

Reduction of dioxin emissions and determination of a plant comparison index by long time monitoring support

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1 Introduction

In the middle 80's the knowledge about dioxins and their toxicity increased. Different investigations came to the result that restriction of the emission of this compounds shall be limited. That time the technology for analysing this compound was compared to today in the very beginning. The same is valid for the available technology for flue gas treatment to filter or destroy dioxins. First technologies for dioxin destruction had been already tested. An Austrian construction company guaranteed the first time an emission value of below 0,1 ng/m³. The respective plant was a waste incinerator in Vienna. This limit was set up to the legislation of several countries. The limited available measurement technology caused, that this limits were proved just a few times a year.

In 1993 it was again in Vienna where that the first continuous dioxin monitoring system was introduced, installed and in use. With this prototype installation already many details of the plant characteristics could be recognised.

Especially a construction using at least two sampling positions is needed to gain representative results when the plants runs at full capacity as far as it runs at partial capacity.

With the first standardised device, first installed in 1994, and constructed in detail according to the today's EN 1948-1 an additional tool for the plant operator to optimise the plant for lowering the dioxin emission was provided.

Today the technique is well known and discussed to be included in the legislation of some countries.

2 Description of the continuous monitoring device 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

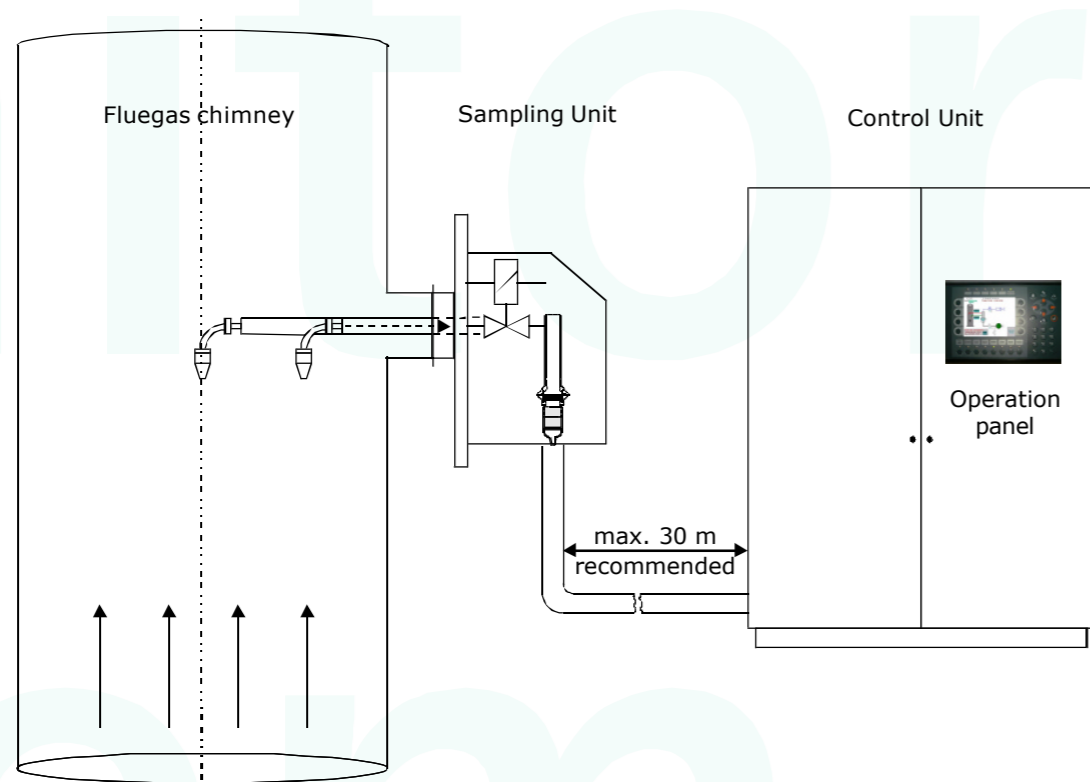


Figure 1: DioxinMonitoringSystem® schema

3 Analytical method

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

The dioxin emission measurements have been done with 2-week sampling intervals. The whole measurement principle and process was in accordance with the European standard EN 1948-part 1. Using this long monitoring time detection limits of 0.1 pg/m³ could be obtained with a very low uncertainty..

