

Guidelines on the Destruction of Halon in Japan

May 2006

Office of Fluorocarbons Control Policy
Global Environment Issues Division
Global Environment Bureau
Ministry of the Environment
Government of Japan

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1. Purpose

Phasing out of halon, one of the ozone depleting substances, was internationally agreed at the Montreal Protocol on Substances that Deplete the Ozone Layer. In order to achieve this objective, the production of halon has been controlled in Japan based on the “Law Concerning the Protection of the Ozone Layer through the Control of Specified Substances and Other Measures” (hereinafter referred to as the “Ozone Layer Protection Law”), and consequently the production of halon was fully phased out in 1994.

With regard to the halon produced in the past and used in the fire extinguishing equipment, etc., “Halon Recycling and Banking Support Committee” (NPO “Syoubou kankyo Network” at present) was established in 2003, and database management, and recovery and recycling of halon have been continuously conducted until now. Increase of halon recovery is anticipated from now as a large number of buildings constructed from 1980s to the early 1990s get to the time for demolition. If the demand of halon continues to be low, the amount of surplus halon is anticipated to grow.

In order to promote the development and utilization of facilities which contribute to the emission control of halon based on the Ozone Layer Protection Law, the Ministry of the Environment has conducted halon destruction experiments with the waste co-combustion method, the cement/lime mixing incineration method, and the liquid injection incineration method from FY 1998 to FY 2000 and FY 2003, and reviewed the feasibility of halon destruction technologies.

The Ozone Layer Protection Law urges the halon user companies to control the emission and rationalize the use. In order to promote recovery and destruction of halon and to rapidly disseminate the halon destruction technologies, these guidelines compile any necessary items to appropriately perform the destruction of halon. This document was developed under the direction of the “Halon Destruction Guidelines Review Commission” based on the experimental results mentioned above.

These guidelines are to be reinforced, if necessary, according to the accumulation of knowledge in the future.

(Members of the Halon Destruction Guidelines Review Commission)

Chairman	Kohei Urano	Prof., Graduate School of Environment and Information Science, Yokohama National Univ.
Members	Yoshiharu Iwasaki	Vice-President, Japan Association of Odor Environment, Lecturer, Faculty of Engineering, Graduate School of Tokyo Univ. of Science
	Hideo Otani	Prof., Graduate School of Environment and Information Science, Yokohama National Univ.
	Shin-ichi Sakai	Prof., Environment Preservation Center, Kyoto Univ.
	Hiroshi Moritomi	Prof., Environmental and Renewable Energy Systems Division, Graduate School of Engineering, Gifu Univ.

2. Current Halon Destruction Technologies and Their Requirements

(1) Current Destruction Technologies

Technologies that contribute to the appropriate destruction of halon are categorized into: (1) technology using a rotary kiln of waste incinerators (cylindrical rotational incinerator) (hereinafter referred to as the “waste co-combustion method”), (2) technology using a rotary kiln incinerator of cement production facilities etc. (hereinafter referred to as the “cement/lime mixing incineration method”), and dedicated fluorocarbons (including halon) destruction technologies such as (3) in-furnace decomposition type liquid injection incineration method and (4) superheated steam reaction method. Requirements for the application of these technologies are compiled below.

The Montreal Protocol specifies that the amount of ozone depleting substances destroyed using the technologies approved by the Meeting of the Parties to the Montreal Protocol may be subtracted from the amount of substances produced. The five approved technologies for halon destruction are as follows: the rotary kiln incineration (included in the waste co-combustion method), the gaseous/fume oxidation, the liquid injection incineration, the argon plasma arc, and the inductively coupled radio frequency plasma.¹

With regard to fluorocarbons, the “Law Concerning the Recovery and Destruction of Fluorocarbons” (hereinafter referred to as the “Fluorocarbons Recovery and Destruction Law”) specifies the destruction methods such as (1) waste co-combustion method, (2) cement/lime mixing incineration method, (3) liquid injection incineration method, (4) plasma methods (the inductively coupled radio frequency plasma method, the microwave plasma method, and the plasma arc method), (5) catalyzer method, and (6) superheated steam reaction method.

(2) Requirements for Destruction Technologies

The halon destruction technologies to be disseminated should generally meet the following requirements:

- 1) High halon destruction and removal efficiency²;
- 2) Ensure to treat and dispose of chlorides, fluorides, bromides, and a trace of toxic by-products in exhaust gasses, effluent water, ashes etc.;
- 3) Easy operation control and stable treatment;
- 4) Facilities with resistance against decomposition products such as chlorides, fluorides and bromides; and
- 5) Reasonable costs of equipment and operation.

¹ Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, UNEP/OzL.Pro.15/9, United Nations Environment Program, 2003.

² “Destruction and removal efficiency (DRE)” is used in this document and the Montreal Protocol related documents, while “removal efficiency” is used in the “Guidelines on the Destruction of CFCs in Japan” in the same meaning.

3. Requirements for Halon Destruction

As mentioned in “2. (2) Requirements for Destruction Technologies,” it is necessary to ensure in practice that halon is efficiently destroyed and that toxic substances are not emitted in a considerable level through the destruction process. Specifically, the following items should be examined or measured and the operation control conditions (refer to “4. Major Destruction Technologies and Their Operation Control Conditions”) shall be reviewed in the case of any inconformity with the requirements, and be corrected to meet the requirements.

(1) Verification of Halon Destruction

- a. The quantity of halon fed for destruction and the halon concentration in the exhaust gas shall be identified. The halon destruction shall be verified based on the destruction and removal efficiency, which is calculated with the following equation.

$$\text{Halon destruction and removal efficiency} = \{1 - (\text{Halon emission}/\text{the quantity of Halon fed})\} \times 100$$

- b. The destruction of halon shall be checked by the halon concentration in the exhaust gas and destruction and removal efficiency, and the condition 1 or 2 indicated below shall be met. Both of the requirements for the halon concentration in the final exhaust gas and the destruction and removal efficiency shall be met in each condition.

	Halon Concentration in the Final Exhaust Gas	Destruction and Removal Efficiency
Condition 1	1 ppm or lower	99% or higher
Condition 2	15 ppm or lower	99.9% or higher

- c. In any facilities that destroy halon on a regular basis, the halon destruction shall be checked according to the previous Paragraph b. at appropriate frequencies depending on the type of facilities (at least once per year). In particular, in introducing the halon destruction technologies into facilities or drastically changing the operation control conditions of combustion temperatures etc., such check shall be assured.

[Explanatory Notes]

- (1) Three kinds of halons – halon 1301, 1211 and 2402 – are used for fire extinguishers. Major physicochemical properties of them are as follows.

