Appendix 10-3:
Dioxin Analysis

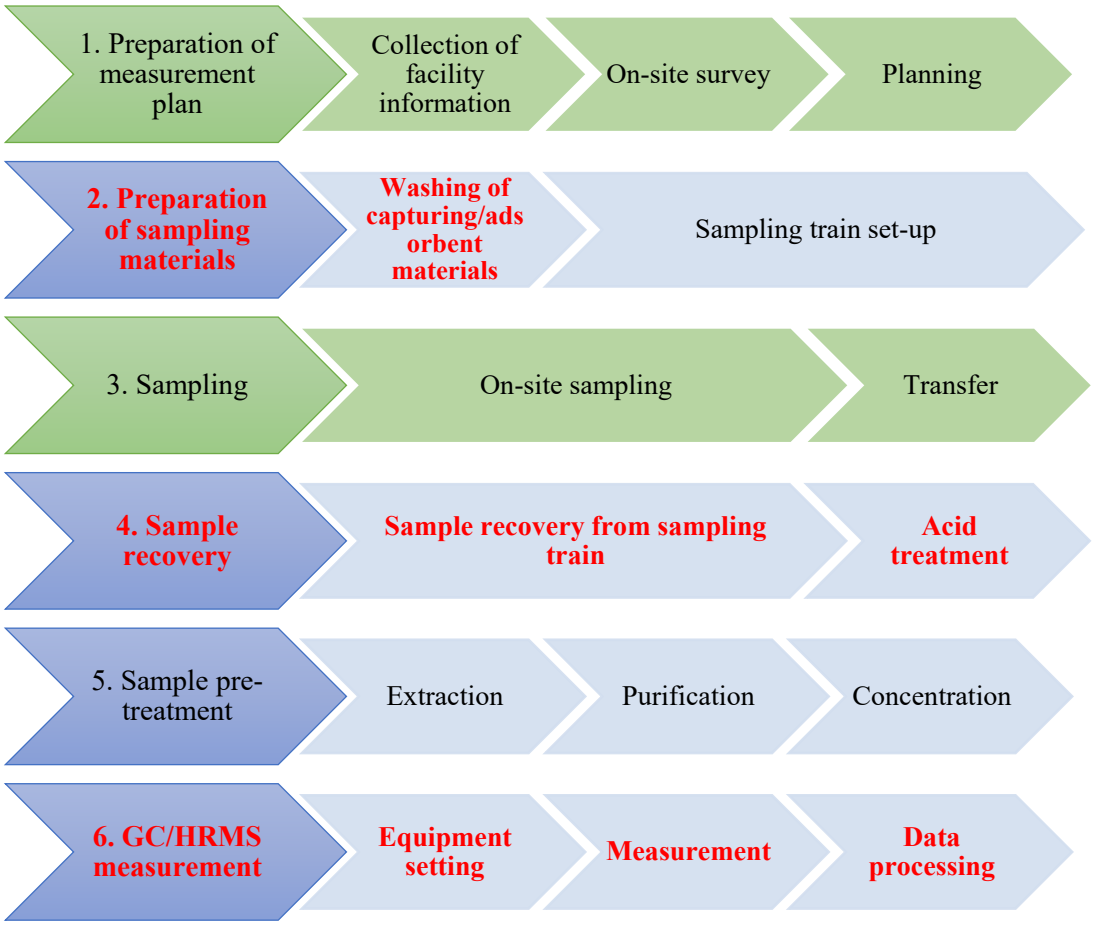
November 16-18, 2021

The Project for Capacity Development on Improving Solid Waste Management through Advanced/Innovative Technologies in The Republic of Philippines

Overview of Online training for Dioxins Analysis

1. Introduction

The procedures for measuring Dioxins in stack gas, including the preparation step, are as follows.



In the above chart, green parts (sampling) are to be conducted by the sampling organization, and the rest are to be conducted by the analysis organization. “4. Sample recovery” may be conducted on site by the sampling organization in some cases, for example, when shipment by air is restricted, but generally, the step is to be conducted at the analysis laboratory by a person in charge of the analysis to prevent sample contamination.

Since the same operation is likely to be adopted at EMB, training materials were prepared on the assumption that sample recovery from sampling train will be conducted by ERLSD.

2. Contents of training materials

For this online training, the following 3 textbooks, corresponding to the parts indicated in red letters in the above chart, were prepared.

- Preparation of stack gas and ambient air sample capturing/adsorbent materials
- Sample recovery from sampling train
- GC/HRMS measurement and Data processing by Diok

Of the tasks to be conducted by ERLSD, "5. Sample pre-treatment" has many parts in common with POPs analysis, so ERLSD has abundant experience conducting similar tasks. The pre-treatment operation was included in World Bank's training held in Australia, so it should be relatively easy for ERLSD to imagine the details of operation.

Meanwhile, since sampling train for Dioxins is quite special and ERLSD has no experience in analyzing Dioxins in stack gas yet, it is probably difficult to imagine the details of operations for the preparation of capturing/adsorbent materials and recovery after sampling.

In addition, GC/HRMS measurement and data processing by Diok require the use of devices and software specialized for Dioxins analysis and result calculation, and it can be seen from past activities that ERLSD has difficulties in operating Diok.

Due to time restrictions, this online training will focus on the tasks specific to Dioxins measurement (i.e. those that are difficult to imagine without actually experiencing the operations) and the tasks with which ERLSD is having issues. There will be a question-and-answer session at the end of training each day, so please feel free to ask any questions regarding Dioxins analysis.

End

November 16-18, 2021

The Project for Capacity Development on Improving Solid Waste Management through Advanced/Innovative Technologies in The Republic of Philippines

Preparation of stack gas and ambient air sample capturing/adsorbent materials

1. Examples of facility and equipment

1-1. Capturing/adsorbent materials preparation room

To prevent contamination, there is a room dedicated for washing, drying, etc. of the capturing/adsorbent materials. To prevent contamination, samples are not allowed to be brought into this room. Instruments preliminarily washed in the pre-treatment room are brought into this room, where filter papers are burned, and XAD resins and PUFs are washed and packed into the sampling train.

1-2. Devices and equipment

Representative devices and equipment are introduced below.

1) Large Soxhlet extractor: for Polyurethane foam (PUF) only

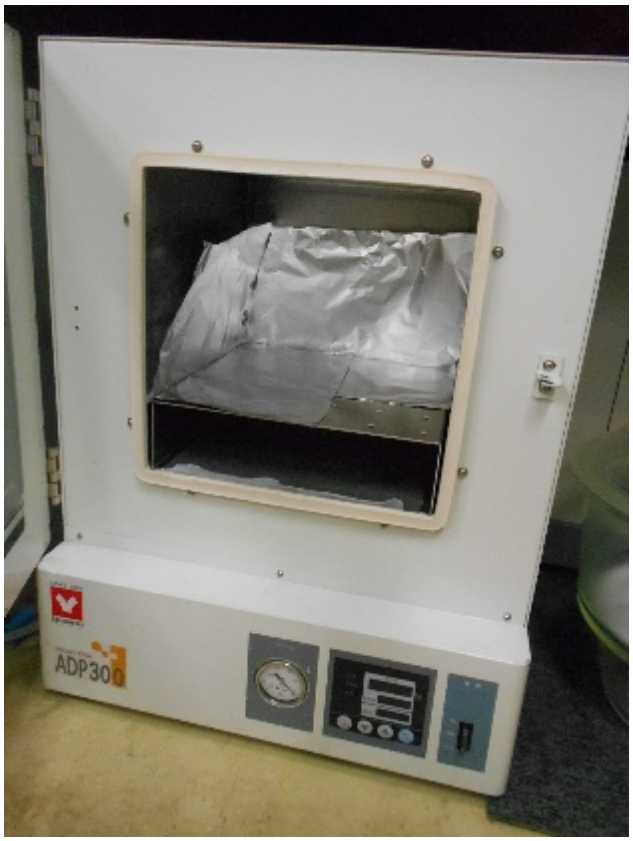
2) Soxhlet extractor for washing XAD resin (2L size)

3) Large muffle furnace: for preparation of filter paper

It is equipped with an exhaust fan and a duct to facilitate air circulation and prevent retention of air inside the furnace. It is large enough to hold several large filter papers for high volume air sampler. Including those used for Soxhlet extraction, glass fiber filter papers used for

the projects are heated in this device.

4) Vacuum dryer: used for drying XAD resins and PUF after washing.



5) Cage for storing washed materials: Washed filter papers are stored in dedicated cages.

2. Method for preparing stack gas capturing/adsorbent materials

2-1. Filter paper

1) Place thimble filter for stack gas sampler on aluminum plates and put them in a muffle furnace for burning filter papers.

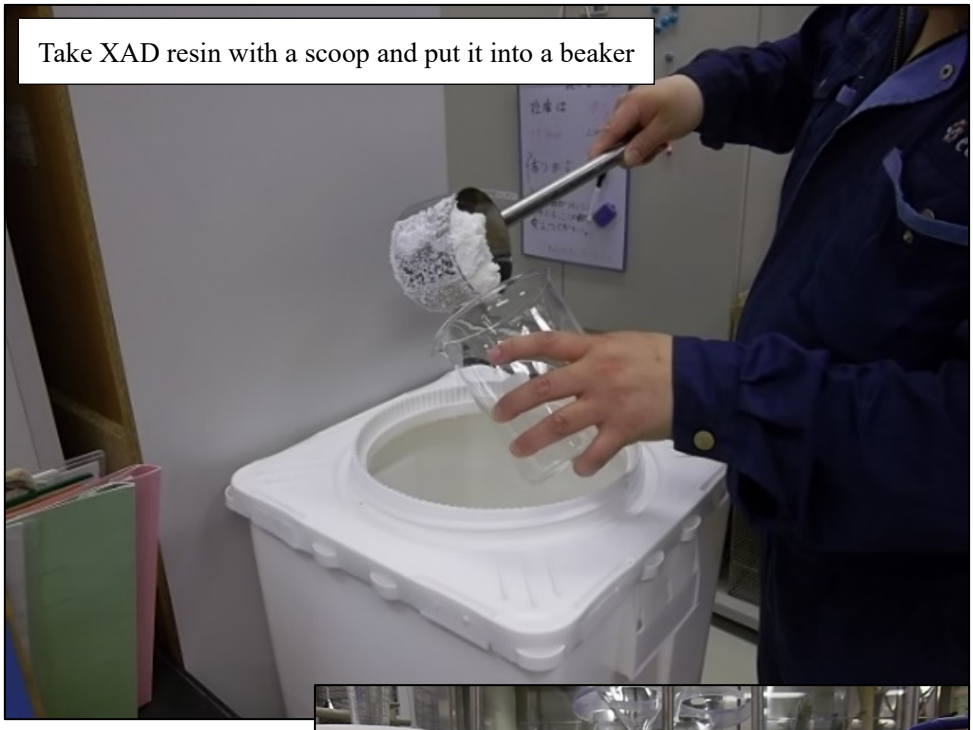
2) Close the door of the muffle furnace and set the temperature to 450℃.
3) Confirm that the temperature has reached 450℃ and burn for 18 hours.
4) Stop heating the muffle furnace and wait until the temperature drops to about 150℃.
5) Transfer the filter papers to a dedicated desiccator with tongs and wait until they cool to room temperature.
6) Wrap the filter papers with aluminum foil and store them in dedicated cages.

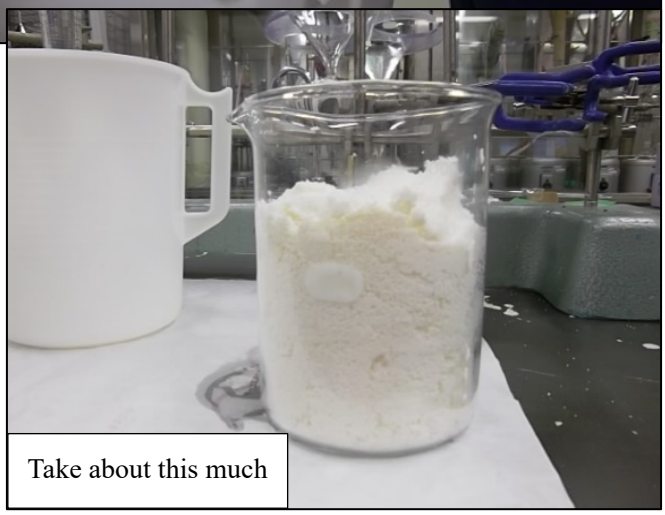
2-2. XAD resin

1) Use dedicated instruments. The instruments must be washed with acetone and dried immediately before use.

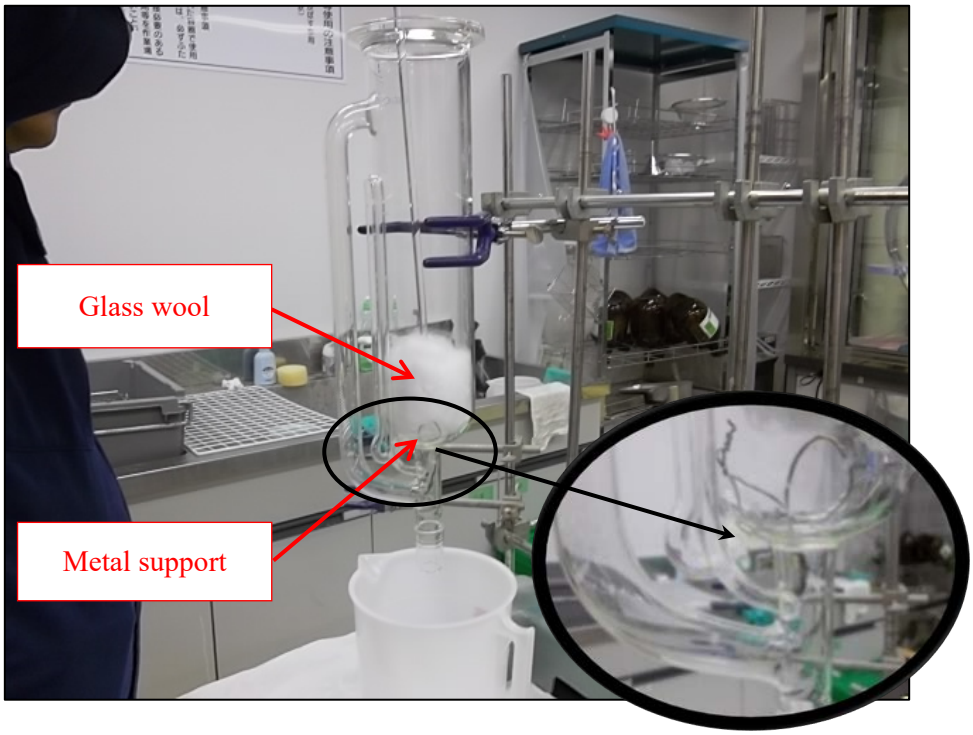
2) Instruments used are as follows.
Stainless scoop, beaker (1L), Soxhlet extractor, metal support, glass rod, glass funnel, glass wool (washed), Buchner funnel, beaker (500 ml, two for drying)

3) Transfer XAD resin to 1L beaker with a stainless scoop. （800ml～1000ml）
(After use, XAD resin is attached to the scoop, so rinse the scoop with acetone, dry the scoop and brush off the remaining XAD resin before storing.)





4) Secure the siphon tube of the Soxhlet extractor onto the holder and place a metal support in the extractor. Put some washed glass wool on top of the metal support and stuff it into the siphon tube using a glass rod. Be careful not to stuff the glass wool too tightly. Also be careful not to block the hole to the siphon tube part with the glass wool.

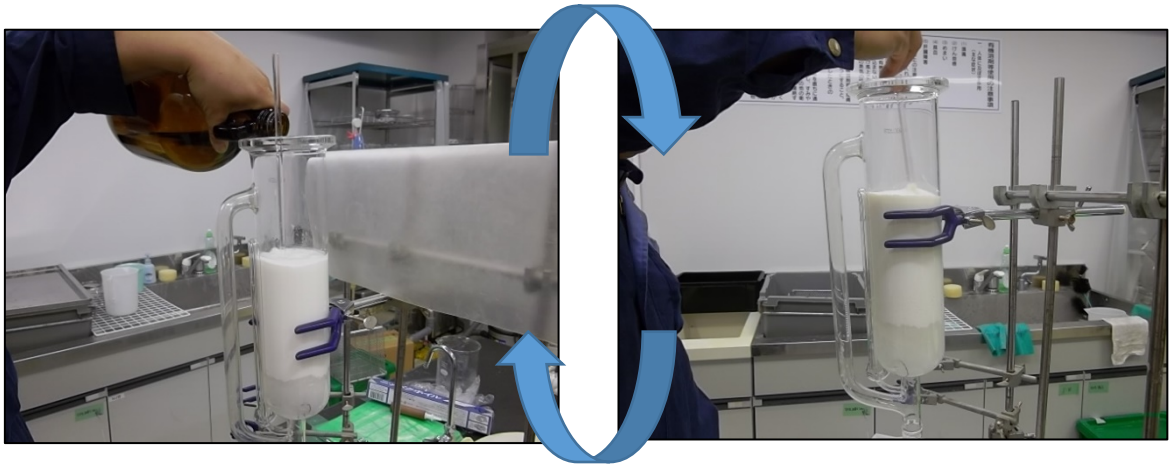


5) Set a waste liquid cup beneath the extractor.

6) Place a glass funnel on the extractor and thoroughly wash the XAD resin collected in the beaker with industrial acetone.

7) While stirring with a glass rod, pour industrial acetone into the extractor up to a level at

which siphoning does not occur, and stir with the glass rod. Tilt the extractor to induce siphoning and let acetone drop. Repeat this step (pre-washing) at least 2 times. (Judge by the color of the acetone wash effluent.)



8) After pre-washing is completed, thoroughly wash the glass rod using a wash-bottle filled with acetone to remove the remaining XAD resin.

9) Put a few pieces of boiling stones and 2L of industrial acetone in a flat-bottomed flask (2L) of the Soxhlet extractor.

10) Place the extractor into which the XAD resin has been transferred in step 6) on top of the flask and wrap seal tape around the joint.

11) Secure with a joint clamp. Connect a condenser to assemble the Soxhlet extractor.

12) Put the condenser into operation, turn on the mantle heater, and set the temperature to that for acetone.
Confirm that the device is siphoning properly, and perform Soxhlet extraction for at least 6 hours.

Note: To prevent drying up due to acetone leakage, check the odor, acetone volume, bending of condenser tube and coolant temperature and volume 1 hour after starting the extraction to ensure that there is no abnormality.

13) Turn off the mantle heater and let it cool. At this point, let the acetone remaining in the extractor drop into the flask.

14) Prepare another 2L flat-bottomed flask containing a few pieces of boiling stones and 2L of toluene (JIS special grade). When the acetone in step 9) has cooled, replace the flask with the one containing toluene.

15) Put the condenser into operation, turn on the mantle heater, and set the temperature to that for toluene. Confirm that the device is siphoning properly, and perform Soxhlet extraction for at least 6 hours.

Note: To prevent drying of toluene due to leakage, check the odor, toluene volume, bending of condenser tube and coolant temperature and volume 1 hour after starting the extraction to ensure that there is no abnormality.

16) Turn off the mantle heater and let it cool. At this point, let the toluene remaining in the extractor drop into the flask.

17) When sufficiently cooled, remove the extractor and proceed to the next filtration step.

18) Set a Buchner funnel on a filtration bottle.

19) Using a glass rod, transfer the XAD resin from the extractor onto the Buchner funnel.

20) Wash the wall of the extractor using a wash bottle filled with acetone (JIS special grade) to remove the remaining XAD resin.

21) Wash the Buchner funnel at least twice with methanol (pesticide analysis grade) to remove the remaining XAD resin. Note that any residual toluene makes it difficult to dry the XAD resin.

(1) Pour methanol

(2) Suck while stirring with a glass rod.

*Repeat this at least twice.

22) Using a glass rod, transfer the XAD resin from the Buchner funnel to two 500ml beakers.

23) Place the beakers in a vacuum dryer.

Note: Clean inside the vacuum dryer to make sure that there is no residue of previous use.

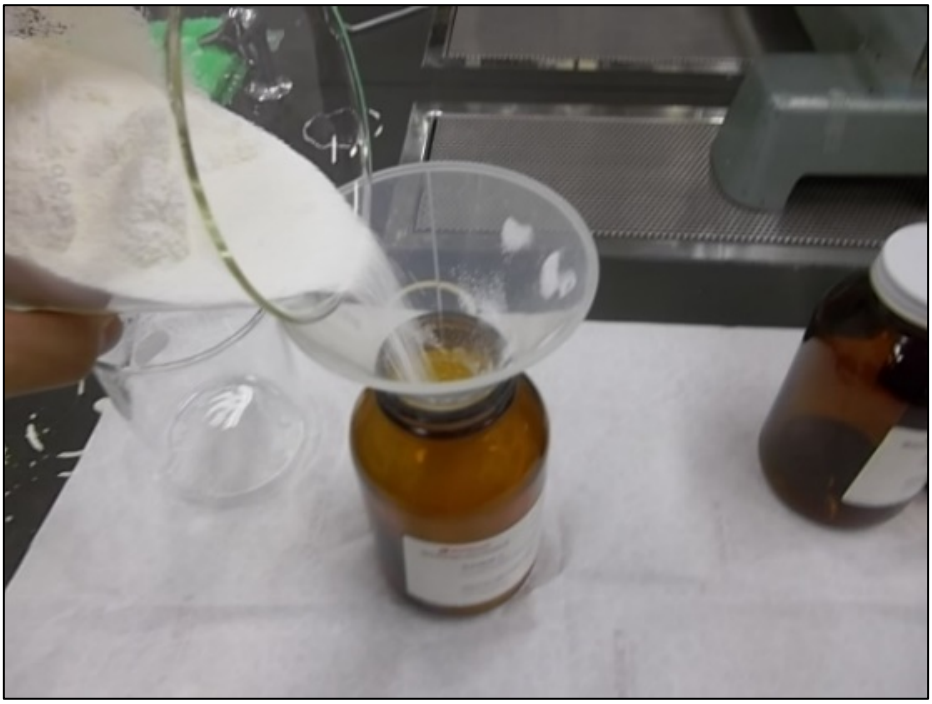
24) Put the vacuum pump and the vacuum dryer into operation and dry the XAD resin at 130 degrees for at least 7 hours.

