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Certification and Quality Control of the Official Test Facilities of Dioxins in Korea

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요 약: 생활폐기물 처리용량이 일일 50톤 이상인 소각시설에 대한 배출가스중의 다이옥신 농도는 신규시설인 경우 0.1 ng-TEQ/Nm^3, 기존시설인 경우 0.5 ng-TEQ/Nm^{3}로 규제하고 있으며, 기존시설인 경우에도 2003년에는 0.1 ng-TEQ/Nm^{3}로 강화할 예정이다. 이들 소각시설은 다이옥신 측정분석기관으로부터 년 2회 이상 배출가스중의 다이옥신 농도를 측정하여야 한다. 현재까지 7개 기관이 다이옥신 측정분석기관으로 지정을 받았으며, 이들 기관은 매년 국립환경연구원이 제공하는 정도관리 프로그램에 따라 평가를 받아야 한다. 1999년에는 1998년에 지정받은 4개 기관에 대하여 M 소각시설에서 대기오염공정시험방법에 따라 다이옥신 시료채취 및 분석을 하여 정도관리를 실시하였다. 정도관리 실시결과 등속흡인계수는 각각 100.9%, 102.4%, 102.1%, 99.2%로 4기관 모두 양호하였으며, 분해능(10,000 이상), 질량검정결과(±5 ppm 이내), 동위원소 존재비(15% 이내) 및 회수율(50-120%) 모두 대기오염공정시험방법 기준을 만족하였다.

Abstract: The concentration of dioxins from flue gases of municipal waste incineration facilities with capacities over 50 tons/day are regulated by the guideline: 0.1 ng-TEQ/Nm^3 for new facilities, and 0.5 ng-TEQ/Nm^3 for existing facilities and it will be strengthened to 0.1 ng-TEQ/Nm^3 until 2003 year. Dioxins from these incineration facilities have to be measured more than 2 times annually by the Official Test Facilities of Dioxins. Seven institutions have been certified so far as the Official Test Facilities of Dioxins. These facilities have to be evaluated by the quality control program provided by National Institute of Environmental Research every year. We reported the results of quality control test performed in 1999. Four institutions certified in 1998 sampled flue gases at stack of M incineration facilitiy and analyzed dioxins by Official Methods of Air Pollution. The isokinetic coefficients, the parameter for evaluation of sampling ability were excellent for all four institutions. They were 100.9%, 102.4%, 102.1% and 99.2%, respectively. The criteria required are as follows ; resolution over 10,000, mass calibration within ±5ppm, ion abundance ratio within 15%, and the recovery of 50-120%. As results, those institutions also met these parameters of Official Method of Air Pollution.

Key words: cetification, quality control, Official Test Facility of Dioxins

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1. Introduction

Dioxins are the most toxic environmental pollutant untill now. Dioxins made up of the polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzo furans (PCDF), have received widespread attention and attracted a great deal of research after the use of 2, 4, 5-T (including 2, 3, 7, 8-TCDD) during Veitnam War and the accidental release of 2, 3, 7, 8-TCDD at Seveso.

Dioxins are found in all environmental compartments, are persistent, and being fat soluble tend to accumulate in higher animals including humans. Their resistence to degradation and semi-volatility means that they may be transported over long distances and give rise to trans-national exchanges of pollutants. In addition, dioxins released into the environment many years ago continue to contribute to contemporary exposure.

Dioxins have never been intentionally manufactured but can be released into the environment from a number of different sources; including chemicals manufacturing, combustion processes, metallurgical processes, paper and pulp processing. Although there are 210 congeners of PCDD/PCDF, only the 17 which have chlorine substitution in at least all of the 2, 3, 7, 8 positions are of concern, owing to their toxicity, stability and persistence in the environment. In order to simplify the handling of data on the individual compounds, a system of toxic equivalency factors (TEFs) is used to derive an equivalent concentration of the most toxic dioxin (2, 3, 7, 8-TCDD). This enables the toxicity of complex mixtures to be expressed as a single number-TEQ (Toxic Equivalent).[1]

