Statistical evaluation of dioxin filters efficiency using a fixed installed dioxin emissions monitoring and statistical control charts

Dioxin Monitoring System

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1 Introduction

In 1993 a fixed bed activated carbon filter was installed at the hazardous waste incinerator (DTO 9) of Rotterdam by Austrian Energy GmbH to reduce dioxin emissions below the legal limit of 0.1 ng/m³.

During the start up of this filter system numerous performance tests were done.

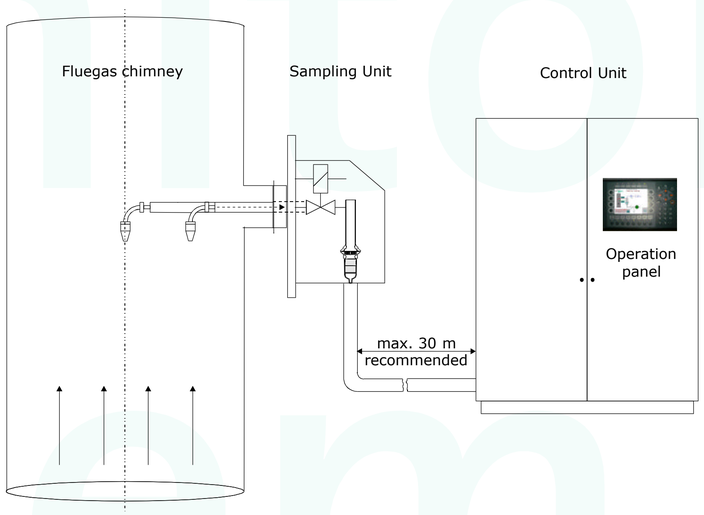
In August 2000 the DioxinMonitoringSystems® was installed at this hazardous waste incinerator to check and to evaluate periodically (once a month) the performance of this filter system.

In this paper the control chart using the data of the DioxinMonitoringSystem® is introduced which enables the operator to evaluate the I-TE emission values by statistical methods.

2 Description of DioxinMonitoringSystem®

The complete system for surveillance of 1 stack consists of the following components:

- one sampling unit with 2 probes
- one control unit
- filter units for delivery to the laboratory



Picture 1: DioxinMonitoringSystem® schema

3 Analytical method

The sampling unit was mounted at the stack of the hazardous waste incinerator DTO 9. The control and evaluation unit was installed close to the mounted sampling unit.

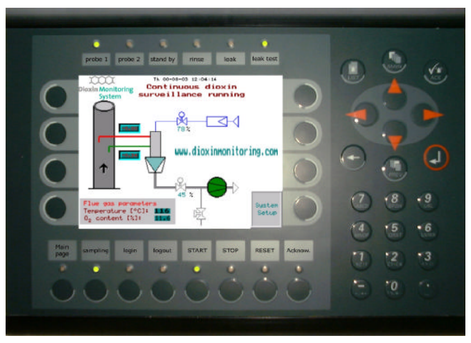
Dioxin emission measurements at concentrations of the legal limit (0.1 ng/m³) were done with 8-hour monitoring period to enable measurement periods conform to the European standard EN 1948-part 1.

Dioxin emission measurements at very low concentrations (below 0.01 ng/m³) were done with 1-week monitoring period to have the advantage of very low detection limits. Using 1-week monitoring time detection limits of 0.001 ng/m³ could be obtained.

The DioxinMonitoringSystem® performs the following routines automatically during measurement:

- automatic leak test (to avoid leakage) before start
- automatic cleaning routine for the probes before start (to reduce blank values)
- automatic control of the isokinetic sampling
- automatic temperature control of mixing chamber and filter unit
- configurable stand by parameters (e.g. in case of plant shut down)
- automatic measurement reports

Once a month the process engineer of the plant performed the dioxin monitoring using the fixed installed monitoring system, which did the monitoring fully automatically. Details are described in (3).



Picture 3:control panel

After stopping the measurement the engineer sent the filter unit together with the measurement protocol and corresponding parameters in a transportation box to the laboratory, where the filter unit was extracted and cleaned according European standards.
1 week later the process engineer received the results by E-mail from the laboratory. The evaluation of the results was done by him according the introduced control charts, which are based on a standard spread sheet

The engineer receives the results by E-mail from the laboratory, including

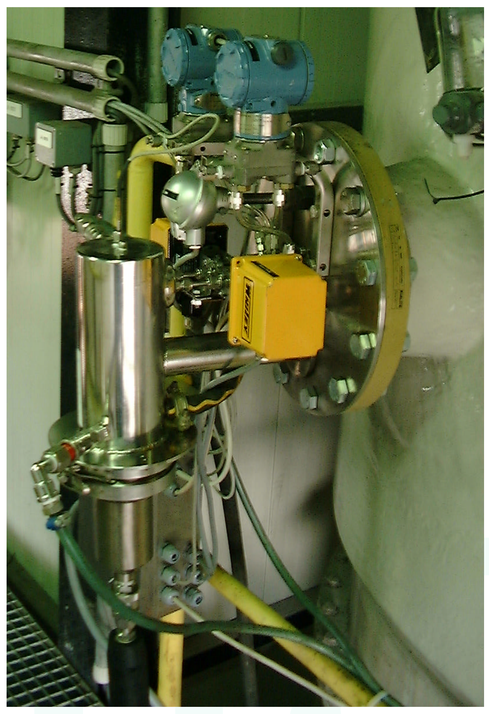
- the I-TE values obtained at the laboratory
- the statistical evaluation of the obtained results

4 Results of the performance tests in 1992

In 1992 several performance tests [1] of the fixed bed activated carbon filter were done during the start up of the filter system.