25) Gradually release vacuum, and when ambient pressure is reached, turn power off. Take out

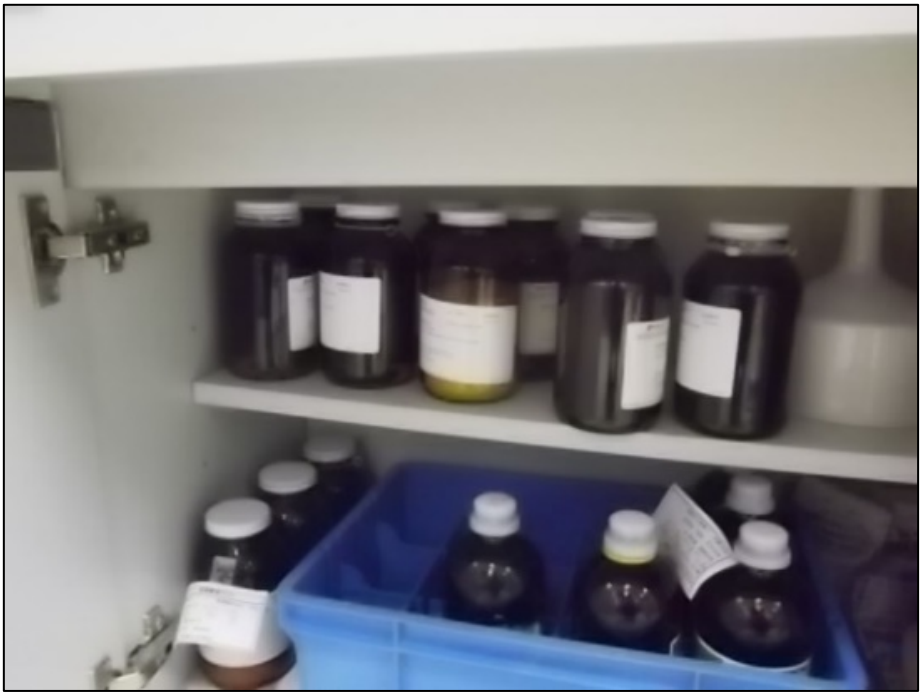
the beakers with tongs and check whether they are dry. If they are not sufficiently dry, continue vacuum drying.

26) If the beakers are completely dry, put them into a desiccator and let them cool.

27) After they have sufficiently cooled, transfer the washed XAD resin through a funnel into a brown bottle dedicated for washed XAD resin.



28) Seal the bottle and store it in a prescribed place.



29) Write the following items in the capturing/adsorbent material preparation record.
- Name of reagent
- Lot No.
- Volume prepared
- Washing start date, washing completion date, storage date
- Storage place
- Person in charge of preparation

3. Preparation of ambient air capturing/adsorbent materials

3-1. Filter paper

1) Place filter papers for high volume air sampler in a muffle furnace for burning filter papers.
2) Close the door of the muffle furnace and set the temperature to 450℃.
3) Confirm that the temperature has reached 450℃ and burn for 18 hours.
4) Stop heating the muffle furnace and wait until the temperature drops to about 150℃.
5) Transfer the filter papers to a dedicated desiccator and wait until they cool to room temperature.
6) Wrap each filter paper with aluminum foil and store it in a dedicated cage.

3-2. Polyurethane foam (PUF)

1) Use dedicated instruments. The instruments must be washed with acetone and dried immediately before use.

2) Instruments used are as follows.

Stainless tray, Soxhlet extractor (upper metal fitting, lower metal fitting)

1L graduated cylinder, beaker (500ml, two for drying)

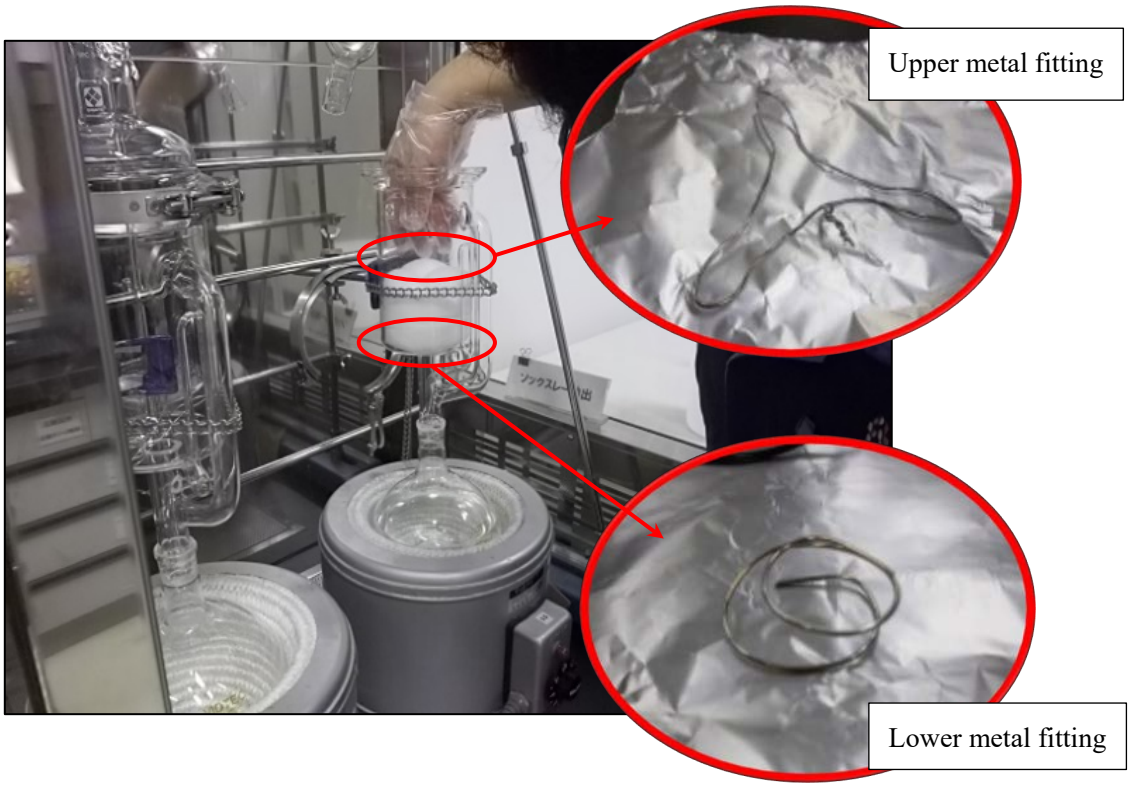
3) Put the necessary number of PUFs on a stainless tray. Up to 5 PUFs can be treated per Soxhlet extractor.

4) Wear Saniment gloves and wash the PUFs by rubbing them while soaking with tap water. Rub them 40 times on one side, then turn over and rub another 40 times. After washing, squeeze the PUFs thoroughly.

5) Pour purified water onto the PUFs to replace the tap water with purified water. Then, squeeze them thoroughly.

6) Finally, pour acetone (JIS special grade) to soak the PUFs and squeeze them thoroughly.

7) Disassemble the Soxhlet extractor and place the lower metal fitting at the bottom of the extractor to prevent inlet of siphon tube from being blocked by the PUFs. Then, push and stuff the pre-washed PUFs into the extractor.
8) When all the PUFs is stuffed, secure the urethane foam using the upper metal fitting to prevent the PUFs from exceeding to the top of siphon tube as they absorb acetone and swell during extraction.



9) Using a 1L graduated cylinder, put 1.6L of acetone (JIS special grade) into each flask. Make sure that boiling stones are placed in the flasks beforehand.

10) Place a silicone O-ring, place the upper lid, and secure it with a metal ring. Connect a condenser and seal the joint with seal tape.

11) Put the condenser into operation, turn on the mantle heater, and set the temperature to that for acetone. Confirm that the device is siphoning properly, and perform Soxhlet extraction for at least 6 hours.

    Note: To prevent drying of acetone due to leakage, check the odor, acetone volume, bending of condenser tube and coolant temperature and volume 1 hour after starting the extraction to ensure that there is no abnormality.

12) Turn off the mantle heater and let it cool. At this point, let the acetone remaining in the extractor drop into the flask.

13) Clean the vacuum dryer in advance and make sure that it is clean. Wear Saniment gloves and line the vacuum dryer with new aluminum foil as shown in the picture for step 15).

    Note: For the operations hereafter, wear Saniment gloves and avoid touching the PUF directly with bare hands.

14) When the Soxhlet extractor cools to room temperature, remove the condenser and the lid, wear Saniment gloves and take out the PUFs.

15) Squeeze the PUFs and put them in the dryer. Squeeze the PUFs carefully so that they do not lose their shape.

16) Put the vacuum pump and the vacuum dryer into operation and dry the PUF at 40 ℃ for at least 6 hours.

17) Gradually release vacuum, and when ambient pressure is reached, turn power off. Confirm that the PUFs are sufficiently dry.

18) Prepare the necessary number of polyethylene zipper bags with date labels. Wear Saniment

gloves, put 2 PUFs in each bag and seal.

19) Store them in a dedicated place of the Capturing/adsorbent materials preparation room in the order of preparation date. During storage of PUFs, increase in PCB blank value cannot be avoided, so their use-by date should be about 2 weeks from washing.

20) Write the following items in the capturing/adsorbent material preparation record.

- Name of reagent
- Lot No.
- Volume prepared
- Washing start date, washing completion date, storage date
- Storage place
- Person in charge of preparation

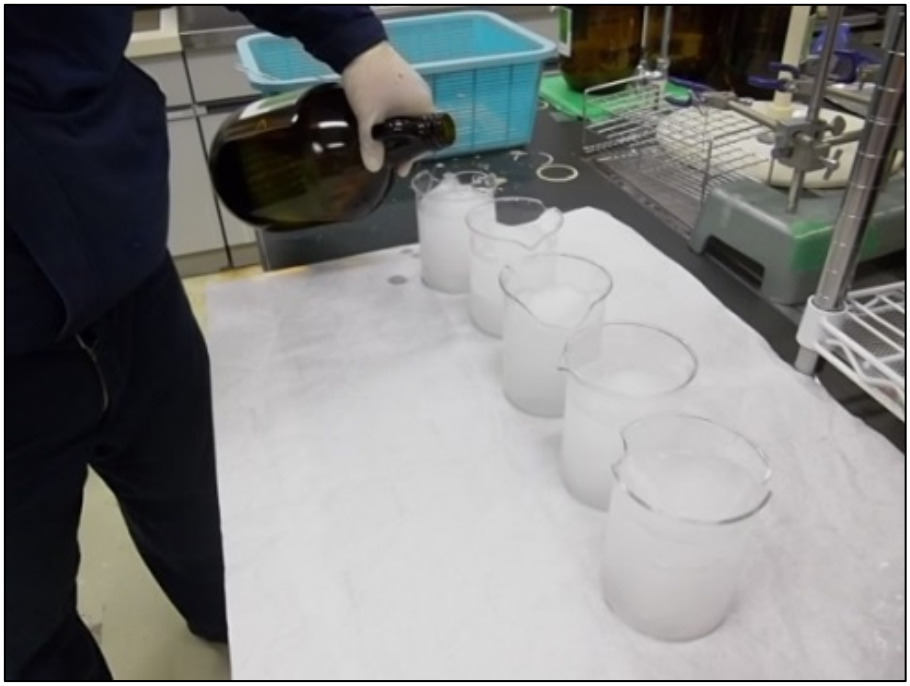
4. Washing of other materials

Glass wool and skimmed cotton used for washing XAD resin and conducting the analysis must be washed with solvents before use. The procedures are as follows.

* Glass wool damages the skin if handled with bare hands. Glass wool fibers readily float in the air, so also wear protective equipment upon handling to avoid inhalation risks.

1) Use dedicated instruments. The instruments must be washed with acetone and dried immediately before use.
2) Instruments used are as follows.
   Beaker (500ml), tweezers, aluminum drying plate
3) Wear a new pair of Saniment gloves. Tear the materials to be washed and put them in beakers.

4) Put 500ml of acetone (JIS special grade) in each beaker. Push the materials with tweezers to remove bubbles.



5) Place the beakers in a small ultrasonic bath and perform ultrasonic washing for 15 minutes.
*Use a cover to prevent dust contamination.

6) When ultrasonic washing is completed, take out the beakers. Be sure to wipe off moisture on the outside of the beakers with paper towels.
7) Hold the materials with tweezers and pour out acetone into a waste liquid vessel.

8) Put 500ml of toluene (JIS special grade) in each beaker. Remove bubbles with tweezers.
9) As in step 5), place the beakers in an ultrasonic bath and perform ultrasonic washing for 15 minutes.
10) When ultrasonic washing is completed, take out the beakers. Be sure to wipe off moisture on the outside of the beakers with paper towels.

11) Hold the materials with tweezers and pour out toluene into a waste liquid vessel.
12) Any residual toluene makes it difficult to dry the materials, so wear Saniment gloves and squeeze the materials thoroughly. The material fibers will pulverize if squeezed too tightly, so it is recommended to squeeze them flat between both hands.
13) Put 500ml of acetone (JIS special grade) in each beaker. Remove bubbles with tweezers.
14) As in step 5), place the beakers in an ultrasonic bath and perform ultrasonic washing for 15 minutes.
15) When ultrasonic washing is completed, take out the beakers. Be sure to wipe off moisture on the outside of the beakers with paper towels.
16) Hold the materials with tweezers and pour out acetone into a waste liquid vessel.
17) Wear Saniment gloves and squeeze out acetone thoroughly. The material fibers will pulverize if squeezed too tightly, so it is recommended to squeeze them flat between both hands.
18) Spread the materials on aluminum drying plates to make them easier to dry.

19) Place them in a vacuum dryer.

Note: Clean inside the vacuum dryer to make sure that there is no residue of previous use.

20) Put the vacuum pump and the vacuum dryer into operation and dry the XAD resin at 130 degrees for at least 7 hours.
21) Gradually release vacuum, and when ambient pressure is reached, turn power off.
22) When ambient pressure is reached, wear Saniment gloves and transfer the materials into dedicated containers.

23) Attach labels indicating preparation dates, etc. on the containers and store them in dedicated cages.

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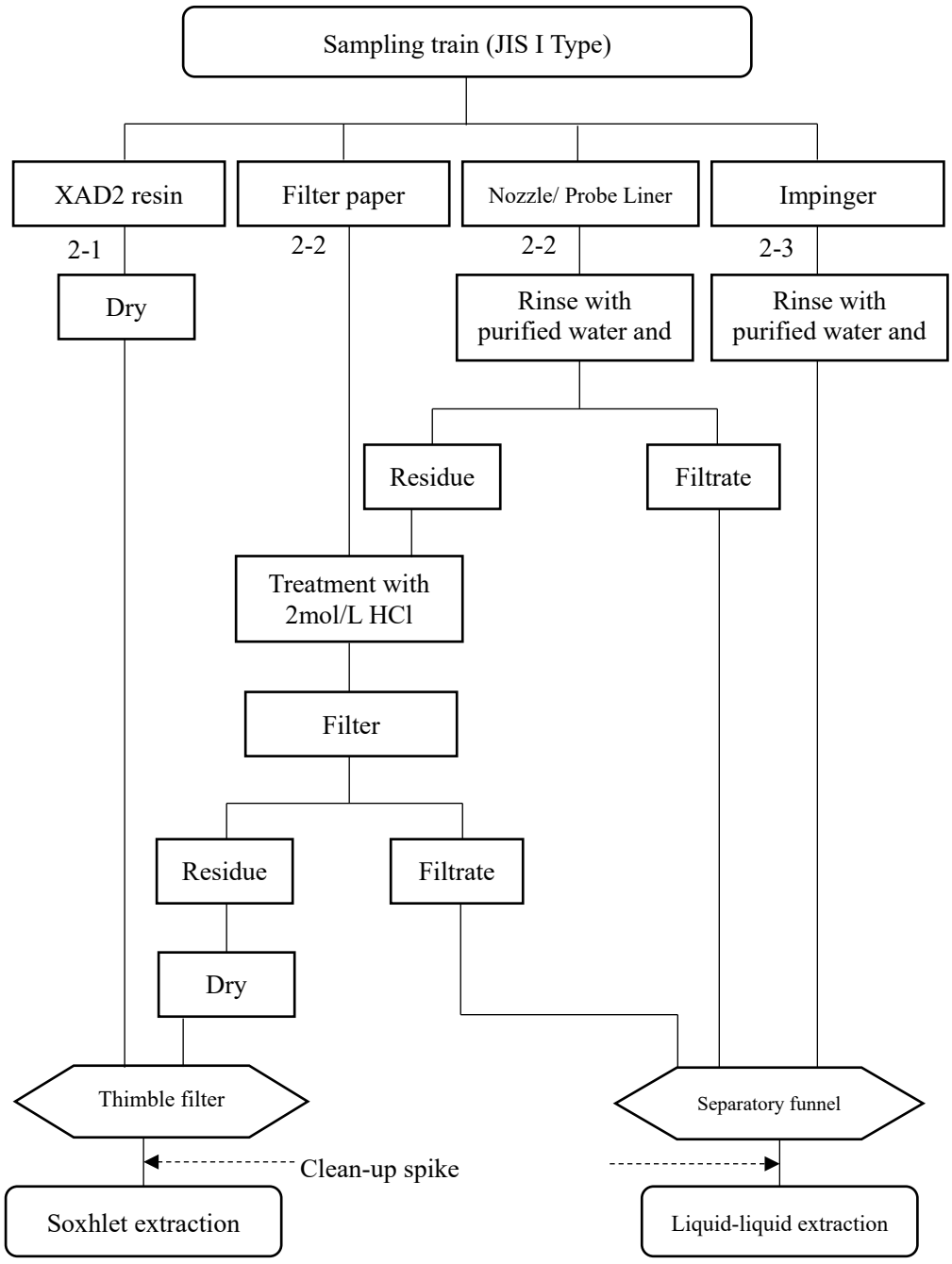
Sample recovery from sampling train

1. Outline of sample recovery procedures in Japan

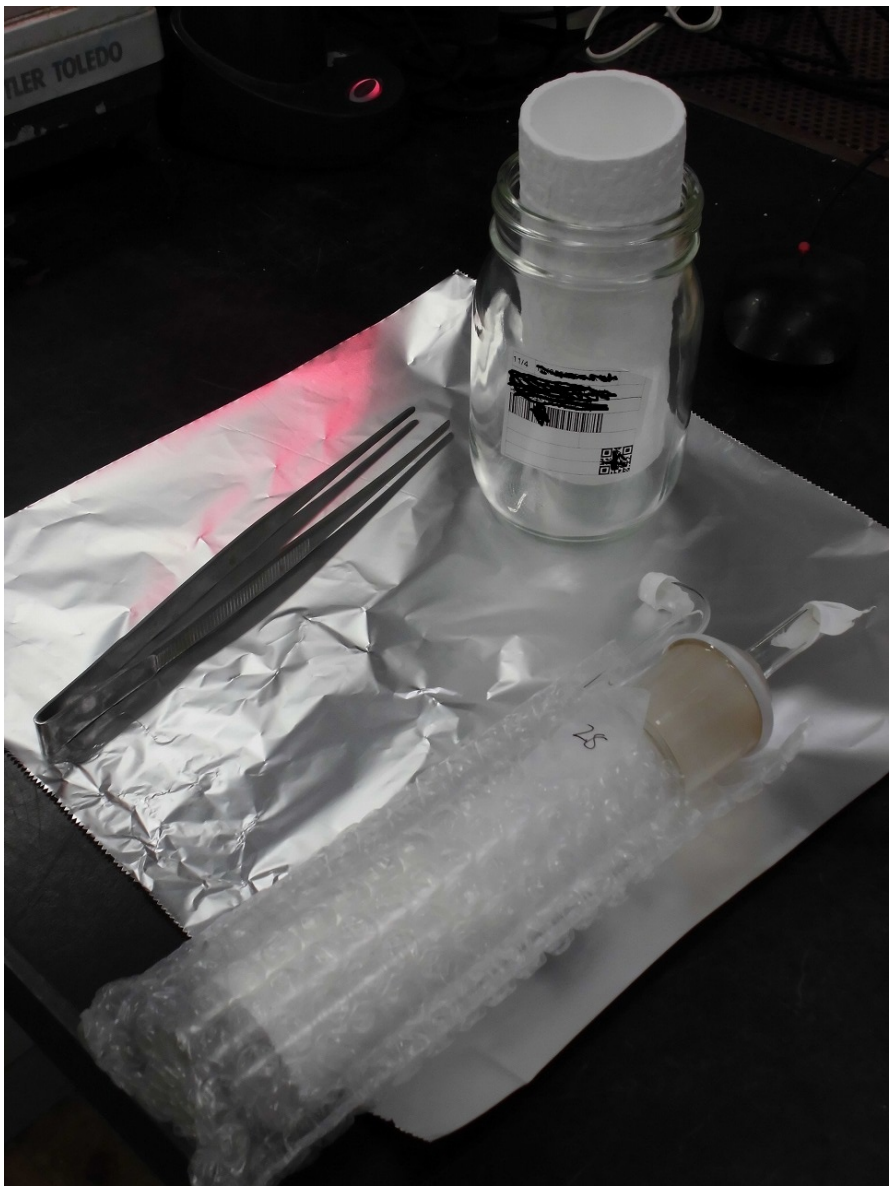
The outline of sample recovery procedures is provided below. Solids containing dust are separated and subjected to Soxhlet extraction. Liquids such as liquid in the impinger and rinse effluents produced during the treatment are combined and subjected to liquid-liquid extraction.