The concentration of dioxins from flue gases of municipal waste incineration facilities with capacities over 50 tons/day are regulated by the guideline: 0.1 ng-TEQ/Nm^3 for new facilities, and 0.5 ng-TEQ/Nm^3 for existing facilities and it will be strengthened to 0.1 ng-TEQ/Nm^3 by year 2003. These incineration facilities have to measure dioxins more than 2 times annually by the Official Test Facilities of Dioxins (OTFD).[2]

Seven institutions such as Environmental Management Corporation, Korea Test Laboratory, Pohang Research Institute of Science Technology, Seoul City Institute of Health and Environment, University of Seoul City, Kyungki Province of Health and Environment, Pohang University of Science and Technology have been certified so far as the OTFD. These institutions have to be evaluated by the quality control program provided by National Institute of Environmental Research (NIER) every year.[3]

This report is the results of quality control test performed in 1999. Four institution certifed in 1998 sampled flue gases at stack of M incinaration facility and analyzed dioxins by Official Methods of Air Pollution.[4]

2. Methods

2.1. Certification Procedure of the OTFD

Procedure of the certification are following the regulation about Certification of Dioxins Measurement and Analysis Facility.

First, institution who wants the certification of the OTFD has to submit the application documents to NIER. Second, NIER reviews the application document and then, requests the modification, if necessary. Third, Field Evaluation is carried out and Evaluation Committee decides comprehensive evaluation. Lastly, NIER report to the Ministry of Environment (MOE) and MOE designates the applicants as the OTFD.

Application documents are consisted of

① Description of laboratory, experimental equipment and technical capacity

② Documents for proving the capacity of measurement and analysis of dioxins

③ Research plan for measurement and analysis of dioxins

Guidelines of experimental equipments for the OTFD are shown in *Table* 1 and *Table* 2.

2.2. Quality control

Four institution certifed in 1998 sampled flue gases at stack of M incineration facilitiy and analyzed dioxins by Official Methods of Air Pollution (*Fig.* 1). Calibra-

Table 1. Sampling equipments for the OTFD

No.	Name	Quantity
1	Stack sampler (Isokinetic)	2
2	Flue gas analyzer	2
3	Sampling apparatus of dioxins	2
4	Pitot tube	2

Table 2. Analysis equipments for the OTFD

No.	Name	Quantity
1	HRGC/HRMS (resolution : over 10,000)	1
2	GC/ECD	1
3	Ultrasonic extractor	1
4	Soxhlet extractor	4
5	Column chromatography	4
6	K.D concentrator (or rotary evaporator)	4(1)
7	Refrigerator (4°C)	1

tion standard of dioxins is shown in Table 3.

And then those institutions submitted the results of sampling and analysis of dioxins to NIER. Each results have to satisfy these parameters of Official Method of Air Pollution.

① Isokinetic coefficient is 95-110%
② Sampling time is over 4 hrs
③ Sampling amount is over $3Nm^3$
④ Resolution is over 10,000 (10% valley)
⑤ Mass calibration is within ±5 ppm
⑥ Ion abundance ratio is within 15%
⑦ Recovery is 50-120%

3. Result and Discussion

3.1. Certification of the OTFD

In Korea, seven institutions, Environmental Management Corporation, Korea Test Laboratory, Pohang Research Institute of Science Technology, Seoul City Institute of Health and Environment, University of Seoul City, Kyungki Province of Health and Environ-