The monitoring devices perform 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

The samplings including exchange and analysis of the filter cartridges as far as the device maintenance have been served by an accredited measurement institut.

After stopping the sampling the engineer took 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 analysed.

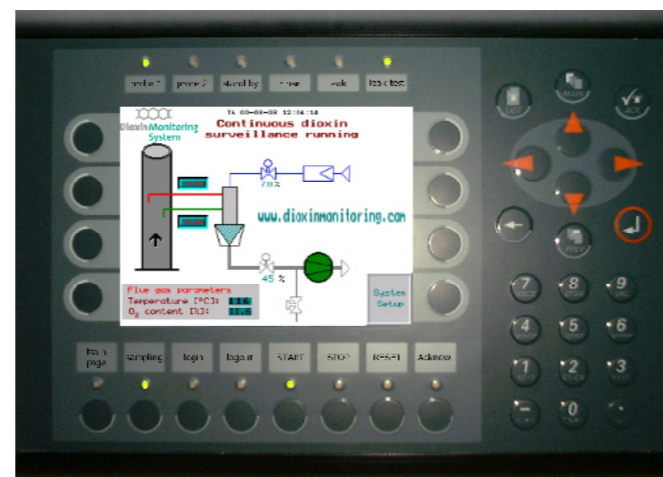


Figure 2: control panel

4 Applications of continuous monitoring

4.1 Permanent emission surveillance

The main application of the long term dioxin monitoring is simply the permanent emission surveillance. Even if the result of a continuous sampling cycle is not directly comparable to the short time measurements described in different countries to check the legal limit fulfilment, it includes the most important information. Dioxins are known to be chronic toxically compounds. That's why the actual emission value of a few hours of measurement gives less information compared to a long time result. Short time measurements would have to be preferred for acute toxic compounds.

4.2. Mass flow calculation

Advanced application of the continuous monitoring, especially using the measurement results for additional calculations and plant optimisation procedures, indicate how powerful this advanced technique can be used.

To calculate the mass flow of a plant the result of the continuous monitoring is simply multiplied by the volume flow of the surveyed chimney of the same period. For different plants this results vary in a huge. Known emission sources in the concentration range of the legal limit and a volume flow of 1 million cubic meter per hour have mass flows of about 1 g TEQ of dioxins per year.

On the other hand the example presented in the following table shows the emission values from the hazardous waste incinerator Vienna which is equipped with a sophisticated flue gas cleaning system including an activated carbon filter.



Figure 3: sampling unit installed at the hazardous waste incinerator

sampling cycle	calendar week '96	cycle number	sampled flue gas	measurement result	total volume	mass flow
			chimney A + B [m ³ _N]	i-TEQ [ng/m ³ _N]	chimney A + B [mio m ³ _N]	i-TEQ [mg]
09.01.-23.01.96	KW04	68	128,3	0,0019	14,75	0,0274
23.01.-06.02.96	KW06	69	140,5	0,0016	16,16	0,0257
06.02.-20.02.96	KW08	70	282,2	0,0010	32,45	0,0324
20.02.-05.03.96	KW10	71	234,7	0,0007	26,99	0,0179
05.03.-19.03.96	KW12	72	331,8	0,0010	38,14	0,0381
19.03.-02.04.96	KW14	73	257,3	0,0011	29,58	0,0314
02.04.-16.04.96	KW16	74	100,4	0,0017	11,54	0,0199
16.04.-30.04.96	KW18	75	243,8	0,0009	28,03	0,0261
30.04.-14.05.96	KW20	76	255,0	0,0008	29,32	0,0234
14.05.-28.05.96	KW22	77	213,1	0,0005	24,50	0,0130
28.05.-12.06.96	KW24	78	275,4	0,0013	31,67	0,0420
12.06.-25.06.96	KW26	79	247,6	0,0009	28,46	0,0265
25.06.-09.07.96	KW28	80	191,4	0,0008	22,01	0,0175
09.07.-23.07.96	KW30	81	278,8	0,0023	32,06	0,0724
23.07.-27.08.96	KW35	82	379,4	0,0012	43,62	0,0521
27.08.-10.09.96	KW37	83	240,5	0,0023	27,65	0,0624
10.09.-24.09.96	KW39	84	185,0	0,0021	21,28	0,0452
24.09.-08.10.96	KW41	85	85,2	0,0003	9,79	0,0026
08.10.-22.10.96	KW43	86	210,3	0,0007	24,18	0,0161
22.10.-05.11.96	KW45	87	268,0	0,0010	30,82	0,0308
05.11.-19.11.96	KW47	88	284,2	0,0016	32,67	0,0521
19.11.-03.12.96	KW49	89	284,4	0,0008	32,70	0,0260
03.12.-17.12.96	KW51	90	231,4	0,0008	26,61	0,0212
17.12.-31.12.96	KW53	91	177,9	0,0031	20,45	0,0625
annual total / average			5527	0,0013	635	0,78