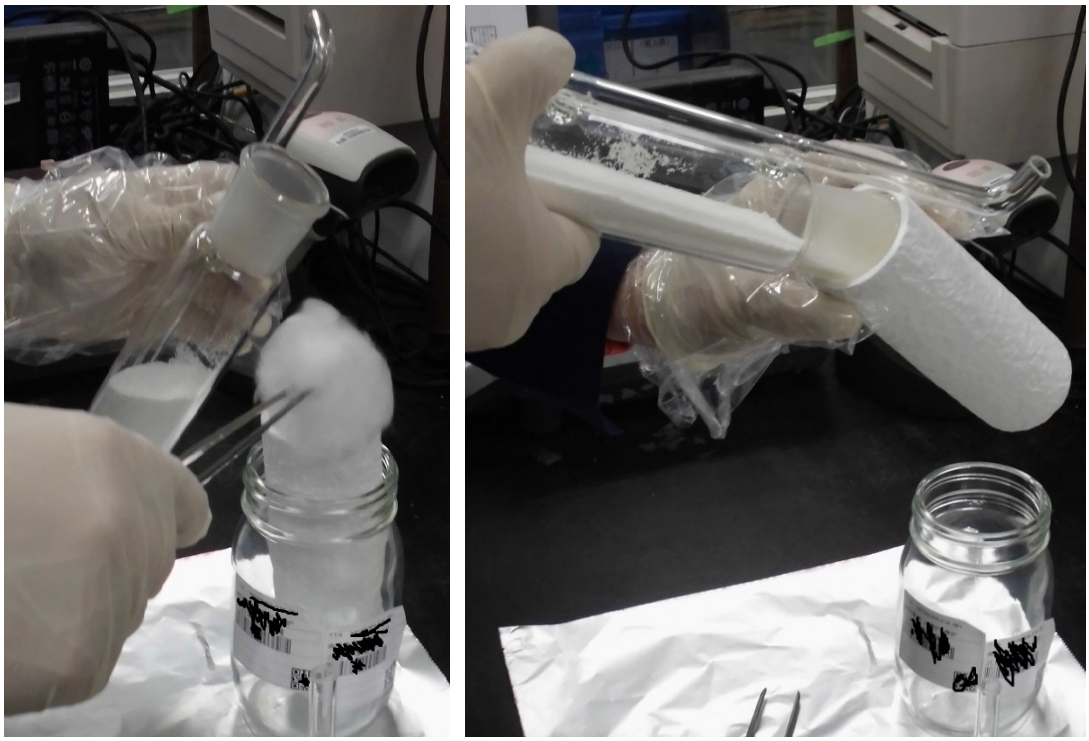
2. Sample recovery procedures

2-1. Recovery of XAD resin

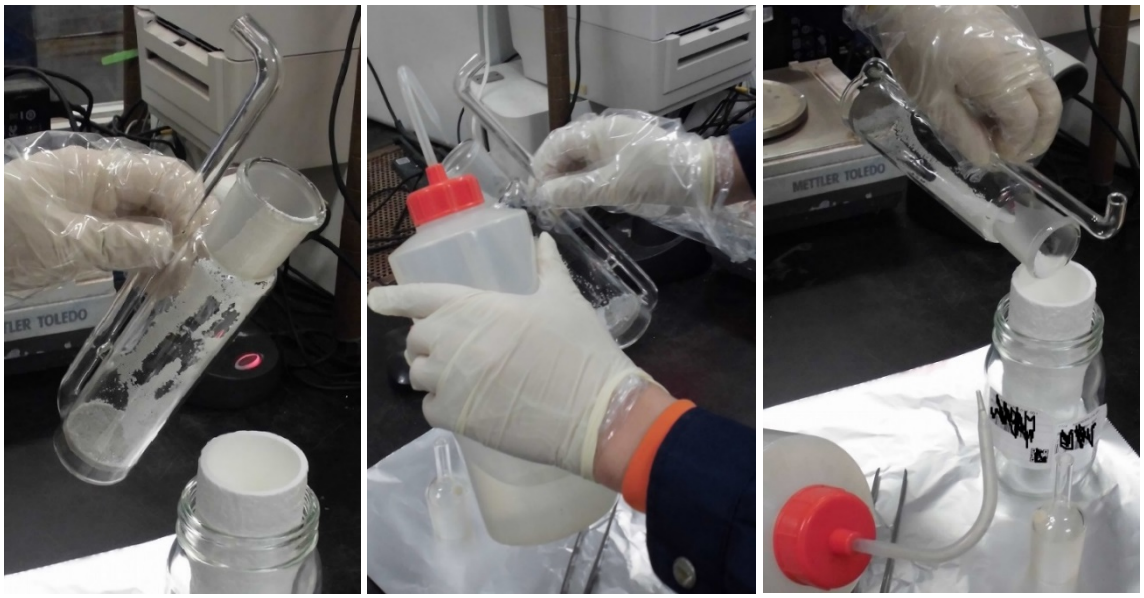
1) Subject a thimble filter for Soxhlet extraction to heat-treatment at 450℃ and place it upright in a beaker. Cut aluminum foil into about 30cm and spread it under the beaker so that scattered XAD resin can be recovered.



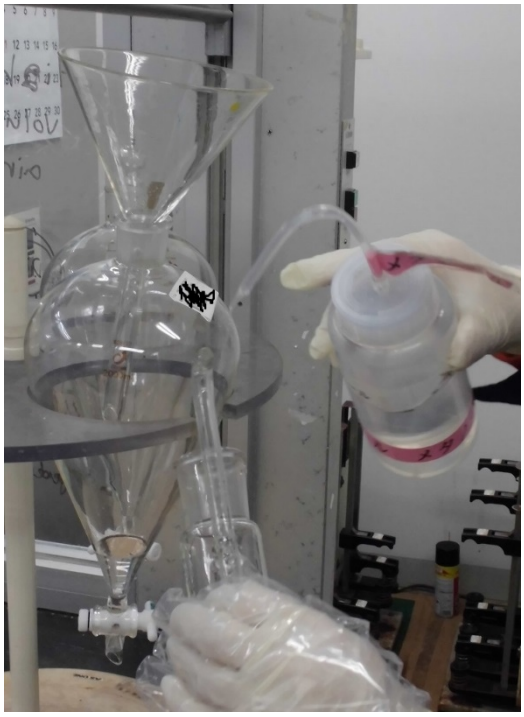
2) Remove glass wool from the XAD tube with tweezers and put the glass wool into the thimble filter, and then pour the XAD resin into the thimble filter with care so as not to spill it.



3) Rinse the XAD tube with a small amount of methanol and recover the remaining resin completely in the thimble filter. Recover any XAD resin spilled on the aluminum foil.



4) Rinse the XAD tube with hexane-washed water, methanol, dichloromethane and methanol in that order. Recover the rinse effluents, combine them with rinse effluents from other instruments and put them in a separatory funnel.




2-2. Recovery and hydrochloric acid treatment of dust

2-2-1. Recovery

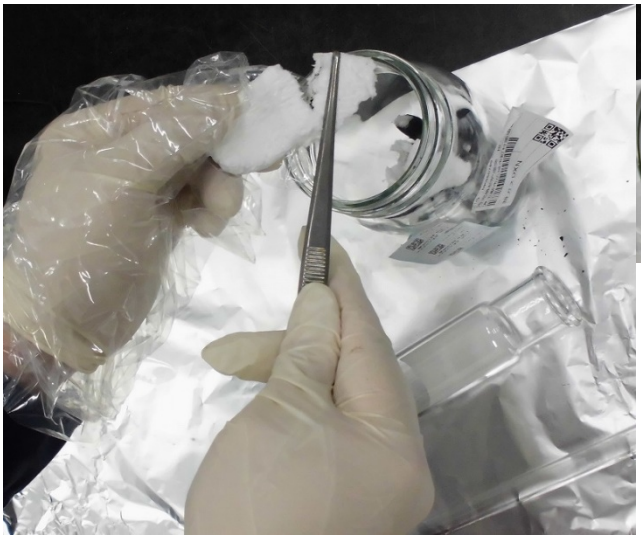
Dust is deposited on parts of a sampling train between the nozzle and the filter paper. It is known that dioxins are mostly present in dust. Dioxins in dust cannot be completely extracted unless using highly efficient extraction methods such as Soxhlet extraction. It is thus important to securely separate and recover the dust portion. The procedures are as follows.

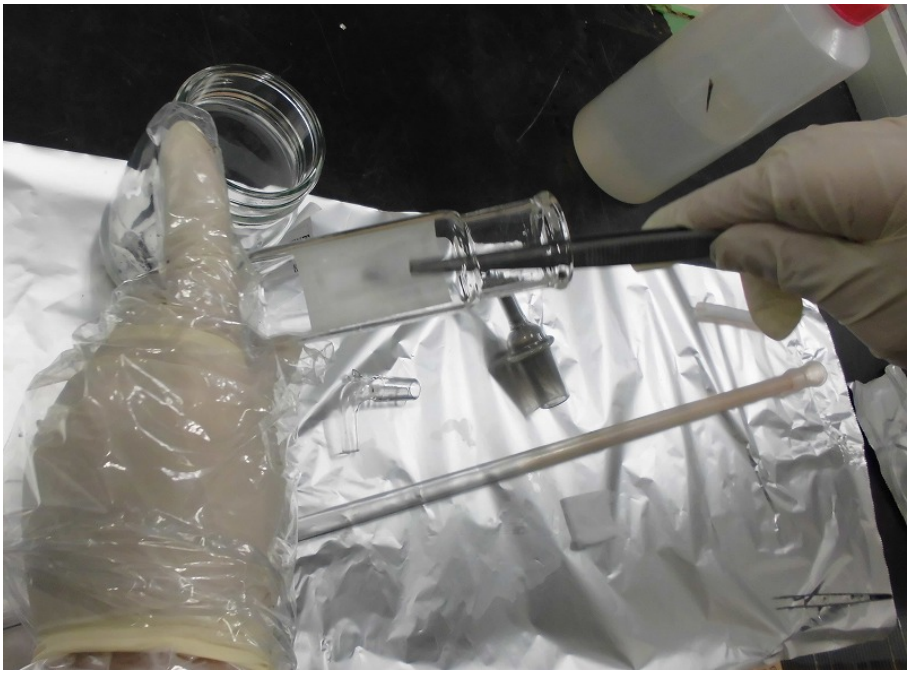
* An example of a nozzle with dust. As can be seen, a large amount of dust may be deposited in some cases. It is difficult to visually detect dust when the amount is small, or its color is white, etc. Nevertheless, always handle these parts assuming that dust is deposited on them.

1) Using tweezers, take out a shimble filter paper for stack gas sampling from the filter paper holder, cut it into small pieces and put them in an acid treatment bottle. When dust is also deposited on the filter paper holder, wipe off the dust with skimmed cotton soaked with hexane-washed water, and put the skimmed cotton with dust in the same acid treatment bottle. Then, wash inside the holder with hexane-washed water, and put the wash effluent in the same acid treatment bottle.

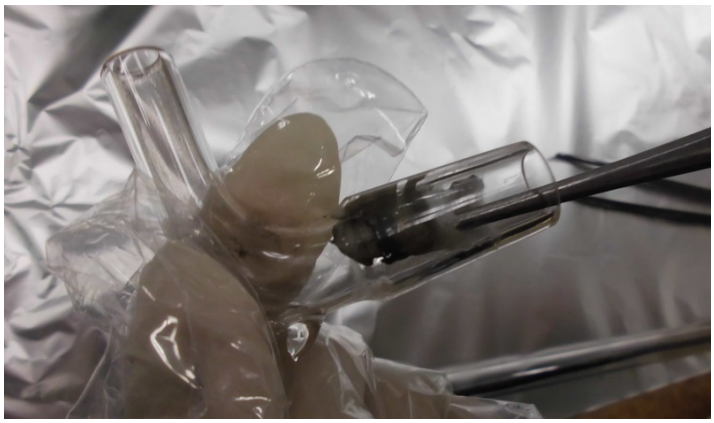
* If acid treatment is not performed, put the filter paper and dust recovered in this step into the thimble filter in which the XAD resin has been recovered in step 2-1. (See 2-2-2 for acid treatment.)

*If acid treatment is not performed, methanol should be used instead of hexane-washed water.

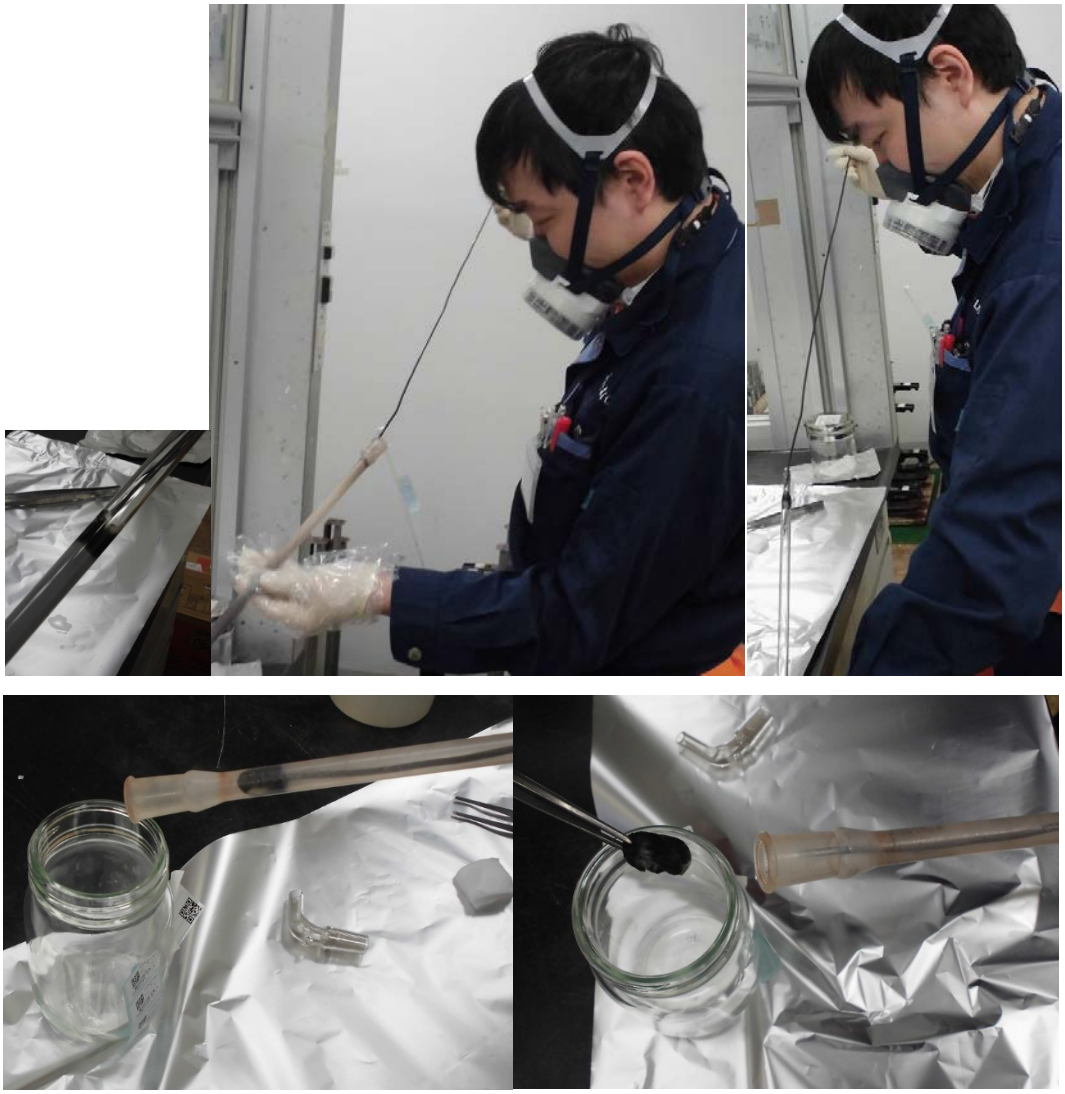




2) Wipe off dust deposited on the nozzle with skimmed cotton soaked with hexane-washed water, and put the cotton in the acid treatment bottle. Then, wash inside the holder with hexane-washed water, and put the wash effluent in the same acid treatment bottle.



3) Stuff skimmed cotton soaked with hexane-washed water into the probe liner. Then, push the cotton out with a brass rod so that dust deposited on the inner surface of the tube is recovered in the acid treatment bottle. Repeat this step until dust deposited on the inner surface of the tube is completely removed. Then, wash inside the holder with hexane-washed water, and put the wash effluent in the same acid treatment bottle.



4) Nozzle, filter paper holder, and collection tube after dust recovery

5) If the water inside the impinger is contaminated with dust, filter the water beforehand. Combine the recovered dust with the wash effluent, and put them in the acid treatment bottle in step 1).

2-2-2. Acid treatment

Acid treatment of recovered dust sample is not provided in the EPA method but is provided in the Japanese official method (JIS). This may be due to the fact that, in Japan, application of calcium carbonate and use of bag filters are the major treatments adopted for reducing dioxins in stack gas of incinerators. Past studies reported that treating dust with calcium carbonate causes dioxins to be trapped in capsules of calcium carbonate, resulting in a poor extraction rate in Soxhlet extraction. Procedures up to Soxhlet extraction including acid treatment are provided below.

1) To the acid treatment bottle in step 2-2-1, add 2 mol/L hydrochloric acid until the recovered sample is completely immersed. Stir well. Cover the bottle opening with aluminum foil and let it stand for 1 hour to react.
2) If the amount of dust is large, add a small amount of hydrochloric acid after 1 hour to confirm that no further reaction occurs. (If further reaction occurred, repeat addition of hydrochloric acid and letting it stand until no further reaction occurs.)
3) Set a Buchner funnel and perform suction filtration of the acid-treated sample. After filtration, wash the residue on the Buchner funnel with hexane-washed water until the pH becomes close to neutral.
4) When filtration is completed, continue suction for 5 minutes to dry the filter paper.
5) Combine the filtrate recovered in the suction bottle with the rinse effluent obtained in step 2-3 and perform liquid-liquid extraction.
6) Remove the filter paper from the Buchner funnel with tweezers and put it into the thimble filter into which the XAD resin was put in step 2.1. After removing the filter paper, recover dust remaining on the Buchner funnel and the perforated plate by wiping them thoroughly with skimmed cotton soaked with acetone. Put the cotton in the thimble filter.
7) Dry the thimble filter in a dedicated desiccator. Add granular sodium hydroxide to the desiccator to remove any residual hydrochloric acid. If reaction occurs, replace the granules as needed. (Any residual hydrochloric acid makes it difficult to dry the sample.)
8) After confirming that the sample in the thimble filter has sufficiently dried, add clean-up spike to the sample, plug the top with skimmed cotton, and set the thimble filter in a Soxhlet extractor equipped with a Dean-Stark adapter. (It is difficult to dry the sample completely in the thimble filter. Even if some moisture remained in the sample, reduction of extraction

efficiency can be prevented by using a Soxhlet extractor equipped with a Dean-Stark adapter to perform extraction while dehydrating the sample.)

2-3. Thorough washing of impinger

In JIS, the liquid inside the impinger is also regarded as a target of analysis. Meanwhile, the sampling train illustrated in the EPA method adopts a design in which an XAD resin holder is installed immediately below the condenser. This is based on the assumption that gaseous dioxins passing through the filter are cooled here so that all dioxins, including those in the condensed water, can be recovered in the XAD resin. The impinger part is only used for weighing water content and correcting the calculated volume of sampled gas, so it is not regarded as a target of dioxins analysis.

For reference, the method specified in JIS for recovering dioxins from impinger liquids by liquid-liquid extraction is described below.

1) Set a large glass funnel on a recovery container (gallon glass bottle is used in our laboratory) and transfer the drain water from the impinger to the bottle. Rinse the impinger with hexane-washed water and put the rinse effluent in the separatory funnel. As described in2-2.2, if the drain water contains a large amount of dust, filter the drain water and treat the filter paper with hydrochloric acid together with other dust.

   *The liquids may be recovered directly in the separatory funnel, but to avoid the risk of damaging the separatory funnel, they are first recovered in a large glass bottle and then combined in the separatory funnel.

2) Rinse the impinger with methanol, dichloromethane and methanol in this order and recover all rinse effluents in the recovery container.

3) Combine the liquids recovered in this step and the rinse effluents obtained in other steps, and put them in a 2L separatory funnel. Add clean-up spike to the sample and perform liquid-liquid extraction with dichloromethane.

4) Concentrate the extracted dichloromethane layer in a rotary evaporator, combine it with the extract from Soxhlet extraction and proceed to clean-up.