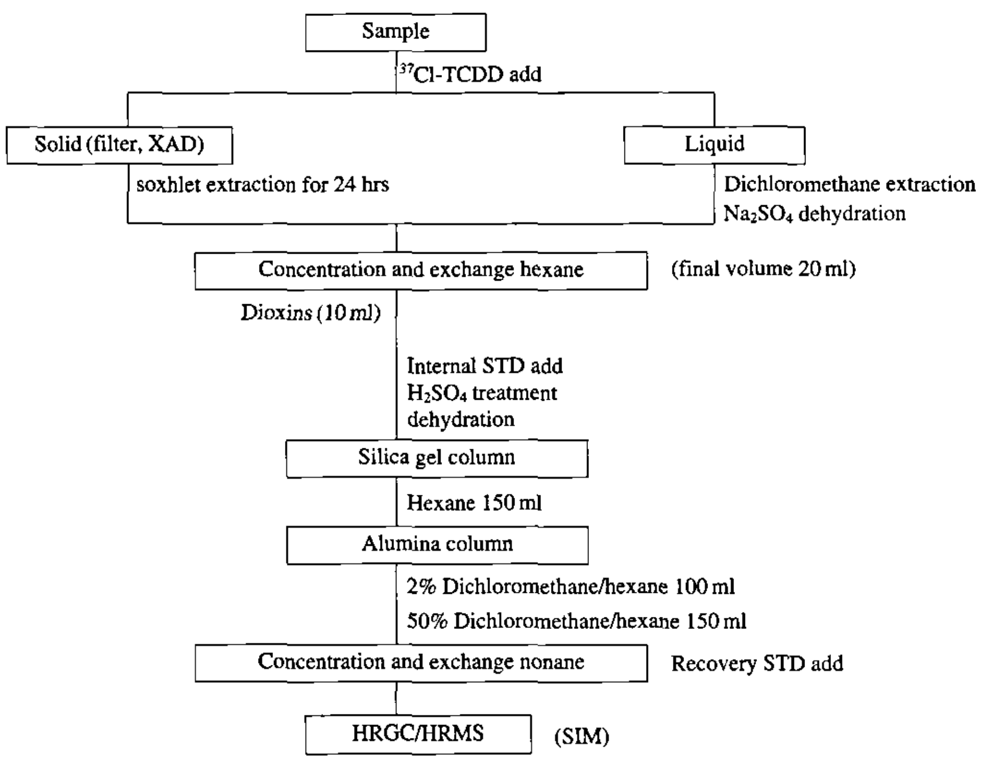

Fig. 1. Flow chart of dioxins analysis.

Table 3. Calibration standard of dioxins

Native compounds	Labeled compounds
2,3,7,8-TCDD	$^{13}C_{12}$-2,3,7,8-TCDD
	$^{13}C_{12}$-1,2,3,4-TCDD recovery STD
	^{37}Cl-2,3,7,8-TCDD
1,2,3,7,8-PeCDD	$^{13}C_{12}$-1,2,3,7,8-PeCDD
1,2,3,4,7,8-HxCDD	$^{13}C_{12}$-1,2,3,4,7,8-HxCDD
1,2,3,6,7,8-HxCDD	$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
1,2,3,7,8,9-HxCDD	$^{13}C_{12}$-1,2,3,7,8,9-HxCDD recovery STD
1,2,3,4,6,7,8-HpCDD	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD
OCDD	$^{13}C_{12}$-OCDD
2,3,7,8-TCDF	$^{13}C_{12}$-2,3,7,8-TCDF
1,2,3,7,8-PeCDF	$^{13}C_{12}$-1,2,3,7,8-PeCDF
2,3,4,7,8-PeCDF	$^{13}C_{12}$-2,3,4,7,8-PeCDF
1,2,3,4,7,8-HxCDF	$^{13}C_{12}$-1,2,3,4,7,8-HxCDF
1,2,3,6,7,8-HxCDF	$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDF	$^{13}C_{12}$-1,2,3,7,8,9-HxCDF
2,3,4,6,7,8-HxCDF	$^{13}C_{12}$-2,3,4,6,7,8-HxCDF
1,2,3,4,6,7,8-HpCDF	$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF	$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF
OCDF	

Table 4. Experimental equipments of the OTFDs

Field	Name	Quantity	A	B	C	D	E	F	G
Sampling	Stack sampler	2	4	2	3	3	2	2	2
	Flue gas analyzer	2	5	3	3	3	2	2	2
	Sampling apparatus of dioxin	2	10	3	6	3	4	4	3
	Pitot tube	2	13	2	6	3	2	6	3
Analysis	HRGC/HRMS	1	1	2	1	1	1	1	1
	GC/ECD	1	1	5	1	2	2	1	2
	Ultrasonic extractor	1	1	4	4	1	1	1	3
	Soxhlet extractor	4	40	4	12	7	4	6	15
	Column chromatography	4	50	30	10	50	6	6	10
	K.D concentrator	1	20	5	2	2	4	6	2
	Refrigerator	1	1	4	2	1	2	1	1