Properties of Halons³

Sub-stance	Chemical Formula	Molec. Weight	Melting Point	Boiling Point	Gas Concent.	Liquid Concent.	ODP	GWP	Atmospheric Lifetime
Halon 1301	CBrF ₃	149	-172° C	-57.8° C	6.20g/L (20° C)	1.58g/cm ³ (20° C)	10	6,900	11 years
Halon 1211	CBrClF ₂	165	-159.5° C	-3.7° C	6.86g/L (20° C)	-	3	1,300	65 years
Halon 2402	C ₂ Br ₂ F ₄	260	-110.3° C	47.35° C	-	2.15g/cm ³ (20° C)	6	-	20 years or less

- (2) The quantity of halon fed and the halon emission (= halon concentration in the exhaust gas × dry exhaust gas volume) are required to be identified to verify the halon destruction.
- (3) As for the verification of halon destruction, it is indicated above that either of the two conditions – “halon concentration is 1ppm or lower, and destruction and removal efficiency is 99% or higher” and “halon concentration is 15ppm or lower, and destruction and removal efficiency is 99.9% or higher” – shall be met pursuant to the Standards on the Destruction Performance of Fluorocarbons Destruction Facilities specified in the Enforcement Regulation of the Fluorocarbons Recovery and Destruction Law. The reason why the halon concentration and destruction and removal efficiency are combined is that it is necessary to distinguish between the cases where the halon concentration would be limited to several ppm at most (e.g., in the cement kiln method) and the cases where halon is fed with high concentration (e.g., in the dedicated halon destruction methods).
- (4) The United Nations Environment Program (UNEP) specifies the indicative destruction and removal efficiency of 99.99% for approval of destruction technologies, and stipulates that the daily operation control shall be conducted pursuant to domestic regulations.
- (5) For measurement of the halon concentration, refer to the measurement procedures in the following table.

Items	Measurement Procedures
Halon	<ol style="list-style-type: none"> 1) According to the general rules for gas chromatographic analysis by JIS K 0114, analyze the concentration using an electron capture detector. 2) Introduce a certain known amount of sample gas to the gas chromatographic spectrometer and determine quantity of the sample using the prepared analytical curve.

³ GWP and Atmospheric Lifetime are from IPCC Third Assessment Report: Climate Change 2000. The other data are from the database of the National Institute of Technology and Evaluation. Gas concentrations are calculated from molecular weights.

(2) Measurement of Toxic Substances

- a. It shall be verified that the exhaust gas emitted from the halon destruction facilities meet the standards specified by the applicable laws and regulations. The following items which could generate or increase through the halon destruction shall be measured.
 - 1) Concentration of carbon monoxide (CO) in the final exhaust gas
 - 2) Concentration of hydrogen chlorides (HCl) in the final exhaust gas
 - 3) Concentration of hydrogen fluorides (HF) in the final exhaust gas
 - 4) Concentration of hydrogen bromides and bromine (HBr+Br₂) in the final exhaust gas (converting to the bromine concentration)
 - 5) Concentration of dioxins in the final exhaust gas
 - 6) Concentration of PFC (perfluorocarbon) in the final exhaust gas
 - 7) Concentration of hydrogen ions in effluent water
 - 8) Concentration of fluorine in effluent water
 - 9) Concentration of dioxins in effluent water
 - 10) Concentration of chrome in effluent water
 - 11) Concentration of hexavalent chromium compounds in effluent water (converting to the hexavalent chromium concentration)
 - 12) Concentration of nickel in effluent water, and
 - 13) Concentration of dioxins in solid waste (sludge)
- b. The measurements shall be pursuant to the procedures set in the applicable laws and regulations and the standards such as the Japanese Industrial Standards (JIS).
- c. The measurements as prescribed in Paragraph a. shall be conducted at least once per year in addition to those required in the applicable laws and regulations. Furthermore, in introducing the halon destruction technologies into facilities or drastically changing the operation control conditions of combustion temperatures etc. such check shall be assured.
- d. With regard to “10) Concentration of chrome in effluent water,” “11) Concentration of hexavalent chromium compounds in effluent water,” and “12) Concentration of nickel in effluent water,” the measurement shall be conducted in the case where a destruction method in which corrosion of equipment, pipes, etc., is likely to occur in high probability is adopted.

[Explanatory notes]

- (1) Due to its persistency, halon would not be effectively decomposed and other by-products such as halide would be generated unless operation control conditions including the combustion temperature and the amount of oxygen are kept appropriately per destruction methods. These Guidelines, therefore, specify measurement items required for such halon destruction facilities in the light of verification that the facilities meet the judgment standards for exhaust gas specified by the “Document which is Encouraged to be Submitted for the Judgment of the Minister of the Environment (Guidebook for the Operation of Fluorocarbons Destruction, Ed. 6)” of the “Fluorocarbons Recovery and

Destruction Law” and the emission standards for toxic substances specified by the applicable laws and regulations for air pollution control etc., as well as in the light of checking the safety of halon destruction.

In the measurement, it is essential that the compliance with the standards shall be checked based on the destruction data of the most hard-to-destroy substance i.e., halon 1301, under the operational condition for any kind of halon (halon 1301, 1211 or 2402). In the case where the operation control condition is changed according to the kind of halon, the compliance shall be checked based on the data for each condition, considering that the toxic substances generated differ depending on the kind of halon.

- (2) The standards to be referred for each measurement item are indicated in the following table. As for the effluent water and sludge, compliance with the standards shown below shall be verified even after a considerable operation period has passed, because the exhaust gas cleaning water is recycled in the exhaust gas treatment system.

Standards to be referred

	Standard values	Laws and Regulations
1) Carbon monoxide (CO) concentration in the final exhaust gas	< 100mg/Nm ³	Guidebook for the Operation of Fluorocarbons Destruction ⁴
2) Hydrogen chlorides (HCl) concentration in the final exhaust gas	< 100mg/Nm ³	Guidebook for the Operation of Fluorocarbons Destruction
3) Hydrogen fluorides (HF) concentration in the final exhaust gas	< 5mg/Nm ³	Guidebook for the Operation of Fluorocarbons Destruction
4) Hydrogen bromides and bromine (HBr+Br ₂) concentration in the final exhaust gas (converting to the bromine concentration)	< 5mg/Nm ³	Exhaust gas standards recommended by UNEP Advisory Committee on Destruction Technologies
5) Dioxins concentration in the final exhaust gas	1.0ng-TEQ/Nm ³ 0.1ng-TEQ/Nm ³ (Newly constructed waste incinerator with burning capacity of 4,000kg/hr or higher)	Guidebook for the Operation of Fluorocarbons Destruction, Special Dioxins Measures Law
6) PFC concentration in the final exhaust gas	1ppm or lower, or 15ppm or lower	Guidebook for the Operation of Fluorocarbons Destruction

⁴ Guidebook for the Operation of Fluorocarbons Destruction (Ed. 6), the Fluorocarbons Recovery and Destruction Law, March/24/2006, Ozone Layer Protection Policy Office, Manufacturing Industries Bureau, the Ministry of Economy, Trade and Industry / Office of Fluorocarbons Control Policy, Global Environment Issues Division, Global Environment Bureau, the Ministry of the Environment. (II.1.(5) The Document which is Encouraged to be Submitted for the Judgment of the Minister of the Environment)

7) Hydrogen ions concentration (pH) in the final exhaust gas	5.8 - 8.6	Guidebook for the Operation of Fluorocarbons Destruction
8) Fluorine concentration in effluent water	8mg/L	Guidebook for the Operation of Fluorocarbons Destruction
9) Dioxins concentration in effluent water	10pg-TEQ/L	Guidebook for the Operation of Fluorocarbons Destruction
10) Chrome concentration in effluent water	2mg/L	Guidebook for the Operation of Fluorocarbons Destruction
11) Hexavalent chromium compounds concentration in effluent water (converting to the hexavalent chromium concentration)	0.5mg/L	Water Pollution Control Law
12) Nickel concentration in effluent water	0.1mg/L	Guidebook for the Operation of Fluorocarbons Destruction
13) Dioxins concentration in solid waste (sludge)	3ng-TEQ/g	Guidebook for the Operation of Fluorocarbons Destruction

- (3) If any toxic substances that are not specified herein or any halide other than the destroyed halon are potentially generated through the halon destruction, such byproducts including phosgene and chlorides in the final exhaust gas shall also be measured.