Table 1: Results of the long term monitoring of the hazardous waste incinerator Vienna of a whole year including mass flow

The calculated mass flow of 0,78 mg per year is a very low value and underlines the performance of the flue gas cleaning system as well as the experience of the plant engineers responsible for the operation.

4.3. Definition and calculation of the dioxin emission index

The dioxin emission index i_{TEQ} shall be defined being the emitted amount of dioxins (TEQ) in the respective medium per unit of processed material. The unit of processed material shall be e.g. for waste incinerators tons of incinerated waste, for cement kilns both (depending on the viewpoint), tons of produced cement or tons of incinerated waste fraction.

$$\theta_{TEQ} = \frac{m_{TEQ}}{m_p} \quad \text{Formula 1: calculation of dioxin emission index, where } m_{TEQ} \text{ resents the dioxin mass flow and } m_p \text{ the processed material mass flow}$$

In the presented example the processed material has been the incinerated waster of an amount of about 390.000 tons per year. The calculated dioxin emission index for the flue gas was 20 ng TEQ per ton of incinerated waste being equivalent to 2×10^{-14} .

4.4. Plant optimisation

The opportunity of the reduction of the emission levels and to keep them low following becomes easy by using continuous monitoring. One of the plant operators started to changed the design of the activated carbon injection while the monitoring was done. After just a few sampling cycles a very efficient design was found and the emission level was decreased to about 15 pg/m³. This design was used for permanent installation. Following, by using statistical methods, changes of the efficiency of the flue gas cleaning are recognised early². The dioxin mass flow as far as the emission level can be kept at a low level.

The respective mass flow was decreased to about 25 mg per year. Nevertheless, this was done using a fuel possibly containing more chlorine than before usually causing higher dioxin emission values.

sampling cycle	calendar week	sampled flue gas [m ³ _N]	measurement result i-TEQ [ng/m ³ _N]
23.12. - 20.01.97	KW4	394,9	0,052
20.01. - 03.02.97	KW6	186,4	0,025
03.02. - 17.02.97	KW8	321,0	0,003
17.02. - 01.03.97	KW9	137,1	0,030
06.03. - 01.04.97	KW14	446,9	0,048
01.04. - 21.04.97	KW17	137,5	0,004
21.04. - 07.05.97	KW19	96,1	0,093
total / average		1.720	0,036

Table 2: Results of the long term monitoring after plant optimisation with a fuel with higher chlorine content

5 Discussion

The continuous monitoring of dioxins gives new opportunities for both, plant operators and authorities. Especially the definition of a defined index to compare different plants objectively is an important base for e.g. investment and support decisions.

By including the data to known methods of distribution calculation⁴, the dioxin emission distribution can be calculated with highest accuracy.

The advantage of using a continuous monitoring device is the included quality management system of the sampling process and an absolutely constant sampling process ensured by the automatic process control.

Different applications have shown that especially the selection of the sampling positions is one of the most important steps of continuous sampling. The use of at least two sampling positions is needed to have representative locations in case the plant is operating at full capacity as well as operating at partial capacity.

Further, special application use of the continuous monitoring is recommended to be supported by experienced people e.g. of measurement institutions to ensure the proper interpretation of results including the plant's and the sampling process' parameters.

6 References

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