Table 1: results of these performance tests 1992

Date	Laboratory No	Toxicity equivalent I-TE (dry)
4.9.1992	920357	0.014
10.9.1992	920361	0.032
22.9.1992	920379/1	0.021
23.9.1992	920379/2	0.043
25.9.1992	920386/1	0.016
29.9.1992	920386/2	0.012
30.9.1992	920386/3	0.010
1.10.1992	920386/4	0.008
Average value		0.0193
Confidence limit (p = 0.95)		0.0080



Picture 2: sampling unit installed at the hazardous waste incinerator

5 Statistical evaluation of the performance data

Table 2:Check values for drift of dioxin emissions at level of 0.019 ng/m³

Monitoring period	h(x)	k(x)	h(s)	k(s)
1 week (ng/m³)	0.014	0.0024	0.0083	0.0022
8 hour (ng/m³)	0.023	0.0040	0.0234	0.0063

Control chart to detect decreasing (increasing) dioxin emissions

Surveyed period	c(I-TE)	sum of +t	sum of -t	calculated trend
1	0,034	0,0000	0,0000	
2	0,025	0,0036	0,0000	
3	0,007	0,0000	0,0096	
4	0,011	0,0000	0,0152	
5	0,007	0,0000	0,024	decreasing emissions
6	0,043	0,021	0,0000	
7	0,102	0,1022	0,0000	increasing emissions
8	0,074	0,1548	0,0000	increasing emissions

The statistical proof for decreasing dioxin emissions is done, in case the sum of negeative t exceeds 0.023 ng/m3 (in case of 8-hour monitoring period) or exceeds 0.014 ng/m3 (in case of 1-week monitoring period).

The statistical proof for increasing dioxin emissions is done, in case the sum of positive t exceeds 0.023 ng/m3 (in case of 8-hour monitoring period) or exceeds 0.014 ng/m3 (in case of 1 week monitoring period)

Control chart to detect scattering dioxin emissions

Surveyed Periode	(I-TE)	dt	sp	calculated scattering
1	0.034	0.015	0	no increase of scattering
2	0.025	0.006	0.00004	no increase of scattering
3	0.007	- 0.012	0.00020	no increase of scattering
4	0.011	- 0.008	0.00021	no increase of scattering
5	0.007	- 0.012	0.00022	no increase of scattering
6	0.043	0.024	0.00087	no increase of scattering
7	0.102	0.083	0.00261	no increase of scattering
8	0.074	0.055	0.00300	no increase of scattering

6 Discussion

The statistical evaluation showed that the use of the described dioxin monitoring system with 1-week monitoring period as well with 8-hours monitoring period is able to detect increasing as well as decreasing dioxin emissions in a very sensitive way.

Especially at low dioxin concentrations (below 0.01 ng/m³), only 1 week measurement periods enables proper statistical evaluation of the obtained results.

The reasons are based on the specific conditions inside the flue gas cleaning system. The flue gas behind activated carbon filters contains activated carbon particles, soot and flyash particles, which have adsorbed different amount of dioxins.

With short measurement time the fractions of activated carbon, soot and fly ash can vary, which leads to higher uncertainty of the measured dioxin emissions. Increasing the measurement time leads to more representative sampling.

With 1-weeks measurement time 20 times more particles are sampled, which increases the representaiveness of the whole measurement. This is the main advantage of 1-weeks measurement time compared to 8-hour measurement period.

Therefore at plants with low particle concentration and complex mixtures of particles in the flue gas it is an advantage to increase the sampling time to 1 week, to use the obtained dioxin emission data for statistical evaluation (trend and drift analysis of dioxin emissions).

The application at the stack of the hazardous waste incinerator of Rotterdam showed that this statistical evaluation can be used as "Quality assurance control chart" to detect increasing or decreasing performance of the installed fixed bed activated carbon filter very well.

Installations until 2001

Fuel and plant type	location and year of installation	number of systems
mobile test system grate / fluidised bed	various locations 1991	1
hazardous waste rotary kiln	Austria 1993	1
wooden material fluidised bed	Germany 1994	1
hazardous waste rotary kiln	Austria 1995	2
sewage sludge fluidised bed	Austria 1995	1
wooden material fluidised bed	Germany 1996	1
municipal waste grate	Germany 1997	2
various fuels (trial plant) fluidised bed/rotary kiln	Austria 1999	1
hazardous waste rotary kiln	The Netherlands 2000	1
municipal waste grate	Austria 2001	1

Contacts

Please visit our exhibition booth for further information.

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8 References

[1] Kahr, Eberl: Report of performance measurement
[2] CEN workgroup Dioxin measurement: Field test reports
[3] Kahr, Steiner: CEN Workshop 2001, Measuring Dioxin Emissions