In particular, CFC (chlorofluorocarbon) 12 can be generated as a byproduct in the destruction of halon 1211. In the facilities where the destruction of CFC12 is not verified, the CFC12 concentration in the final exhaust gas should be measured, and be verified to meet the standards of fluorocarbons content in the exhaust gas in the Standards on the Destruction Performance of Fluorocarbons Destruction Facilities specified in the Fluorocarbons Recovery and Destruction Law. More specifically, it should be verified that the CFC12 concentration is 1ppm or lower in the case where the halon destruction is checked according to the condition 1 indicated in Paragraph 3. (1) b., or 15ppm or lower in the case it is done according to the condition 2.

- (4) PFC14 and PFC116 can be generated as byproducts in the destruction of any kind of halon. The concentrations of PFC14 and PFC116 in the final exhaust gas should be measured, and be verified to meet the equivalent standards of fluorocarbons content in the exhaust gas in the Standards on the Destruction Performance of Fluorocarbons Destruction Facilities specified in the Fluorocarbons Recovery and Destruction Law. More specifically, it should be

verified that the sum of the concentrations of PFC14 and PFC116 is 1ppm or lower in the case where the halon destruction is checked according to the condition 1 indicated in Paragraph 3. (1) b., or 15ppm or lower in the case it is done according to the condition 2. Then, if necessary, improvement of the exhaust gas treatment system or modification of the operational conditions should be conducted.

- (5) In the light of ensuring safety, the concentration of toxic substances in the exhaust gas should not increase considerably through halon destruction which is accompanied with co-combustion of wastes with the waste co-combustion method (rotary kilns method) or calcination of cement with the cement/lime mixing incineration method (cement kilns method).
- (6) The facilities regulated by the domestic laws and regulations are required to verify that they meet the applicable standards for the concentration of toxic substances in the exhaust gas or the effluent water.
- (7) Some facilities with dedicated halon destruction technologies including the liquid injection incineration method and the superheated steam reaction method may have a lower position of discharging the exhaust gas, and therefore have smaller diffusion and dilution effects. In this case, the concentration of toxic substances in the atmosphere around the facility concerned should meet the occupational environment standards provided by the Industrial Safety and Health Law and the tolerable concentration recommended by the Japan Society of Occupational Health, as an indicative index for verification of the concentration of toxic substances in the exhaust gas.
- (8) In introducing the halon destruction technologies into facilities or drastically changing the operation control conditions of combustion temperatures etc., if a destruction method in which corrosion of equipment, pipes, etc., is likely to occur in high probability is adopted, the concentrations of chrome, hexavalent chromium compounds and nickel should be measured and compliance with the effluent standards should be verified.
- (9) When destroying halon in high temperature, there is a concern that brominated dioxins and brominated/chlorinated dioxins are generated. At the present time it is difficult to measure each of these isomers. Therefore, it is desirable that organic bromine with high boiling point, bromine in brominated dioxins and brominated/chlorinated dioxins and other appropriate indexes should be measured instead of each of the isomers, and whether brominated dioxins and brominated/chlorinated dioxins are emitted or not with the amount equivalent to or more than the values specified by the emission standards on chlorinated dioxins should be verified.
- (10) The United Nations Environment Program (UNEP) Ad-hoc Technical Advisory Committee on ODS Destruction Technologies recommends to the Meeting of the Parties to the Montreal Protocol, the standards for the concentration of toxic substances in the exhaust gas. It is desirable to take measures including improvement of facilities and adjustment of operation control conditions, if

necessary, in order to meet the standards recommended by UNEP unless the domestic laws specify the similar standards.

(11) For measurement of toxic substances, refer to the measurement procedures in following table.

Measurement Procedures of Toxic Substances

Items	Measurement Procedures
Carbon monoxide (CO)	1) Continuously measure the CO concentration under the infrared absorption method of the analysis method classification provided by JIS K 0098-88, or measure under the detection tube method and the like. Record the measurements. 2) To collect the sample gas, fill the silica wool in a stainless sampling tube, and continuously introduce exhaust gas. After cooling, removing moisture and dusts, introduce the gas as dry gas into the automatic measurement equipment.
Hydrogen chloride (HCl)	1) Measure HCl under the analysis method for hydrogen chloride in exhaust gas provided by JIS K 0107. 2) Analysis procedure: a. Ion chromatography analysis: Let the hydrogen chloride in the sample gas absorbed into water, introduce it to the ion chromatography, and record the chromatogram. b. Silver nitrate titration method: Let the hydrogen chloride in the sample gas absorbed into sodium hydroxide solution, acidify it weakly, add silver nitrate solution, and titrate it with ammonium thiocyanate solution. c. Ion electrode method: Let the hydrogen chloride in the sample gas absorbed into potassium nitrate solution, add acetate buffer fluid, and measure it with chloride ion electrodes. d. Ion electrode continuous analysis method: Let the hydrogen chloride in the sample gas absorbed into absorbent continuously, and measure it with chloride ion electrodes.
Hydrogen fluoride (HF)	1) Measure HCl under the analysis method for fluorine compound in exhaust gas provided by JIS K 0105. 2) Analysis procedure: a. Lanthanum - alizarin complex absorption photometry method: Let the fluorine compound in the sample gas absorbed into absorbent, and adjust its pH by adding buffer fluid. Add lanthanum solution, alizarin complex solution and acetone to color the solution, and measure the absorbance. b. Ion electrode method: Let the fluorine compound in the sample gas absorbed into absorbent, add buffer solution for ion strength adjustment, and measure it with fluoride ion electrodes.
Hydrogen bromide and bromine (HBr+Br ₂)	1) Measure HBr+Br ₂ under the analysis method for bromine in exhaust gas provided by JIS K 0085. 2) Analysis procedure: a. Thiosulfuric acid titration method: Let the bromine compound in the sample gas absorbed into sodium hydroxide solution, oxidize it with sodium hypochlorite solution into bromate ion, deoxidize the excess hypochlorite with sodium formate, and titrate this bromate ion with thiosulfate. b. Mercuric thiocyanate (II) absorption photometry method: Let the bromine compound in the sample gas absorbed into sodium hydroxide solution and acidify it. After oxidize it with potassium permanganate solution, extract it with carbon tetrachloride. Add