End

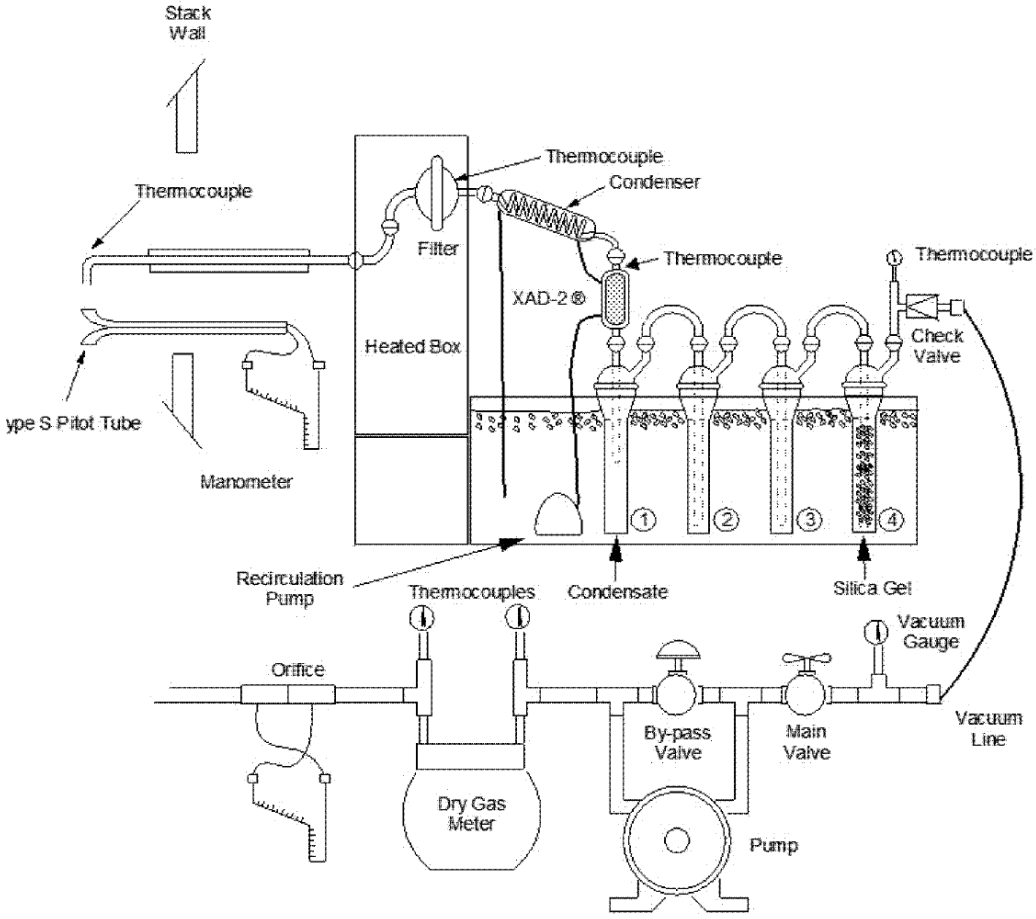


Figure 23-1. Method 23 Sampling Train

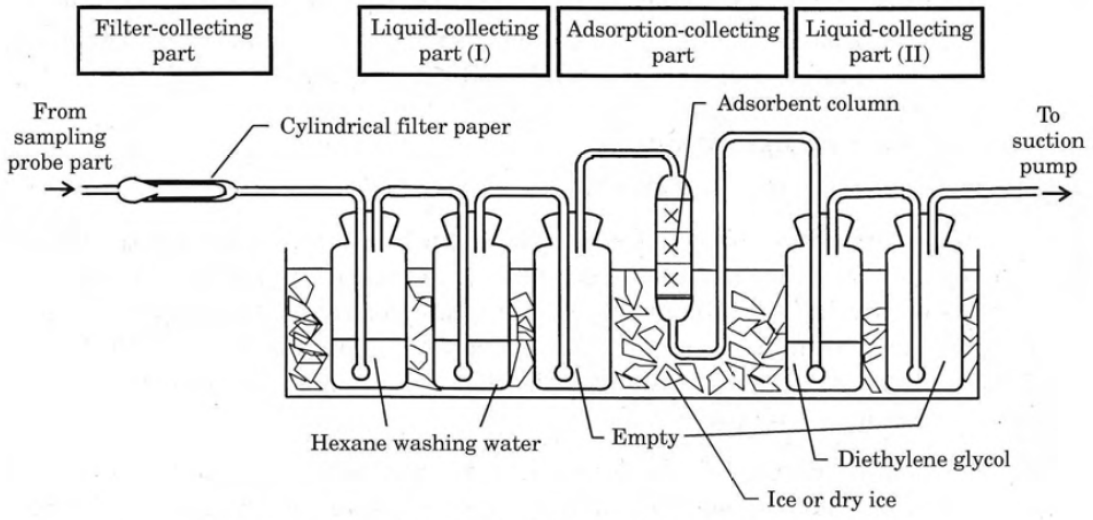


Figure A.1 Example of JIS Type I apparatus

November 16-18, 2021

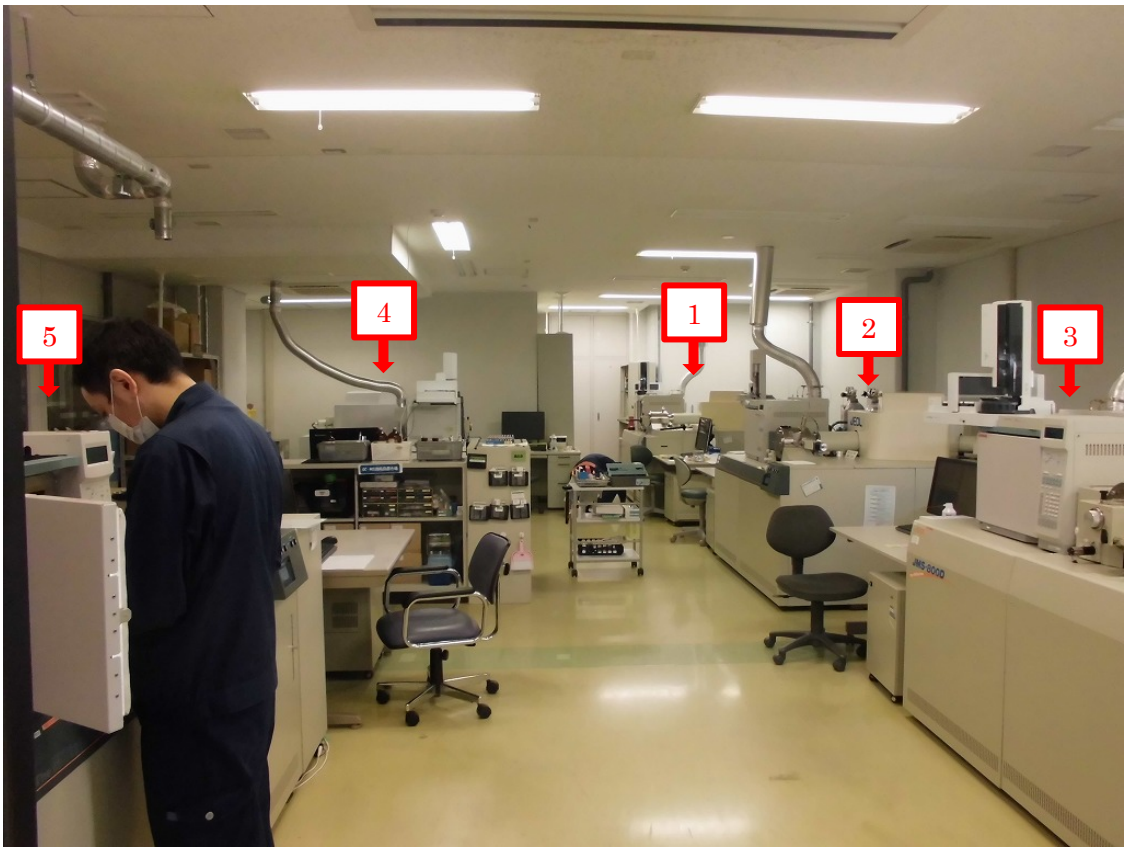
The Project for Capacity Development on Improving Solid Waste Management through Advanced/Innovative Technologies in The Republic of Philippines

GC/HRMS measurement and data processing by Diok

1. Examples of facility and equipment

1-1. GC/HRMS room

Our company has five JEOL GC/HRMS units. They are all installed in the same temperature-controlled room (1 to 5 in the photo below). In this room, measurement of pre-treated samples is conducted.

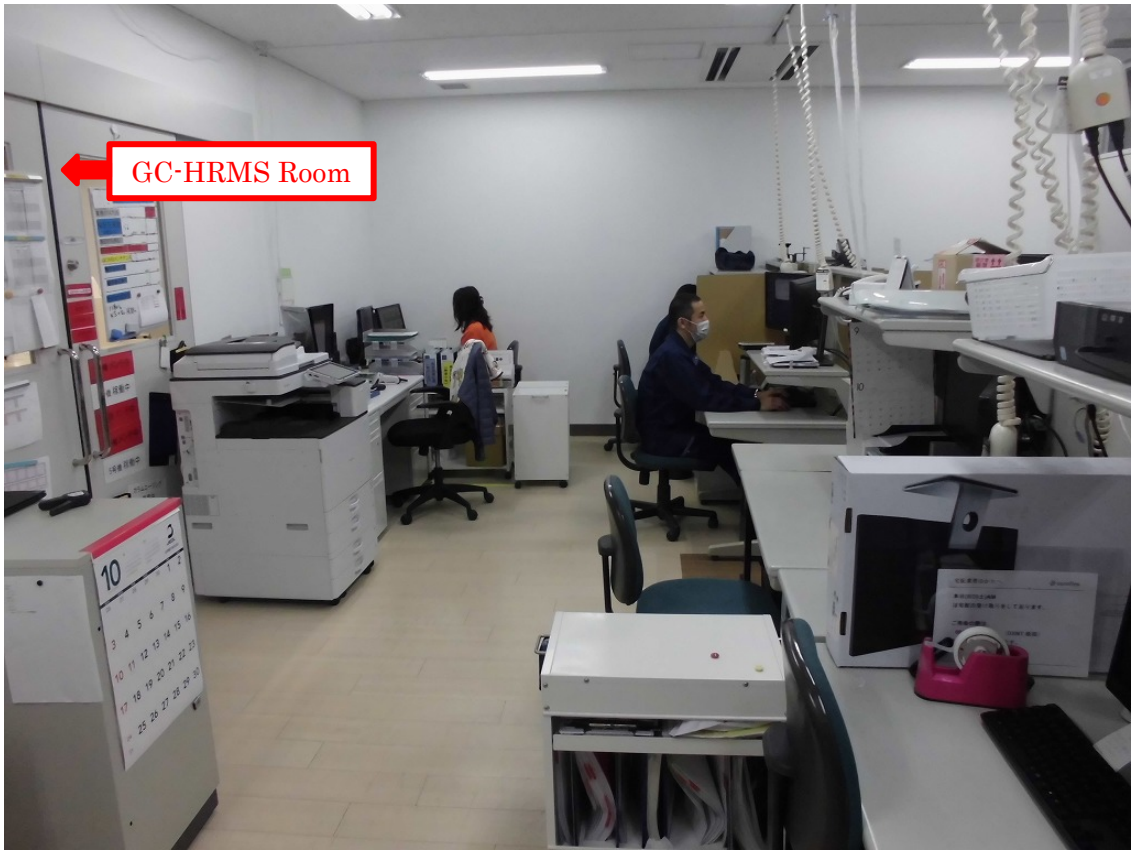


1-2. Data processing room

In the analysis room adjacent to the GC/HRMS room, there are PCs connected to the GC/HRMS room via LAN, and loading of measurement data to Diok, peak integration, calculation, confirm validity of result and preparation of reports are performed.

Persons assigned to work in the data processing room have practical experience in performing all operations of Dioxins pre-treatment. They have been trained to detect abnormalities in measurement

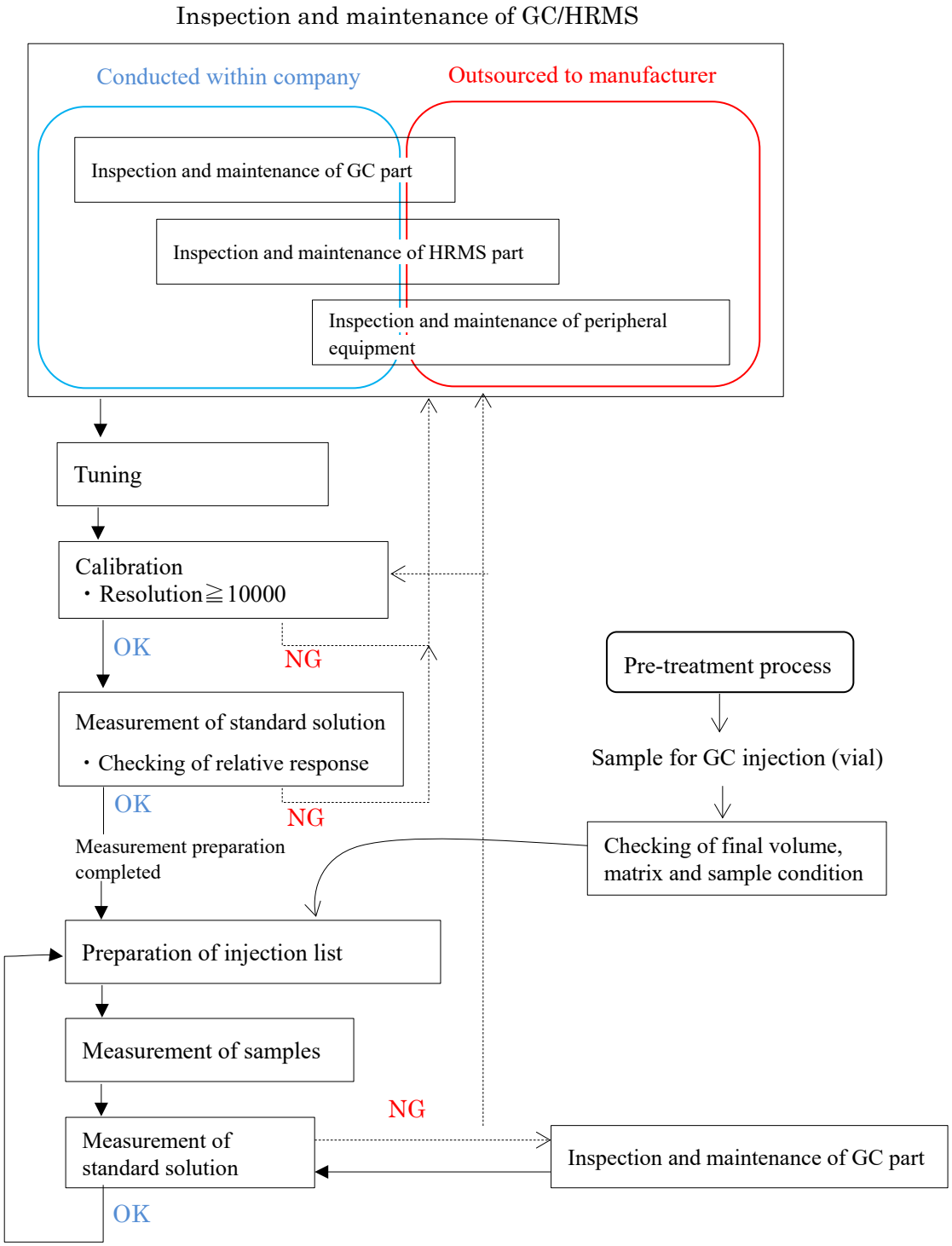
data, select appropriate re-analysis methods and give instructions to persons responsible for the tasks required for re-analysis.



2. Dioxins measurement using GC/HRMS

2-1. Outline of measurement work

The general flow of the measurement work is provided below.



2-2. Maintenance of GC/HRMS

Besides periodical maintenance, maintenance is also conducted whenever needed, e.g., when any problem is found in the measurement or when daily inspection do not meet the criteria. Based on the conditions under which the problem occurred (e.g., measurement results of standard solution for fluctuation of relative response check, chromatogram peak shapes, status of lock channel) and usage conditions of the device (e.g., last replacement dates of consumables, conditions of samples measured in the past, number of injections performed), the person in charge identifies the parts suspected of having problems and performs the necessary maintenance.

Typical examples are given below, but actual cases could be much more complicated.

Symptom	Typical cause	Countermeasures
Severe peak tailing	✓Contamination around GC injection port	✓Replace guard column, liner, gold coating seal
Poor peak resolution	✓Contamination on ion source block	✓Clean or replace ion source block
Electric discharge during measurement	✓Introduction of air by leakage ✓Improper positioning of guard column on outlet side ✓Contamination on ion source block (particularly insulator parts)	✓Re-install guard column on outlet side ✓Clean or replace ion source block
Poor peak shape or separation	✓Deterioration of column	✓Cut front side of column or replace column

The table below summarizes maintenance work that can be conducted within the company.

For problems occurring at detection parts or in peripheral equipment (e.g., cooling and circulation device, exhaust system) and problems that cannot be solved by in-house maintenance, it is necessary to contact the manufacturer and request maintenance.

Maintenance that can be conducted within the company	
GC part	・Replacement of liner ・Replacement of gold coating Sealing ・Replacement or cutting of front-side guard column ・Replacement of rear-side guard column ・Replacement or cutting of capillary column

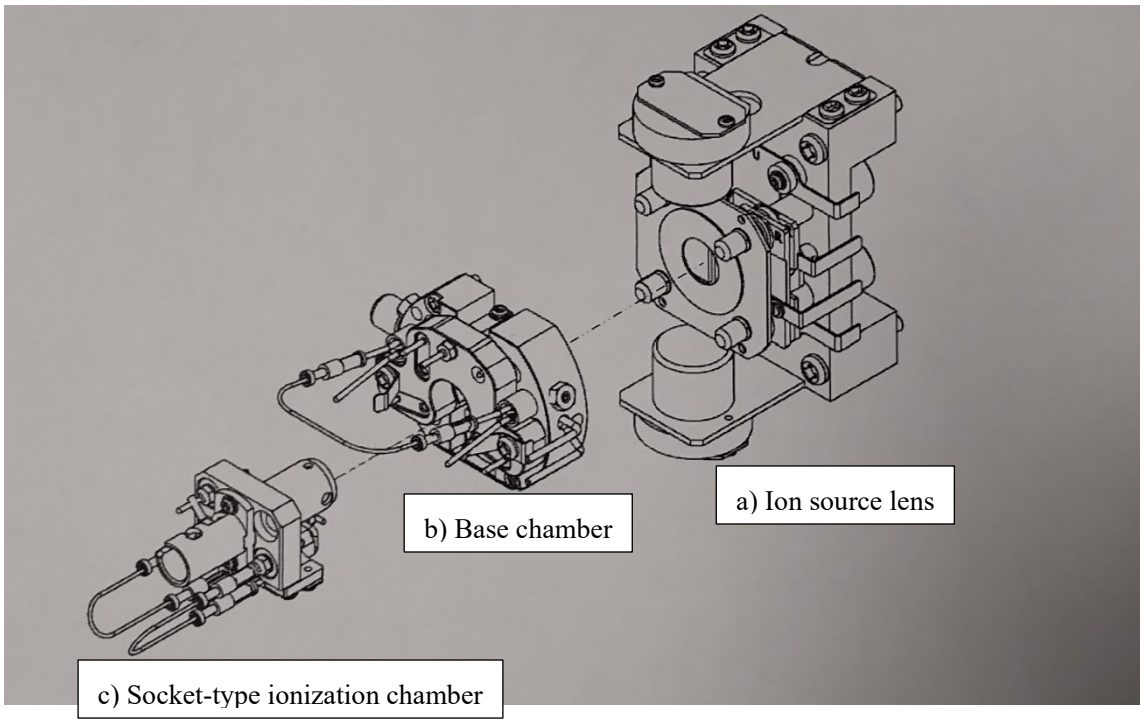
	・Cleaning or replacement of microsyringe ・Replacement of septum ・Replacement of ferrule
HRMS part	・Maintenance of ion source block Clean or replace ion source block Replacement of filament Cleaning of repeller Replacement of lead wire Replacement of heater Bake-out of insulator part Replenishment of PFK Calibration of magnetic and electric fields

2-3. Maintenance of GC/HRMS (how to clean an ion source block)

Procedures for cleaning an ion source block is described. There is no need to clean every part every time. Clean efficiently by focusing on heavily contaminated parts.

As shown below, an ion source block consists of three major parts.

[a) ion source lens, b) base chamber, c) socket-type ionization chamber]



By using an introduction rod, the “c) socket-type ionization chamber” can be removed without releasing vacuum in the ion source part. Thus, it is efficient to perform cleaning when removing the

“c) socket-type ionization chamber”, such as when replacing the filament.

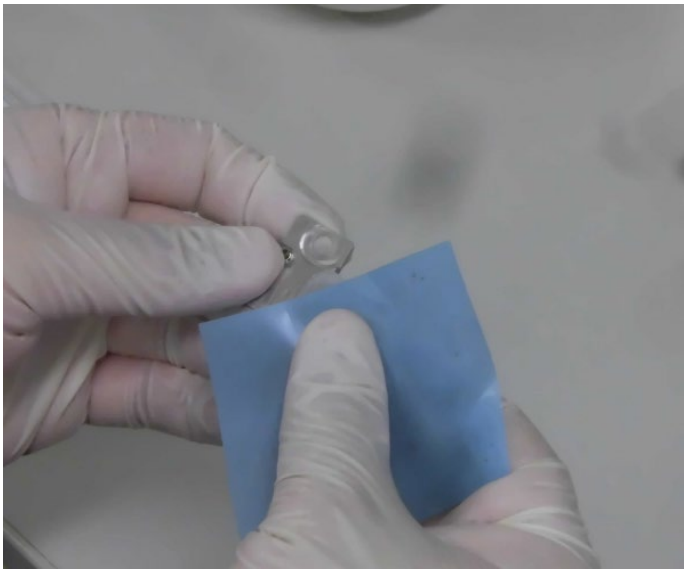
If the ion source block is removed with the ionization chamber vacuum released, it will require more than one day until measurement can be resumed, so such maintenance should be done with proper planning. Collectively clean each of the above parts a), b) and c), focusing on heavily contaminated parts.

For detailed procedures for removing, disassembling and reassembling the ion source block, see manufacturer’s instructions.

When cleaning the ion source, wear powder-free latex gloves to avoid issues with the sebum of your hands.

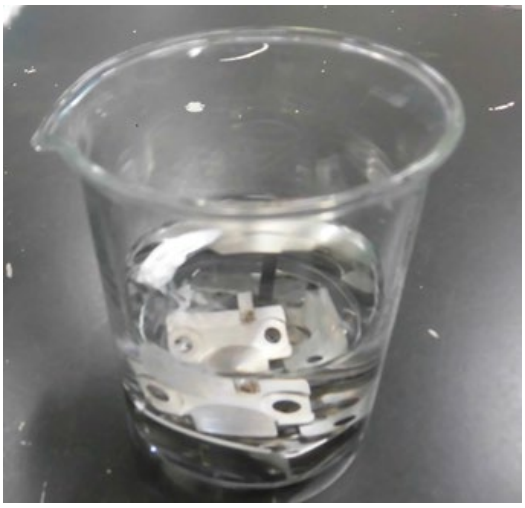
Divide the disassembled ion source block into three categories, i.e., non-washing parts (e.g., heater, lead wire), metal parts and insulator parts, before starting cleaning of the metal parts and the insulator parts.

Polish the metal parts with #3000-10000 sandpaper.

