Analysis of Discharged Gas from Incinerator using Simulated Organic Solution

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1. Introduction

RI organic solution which is occurred in nuclear power plants as well as hospital, the college of pharmacy and nuclear related industry produce a lot of β -nuclides such as ^{18}F, ^{3}H, ^{14}C, ^{32}P etc. To improve the analytic sensitivity for measuring the activity, liquid scintillator material is widely used and it is combined with organic solvent like benzene, toluene and xylene etc. So this organic waste is highly inflammable and explosive material.

Until now, Korea has no experience of treatment of RI organic waste and appropriate measures for treatment of organic waste did not suggested. RI organic wastes which are occurring in KOREA are stored at the RI waste storage building of KORAD. But they can't no more receive the RI organic waste because the storage facility for RI organic waste was saturated with these organic wastes.

In case of Japan, they recognized the dangerousness of long-term storage for RI organic wastes. Therefore, Science and Technology Agency of Japan established new handling law in 1986. The key clause of the law is that the RI organic waste can be incinerated in the restricted area of the place of origin if the incinerator was designed and produced in accord with the proposed standards and regulations for preventing from dangerousness of incinerator. They revised the law more detailed about the incinerator and also added the strict clause about the dioxin concentration released into the environment in 1996.

In case of Korea, the released concentration of gaseous pollutant from the incinerator is regulated by attached table No.1 of the Notification No. 2012-60 of Nuclear Safety Commission and attached table No.8 of Clean Air Conservation Act. And the dioxin from the incinerator is regulated by attached table No.3 of Persistent Organic Pollutants Control Act.

This experiment was performed to examine whether the incinerator introduced from Japan is manufactured suitably for municipal law regulation and to confirm the compliance about the gaseous pollutant released from incinerator with the above-mentioned laws especially attached table No.1 of NSC using simulated organic waste solution.

2. Configuration of Experimental System

2.1 Design Adequacy of Incinerator Demanded by Municipal Law Regulations

According to design adequacy of the incinerator in Nuclear Energy Commission, Notification No. 2012-60, to operate the incinerator, this facility must meet the several criteria as outlined in the nuclear act such as pre-treatment, exhaust gas treatment, discharged water storage, ash storage, exhaust gas monitoring and ventilation system however it also needs to consider technical side from all angles for applying to actuality because it suggests only sketchy standard of the incineration equipment. Table I shows the specification of incinerator used this experiment is whether it is suitable for design adequacy proposed Notification No. 2012-60.

Table I: Legal requirements of incinerator proposed in Notification No. 2012-60 of NSC and Corresponding Specifications of Incinerator

Notification No. 2012-60 of the NSC	Specification of Incinerator
Protective capacity of fire and explosion	The furnace was made of ceramic castable and its heat-resistant temperature of furnace is 2,000℃ To remove unburned inflammable gases in the furnace, the blower is operated before and after operating
Keeping capability of negative pressure during operation	Down flow of the furnace is op en to the air or the ventilation so inside air of the furnace will nat urally make the down flow and defuse to the air.
Air-tightness for exhaust gas treatment system	Dust-removal filter is installed nearby exhaust pipe and the pipe can be connected with exhaust gas treatment system with PVC pipe

2.2 Specifications of Incinerator

Main specifications of incinerator used in this experiment and drawing of exhaust gases treatment system are shown in Table II and Fig. 1.

Table II: Specifications of Incinerator

Items	Specifications
Capacity	3.0ℓ/h
Waste Pump	constant delivery pump
Material of furnace	Ceramic Castable
Temp. range	800~950℃
Flame Sensor	Flame rod type (current 1~6㎂)
Earthquake detector	100~170Gal
Gas consumption	800~900℃, 16ℓ/min
Power consumption	0.9kW/h
Power supply	AC200V×15A×3P
Size	1,520(W)×715(D)×1,670(H)
Weight	780kg

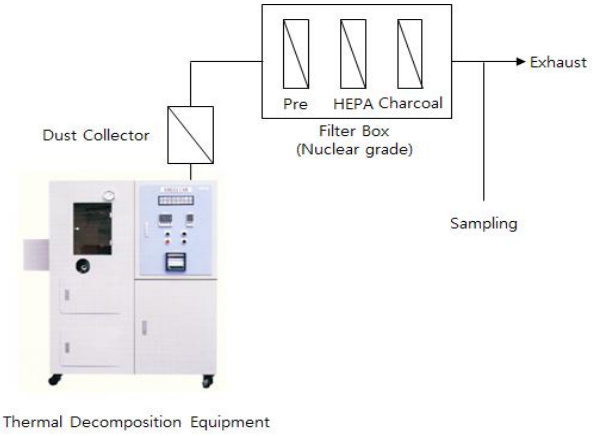

Fig. 1. Schematic diagram of exhaust gas treatment system.

Exhaust gases from incinerator were released through the filter box. Coarse dusts in exhaust gases are removed by a dust removal filter and the filter box is composed of Pre-filter, HEPA-filter and Charcoal filter which are nuclear grade.

2.3 Preparation of Simulated Organic Waste

Simulated organic wastes were prepared by mixing the water, methanol and scintillation liquid(Permafluor E+, PerkinElmer) and the composition of simulated organic waste used in this experiment is shown in Table Ⅲ.