	water, ferrous sulfate (III) ammonium solution and mercuric thiocyanate (II) solution to the carbon tetrachloride layer, and measure the absorbance of the colored water layer.
CFC PFC	(1) According to the general rules for gas chromatographic analysis by JIS K 0114, analyze CFC and PFC using an electron capture detector. (2) Introduce a certain known amount of sample gas to the gas chromatographic spectrometer and determine the quantity of the sample using the prepared analytical curve.
Chloride (Cl ₂)	1) Measure Cl ₂ under the analysis method for chlorine in exhaust gas provided by JIS K 0106. 2) Analysis procedure: a. 2,2'-amino-bis (3-ethylbenzothiazoline-6-sulfonic acid) absorption photometry method (ABTS method): Let the chlorine in the sample gas absorbed into 2,2'-amino-bis (3-ethylbenzothiazoline-6-sulfonic acid) absorbent to color the solution, and measure the absorbance (400 nm). b. 4-pyridinecarboxylic acid-pyrazolone absorption photometry method (PCP method): Let the chlorine in the sample gas absorbed into p-toluenesulfonamide absorbent, add potassium cyanide solution, color the solution with 4-pyridinecarboxylic acid-pyrazolone solution, and measure the absorbance (638 nm). c. Dichloride 3,3'-dimethyl benzene absorption photometry method (o-tolidine absorption metric method): Let the chlorine in the sample gas absorbed into dichloride 3,3'-dimethyl benzene (o-tolidine) absorbent, and measure the absorbance (435 nm) of the colored solution obtained.
Phosgene (COCl ₂)	1) Measure COCl ₂ under the analysis method for phosgene in exhaust gas provided by JIS K 0090. 2) Analysis procedure: Diphenylurea ultraviolet spectrophotometric method: Let the phosgene in the sample gas absorbed into absorbent, extract the formed diphenylurea with solvent, and measure the absorbance (257 nm) of the extract.
Fluorine	1) Measure fluorine under the lanthanum - alizarin complexion absorption photometry method provided by JIS K 0102-34. 2) Analysis procedure: Dilute the sample, and add the lanthanum - alizarin complexion solution to color the extract. Measure the absorbance at the wave length of around 620 nm.
Hydrogen ion concentration (pH)	1) Measure the hydrogen ion concentration under the glass electrode method provided by JIS K 0102-93. 2) Analysis procedure: Rinse the detection part of the constructed pH meter. Dip the detection part in the sample to measure the concentration.
Chromium	1) Measure Cr under the measuring method of the total quantity of chromiums with different valencies provided by JIS K 0102-1998. 2) Analysis procedure: a. Diphenylcarbazide absorption photometry method: Oxidize chromium (III) with potassium permanganate into chromium (VI), add 1,5- diphenylcarbonohydrazide (diphenylcarbazid), and determine the total quantity of chromiums by measuring the absorbance of the formed red-violet complex. b. Flame atomic absorption spectrometry method: After the pretreatment of the sample, spray it into acetylene-air flame and the like, and determine the total quantity of chromiums by

	<p>measuring atomic absorption of chromium at the wave length of 357.9 nm.</p> <p>c. Electrothermal atomic absorption spectrometry method: After the pretreatment of the sample, atomize it in an electric heating furnace, and determine the total quantity of chromiums by measuring atomic absorption of chromium at the wave length of 357.9 nm.</p> <p>d. Inductively coupled plasma atomic emission spectroscopy method: After the pretreatment of the sample, spray it through the sample introduction part into inductively coupled plasma, and determine the total quantity of chromiums by measuring atomic emission of chromium at the wave length of 206.149 nm.</p> <p>e. Inductively coupled plasma mass spectrometry method: After the pretreatment of the sample, add internal standard substance, spray it through the sample introduction part into inductively coupled plasma, measure ion currents of the chromium and internal standard substance at each mass/ charge number ratio, and determine the total quantity of chromiums by calculating the ratio of ion currents of the chromium and internal standard substance.</p>
Hexavalent chromium compounds	<p>1) Measure hexavalent chromium compounds under the chromium (VI) measuring method provided by JIS K 0102-1998.</p> <p>2) Analysis procedure:</p> <p>a. Diphenylcarbazide absorption photometry method: Add 1,5-diphenylcarbonohydrazide (diphenylcarbazid) to the sample, and determine the quantity of chromium (VI) by measuring the absorbance of the formed red-violet complex.</p> <p>b. Flame atomic absorption spectrometry method: After the pretreatment of the sample, spray it into acetylene-air flame and the like, and determine the quantity of chromium (VI) by measuring atomic absorption of chromium (VI) at the wave length of 357.9 nm.</p> <p>c. Electrothermal atomic absorption spectrometry method: After the pretreatment of the sample, atomize it in an electric heating furnace, and determine the quantity of chromium (VI) by measuring atomic absorption of chromium (VI) at the wave length of 357.9 nm.</p> <p>d. Inductively coupled plasma atomic emission spectroscopy method: After the pretreatment of the sample, spray it through the sample introduction part into inductively coupled plasma, and determine the quantity of chromium (VI) by measuring atomic emission of chromium at the wave length of 206.149 nm.</p> <p>e. Inductively coupled plasma mass spectrometry method: After the pretreatment of the sample, add internal standard substance, spray it through the sample introduction part into inductively coupled plasma, measure ion currents of the chromium and internal standard substance at each mass/ charge number ratio, and determine the quantity of chromium (VI) by calculating the ratio of ion currents of the chromium and internal standard substance.</p>
Nickel	<p>1) Measure nickel under the nickel measuring method provided by JIS K 0102-1998.</p> <p>2) Analysis procedure:</p> <p>a. Dimethylglyoxime absorption photometry method: Add citrate to the sample, alkalize it weakly with ammonia water, add 2,3-butandiondioxim (dimethylglyoxime), extract the formed nickel complex with chloroform, back-extract it with dilute hydrochloric acid. Oxidize the nickel by adding bromine and</p>