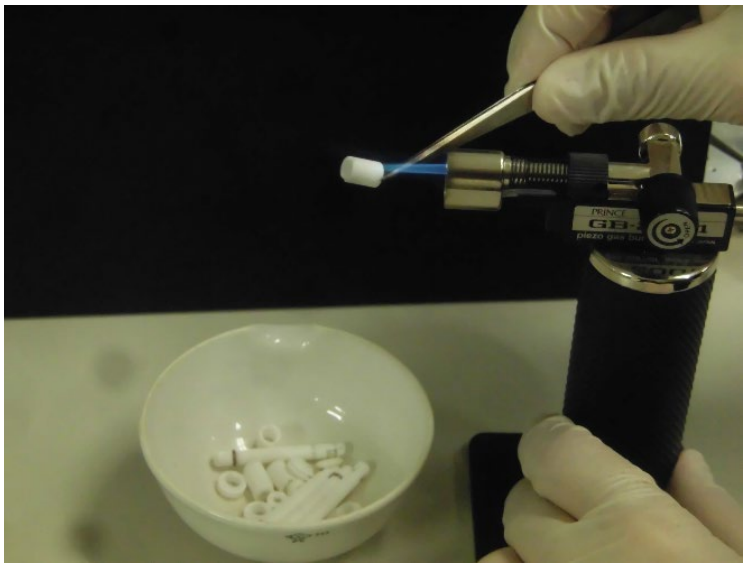


Alternatively, polish them with a paste of alumina powder (particle size of #3000 or larger) suspended in water using a felt buff (mini hand grinder).

Soak and clean the polished parts in a solvent in an ultrasonic bath.



For insulator parts, it is recommended to bake out with a gas burner.



2-4. Daily inspection

Daily inspection is carried out to retain the performance of GC/HRMS and ensure stable measurement. Perform daily inspection at the start of work or at predetermined intervals, and record the results in a prescribed format. Standard inspection items and problems expected to occur when defects are found in these items are summarized in the table below.

Inspection items	Frequency	Problems expected to occur when defects are found
a) Coolant temperature	Work start time	Shutdown of GC/HRMS Drift from center of calibrated mass
b) Temperature of room in which GC/HRMS is installed	Work start time	Drift from center of calibrated mass Board failure caused by dew condensation
c) Gas pressure in carrier gas cylinder	Work start time	Damage of column Unstable separation by GC
d) Pressure of air compressor	Work start time	Shutdown of turbo pump/rotary pump
e) Vacuum degree of ion source	Work start time	Reduced sensitivity of GC/HRMS
f) Noise (operation noise) from turbo pump/rotary pump	Work start time	Malfunction or deterioration in exhaust efficiency causing a critical problem and shutdown
g) Rotary pump oil level and oil leakage	Once a month	Leads to pump failure (replace oil once a year during regular maintenance)
h) GC injection temperature	Work start time	Reduced sensitivity Peak tailing
i) EI ion source status ・Emission efficiency ・Chamber temperature	At MS tuning (see 2-5, 2-7)	Reduced sensitivity Reduced filament life Peak tailing
j) Lens conditions Move the lens and confirm that beam intensity changes	At MS tuning (see 2-5, 2-7)	Reduced sensitivity, unstable measurement results
k) Accelerating voltage, Q1, Q2, Q3 lens voltage, Q lens 1, 2 correction values, magnetic field intensity,	At MS tuning (see 2-5, 2-7)	Failure to detect specified ion Reduced resolution, poor peak shape, poor S/N ratio

	resolution		
l)	**Vacuum degree in analyzer part**	At restart after vacuum release	Reduced sensitivity, reduced resolution
m)	**Operations of entrance slit, alpha slit, beta slit, exit slit**	At restart after vacuum release	Reduced sensitivity, reduced resolution
n)	**Detector voltage, preamplifier setting, baseline**	At restart after vacuum release	Reduced sensitivity, reduced quantitativity Monitor detector voltage→Recognize appropriate timing of detector maintenance

2-5. Tuning

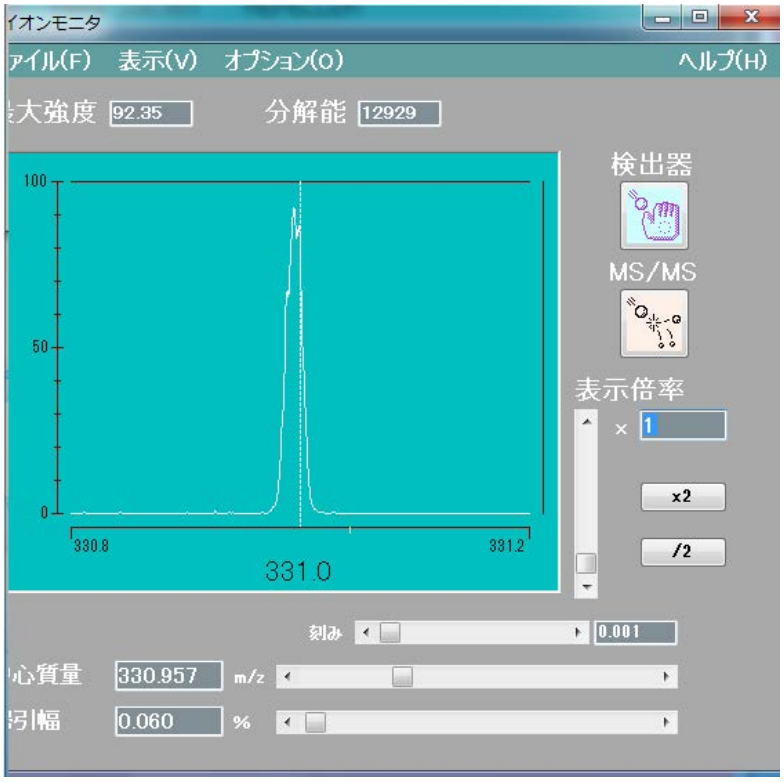
When GC/HRMS has been shutdown, be sure to perform tuning after restarting the device to adjust the resolution of the mass spectrometer to 10000 or higher.

The tuning window can be accessed from the MS Controller menu preset in the PC connected to the CG/HRMS.

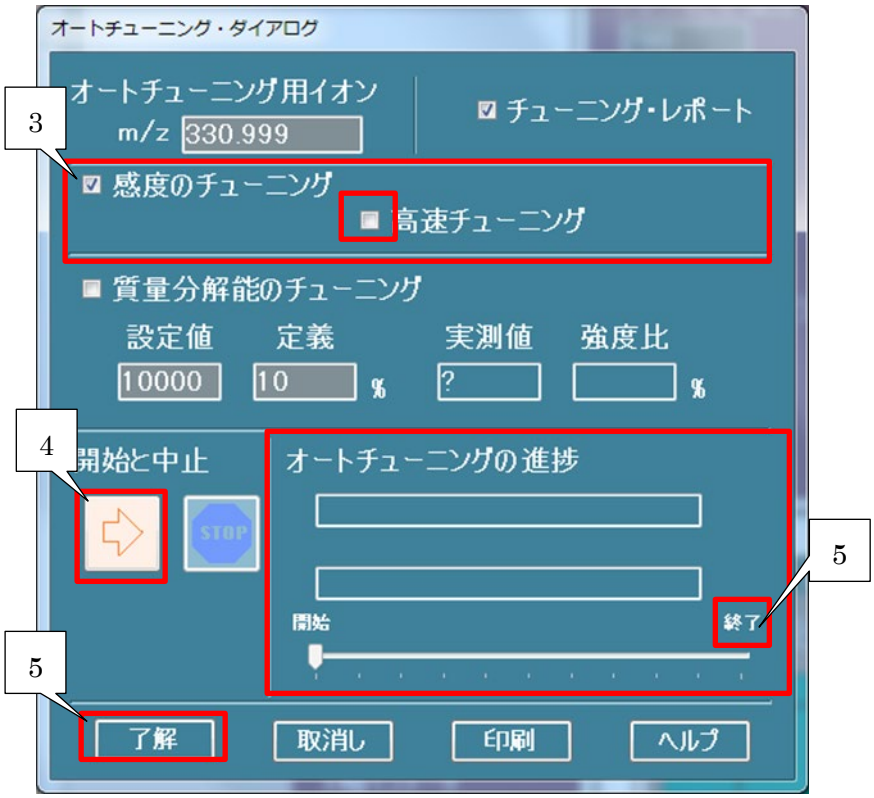
a) Auto Tuning Dialog
b) Mode Controller
c) Ion Source Controller
d) Lens Controller
e) Analyzer Controller
f) Detector Controller
g) Ion Monitor

2-5-1. Auto Tuning

1) Open g) Ion Monitor, and adjust the PFK valve so that adequate response is achieved, i.e., the PFK peak does not go off the scale.



2) Open a) Auto Tuning Dialog

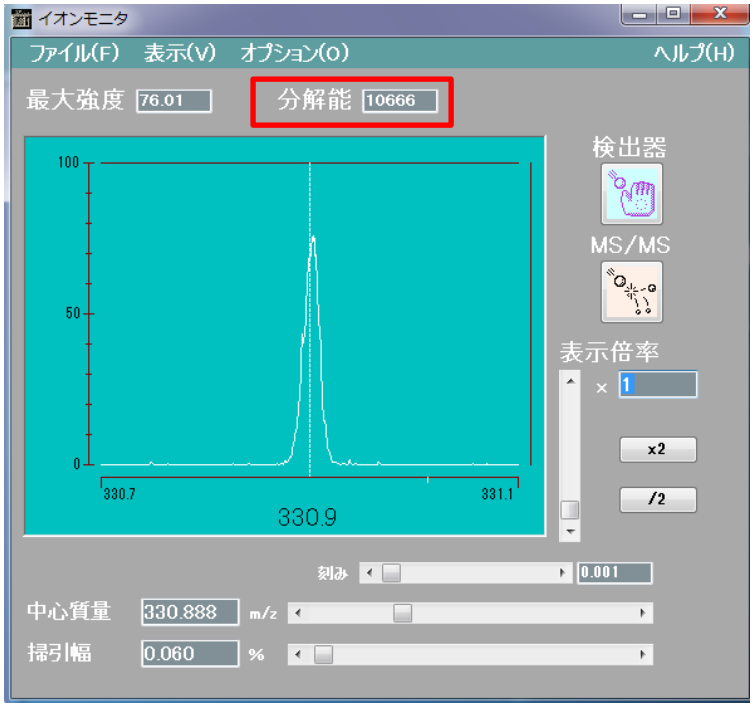


3) Put a check mark in Sensitivity Tuning and remove a check mark from High-speed Tuning.

4) Click ⇨ and Start Tuning

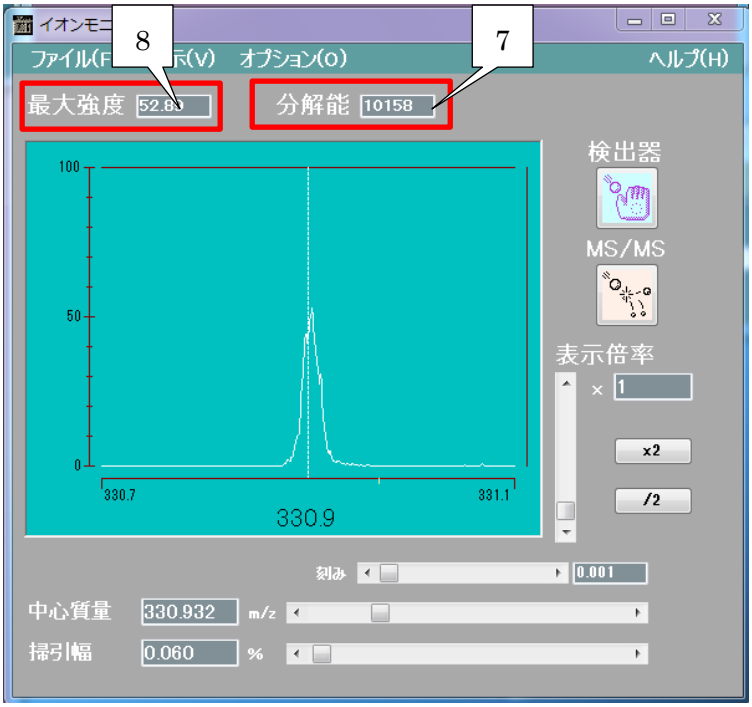
5) When the Progress of Auto Tuning reaches Complete, click OK.

6) After Auto Tuning, confirm that the resolution indicated on Ion Monitor is 10000 or higher.



*If the resolution is below 10000, perform Tuning again or manually change the parameters of lens, etc.

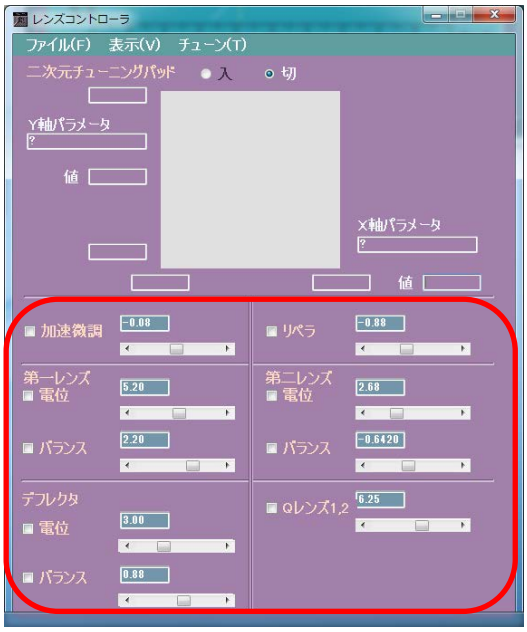
7) Change the accelerating voltage on Mode Controller to 7.5kV, and confirm that the resolution is 10000 or higher.



8) Perform adjustment so that the ratio of ion intensity at this voltage to that at 10kV becomes about 7.5:10.

*Manual adjustment of lens

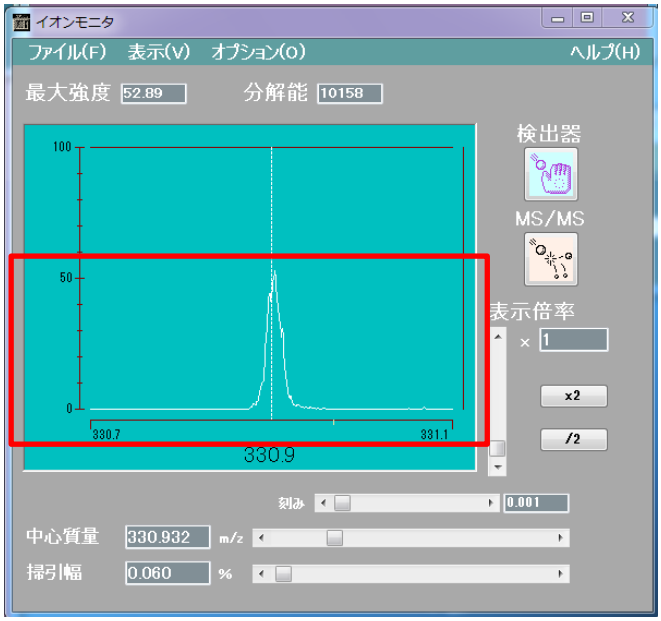
When the resolution does not reach 10000 by Auto Tune, open d) Lens Controller and adjust the lens values while watching the Ion Monitor. Take a screen shot to keep a record of the settings.



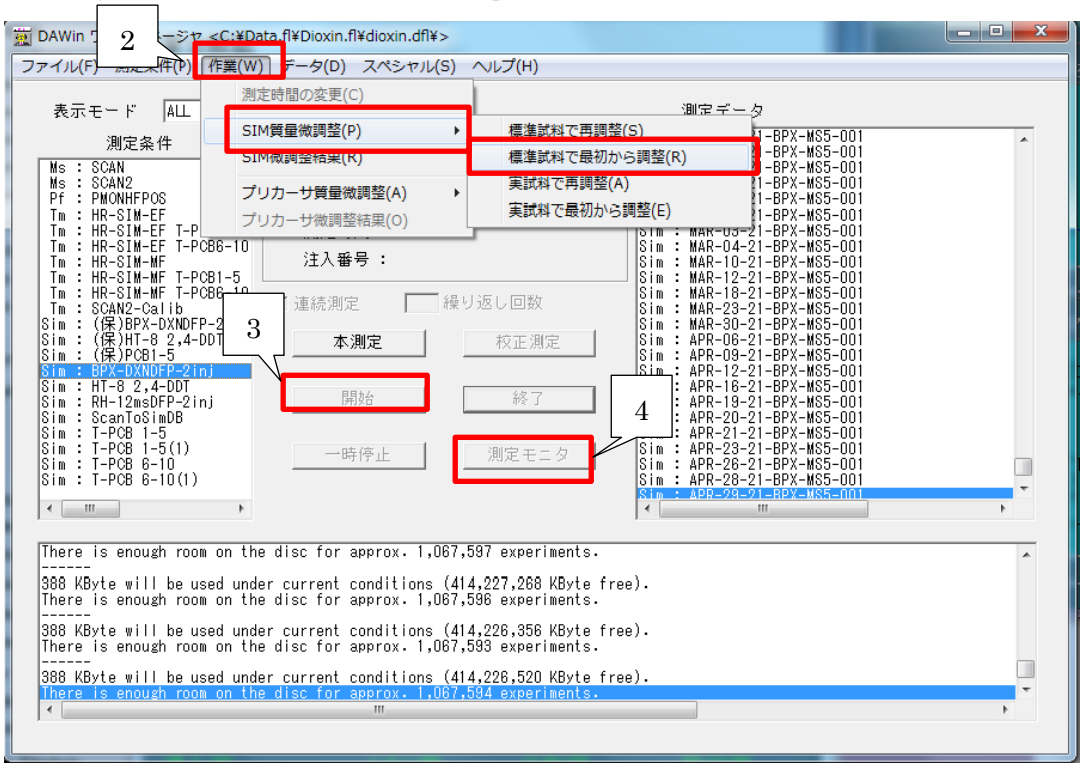
2-6. Peak adjustment

In SIM measurement, perform peak adjustment within the mass range used for the measurement to calibrate the difference between the measured and theoretical mass numbers of the individual PFK peaks.

1) Open Ion Monitor and adjust the PFK valve so that the PFK ion intensity on Ion Monitor becomes about 50%.



2) Start DAWin Work Manager ⇒ click Work (W) ⇒SIM Mass Fine Adjustment (P) ⇒ Adjust From Start With Standard Sample (R)



3) Click Start

4) Click Measurement Monitor

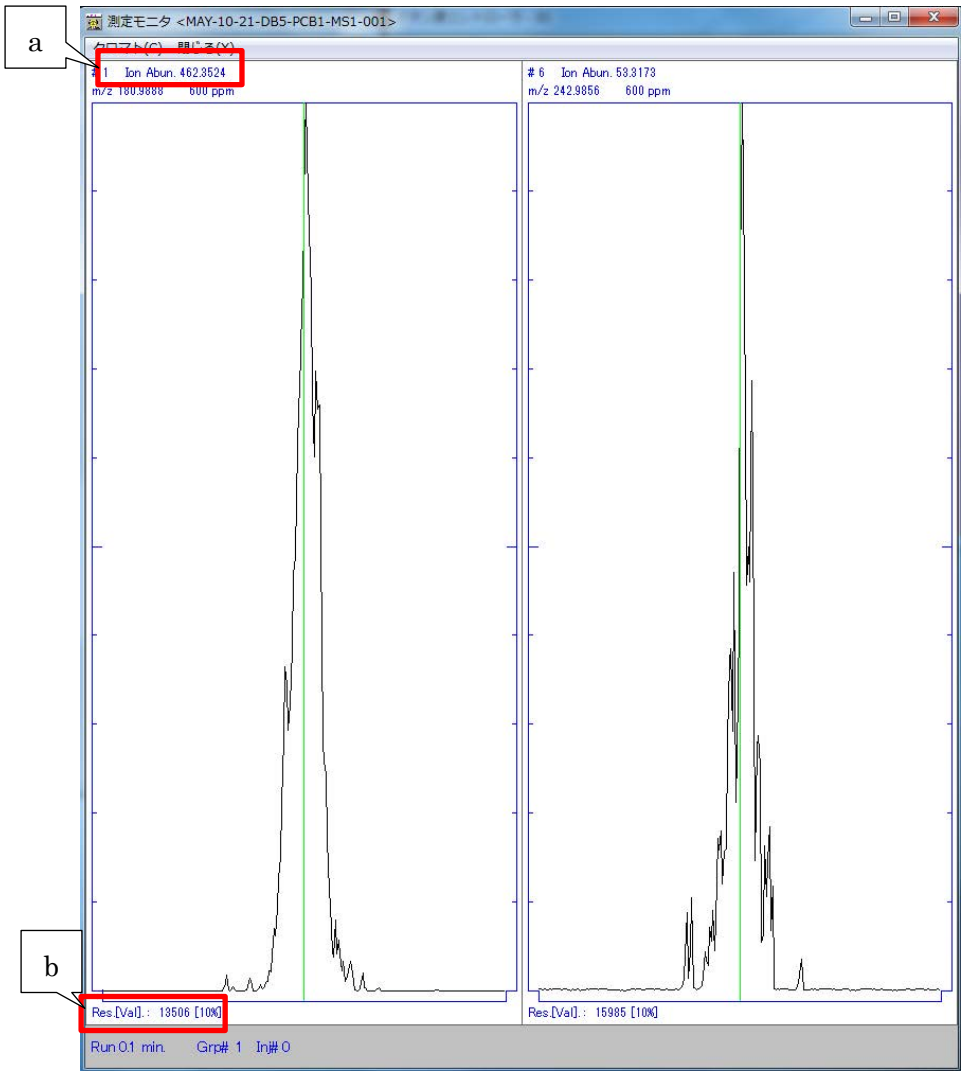
5) Peak Adjustment starts and Measurement Monitor is displayed, so check a) and b) and perform fine adjustments as needed.

   a) Make sure that Ion Abun has not gone off the scale (upper limit 1600). If Ion Abun has gone off the scale, throttle the PFK valve.