Table 5. Results of dioxins sampling of the OTFDs

	A			B			C			D		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Isokinetic coefficient (%)	104.3	98.5	99.9	102.9	102.8	101.6	103.6	103.3	99.3	102.8	97.9	96.8
O_2 conc. (%)	8.1	8.6	8.5	8.2	8.8	8.4	8.6	8.7	8.8	8.5	8.6	9.6
CO_2 conc. (%)	10.5	10.4	9.5	12.4	11.9	12.2	6.9	6.8	6.2	8.8	8.1	7.4
CO conc. (ppm)	51.1	17.7	16.1	36.1	24.1	25.0	23.9	12.3	17.7	21.3	17.4	20.4
Water (%)	29.1	28.0	29.6	25.8	26.7	25.2	28.3	28.5	26.1	29.1	29.3	29.2
Sampling time (min)	240	240	240	240	240	240	240	240	240	240	240	240
Amount (Nm^3)	3.20	3.12	3.12	3.96	3.68	4.13	3.83	3.92	3.68	3.92	3.47	3.63
Flow rate (m/sec)	19.5	19.6	19.8	19.2	18.9	19.9	18.6	19.1	18.2	19.6	18.4	19.5

Table 6. Relative response factors of calibration standard of the OTFDs

Compounds		A mean RRF	A %RSD	B mean RRF	B %RSD	C mean RRF	C %RSD	D mean RRF	D %RSD
Furan	2,3,7,8-TCDF	0.954	2.38	0.901	10.74	0.996	1.07	1.006	1.70
	1,2,3,7,8-PeCDF	0.910	1.92	0.878	14.71	0.997	1.80	1.026	0.77
	2,3,4,7,8-PeCDF	0.977	2.06	0.895	13.05	1.016	2.04	1.006	1.49
	1,2,3,4,7,8-HxCDF	1.174	1.96	1.148	13.26	1.105	1.43	1.235	1.10
	1,2,3,6,7,8-HxCDF	1.167	2.35	1.132	14.59	1.077	3.00	1.220	0.89
	2,3,4,6,7,8-HxCDF	1.105	1.10	1.197	13.10	0.965	4.83	1.176	1.50
	1,2,3,7,8,9-HxCDF	1.207	2.64	1.076	14.17	0.964	2.07	1.270	1.45
	1,2,3,4,6,7,8-HpCDF	1.375	1.67	1.351	14.46	0.980	2.22	1.494	2.67
	1,2,3,4,7,8,9-HpCDF	1.325	1.89	1.354	12.13	0.988	6.06	1.429	0.89
	OCDF	0.326	7.62	0.753	25.21	0.203	3.95	0.073	42.96
Dioxin	2,3,7,8-TCDD	1.003	1.43	0.875	15.69	1.057	3.84	1.047	0.60
	1,2,3,7,8-PeCDD	1.003	2.12	0.882	14.07	1.223	1.68	1.164	6.37
	1,2,3,4,7,8-HxCDD	1.045	1.63	1.025	16.77	1.113	1.24	1.209	1.26
	1,2,3,6,7,8-HxCDD	0.904	1.51	0.897	14.72	0.948	2.52	1.056	1.67
	1,2,3,7,8,9-HxCDD	1.036	2.39	1.046	13.83	0.980	0.45	1.174	3.97
	1,2,3,4,6,7,8-HpCDD	0.919	2.53	0.879	14.39	0.974	2.33	1.032	0.40
	OCDD	0.969	1.45	0.898	14.61	1.029	2.36	1.029	1.00