	<p>ammonia water to the extract, add 2,3-butandiondioxim again, and determine the quantity of nickel by measuring the absorbance of the formed red-brown nickel complex.</p> <p>b. Flame atomic absorption spectrometry method: After the pretreatment of the sample, spray it into acetylene-air flame and the like, and determine quantity of nickel by measuring atomic absorption of nickel at the wave length of 232.0 nm.</p> <p>c. Inductively coupled plasma atomic emission spectroscopy method: After the pretreatment of the sample, spray it through the sample introduction part into inductively coupled plasma, and determine the quantity of nickel by measuring atomic emission of nickel at the wave length of 221.647 nm.</p>
Dioxins	<p>1) Measure dioxins under the measuring method of dioxins and coplanar PCB provided by JIS K 0311 and JIS K 0312, or the method specified by the Bioassay Method Manual for Dioxins (issued by the Dioxins Control Office, Environmental Management Bureau of the Ministry of the Environment on September 14, 2005).</p> <p>As for the methods described in 2) b. and c. below, the measuring objects are only exhaust gas and ash dust (these methods are not for effluent water and sludge), and the methods are applied only to waste incinerators with burning capacity of less than 2,000kg/hr.</p> <p>2) Analysis procedure:</p> <p>a. Gas chromatography mass spectrometry method: Collect dioxins and coplanar PCB in the exhaust gas by filtration using a filter pursuant to JIS Z 8808, absorption using an absorption bulb (impinger), and adsorption using an adsorption column. After extracting them from these collection apparatuses, clean them up, and determine the quantity by fixing them using the gas chromatography mass spectrometer (GC/MS),.</p> <p>b. After the pretreatment of the sample using a nitrate-impregnated silica gel column and activated carbon column, measure the toxicity equivalence quantity of dioxins by reporter gene assay.</p> <p>c. After the pretreatment of the sample using a multilayer silica gel column and carbon column, measure the toxicity equivalence quantity of dioxins by solid-phase antigen - enzyme immunity reaction using an anti-dioxins monoclonal antibody, standard for creation of analytical curve and plate solid-phase antigen.</p>
Bromine in dioxins ⁵ Organic bromine with high boiling point ⁶	<p>1) Fractionate rough extraction liquid for dioxins measurement, introduce it into a nitrate-impregnated silica/silica gel column, and concentrate it to 200 to 500μl.</p> <p>2) Burn the concentrated extract, introduce the absorbent into the ion chromatograph, and determine the quantity of it.</p>

⁵ “Instruction Manual on Simplified Measuring Methods for Dioxins in Soil” compiled by Incorporated Administrative Agency Public Works Research Institute, Kajima Institute Publishing Co., Ltd.

⁶ With regard to the measurement of bromine with high boiling point, omit the procedure of “introduce it into a nitrate-impregnated silica/silica gel column ” in 1).

[Reference] Standards for the Toxic Substances Specified in the Applicable Laws and Regulations

- Standards for Exhaust Gas, etc. under the Guidebook for the Operation of Fluorocarbons Destruction

Exhaust Gas

Items	Standards
Carbon monoxide (CO) concentration	< 100mg/Nm ³
Hydrogen chloride (HCl) concentration	< 100mg/Nm ³
Hydrogen fluoride (HF) concentration	< 5mg/Nm ³

Effluent Water

Items	Standards
Hydrogen ion concentration (pH)	5.8-8.6
Fluorine content	8mg/L
Chrome concentration	2mg/L
Nickel concentration	0.1mg/L

Dioxins

Items	Standards
Exhaust gas	1.0ng-TEQ/Nm ³
Effluent water	10pg-TEQ/L
Sludge	3ng-TEQ/g

- Emission Standards for Ash Dust under the Air Pollution Control Law (waste incinerators such as the rotary kiln, and cement kilns)

Substance	Waste Incinerator ¹⁾	Calcination and Fusion Furnace Used for Ceramic Manufacture ²⁾
Ash Dust	0.04g/Nm ³ (Burning capacity of 4,000 kg/hr or higher) 0.08g/Nm ³ (Burning capacity of not less than 2,000 kg/hr to less than 4,000 kg/hr) 0.15g/Nm ³ (Burning capacity below 2000 kg/hr)	0.10g/Nm ³ 0.05g/Nm ³ (special emission standard ³⁾)
Hydrogen chloride	700mg/Nm ³	-
Nitrogen oxide	250ppm	250ppm (emission of 100,000 Nm ³ /hr or higher) 350ppm (emission below 100,000 Nm ³ /hr)
Sulfuric oxide	According to the K-value ⁴⁾	According to the K-value ⁴⁾

1) Waste incinerators with the fire grate area of 2 m² or larger, or with the burning capacity of 200 kg/hr or higher

2) Furnaces with the fire grate area of one square meter, or with burner's burning capacity of 50 /hr

- converting to heavy oil, or otherwise, the specific capacity of the transformer of 200 kVA or higher
- 3) Applied to facilities in the areas listed in the Enforcement Regulations of Air Pollution Control Law.
 - 4) Use the K-Value specified for each area listed in the Enforcement Regulations of Air Pollution Control Law, and calculate q according to the equation below.

$$q = K \times 10^{-3} He^2$$

q: Quantity of sulfur oxides (cubic meter/hr converting to the value at 0° C, 1atm)

K: Value specified for each area

He: Height of the outlet corrected (meter)

- Emission Standards for Waste Incinerators under the Law Concerning Special Measures against Dioxins

Exhaust Gas

Capacity of Combustion Chamber	Standards for New Facilities	Standards for Existing Facilities
4,000kg/hr or higher	0.1ng-TEQ/Nm ³	1 ng-TEQ/Nm ³
Not less than 2,000kg/hr to less than 4,000kg/hr	1 ng-TEQ/Nm ³	5 ng-TEQ/Nm ³
Below 2,000kg/hr	5 ng-TEQ/Nm ³	10 ng-TEQ/Nm ³

Effluent Water

Facilities	Standards
Facilities for treatment of gas from waste incinerators (exhaust gas scrubbing systems and wet dust collecting systems), and retention facilities of ash which discharge waste water or waste fluid	10pg-TEQ/L
Facilities used for fluorocarbons destruction* (plasma reaction systems, exhaust gas scrubbing systems and wet dust collecting systems)	10pg-TEQ/L

*Applied only to the waste co-combustion method, liquid injection incineration method, plasma method, and superheated steam reaction method.

The Waste Management Law specifies the maintenance and control standards for dioxins from waste incinerators as the same values listed in the table above. The Ambient Environment Guidelines specify the standards for dioxins in the air of 0.6 pg-TEQ/m³ in annual average.

- Effluent Water Standards under the Water Pollution Control Law

Substance	Standards
Concentration of hydrogen ions (pH)	Not less than 5.8 to not more than 8.6 (Effluent water discharged to public water except the ocean) Not less than 5.0 to not more than 9.0 (Effluent water discharged to the ocean)
Fluorine	8mg/L (Effluent water discharged to public water except the ocean) 15mg/L (Effluent water discharged to the ocean)
Chrome	2mg/L
Hexavalent chromium	0.5mg/L

- Occupational Environment Standards under the applicable laws and regulations

Substance	Standards	
Hydrogen chloride	Tolerable concentration recommended by JSOH Tolerable concentration set by ACGIH	5 ppm or 7.5 mg/m ³ 2 ppm (STEL)
Hydrogen fluoride	Controlled concentration for the Occupational Environment Standards of the Industrial Safety and Health Law Tolerable concentration recommended by JSOH Tolerable concentration set by ACGIH	2 ppm 3 ppm or 2.5 mg/m ³ 0.5ppm (TWA) 2ppm (STEL)
Chloride	Controlled concentration for the Occupational Environment Standards of the Industrial Safety and Health Law Tolerable concentration recommended by JSOH Tolerable concentration set by ACGIH	0.5 ppm 0.5ppm or 1.5 mg/m ³ 0.5ppm (TWA) 1ppm (STEL)
Hydrogen bromide	Tolerable concentration set by ACGIH	2ppm (STEL)
Bromine	Tolerable concentration recommended by JSOH Tolerable concentration set by ACGIH	0.1ppm or 0.65 mg/m ³ 0.1ppm (TWA) 0.2ppm (STEL)
Phosgene	Tolerable concentration recommended by JSOH Tolerable concentration set by ACGIH	0.1 ppm or 0.4 mg/m ³ 0.1ppm (TWA)
Dioxins	Prevention Countermeasures for Dioxins Exposure in Occupation at Waste Incinerator Facilities (Notification by the Ministry of Health, Labour and Welfare)	2.5 pg-TEQ/m ³