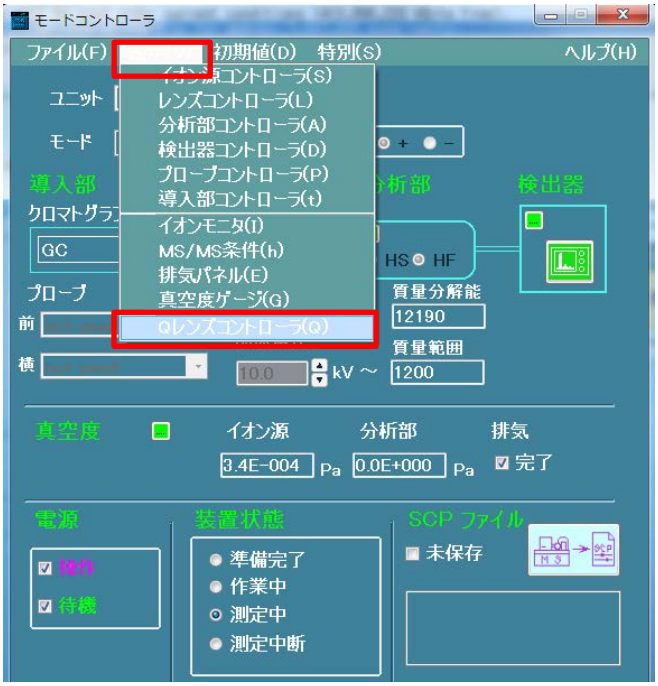
   b) Check the dynamic resolution. If it is lower than 10000, open Lens Controller and perform the following adjustments.

      ・Fine-tune 1, 2 on Lens Controller

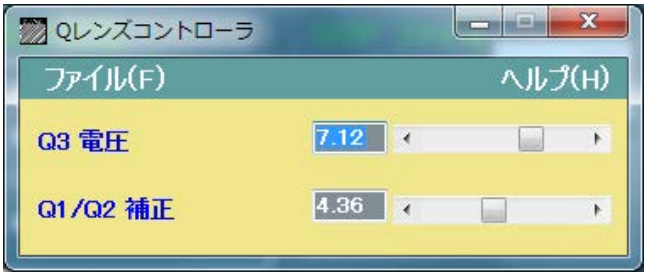
      ・Fine-tune Q1/Q2 correction on Q Lens Controller


a
b
測定モニタ <MAY-10-21-DB5-PCB1-MS1-001>
1 Ion Abun. 462.3524
m/z 180.9888 600 ppm
6 Ion Abun. 53.3173
m/z 242.9856 600 ppm
Res.[Val].: 13506 [10%]
Res.[Val].: 15985 [10%]
Run:0.1 min. Grp# 1 Inj# 0

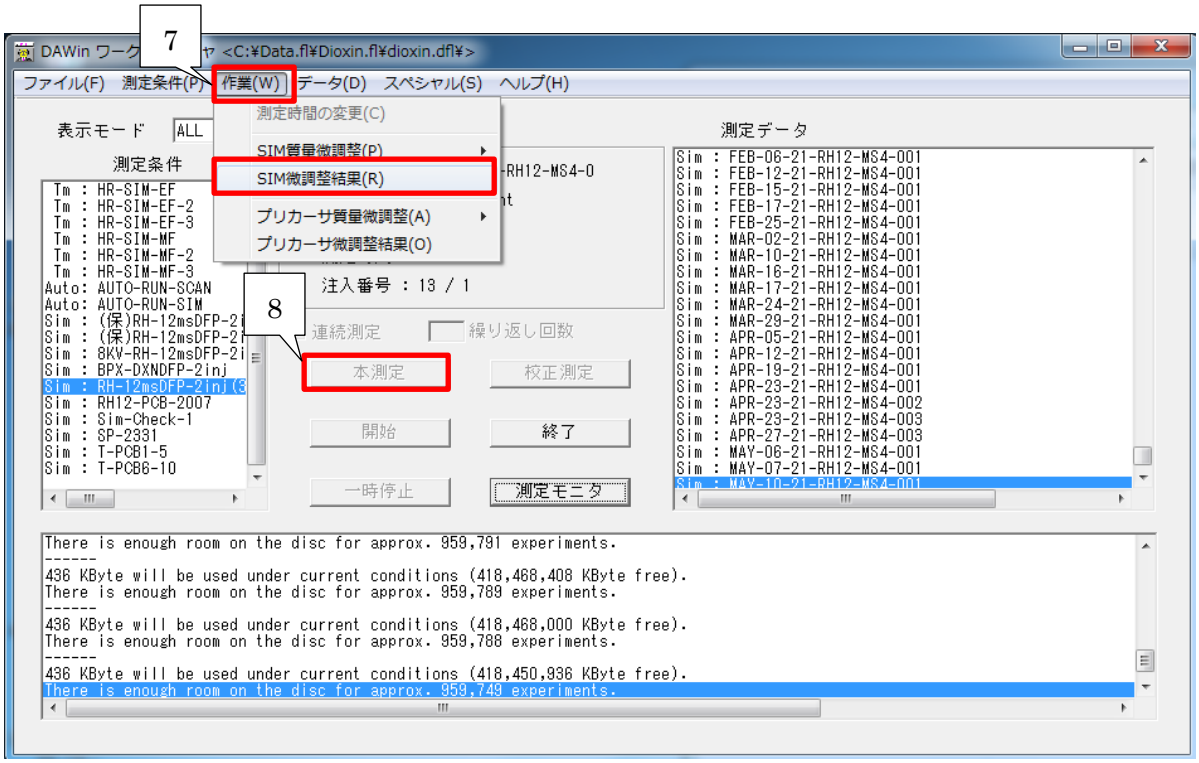
*To open Q Lens Controller, open Mode Controller and select Display (V) ⇒Q Lens Controller (Q).



Q Lens Controller



6) When peak adjustment is completed, check the result. On DAWin Work Manager, ⇒ click Work (W) ⇒SIM Mass Fine Adjustment Results (R) to display the results.

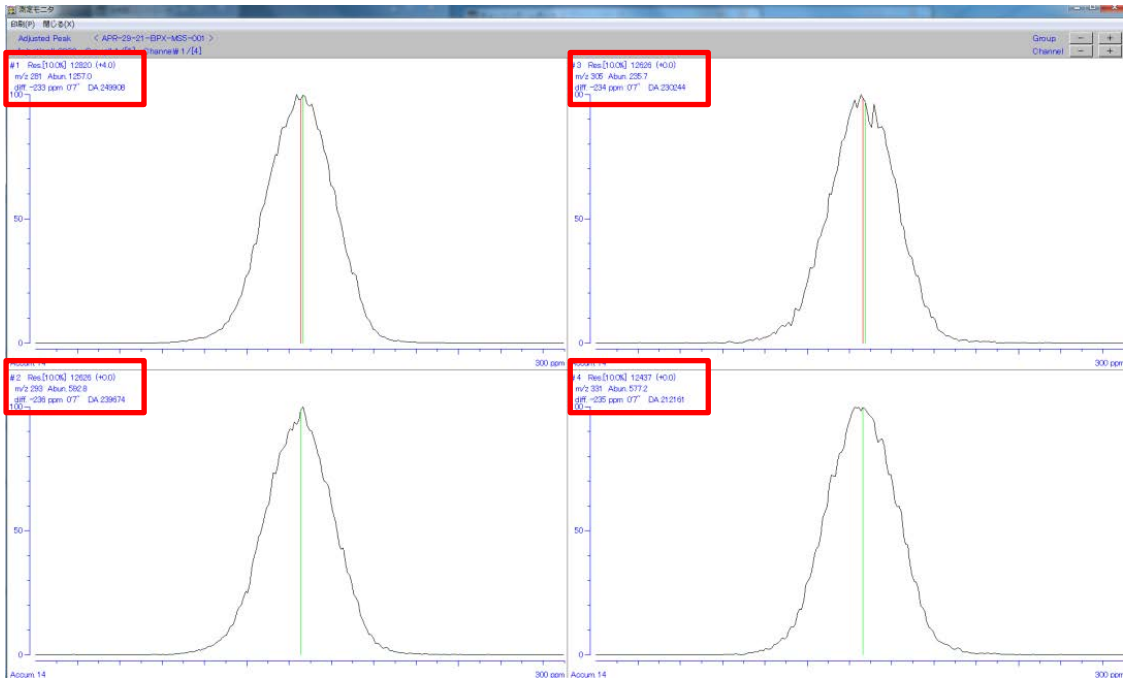


7) Check the following statuses for all group channels. If not satisfied, perform adjustment again.

・Res[10.0%] : 10000 or higher

・Abun: within scale

・diff: not identifying a different peak



8) Click Final Measurement to complete preparation for measurement

2-7. Record of adjustment

Record the adjustment settings by taking and saving screen shots as below.

2-8. Preparation of injection list

When preparation for GC/HRMS measurement is completed, prepare an injection list. An injection list serves as an important management record for ensuring traceability of samples, checking carry-over of samples from the last measurement and preventing misplacement of samples when setting vials to the autosampler.

General rules for preparing injection lists are provided below.

- Choose lots with close delivery dates.
- Measure samples in the order of their expected concentrations from the lowest.
  Categorize the samples by matrix and determine the order, for example, environmental water→ ambient air→ work environment→ soil→ sediment→ bottom ash→fly ash→ stack gas. However, the order should be changed depending on prior information on samples, condition of samples during pre-treatment and condition of sample for GC injection.
- Measure decane (solvent) when the concentration level is expected to change, e.g., when matrix is changed.
- At the end of the measurement lot, measure a standard solution whose concentration is in the middle range to check fluctuation of relative response.

・Measure decane (solvent) before and after the standard solution.

An example of an injection list is provided below.

インジェクションリスト　　別紙5-1

測定日：　21年　09月　16日

ファイル名：　Sep-16-21-BPX-MS5-001

使用測定ファイル：■ BPX-2inj，□ RH12-2inj，□ SP-2331 ，□ RH12ms-Hp.O ，□ RH12ms-PCB ，□ RH12ms-DXN

使用機器：　□ 1 ，□ 2 ，□ 3 ，□ 4 ，■ 5　　担当者　GC-MS：

NO.	Sample name		備 考		妨害成分の有無	DioK読込	ピーク解析者名	ピーク解析(完了日)
1	ST0916-1	感度変動	-0		無	■	[redacted]	9/16
2	d		-0		有・無	□		
3	NK049093-09K-1 [redacted]	水質・排水・溶出	-0		無	□		
4	NK049101-01K-2 [redacted]	様ガス・灰・廃棄物	-0		無	□		
5	d		-0		有・無	□		
6	NK052423-03K-5 [redacted]	水質・排水・溶出	-0	2ul	無	□		
7	NK052423-03K-6 [redacted]	水質・排水・溶出	-0	2ul	無	□		
8	NK052423-03K-1 [redacted]	水質・排水・溶出	-0	2ul	無	□		
9	NK052423-03K-2 [redacted]	水質・排水・溶出	-0	2ul	無	□		
10	NK052423-03K-3 [redacted]	水質・排水・溶出	-0	2ul	無	□		
11	NK049576-03K-1 [redacted]	大気・作環	-0		無	□		
12	NK049839-02K-1 [redacted]	大気・作環	-0		無	□		
13	NK049839-02K-2 [redacted]	大気・作環	-0		無	□		
14	NK052932-01K-1 [redacted]	大気・作環	-0		無	□		
15	NK052932-01K-2 [redacted]	大気・作環	-0		無	□		
16	NK051405-01K-1 [redacted]	様ガス・灰・廃棄物	-0		無	□		
17	NK053928-01K-1 [redacted]	様ガス・灰・廃棄物	-0		無	□		
18	NK053928-01K-4 [redacted]	様ガス・灰・廃棄物	-0		無	□		
19	d		-0		有・無	□		
20	ST0100-2	感度変動	-0		有・無	□		

2.9. Measurement

The procedures of measurement are provided below.

1) Place vials on the autosampler one-by-one while checking the printed injection list.
2) Check the remaining volume of microsyringe cleaning solvent. If there is not enough, add to it or replace it.
3) Set the GC method and start measurement.

   Make sure the setting is correct, as the injection volume differs depending on the medium.
4) After the measurement is completed, recover the vials from the autosampler while checking the injection list. Also check if there are any holes in the septa of the vials to confirm that injection has been properly performed.

5) Replace the vial cap with a new one and store the samples temporarily.
6) After loading data in the next step (dataprocessing) and confirming that the measurement results have no problems, organize and move the samples to the long-term storage area.

3. Data processing using Diok

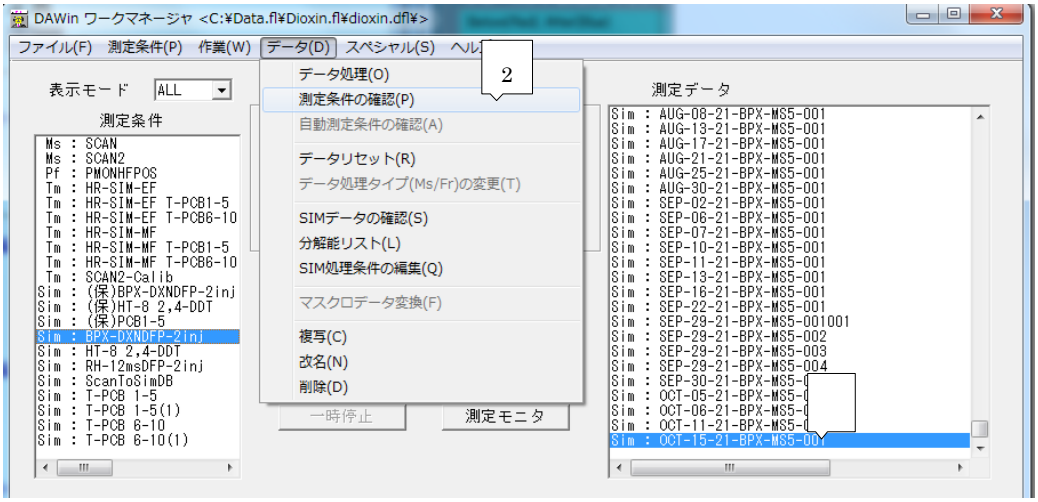
3-1. Loading measurement data into Diok

As a means for detecting any mistakes at loading of measurement data, check whether the sample information entered from DAWin Work Manager, the main program on the GC/HRMS, matches with that loaded on Diok.

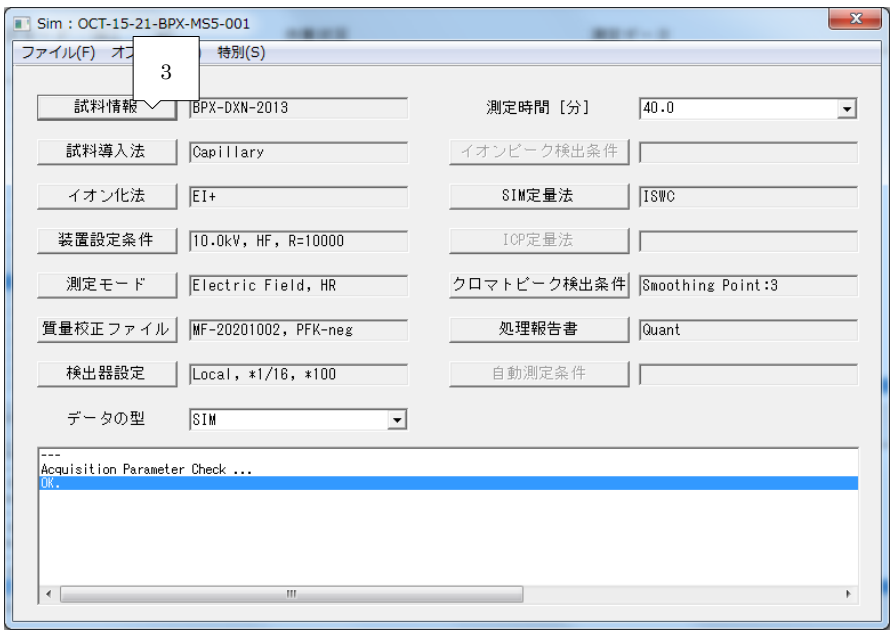
3-1-1. Entry of sample information into GC/HRMS side

1) On DAWin Work Manager, click and select the measurement data to be loaded.

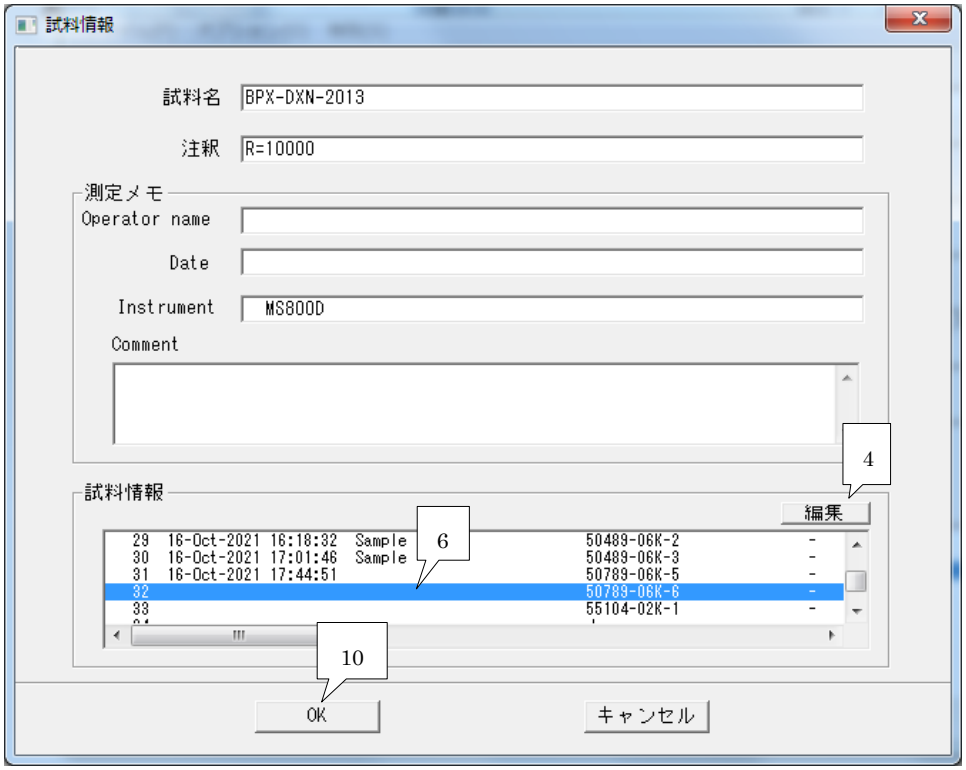
2) Click Data tab→Check Measurement Parameters (P) to open the Sim window.



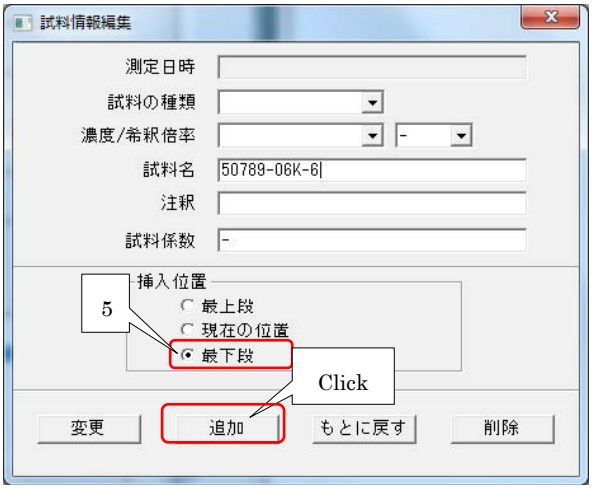
3) On the Sim window, click Sample Information to open the Sample Information window.



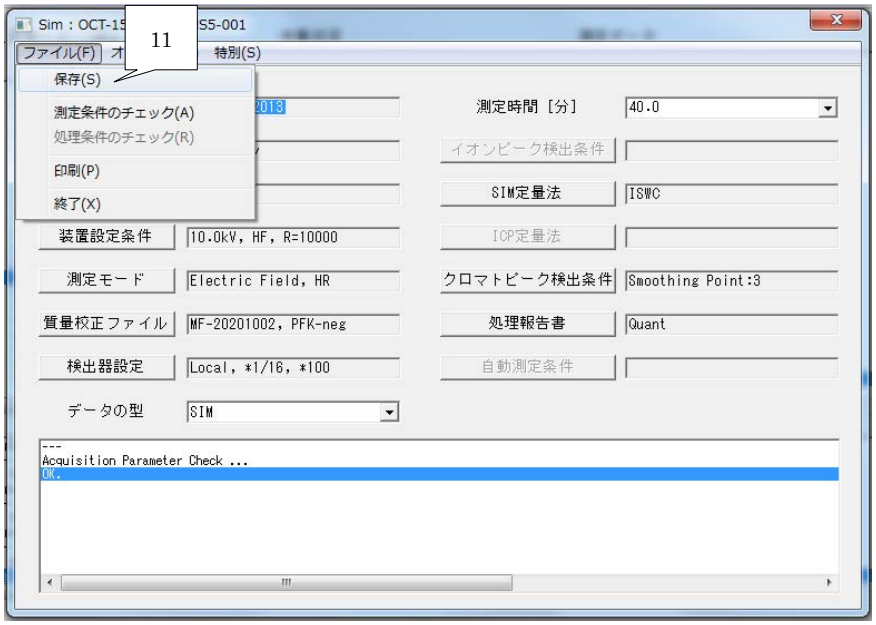
4) On the Sample Information window, click Edit to open the Sample Information Edit window
5) Put a check mark in “Current Position” of Insert Position
6) Check the injection list and click and select the data to be entered
7) Enter sample information into Sample Name
8) Click Change
9) Repeat steps 6) to 8)
10) After entering all data, click OK on the Sample Information window



*The above editing steps are applicable to samples for which measurement has already been performed. When you wish to enter sample information before performing the measurement, put a check mark in “Bottom” of Insert Position and then click “Add” in step 5).



11) Finally, on the Sim window in step 3), click File (F)→Save (S) to save the data.



3-1-2. Loading of measurement data into Diok

After measurement is completed, load the measurement data by DqAuto menu into Diok.

If more than one person works on Diok, it is recommended that you establish rules on folder usage so that the data will not be mixed up or lost. For reference, the rules adopted in our company are provided below.

Examples of Diok folder usage rules

・Data for samples of different matrix are loaded into different folders.