Compounds		A mean RRF	A %RSD	B mean RRF	B %RSD	C mean RRF	C %RSD	D mean RRF	D %RSD
Furan	^{13}C-2,3,7,8-TCDF	1.304	0.71	1.330	4.91	1.305	1.28	1.374	1.79
	^{13}C-1,2,3,7,8-PeCDF	1.359	1.23	1.297	1.46	0.976	2.93	1.116	5.74
	^{13}C-2,3,4,7,8-PeCDF	1.113	0.89	1.270	2.11	0.933	2.56	1.190	6.04
	^{13}C-1,2,3,4,7,8-HxCDF	1.056	1.43	1.138	4.10	1.642	2.03	1.343	2.14
	^{13}C-1,2,3,6,7,8-HxCDF	1.058	1.85	1.133	3.45	1.741	1.11	1.379	2.84
	^{13}C-2,3,4,6,7,8-HxCDF	0.905	2.51	0.948	4.08	1.040	1.38	1.274	2.22
	^{13}C-1,2,3,7,8,9-HxCDF	0.720	2.46	1.086	3.42	1.573	2.10	0.930	3.24
	^{13}C-1,2,3,4,6,7,8-HpCDF	0.760	1.59	0.835	4.41	1.054	1.17	0.824	2.20
	^{13}C-1,2,3,4,7,8,9-HpCDF	0.518	6.15	0.679	6.56	0.458	3.07	0.353	8.16
Dioxin	^{13}C-2,3,7,8-TCDD	1.021	1.84	1.042	2.54	0.992	1.51	1.025	3.64
	^{13}C-1,2,3,7,8-PeCDD	0.983	1.92	0.973	2.03	0.530	2.72	0.652	6.15
	^{13}C-1,2,3,4,7,8-HxCDD	0.915	0.44	0.904	2.63	0.953	0.91	0.927	1.99
	^{13}C-1,2,3,6,7,8-HxCDD	0.935	1.21	0.940	2.31	1.063	1.06	0.964	1.98
	^{13}C-1,2,3,4,6,7,8-HpCDD	0.901	2.01	0.895	3.19	0.676	1.34	0.829	2.51
	^{13}C-OCDD	0.654	5.48	0.785	3.87	0.346	1.74	0.592	6.25
	^{37}Cl-1,2,3,4-TCDD	1.043	4.26	0.944	13.70	1.028	8.21	1.066	2.68

ment, Pohang University of Science and Technology have been certified so far, as the OTFD. Experimental equipments of each facility were shown in *Table* 4.

Table 7. Recoveries of internal standard of the OTFDs

Compounds		A			B			C			D		
		1st	2nd	3rd	1t	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Furan	^{13}C-2, 3, 7, 8-TCDF	92.7	84.3	86.6	108.8	103.8	99.3	82.3	90.9	79.6	92.2	84.3	80.4
	^{13}C-1, 2, 3, 7, 8-PeCDF	92.7	87.0	89.0	90.8	91.8	81.8	8.15	92.3	75.8	103.0	105.9	99.3
	^{13}C-2, 3, 4, 7, 8-PeCDF	90.5	82.3	84.4	105.7	108.1	99.8	79.1	92.6	75.7	88.8	80.8	86.9
	^{13}C-1, 2, 3, 4, 7, 8-HxCDF	86.5	83.0	85.2	102.1	101.1	99.6	89.3	94.8	85.9	91.0	87.3	75.1
	^{13}C-1, 2, 3, 6, 7, 8-HxCDF	88.5	88.9	87.6	103.7	100.4	97.6	89.5	95.0	87.8	91.7	89.5	77.9
	^{13}C-2, 3, 4, 6, 7, 8-HxCDF	89.9	82.6	85.7	120.3	120.6	117.9	85.2	98.6	78.8	86.8	76.9	79.2
	^{13}C-1, 2, 3, 7, 8, 9-HxCDF	96.8	86.8	94.2	123.4	122.7	121.1	86.5	93.7	82.3	85.2	78.9	79.8
	^{13}C-1, 2, 3, 4, 6, 7, 8-HpCDF	82.5	81.4	83.1	117.6	115.1	113.1	79.9	92.1	74.4	90.8	87.5	71.4
	^{13}C-1, 2, 3, 4, 7, 8, 9-HpCDF	80.4	78.8	84.0	117.2	115.8	111.6	86.2	96.6	82.0	87.1	79.3	90.3
Dioxin	^{13}C-2, 3, 7, 8-TCDD	90.8	88.9	84.8	99.2	94.9	95.1	82.8	89.3	75.2	101.3	99.2	95.5
	^{13}C-1, 2, 3, 7, 8-PeCDD	88.3	88.7	89.0	72.2	71.7	62.9	100.0	113.9	94.9	113.6	112.4	115.0
	^{13}C-1, 2, 3, 4, 7, 8-HxCDD	83.5	84.8	85.2	99.1	95.1	95.8	88.8	90.7	85.1	100.6	94.7	98.1
	^{13}C-1, 2, 3, 6, 7, 8-HxCDD	87.9	88.5	88.1	101.6	94.2	98.9	88.3	89.1	86.2	103.5	97.0	100.2
	^{13}C-1, 2, 3, 4, 6, 7, 8-HpCDD	89.0	88.4	87.9	107.4	105.6	100.5	85.4	94.7	85.3	106.2	101.5	102.7
	^{13}C-OCDD	77.0	79.2	80.0	112.5	113.9	103.7	96.9	86.4	94.4	97.9	96.7	99.1
^{37}Cl-1, 2, 3, 4-TCDD		96.5	90.9	88.2	62.4	62.3	101.2	101.0	96.2	99.0	89.9	87.8	92.3