JSOH: Japan Society of Occupational Health

STEL (Short Time Exposure Level)

TWA (Time Weight Average)

- Exhaust Gas Standards recommended by the UNEP Ad-hoc Technical Advisory Committee on ODS Destruction Technologies

Substance	Standards
PCDD/PCDF	< 1.0ng-TEQ/Nm ³
HCl	< 100mg/Nm ³
HF	< 5mg/Nm ³
HBr/Br ₂	< 5mg/Nm ³
Particulates	< 50mg/Nm ³
CO	< 100mg/Nm ³

(3) Measurement of Operation Control Conditions

- a. In order to verify the operation control conditions for each destruction method as provided in “4. Major Destruction Technologies and Their Operation Control Conditions,” the following items shall be measured:
 - 1) Feeding quantity of halon
 - 2) Physical conditions of the portions in the facilities where halon is destroyed, including the temperatures of combustion, or calcination and reaction
 - 3) Exhaust gas volume after treatment
 - 4) Concentration of carbon monoxide (CO) in the exhaust gas
 - 5) Concentration of oxide (O₂) at the outlet of the incinerator or the secondary combustion chamber
- b. The measurements shall be conducted at practical portions in terms of the structure of each facility. The measurements shall be pursuant to the procedures set in the applicable laws and regulations and the standards such as the Japan Industrial Standards (JIS).
- c. The measurements as provided in Paragraph a. shall be conducted on a daily basis.
- d. With regard to “5) Concentration of oxide (O₂) at the outlet of the incinerator or the secondary combustion chamber,” measurement shall be conducted in the case where the principle of halon destruction is thermal decomposition by incineration.

[Explanatory Notes]

- (1) The gas retention time, one of the operation control conditions, is calculated as follows:

$$\text{Gas retention time (sec)} = \frac{\text{Furnace volume [m}^3\text{]} \times 3,600}{\{\text{Wet exhaust gas amount [Nm}^3\text{/hr]} \times (273.15 + \text{Furnace temperature [}^\circ\text{C]}) / 273.15\}}$$

- (2) For the measurement of the operation control items, see the measurement procedures in the table below.

● Measurement Procedures for Operation Control Conditions

Items	Measurement Procedures
Temperature	1) Insert the K-type thermo couple to reference points. Record measurements continuously throughout the experiment. 2) For recorded values, calculate the maximum, minimum and average values (use K-type 3.2mmφ sheath and L = 1m).

Exhaust gas flow velocity/rate (1)	<ol style="list-style-type: none"> 1) Measure the exhaust gas flow velocity/rate according to JIS Z 8808-7. 2) Measure the flow velocity at the measurement points specified by JIS Z 8808-4.3 using a special pitot tube (western type). Calculate both wet and dry exhaust gas flow rates using the formula specified by paragraphs 7.4.1 and 7.4.2 of JIS Z 8808-4.3.
Exhaust gas flow velocity/rate (2)	<ol style="list-style-type: none"> 1) Measure the exhaust gas flow velocity/rate under the pitot tube method as per JIS Z 8808-7. Insert the sensor of the hot-wire anemometer into the position indicating an average flow velocity to measure and record the flow velocity. 2) Similarly, use the exhaust gas temperatures measured continuously, and calculate a wet exhaust gas flow rate using the formula provided by JIS Z 8808-7.4. 3) In addition, correct the moisture in the exhaust gas to obtain a dry exhaust gas flow rate.
Carbon monoxide (CO)	<ol style="list-style-type: none"> 1) Continuously measure the CO concentration under the infrared absorption method of the analysis method classification provided by JIS K 0098-88, or measure under the detection tube method and the like. Record the measurements. 2) Collect the sample gas similarly to the method for oxygen below.
Oxygen (O ₂)	<ol style="list-style-type: none"> 1) Measure the O₂ concentration under the continuous analysis method (the magnetic oxygen automatic meter specified by JIS B 7983) of the analysis method classification provided by JIS K 0301-3. 2) To collect the sample gas, fill the silica wool in a stainless sampling tube, and continuously introduce exhaust gas. After cooling, removing moisture and dusts, introduce the gas as dry gas into the automatic measurement equipment.

4. Major Destruction Technologies and Their Operation Control Conditions

In order to perform appropriate halon destruction, it is necessary to meet the requirements of selection of facilities and operation control conditions etc. for each type of halon destruction technologies.

(1) Waste Co-Combustion Method (Rotary Kiln Method)

a. Selection of Facilities

- (a) The facility shall be equipped with an appropriate exhaust gas treatment system including an anti-ash dust device such as a filter type dust collector and an acid gas treatment device such as a cleansing tower so that it meets the standards for concentration of ash dusts and toxic substances such as hydrogen chlorides generated due to the feeding of halon. The exhaust gas treatment system should be preferably designed to cool down heated combustion gas as soon as possible.
- (b) If the facility concerned discharges effluent water, it shall be equipped with an appropriate effluent treatment system so that it meets the standards for content of fluorides and concentration of hydrogen ion, etc. as provided by the applicable laws and regulations.
- (c) It shall be equipped with a system to properly deliver and discharge incineration ash dusts so that it prevents their influences on combustion conditions.
- (d) Equipment for feeding halon shall consist of valves, a flow meter and other relevant devices to feed halon quantitatively.

b. Operation Control Conditions

- (a) It is necessary to operate the incinerator so that successful destruction of halon and safe control of exhaust gas are ensured. It shall be verified in principle that halon gas retention time is 1.5 seconds or longer, gas temperature at the furnace outlet is 850°C or higher, and these conditions have consistency with the conditions of measurement of the destruction and recovery efficiency, etc.

c. Halon Feeding Conditions

- (a) Halon shall be sprayed at the position close to the burner under the normal operation control conditions.
- (b) The quantity of halon to be fed shall be properly controlled according to its flow rate.
- (c) Wastes co-combusted with halon shall have homogenous property as much as possible.
- (d) The quantity of halon to be fed shall be determined taking into account the destruction and removal efficiency of halon and the halide treatment capacity of the exhaust gas treatment system. In principle, the quantity of halon should be around 1.5% of the wastes to be co-combusted.

- (e) If fluorocarbons are fed with halon, the total quantity of halon and fluorocarbons to be fed shall not exceed 3% (1.5% for halon alone) of the wastes to be co-combusted. The quantity shall be determined taking into account the destruction and removal efficiency of halon and fluorocarbons, the generation condition of toxic substances, and the halide treatment capacity of the exhaust gas treatment system.

