industrial waste incinerator (IWI), one waste liquid incinerator (WLI) and three medical waste incinerators (MWIs) were measured for PCDD/Fs in the stack flue gases when combustion condition reached stabilization after start-up to evaluate the influence of memory effect caused by start-up on PCDD/F emission. For verifying the PCDD/F characteristics of incinerators during start-up, one large scale continuously operating MSWI was chosen to be investigated for two years. In the first year, a total of five start-up stack flue gas samples were collected. For more detailed characterization, the next year, a total of 10 stack flue gas samples were sampled and the sampling time was changed so it's more accordant with the start of waste feeding. Only the 2,3,7,8-PCDD/F congeners in the stack flue gases of the incinerator were measured because

of their toxicities. The obtained results were not only compared to the typical concentrations during normal operations of the MSWI but also evaluated for the PCDD/F emission during start-up.

2. Experimental section

2.1. Basic information concerning the incinerators

The basic operation information concerning the intermittent incinerators, including one IWI, one WLI and three MWIs is described in Table 1. The feeding waste and air pollution control devices (APCDs) between these three categories of incinerators are not similar, but each kind of incinerator possesses its representation.

The continuously operating MSWI investigated for two years in this study consists of four 450 ton day⁻¹, two-stage, starved-air modular incinerators, each of which includes its own heat recovery system, dry scrubber, activated carbon injection, bag filter and stack. During start-up, the incinerators were preheated by burners operated with diesel.

2.2. PCDD/F sampling

On a usual day, the intermittent incinerators were started up in the morning and operated during the day. At night, the combustion chamber cooled down. However, in this study, the feeding waste was accumulated to enough for three consecutive 3 h stack flue gas samples during normal operations after start-up, which is characterized by the stable reading of combustion temperature and traditional pollutant, like CO concentration.

The sampling time of each stack flue gas sample of the MSWI during start-up was about 2–3 h and a total of five samples were collected in the first year. For more detailed characterization, the next year, the sampling time was changed to once an hour and a total of 10 stack flue gas samples were sampled.

The PCDD/F samples were collected isokinetically from the stack flue gas of the selected incinerators according to US EPA modified Method 23. The sampling train adopted in this study is comparable with that specified by US EPA

Table 1
Basic information concerning these five intermittent incinerators

Emission sources	IWI	WLI	MWI	MWI	MWI
Denotation	A	B	C	D	E
Feeding waste (kg h ⁻¹)	Industrial waste (420)	Waste liquid (200)	Infectious and pathological waste (400)	Infectious and pathological waste (300)	Infectious and pathological waste (300)
Auxiliary fuel (l h ⁻¹)	–	Diesel (0.1)	Diesel (22)	Diesel (21)	Diesel (19)
APCDs in sequence (operation temperature) (°C)	Cyclone (200) BF (160)	VS (90)	DS (250) ACI BF (150)	QC VS (90)	DS (250) ACI BF (160)
Mean stack flue gas flow (N m ³ h ⁻¹)	8500	2900	4500	4000	6000

Activated carbon injection: ACI; Bag filter: BF; Dry scrubber: DS; Quench chamber: QC; Venturi scrubber: VS.

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