Table 8. Concentration of 2, 3, 7, 8-substituted congeners of the OTFDs

Compounds		A			B			C			D		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Furan	2, 3, 7, 8-TCDF	2.235	1.917	1.845	2.405	2.930	3.875	2.735	2.613	1.520	1.797	2.437	1.950
	1, 2, 3, 7, 8-PeCDF	8.497	6.352	6.045	8.424	8.218	11.389	4.204	4.199	2.739	4.030	6.953	4.310
	2, 3, 4, 7, 8-PeCDF	8.226	5.912	6.342	6.787	7.743	9.481	6.944	9.206	5.637	3.493	6.127	4.067
	1, 2, 3, 4, 7, 8-HxCDF	9.781	7.106	7.093	8.932	8.712	10.580	5.240	3.698	3.064	4.460	7.683	5.153
	1, 2, 3, 6, 7, 8-HxCDF	10.043	7.206	7.315	8.370	8.747	10.621	9.093	9.274	7.651	4.853	8.570	5.293
	2, 3, 4, 6, 7, 8-HxCDF	12.885	9.149	9.248	3.651	3.455	3.159	12.381	12.645	6.327	6.947	11.567	7.720
	1, 2, 3, 7, 8, 9-HxCDF	1.056	0.774	0.515	10.198	12.296	13.044	–	–	–	–	–	–
	1, 2, 3, 4, 6, 7, 8-HxCDF	28.980	18.859	20.578	22.285	19.092	19.533	26.658	24.134	16.651	15.200	23.700	17.600
	1, 2, 3, 4, 7, 8, 9-HxCDF	5.989	3.569	4.592	7.506	5.491	7.379	–	–	–	3.713	4.373	3.257
	OCDF	9.573	5.512	5.083	21.500	16.658	19.387	–	–	–	121.47	54.167	32.633
Dioxin	2, 3, 7, 8-TCDD	1.007	1.066	1.097	3.138	2.158	2.384	0.790	1.828	1.177	0.700	0.899	0.877
	1, 2, 3, 7, 8-PeCDD	8.487	7.691	7.788	6.359	8.322	10.461	2.031	7.093	3.125	6.733	8.683	8.090
	1, 2, 3, 4, 7, 8-HxCDD	19.746	14.689	15.829	9.147	10.333	13.235	21.425	20.208	10.945	6.280	9.707	7.537
	1, 2, 3, 6, 7, 8-HxCDD	66.120	53.394	56.694	23.281	31.970	44.740	67.557	59.150	38.353	23.833	36.100	30.367
	1, 2, 3, 7, 8, 9-HxCDD	41.108	33.808	33.631	12.606	19.735	25.814	39.033	37.882	22.539	10.867	17.767	14.833
	1, 2, 3, 4, 6, 7, 8-HpCDD	714.56	519.83	524.18	225.94	340.21	483.25	543.97	525.03	248.24	191.00	298.00	219.00
	OCDD	681.29	502.32	508.96	249.95	332.10	446.55	500.02	497.21	246.38	172.33	281.33	183.00
Total (PCDFs+PCDDs)		1629.6	1199.1	1216.8	630.48	838.17	1134.9	1242.1	1214.2	614.36	613.82	826.69	545.90
mean Con.		1348.49			867.85			1023.54			662.14		