Folders are separated by matrix, as more than one person cannot open the same folder at the same time. In addition, data processing work of samples of different matrix are assigned to different persons. In this way, analysis, the most time-consuming work, can be performed concurrently by persons assigned to individual types of matrix.

Separating folders by matrix type also makes it easier for each person in charge to notice the abnormal peak patterns in chromatograms or errors in the addition of cleanup standard during analysis work.

・Measurement results of standard solution for checking fluctuation of relative response are loaded into all folders.

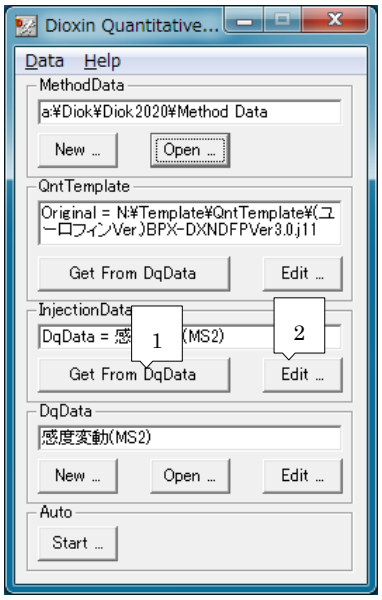
JIS stipulates that standard solutions for calibration curve preparation with intermediate concentrations should be measured regularly to check fluctuation of relative response. At Eurofins, it is performed daily, but sometimes, measurements of more than one matrix type are performed on the same day. Therefore, when folders are separated by matrix type, the same measurement results of the standard solution for checking fluctuation of relative response will be redundantly loaded into more than one folder. This enables all persons assigned to different matrix types to simultaneously check fluctuation of relative response and recovery rate of GC/HRMS.

・Folders are switched to new folders every six months to one year.

The operating speed of Diok becomes slower as the number of injection increases, so it is efficient to prepare new folders regularly.

The actual operation procedures are provided below.

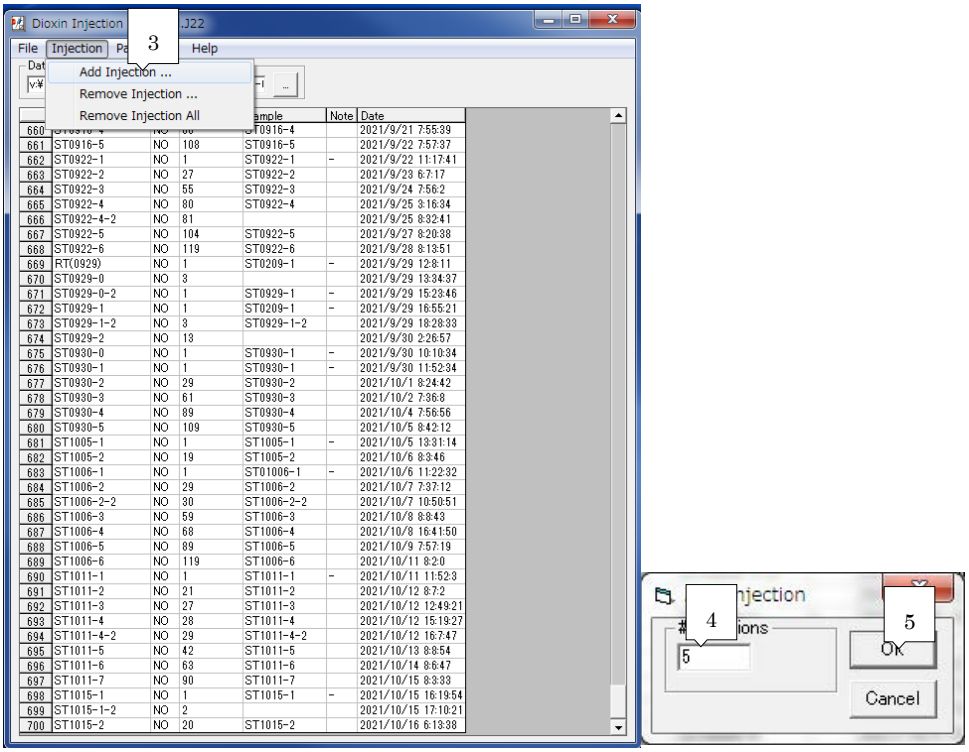
1) On the Dioxin Quantitative Auto window, click Get From DqData in InjectionData to update information.
2) Click Edit in InjectionData to open the Dioxin Injection Data window.



3) Click Add Injection on the Injection tab to open the Add Injection window.

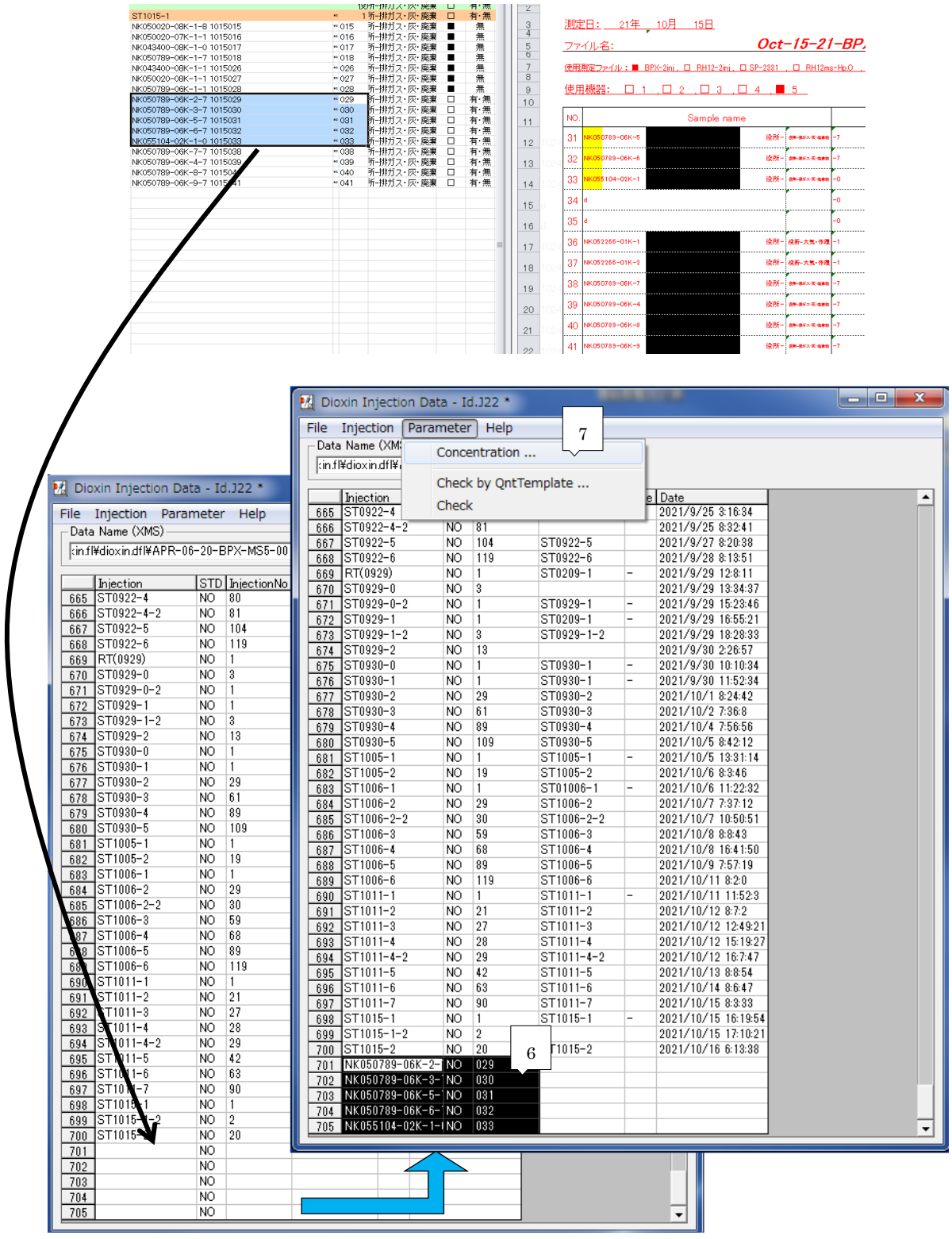
4) Edit the number of samples to be loaded. (* Five samples in this example)

5) Click OK to add Injection.



6) To the added injection, copy and paste the data on the injection list sorted by matrix.

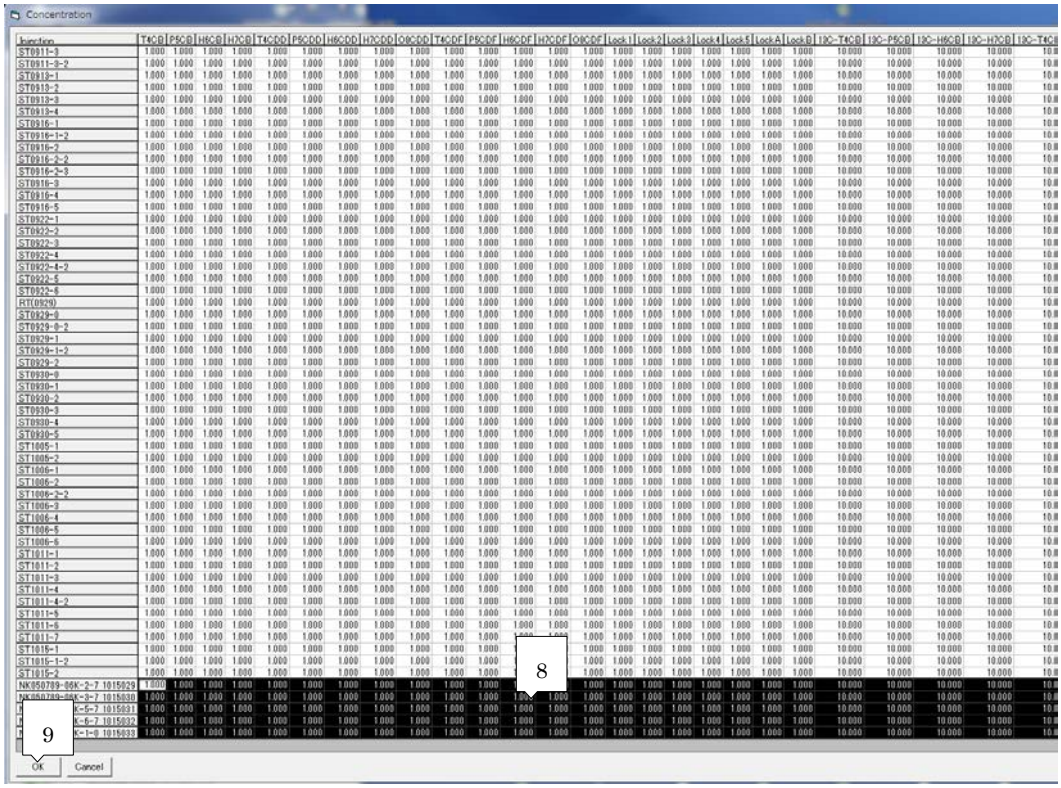
7) Click Concentration on the Parameter tab to open the Concentration window.



8) On the Concentration window, enter the concentration of the standard material used for the

added injection.

9) Click OK.

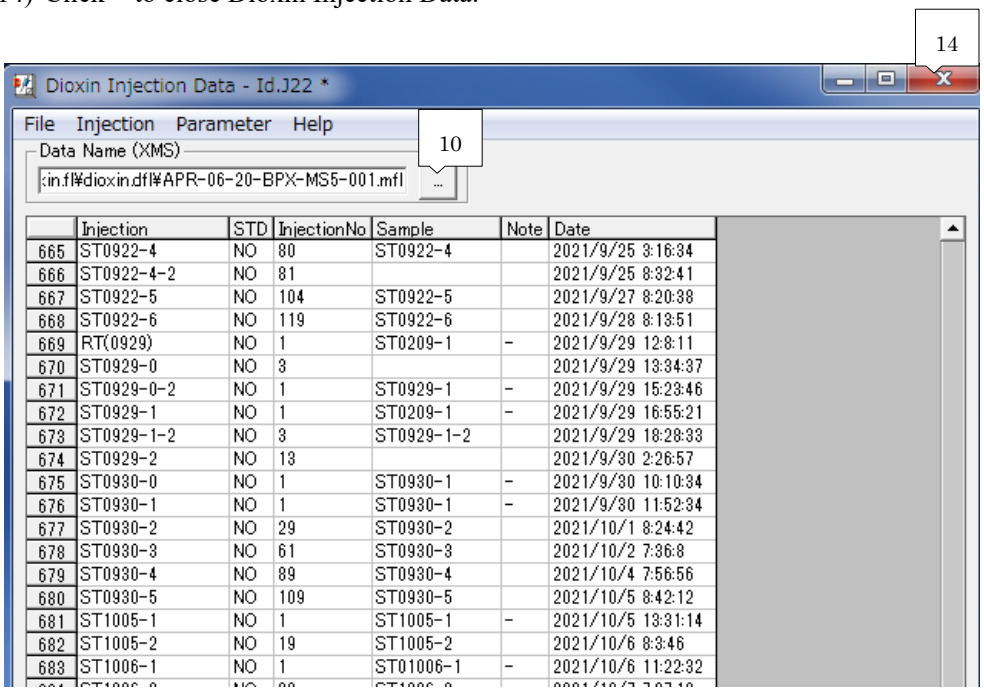


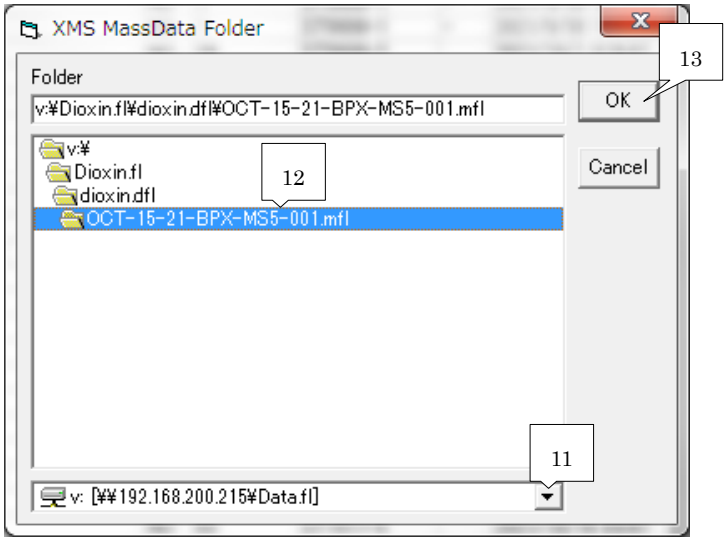
11) Select the device containing the measurement data to be loaded.

12) Select the measurement data to be loaded from the folder.

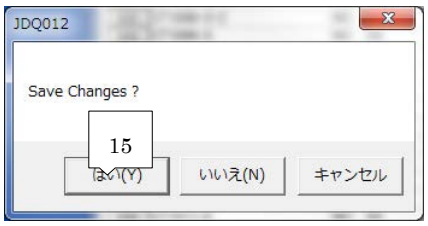
13) Click OK.

14) Click × to close Dioxin Injection Data.





15) The window shown below pops up, so click Yes to save the settings.



17) Put a check mark in Partial.

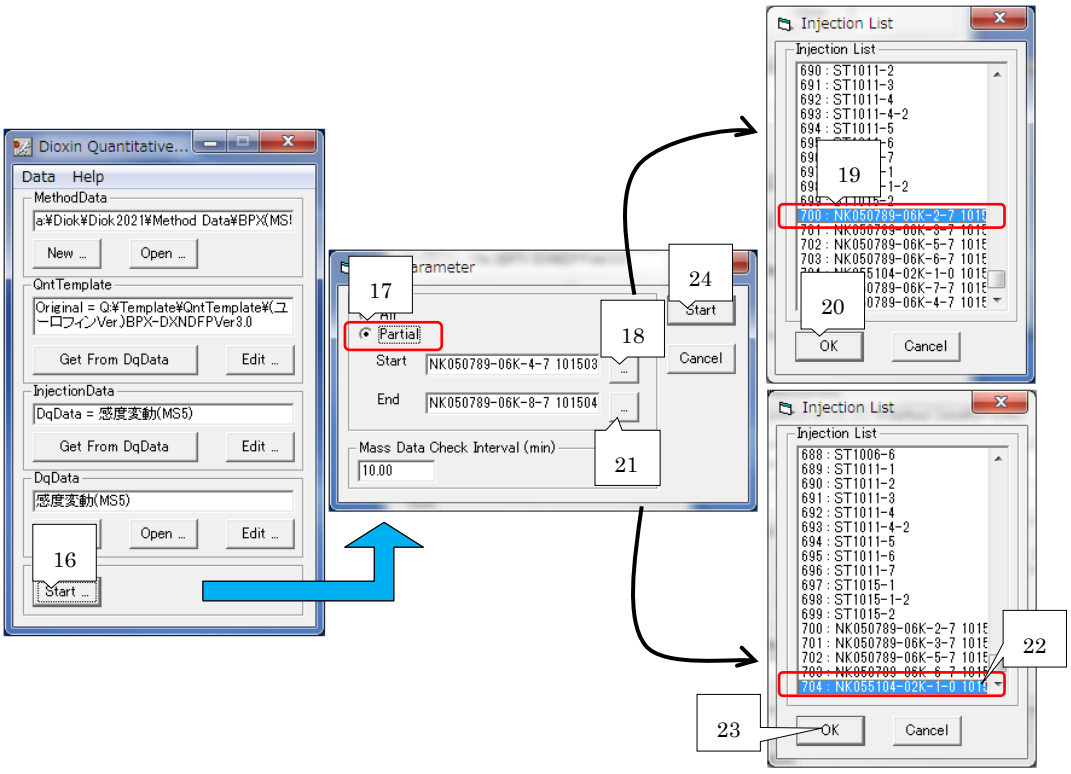
19) Select the injection for which loading is to be started.

20) Click OK.

22) Select the injection for which loading is to be ended.

23) Click OK.

24) Click Start to start loading.

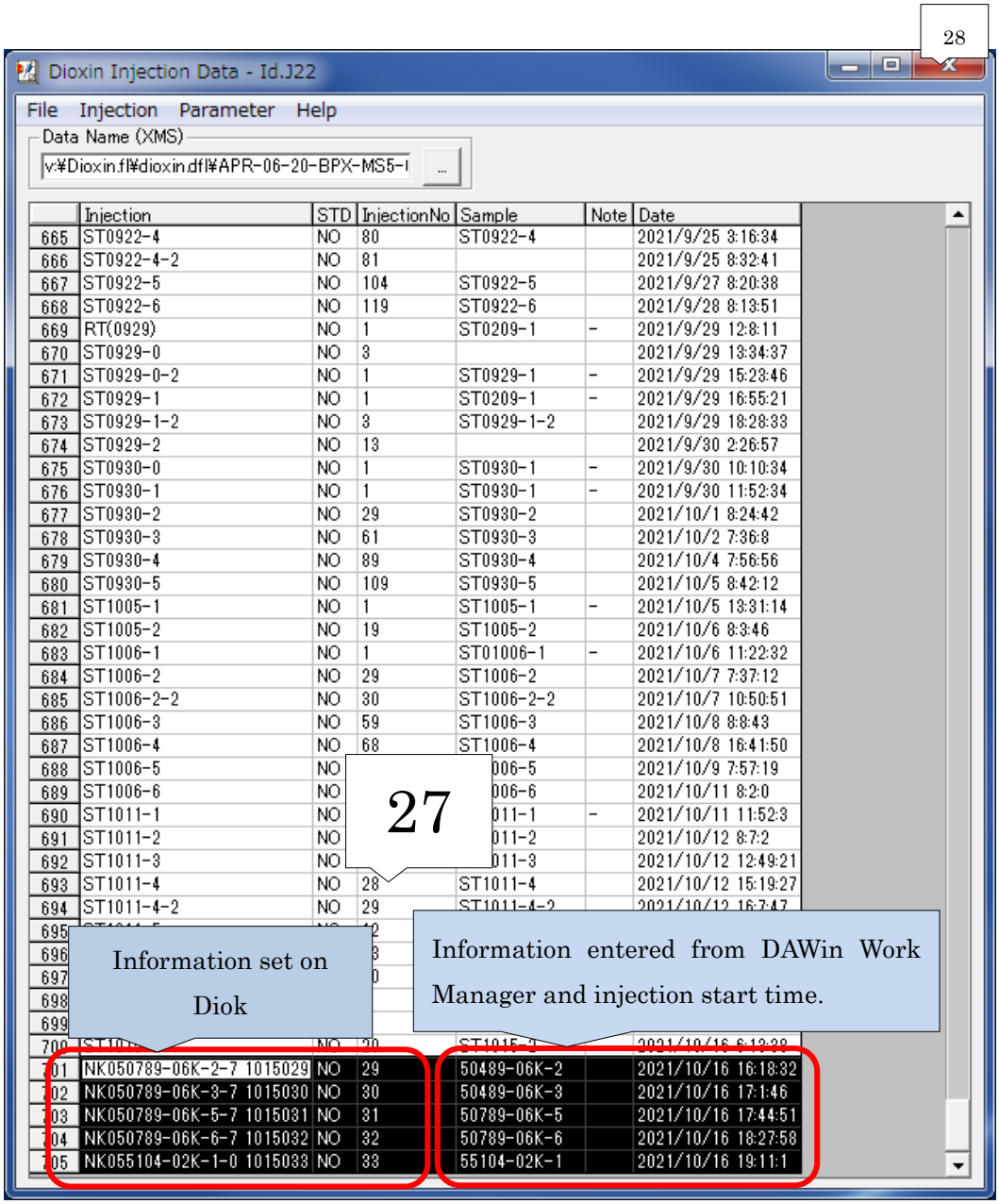


25) When loading is completed and a pop-up window appears, click OK.

26) Repeat the operations in steps 1) and 2) to open the updated Dioxin Injection Data.

27) On the Dioxin Injection Data window, check whether the information set on Diok matches with the information entered from GC/HRMS side (i.e., data entered in 3-1-1).

28) If matching is confirmed, click × to close Dioxin Injection Data and end loading operation.