[Explanatory Notes]

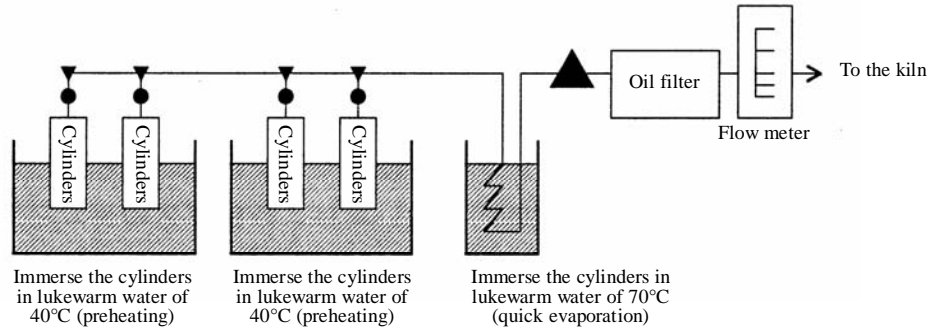
- (1) Standards for the Structure of Fluorocarbons Destruction Facilities in the Fluorocarbons Recovery and Destruction Law specify that the facilities should be equipped with the devices listed in the table below according to the types of fluorocarbons destruction facilities.

Types of Fluorocarbons Destruction Facilities	Devices
Facility adopting the waste co-combustion method	1 Combustion device 2 Fluorocarbons feeding device 3 Combustion improver feeding device 4 Air feeding device 5 Measuring device required for operation and control 6 System to treat the exhaust gas and other substances generated by the destruction

- (2) Specifications of halon cylinders are different from those of fluorocarbons recovery cylinders, and the caps of halon cylinders differ depending on their manufacturers. Therefore, it is required to prepare a proper connection valve in advance.
- (3) Though the filling pressures of fluorocarbons recovery cylinders do not exceed 1MPa at ambient temperature generally, the standard filling pressure of halon cylinders used in fire extinguishing equipment reaches 4.2MPa in the case of halon 1301. Thus, the pipes, flow meter, etc. used for halon feeding should have specifications conforming to the high feeding pressure of halon. Furthermore, the indicated value of the flow meter should be corrected according to the gas density, pressure, temperature, etc. for each kind of halon so that the flow rate of halon should be measured accurately.
- (4) The general way of feeding halon 1301 and 1211 is to connect the high-pressured gas cylinder with the inlet via a flow meter and feed halon constantly by the cylinder's own pressure. In the case of feeding a large volume of halon, it is necessary to provide heat equal to the latent heat to secure its supply pressure, because the vaporization will cool the cylinder by consuming the latent heat around it. Some devices for soaking the gas cylinder in a hot tub or heating the cylinder in a thermostatic chamber filled with steam are required, because the halon fed will be a considerable volume even if the feeding rate is as low as 1.5%, in the case of destruction using a

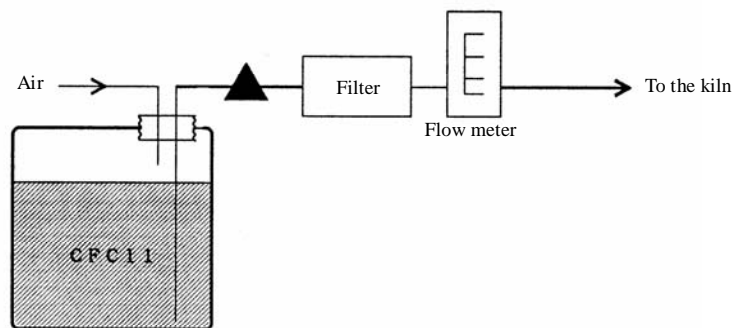
waste incinerator. The figure below is an example of feeding device where the cylinders are soaked in a hot tub at the temperature of 40° C or lower.

(Example of Feeding System)



- (5) Because halon 2402 is liquid at ambient temperatures, an easy way of feeding it constantly is to press air into the tank filled with halon 2402, or to suck the halon using a liquid supply pump. In this case, the opening of the container shall be equipped with two pipes as illustrated below. For the first pipe, one end shall be connected with the inlet of pressing air, while the other end shall not reach the liquid surface of halon 2402. For the second pipe, one end shall reach near the bottom of the container, while the other end shall be connected with the inlet of the kiln via an oil filter and a flow meter. When air is pressed into the tank, the pressure capacity of the containers should be checked. Furthermore, the indicated value of the flow meter should be corrected according to the liquid density, etc. for each kind of halon so that the flow rate of halon should be measured accurately.

(Example of Feeding System)



- (6) Irrespective of the kind of halon, the flow rate of halon is apt to become unstable due to the phase change from liquid to gas, and vice versa in the feeding process. Therefore, some countermeasures to stabilize the flow rate are required – for example, vaporizing the halon fully by providing heat at the upstream of the flow meter as mentioned in (4), or preventing the liquid halon

in the cylinder from entering the feeding device by turning the cylinder upside down.

Furthermore, it is desirable to take measures to verify the feeding quantity – for example, continuously recording the weight of the cylinder by setting it on a scale when the halon is fed.

- (7) Because halon is a fire extinguisher, the combustion condition could become unstable if halon is fed at the position close to the burner in high concentration. Therefore, halon shall be fully mixed with combustion air in advance and diluted to the concentration of around 100 to 200 ppm before it reaches the high temperature zone where halon destruction occurs.

(2) Cement/Lime Mixing Incineration Method (Cement Kiln Method)

a. Selection of Facilities

- (a) The facility shall be equipped with exhaust gas treatment system for ash dusts so that it meets the standards for concentrations of ash dusts and toxic substances such as hydrogen chlorides generated due to the feeding of halon into raw materials and fuels.
- (b) Equipment for feeding halon shall consist of valves, a flow meter and other relevant devices to feed halon quantitatively.

b. Operation Control Conditions

- (a) It is necessary to operate the calcination furnace so that successful destruction of halon and safe control of exhaust gas are ensured. It shall be verified in principle that halon gas retention time is 6 seconds or longer, gas temperature at the furnace outlet is 1,000°C or higher, and these conditions have consistency with the conditions of measurement of the destruction and recovery efficiency, etc.

c. Halon Feeding Conditions

- (a) It is necessary to operate the facility in a similar manner to ordinary cement production so that successful destruction of halon and safe control of exhaust gas are ensured.
- (b) The quantity of halon to be fed shall be properly controlled according to its flow rate.
- (c) Halon shall be fed considering its influence on the product quality. In the case of cement, it shall be verified that the concentration of chlorine in a product does not exceed the value specified in the Japanese Industrial Standards (JIS) – for example, 350ppm in the case of ordinary Portland cement (JIS R5210, as of November 20, 2003).

[Explanatory Notes]

- (1) Standards for the Structure of Fluorocarbons Destruction Facilities in the Fluorocarbons Recovery and Destruction Law specify that the facilities should be equipped with the devices listed in the table below according to the types of fluorocarbons destruction facilities.