Table Ⅲ: Composition of simulated organic waste used in this experiment

Water (ℓ)	Methanol (ℓ)	Scintillation Liquid (ℓ)	Total (ℓ)
3	3	14	20

2.4 Incinerating, sampling and analysis

At first step, after increasing the inside of reactor temperature up to 800℃ by LPG burning, then 3ℓ/hr of simulated solution injected into the inside of reactor. While operating, the temperature is holding from 800℃ to 930℃ in order to help a perfect combustion.

Fig. 2. Grab Sampling Scene for Releasing Gas

For exhaust gas sampling, detecting and sampling probe was installed in 100mm hole on an exhaust pipe. Dioxin and air pollutants in released gases were analyzed by Korea Environment Corporation and Hitech Environment Co. Ltd. which are authorized agency each.

2.5 Result of analysis

The result of dioxin analysis issued from Korea Environment Corporation is shown in Table Ⅳ.

Table Ⅳ: Analytical Results of Dioxin

Pollutant	Unit	Persistent Organic Pollutants Control Act		Results
Dioxin	Ng-TEQ/Sm³	4ton/hr~	0.1	0.007
		2~4ton/hr	1	
		25kg/hr~ 2ton/hr	5	

Exhaust regulation of Dioxin, regard to all sorts of exhaust facilities is proposed in attached table No.3 of Persistent Organic Pollutants Control Act and exhaust standard of dioxin depends on treatment capacity of exhaust system. The treatment capacity of incinerator used in this experiment is 3ℓ/hr and this incinerator is not object of regulation because it is possible to be subject of exemption in case of that capacity of facilities is less than 25 kg/hr. By the way, the analysis result of dioxin is 0.007ng-TEQ/Sm^3 and less than 0.1ng-TEQ/Sm^3 which is enacted in Exhaust standard. This result shows that dioxin exhaust quantity is very slight level.

If the temperature of exhaust gases could not reduced less than 200℃ by cooling system, dioxin will be regenerated by De-novo synthesis at release path. Therefore exhaust gases have to be reduced less than 200℃ rapidly. Dioxin was not found in this experiment because the temperature of exhaust gases was decreased

less than 50℃ rapidly by a separately designed heat exchanger.

Meanwhile, Exhaust standard of air pollutants is enacted by Clean Air Conservation Act and Notification of Nuclear Safety Commission, but Clean Air Conservation Act applies a provision strictly more than Notification of Nuclear Safety Commission. Table V shows the analysis result of exhaust gases from incinerator issued by Hitech Environment Co. Ltd. in comparison with exhaust standard of air pollutants in Notification of Nuclear Safety Commission and Clean Air Conservation Act.

Table V: Analytical Results for exhaust gas

(a) Gas & Particle

Pollutant	Unit	Notification No. 2012-60 of the NSC	Clean Air Conservation Act	Results
NH_3	ppm	100	30	N/A
CO	ppm	600(12)	200	36.6
Cl_2	ppm	60(12)	-	N/A
SOx	ppm	300(12)	70	N/A
NOx	ppm	200	100	57.4
CS_2	ppm	30	30	N/A
HCHO	ppm	20	10	N/A
H_2S	ppm	15	10	N/A
Benzene	ppm	50	20	N/A
Phenol	ppm	10	10	N/A
As	ppm	3	0.5	N/A
dust	mg/Sm^3	100(12)	70	2.6
Cd	mg/Sm^3	1	0.2	N/A
Pb	mg/Sm^3	5	0.2	N/A
Dusts	mg/Sm^3	0.5	0.5	0.038
Fumes	Ringelman	2°	2°	1

(b) Bad smell

Pollutant	Unit	Notification No. 2012-60 of the NSC	Results
Complex smell	Dilution	500	144
Ammonia	ppm	2	N/A
Methyl mercaptan	ppm	0.0004	N/A
Hydrogen sulfide	ppm	0.06	N/A
Methyl sulfide	ppm	0.05	N/A

3. Conclusions

In this experiment, we examined whether the incinerator was manufactured suitably for municipal law regulation and confirmed the compliance about the gaseous pollutant released from incinerator with the above-mentioned laws using simulated organic waste solution.

The design requirement of incinerator for RI organic waste in the municipal law regulation is proposed briefly but the requirements for more detail about the incinerator are proposed in regulation of Japan. The incinerator used in this experiment is satisfied with all clauses of the domestic as well as Japan.

Multiple safety functions were installed in the incinerator such as air purge system to remove unburned inflammable gases in the furnace and earthquake detector. Also, perfect combustion of RI organic waste is achieved because the temperature in the furnace is controlled from 800℃ to 930℃ using temperature controller.

The concentration of gaseous pollutants released by incinerating simulated organic waste is satisfied with Clean Air Conservation Act, Notification of Nuclear Safety Commission, Persistent Organic Pollutants Control Act and related statute. The incinerator used in this experiment is not object of regulation but the concentration of dioxin released from incinerator, 0.007ng-TEQ/Sm^3, could be ignored because it is just 7%, in comparison with the limit of exhaust standard, 0.1ng-TEQ/Sm^3. This is due to the rapid cooling of exhaust gas using heat-exchanger.

REFERENCES

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