* - : ND(Not Detected)

Table 9. Mean conc. and % RSD of 2, 3, 7, 8-substituted congeners of the OTFDs

	Compounds	A		B		C		D	
		mean conc.	%RSD	mean conc.	%RSD	mean conc.	%RSD	mean conc.	%RSD
Furan	2, 3, 7, 8-TCDF	1.999	10.4	3.070	24.3	2.289	29.2	2.061	16.2
	1, 2, 3, 7, 8-PeCDF	6.968	19.2	9.344	19.0	3.714	22.7	5.098	31.6
	2, 3, 4, 7, 8-PeCDF	6.827	18.0	8.004	17.1	7.262	24.9	4.562	30.4
	1, 2, 3, 4, 7, 8-HxCDF	7.993	19.4	9.408	10.9	4.001	28.0	5.765	29.4
	1, 2, 3, 6, 7, 8-HxCDF	8.188	19.6	9.155	13.9	8.6673	10.3	6.239	32.6
	2, 3, 4, 6, 7, 8-HxCDF	10.427	20.4	3.422	7.2	10.451	34.2	8.745	28.3
	1, 2, 3, 7, 8, 9-HxCDF	0.782	34.6	11.846	12.5	0.000	0.0	0.000	0.0
	1, 2, 3, 4, 6, 7, 8-HpCDF	22.806	23.7	20.303	8.5	22.481	23.2	18.833	23.3
	1, 2, 3, 4, 7, 8, 9-HpCDF	4.717	25.8	6.792	16.6	0.000	0.0	3.781	14.8
	OCDF	6.723	36.9	19.182	12.7	0.000	0.0	69.422	66.8
Dioxin	2, 3, 7, 8-TCDD	1.057	4.3	2.560	20.0	1.265	41.5	0.825	13.2
	1, 2, 3, 7, 8-PeCDD	7. 989	5.4	8.381	24.5	4.083	65.2	7.835	12.8
	1, 2, 3, 4, 7, 8-HxCDD	16.755	15.8	10.905	19.3	17.526	32.7	7.841	22.1
	1, 2, 3, 6, 7, 8-HxCDD	58.736	11.2	33.330	32.4	55.020	27.3	30.100	20.4
	1, 2, 3, 7, 8, 9-HxCDD	36.182	11.8	19.385	34.1	33.151	27.8	14.489	23.9
	1, 2, 3, 4, 6, 7, 8-HpCDD	586.188	19.0	349.799	36.9	439.078	37.7	236.000	23.5
	OCDD	564.194	18.0	342.869	28.8	414.539	35.1	212.222	28.3