Types of Fluorocarbons Destruction Facilities	Devices
Facility adopting the cement/lime mixing incineration method	1 Combustion device 2 Fluorocarbons feeding device 3 Combustion improver feeding device 4 Measuring device required for operation and control 5 System to treat the exhaust gas and other substances generated by the destruction

- (2) Halon feeding device for this method is similar to the device for the rotary kiln method.
- (3) Though JIS does not specify the concentration of bromine in cement products, it would become an index that the sum of the concentrations of bromine and chlorine does not exceed the concentration of chlorine specified in JIS.

(3) Liquid Injection Incineration Method (In-Furnace Decomposition Type Liquid Injection Incineration Method)

a. Selection of Facilities

- (a) The facility shall be equipped with an appropriate exhaust gas treatment system such as a cleansing tower and adsorption tower so that it meets the standards for concentration of toxic substances such as hydrogen chlorides generated due to the destruction of halon.
- (b) If exhaust gas is discharged from a lower position, not from a higher position such as chimneys, the facility shall be managed so that it prevents significant increase in the concentration of toxic substances generated through the halon destruction in the atmosphere around the facilities.
- (c) If the facility discharges effluent water, it shall be equipped with an appropriate effluent treatment system so that it meets the standards for concentrations of fluorides and hydrogen ion as provided by the applicable laws and regulations.
- (d) Equipment for feeding halon shall consist of valves, a flow meter and other relevant devices to feed halon quantitatively.

b. Operation Control Conditions

- (a) It is necessary to operate the furnace so that successful destruction of halon and safe control of exhaust gas are ensured. It shall be verified in principle that halon gas retention time is one second or longer, gas temperature at the furnace outlet is 1,200°C or higher, and these conditions have consistency with the conditions of measurement of the destruction and recovery efficiency, etc.

c. Halon Feeding Conditions

- (a) It is necessary to operate the facility in accordance with the operation control conditions so that successful destruction of halon and safe control of exhaust gas are ensured.
- (b) The quantity of halon to be fed shall be properly controlled according to its flow rate.

[Explanatory Notes]

- (1) Standards for the Structure of Fluorocarbons Destruction Facilities in the Fluorocarbons Recovery and Destruction Law specify that the facilities should be equipped with the devices listed in the table below according to the types of fluorocarbons destruction facilities.

Types of Fluorocarbons Destruction Facilities	Devices
Facility adopting the liquid injection incineration method	1 Combustion device 2 Fluorocarbons feeding device 3 Combustion improver feeding device 4 Steam feeding device 5 Air feeding device 6 Measuring device required for operation and control 7 System to treat the exhaust gas and other substances generated by the destruction

- (2) Halon feeding device for this method is similar to the device for the rotary kiln method.
- (3) Facilities which discharge exhaust gas from a lower position shall take countermeasures to meet the indicative concentration levels as described in (7) of 3.(2) in the Explanatory Notes. The facilities shall take countermeasures against the exhaust gas to prevent significant increase of the concentration of toxic substances generated through halon destruction in the atmosphere around the facilities. These countermeasures may include adoption of an exhaust gas treatment system, and changing the position of the exhaust gas outlet to a higher position.

(4) Superheated Steam Reaction Method

a. Selection of Facilities

- (a) The facility shall be equipped with an appropriate exhaust gas treatment system such as a cleansing tower and adsorption tower so that it meets the standards for concentration of toxic substances such as hydrogen chlorides generated due to the destruction of halon. The exhaust gas treatment system should be preferably designed to cool down heated combustion gas as soon as possible.
- (b) If exhaust gas is discharged from a lower position, not from a higher position such as chimneys, the facility shall be managed so that it prevents significant increase in the concentration of toxic substances generated through the halon destruction in the atmosphere around the facilities.
- (c) If the facility discharges effluent water, it shall be equipped with an appropriate effluent treatment system so that it meets the standards for concentrations of fluorides and hydrogen ion as provided by the applicable laws and regulations.
- (d) Equipment for feeding halon shall consist of valves, a flow meter and other relevant devices to feed halon quantitatively.

b. Operation Control Conditions

- (a) It is necessary to operate the reactor so that successful destruction of halon and safe control of exhaust gas are ensured. In the case of feeding halon 1301, it shall be verified in principle that the setting temperature is in the range of 950 to 980° C, the heating temperature at the downstream position in the reactor is kept at 980° C, and these conditions have consistency with the conditions of measurement of destruction and recovery efficiency, etc.
- (b) In the case of feeding halon 1211 or 2402, it shall be verified in principle that the setting temperature is in the range of 880 to 980° C, the heating temperature at the downstream position in the reactor is kept at 980° C, and these conditions have consistency with the conditions of measurement data of the destruction and recovery efficiency, etc.

c. Halon Feeding Conditions

- (a) It is necessary to operate the facility in accordance with the operation control conditions specific to the type of facility so that successful destruction of halon and safe control of exhaust gas are ensured.
- (b) The quantities of halon, steam and air to be fed shall be determined in accordance with the feeding condition specified.

[Explanatory Notes]

- (1) Standards for the Structure of Fluorocarbons Destruction Facilities in the Fluorocarbons Recovery and Destruction Law specify that the facilities should be equipped with the devices listed in the table below according to the types of fluorocarbons destruction facilities.

Types of Fluorocarbons Destruction Facilities	Devices
Facility adopting the superheated steam reaction method	1 Reaction device 2 Fluorocarbons feeding device 3 Steam feeding device 4 Air feeding device 5 Oil filter (if necessary) 6 Measuring device required for operation and control 6 System to treat the exhaust gas and other substances generated by the destruction

- (2) Halon feeding device for this method is similar to the device for the rotary kiln method.
- (3) Feeding conditions of halon, steam and air in the facilities adopting the superheated steam reaction method is indicated in the table below. If halon destruction is conducted according to the conditions different from the ones below, it shall be verified that successful destruction of halon and safe control of exhaust gas are ensured, and the verification shall be informed to the Ministry of the Environment.

Dimension of Reactor: 100A in bore×1,750mm in length

	Feeding quantity of halon (kg/h)	Feeding quantity of steam (kg/h)	Feeding quantity of air (L/min)*
Halon 1301	10	3.5	-
Halon 1211	10	3.5	-
Halon 2402	10	3.5	50

Dimension of Reactor: 100A in bore×1,250mm in length

	Feeding quantity of halon (kg/h)	Feeding quantity of steam (kg/h)	Feeding quantity of air (L/min)*
Halon 1301	3	1.1	-
Halon 1211	3	1.1	-
Halon 2402	3	1.1	20

* CO concentration of 100ppm or lower shall be kept in operation.

- (4) In this method, settings of operation control conditions, halon feeding conditions, etc. should be changed according to the substances to be destroyed. Therefore, appropriate maintenances and controls are necessary through

verification of halon destruction as well as recordkeeping of the temperatures in the reactor and the feeding quantities of halon, steam and air.

- (5) Facilities which discharge exhaust gas from a lower position shall take countermeasures to meet the indicative concentration levels as described in (7) of 3.(2) in the Explanatory Notes. The facilities shall take countermeasures against the exhaust gas to prevent significant increase of the concentration of toxic substances generated through halon destruction in the atmosphere around the facilities. These countermeasures may include adoption of an exhaust gas treatment system, and changing the position of the exhaust gas outlet to a higher position.