Table 10. TEQ concentration of 2, 3, 7, 8-substituted congeners of the OTFDs

Compounds		A			B			C			D		
		1st	*2nd*	*3rd*	*1st*	*2nd*	*3rd*	*1st*	*2nd*	*3rd*	*1st*	*2nd*	*3rd*
Furan	2, 3, 7, 8-TCDF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1, 2, 3, 7, 8-PeCDF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2, 3, 4, 7, 8-PeCDF	0.003	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.002	0.001	0.002	0.002
	1, 2, 3, 4, 7, 8-HxCDF	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	1, 2, 3, 6, 7, 8-HxCDF	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000
	2, 3, 4, 6, 7, 8-HxCDF	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
	1, 2, 3, 7, 8, 9-HxCDF	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	1, 2, 3, 4, 6, 7, 8-HxCDF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1, 2, 3, 4, 7, 8, 9-HxCDF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	OCDF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dioxin	2, 3, 7, 8-TCDD	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	1, 2, 3, 7, 8-PeCDD	0.003	0.003	0.003	0.002	0.003	0.004	0.001	0.003	0.001	0.002	0.003	0.003
	1, 2, 3, 4, 7, 8-HxCDD	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001
	1, 2, 3, 6, 7, 8-HxCDD	0.005	0.004	0.004	0.002	0.002	0.003	0.005	0.004	0.003	0.002	0.003	0.002
	1, 2, 3, 7, 8, 9-HxCDD	0.003	0.002	0.002	0.001	0.001	0.002	0.003	0.003	0.002	0.001	0.001	0.001
	1, 2, 3, 4, 6, 7, 8-HpCDD	0.005	0.004	0.004	0.002	0.002	0.003	0.004	0.004	0.002	0.001	0.002	0.002
	OCDD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total (PCDFs+PCDDs)		0.023	0.019	0.019	0.015	0.018	0.022	0.021	0.022	0.014	0.010	0.015	0.013
mean TEQ Con.			0.020			0.018			0.019			0.013	

Table 11. Recovery range and TEQ concentration of the OTFDs

		A	B	C	D
Recovery (%)	1st	77.0-96.5	62.4-123.4	79.1-101.1	85.2-113.6
	2nd	78.8-90.9	62.3-122.7	86.4-113.9	76.9-112.4
	3rd	80.8-94.2	62.9-121.1	74.4-99.0	71.4-115.0
TEQ-concentration ($ng\text{-}TEQ/Nm^3$)	1st	0.023	0.018	0.021	0.010
	2nd	0.019	0.021	0.022	0.015
	3rd	0.019	0.022	0.014	0.013

3.2. Quality control

We reported the results of quality control test performed in 1999. Four institution certifed in 1998 sampled flue gases at stack of M incineration facilitiy and analyzed dioxins by Official Methods of Air Pollution.

3.2.1. Sampling ability of dioxins

Results of dioxins sampling were shown in *Table* 5.

3.2.2. Analysis ability of dioxins

(1) Relative response factors of calibration standard

Relative response factors of calibration standard were shown in *Table* 6.

(2) Recoveries of internal standards

The recoveries of internal standards were shown in *Table* 7. The recovery range of institution A was 70.0-96.7%, Institution B was 62.3-123.4%, Institution C was 74.4-113.9%, Institution D was 71.4-115.0%. Institution B exceeded the recovery of ^{13}C-2, 3, 4, 6, 7, 8-HxCDF and ^{13}C-1, 2, 3, 7, 8, 9-HxCDF slightly.

(3) Concentration of 2, 3, 7, 8-sustituted congeners

The concentration of 2, 3, 7, 8-substituted congeners for 4 institution was shown in *Table* 8. Institution C did not detect 1, 2, 3, 7, 8, 9-HxCDF, 1, 2, 3, 4, 7, 8, 9-HpCDF and OCDF. Institution D did not detect 1, 2, 3, 7, 8, 9-HxCDF.

Mean concentration and % relative standard deviation for 4 institution were shown in *Table* 9.

(4) TEQ Concentration of 2, 3, 7, 8-substituted congeners

TEQ concentration of 2, 3, 7, 8-substituted congeners for 4 institution was shown in *Table* 10. TEQ concentrations were silimar, but a little lower in institution D.

Conclusions

The following results could be drawn from the quality control study performed in 1999 for 4 institution certifed in 1998.

The isokinetic coefficients, the parameter for evaluation of dioxins sampling ability were excellent for all four institutions. They were 100.9%, 102.4%, 102.1% and 99.2%, respectively.

The parameters for evaluation of dioxins analysis ability were good for all 4 institutions. But institutions C and D showed low senstivity for high chlorinated dioxins and institution B exceeded the range of recovery slightly.

References

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3. Estabilished rule of National Institute of Environmental Research, National Institute of Environment (NIER), 1997.
4. Korean Official Method of Air Pollution, Ministry of Environment (MOE), 1996.