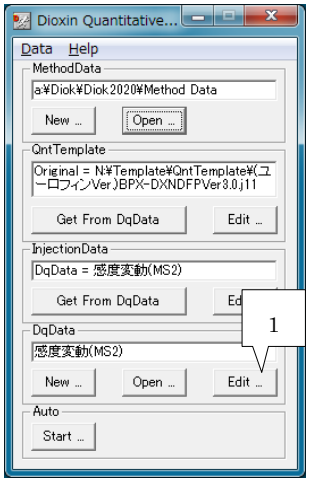


	Injection	STD	InjectionNo	Sample	Note	Date
665	ST0922-4	NO	80	ST0922-4		2021/9/25 3:16:34
666	ST0922-4-2	NO	81			2021/9/25 8:32:41
667	ST0922-5	NO	104	ST0922-5		2021/9/27 8:20:38
668	ST0922-6	NO	119	ST0922-6		2021/9/28 8:13:51
669	RT(0929)	NO	1	ST0209-1	-	2021/9/29 12:8:11
670	ST0929-0	NO	3			2021/9/29 13:34:37
671	ST0929-0-2	NO	1	ST0929-1	-	2021/9/29 15:23:46
672	ST0929-1	NO	1	ST0209-1	-	2021/9/29 16:55:21
673	ST0929-1-2	NO	3	ST0929-1-2		2021/9/29 18:28:33
674	ST0929-2	NO	13			2021/9/30 2:26:57
675	ST0930-0	NO	1	ST0930-1	-	2021/9/30 10:10:34
676	ST0930-1	NO	1	ST0930-1	-	2021/9/30 11:52:34
677	ST0930-2	NO	29	ST0930-2		2021/10/1 8:24:42
678	ST0930-3	NO	61	ST0930-3		2021/10/2 7:36:8
679	ST0930-4	NO	89	ST0930-4		2021/10/4 7:56:56
680	ST0930-5	NO	109	ST0930-5		2021/10/5 8:42:12
681	ST1005-1	NO	1	ST1005-1	-	2021/10/5 13:31:14
682	ST1005-2	NO	19	ST1005-2		2021/10/6 8:3:46
683	ST1006-1	NO	1	ST01006-1	-	2021/10/6 11:22:32
684	ST1006-2	NO	29	ST1006-2		2021/10/7 7:37:12
685	ST1006-2-2	NO	30	ST1006-2-2		2021/10/7 10:50:51
686	ST1006-3	NO	59	ST1006-3		2021/10/8 8:8:43
687	ST1006-4	NO	68	ST1006-4		2021/10/8 16:41:50
688	ST1006-5	NO		006-5		2021/10/9 7:57:19
689	ST1006-6	NO		006-6		2021/10/11 8:2:0
690	ST1011-1	NO		011-1	-	2021/10/11 11:52:3
691	ST1011-2	NO		011-2		2021/10/12 8:7:2
692	ST1011-3	NO		011-3		2021/10/12 12:49:21
693	ST1011-4	NO	28	ST1011-4		2021/10/12 15:19:27
694	ST1011-4-2	NO	29	ST1011-4-2		2021/10/12 16:7:47
695						
696						
697						
698						
699						
700						
701	NK050789-06K-2-7 1015029	NO	29	50489-06K-2		2021/10/16 16:18:32
702	NK050789-06K-3-7 1015030	NO	30	50489-06K-3		2021/10/16 17:1:46
703	NK050789-06K-5-7 1015031	NO	31	50789-06K-5		2021/10/16 17:44:51
704	NK050789-06K-6-7 1015032	NO	32	50789-06K-6		2021/10/16 18:27:58
705	NK055104-02K-1-0 1015033	NO	33	55104-02K-1		2021/10/16 19:11:1

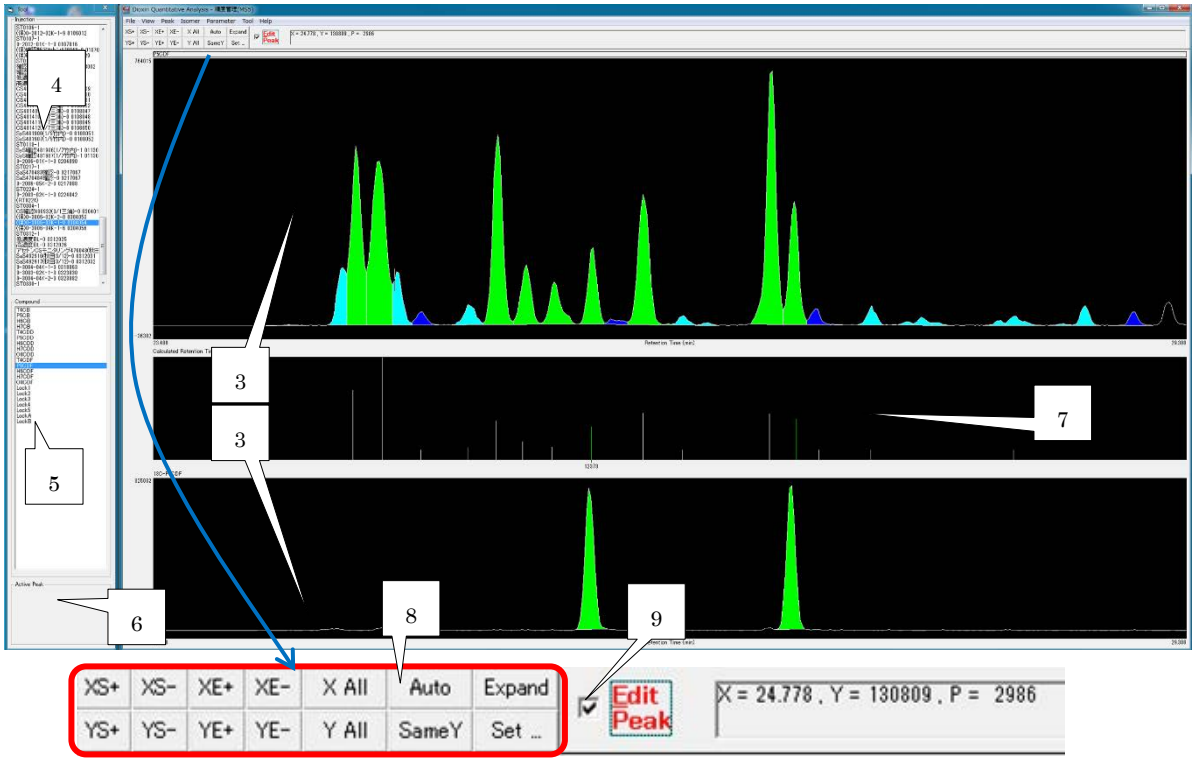
3-2 Confirmation of loaded data and peak integration

3-2-1 How to view and operate the Dioxin Quantitative Analysis window

1) Click Edit in DqData to open the Dioxin Quantitative Analysis window.



2) Methods for viewing and operating the Dioxin Quantitative Analysis window are provided below in steps 3) to 12).



3) The upper chromatogram is peaks averaged across individual channels for Native form. The lower chromatogram is peaks averaged across individual channels for 13C-labeled form.

The colors of the peaks represent the following status.

: assign OK, ion intensity ratio OK

: assign OK, ion intensity ratio NG

: assign NG, ion intensity ratio OK

: assign NG, ion intensity ratio NG

Assign: indicate the condition of information such as isomer name, retention time and area has been assigned to the peak.

4) Displays the loaded sample information. Displays chromatogram of the selected sample on the right.

5) Homologs of the measured substance. Displays chromatogram of the selected homolog on the right.

6) Displays Active Peak information for a peak selected on the right.
Information such as isomer name, RT, Area, Height and S/N are displayed here

7) Assignment bar. Displays retention time of each isomer
Assignment can be done by selecting the lower part of the assignment bar and dragging and

dropping onto the corresponding peak in the upper diagram.

*Note that the position of the assignment bar is not always correct by default.

8) The display range of chromatograph can be changed.

Frequently used operations are introduced below.

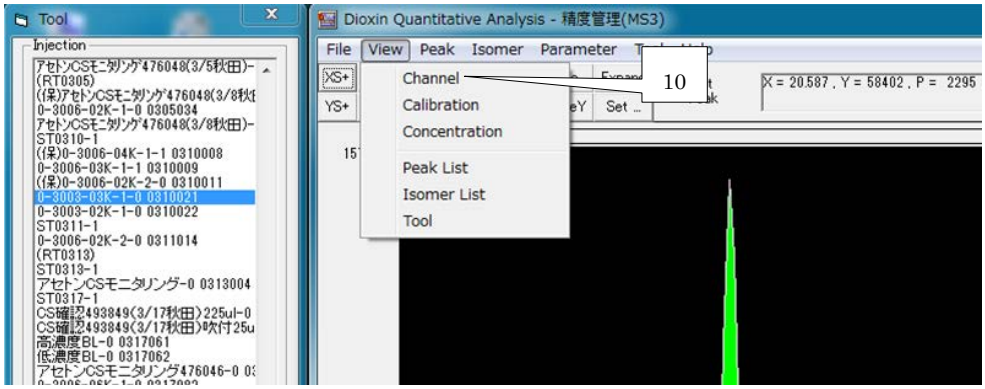
・Click Expand, and drag and draw a square around the range you wish to enlarge →enlarges the range enclosed by the square.

・Click Auto →displays the Display Range set

・Click SameY →Applies and displays the Y-axis range of the selected chromatogram to all chromatograms

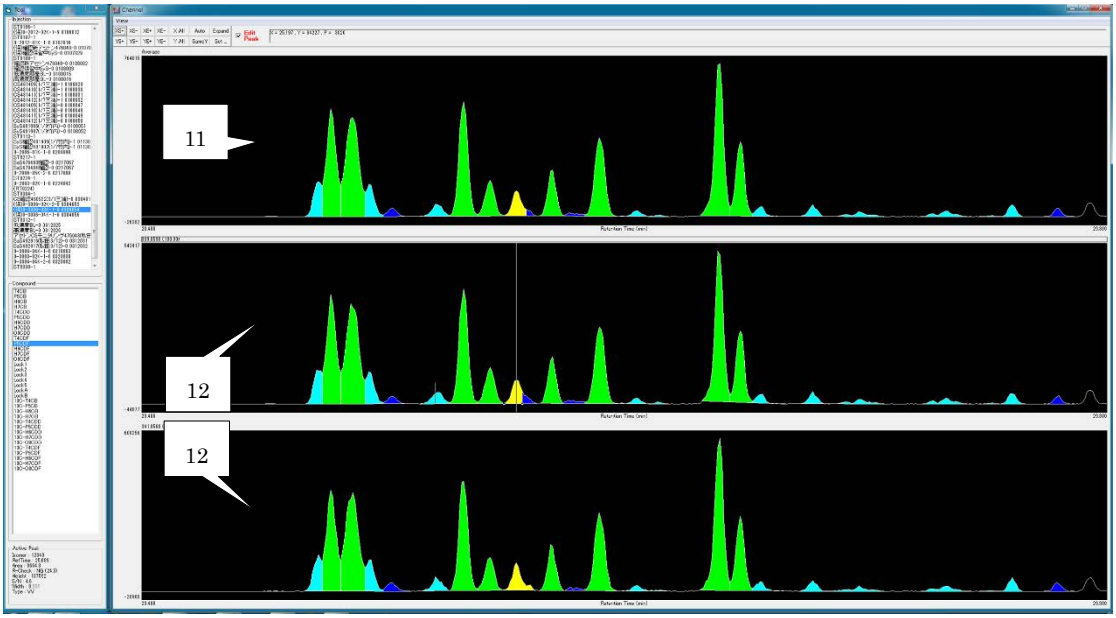
9) The peak can be edited when the checkbox is ☑

10) Click Channel on the View tab to switch to channel display mode.



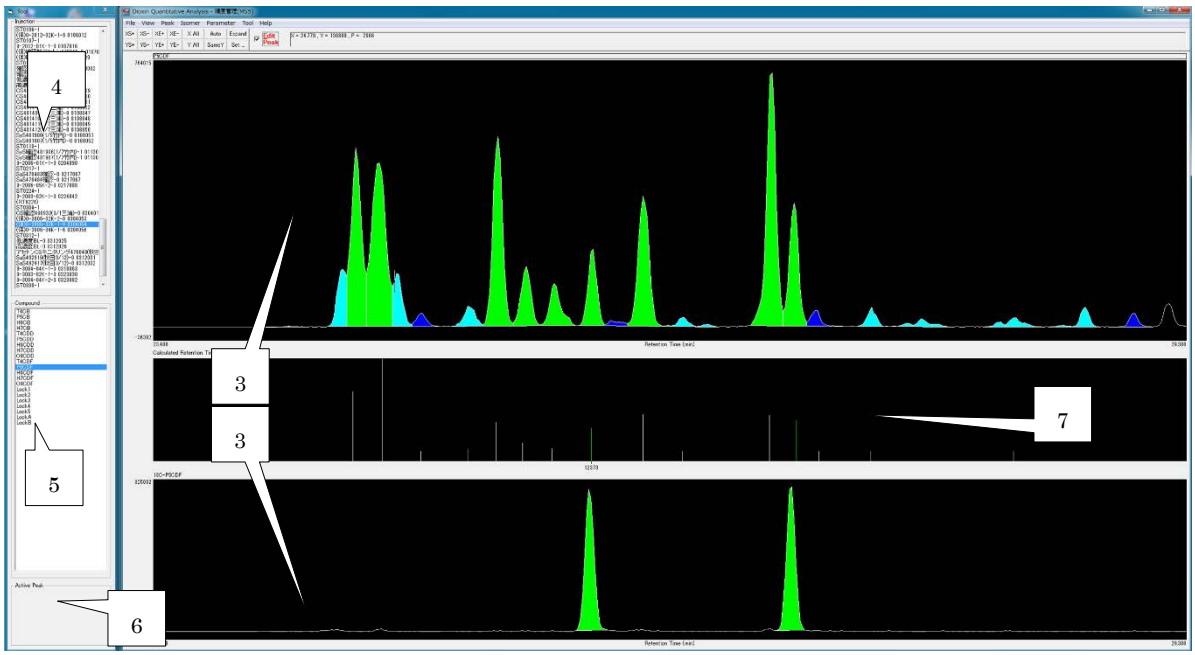
11) The window below is the window displaying individual channels.
The upper chromatogram shows the peaks for Native form averaged across individual channels.

12) The middle and lower chromatogram show the peaks for Native form of individual channels.



3-2-2 Confirmation of loaded data (Identify samples that need to be re-measured & re-analyzed)

The window below is the same as the Dioxin Quantitative Analysis window shown in 3-2-1 step 2).

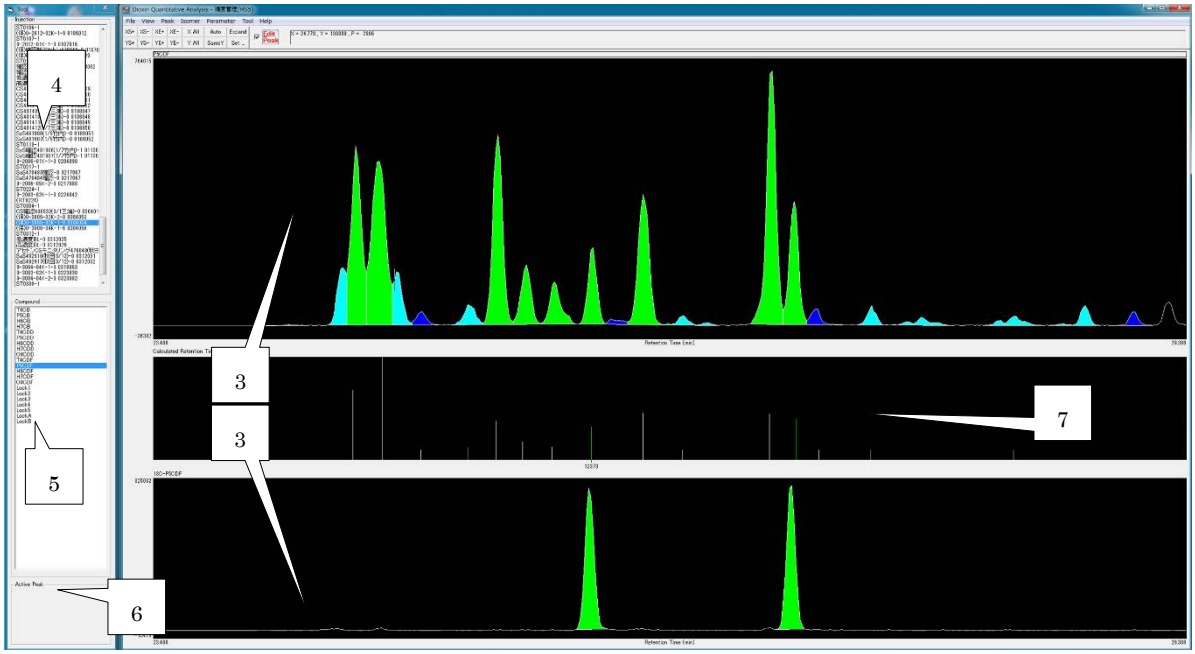


Switch the displays of 3-2-1 step 4) and 5) and check the peaks in the loaded chromatograms. If there are any samples that need to be re-measured, enter the details in the injection list and separate them from other samples before storing GC/HRMS vials. Similarly, if there are any samples that need to be re-analyzed, enter the details in the injection list and give instructions for re-analysis. Examples of status requiring re-measurement or re-analysis are provided below.

Status of measurement results	Operation to be performed
Peak tip splitting	Perform GC/HRMS measurement again
Low sensitivity (peak response)	Perform GC/HRMS measurement again
Ghost peaks (Interference from the previous measurement)	Perform GC/HRMS measurement again
Unstable baseline (Interference from the previous measurement)	Perform GC/HRMS measurement again
Measurement lot for which measurement results of standard solution for checking fluctuation of relative response described in 3-1-2 did not meet the criteria	Subject all samples in the lot to GC/HRMS measurement again (JIS requirement)
Peak saturation	Perform re-analysis (reduce sampling volume or dilute)
Interference overlapping analyte peak	Perform re-analysis (add purification treatment, etc.)
Severe interference from sample	Perform re-analysis (add purification treatment, etc.)
Recovery rate not meeting criteria	Perform re-analysis
Decline or large variation in lock mass	Perform re-analysis (add purification treatment, etc.)

3-2-3 Peak integration and assignment

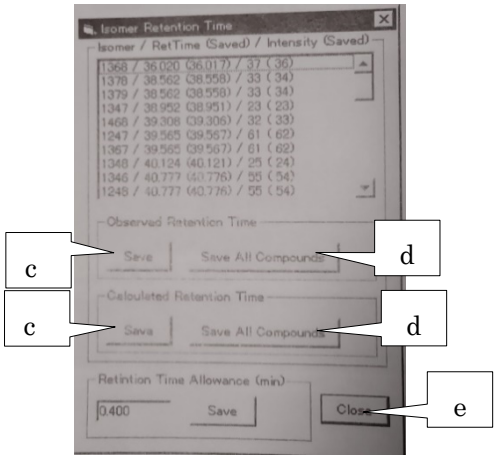
The window below is the same as the Dioxin Quantitative Analysis window shown in 3-2-1 step 2).



1) Assignment can be done by selecting the lower part of the assignment bar in 7) and dragging and dropping onto the peak.

2) If the position of the assignment bar is not correct, perform re-setting according to the following procedures.

a) Assign all isomers by using a sample from which all isomers have been detected (e.g., fly ash).



b) Click Retention Time on the Isomer menu to open the Retention Time window.

c) For saving retention time of the selected homolog, click the two Save buttons.

d) For saving retention time of all isomers, click the two Save All Compounds buttons.

e) Press the Close button to close the window.

3) If display range deviates from the chromatogram that should be displayed , perform re-setting according to the following procedures.

a) Click Data Range on the parameter menu to open the Quantitative parameter Data Range window.

b) Select the homolog to be changed and edit Display Range.

* Setting needs to be individually performed for native and 13C-labeled forms. Make sure that Display Range of 13C-label form is the same as that of Native form. Otherwise, it will be difficult to check.

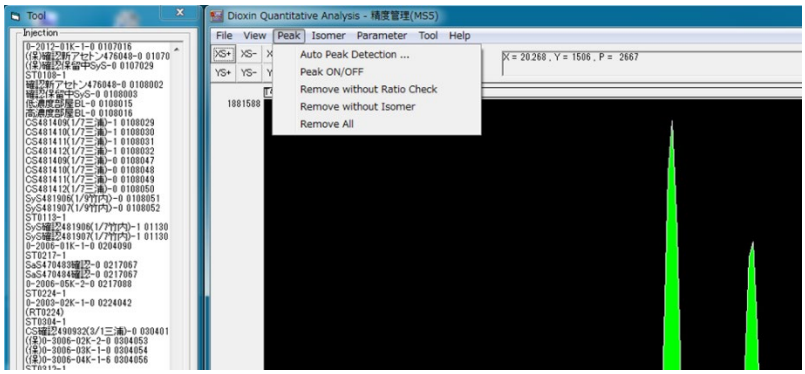
4) Delete any unnecessary peaks or peaks with S/N ratio of 3 or smaller.

*For deleting a peak, select the peak and press the Delete key

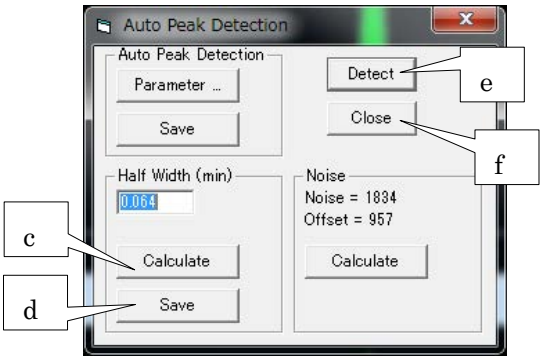
* For re-setting noise, perform the following steps.

a) Ctrl+drag to select a range corresponding to about 10-fold of the half value width of the peak.

b) Click Auto Peak Detection in the Peak menu.



c) Click Calculate to update the half value width.



d) Click Save.

e) Click Detect.

f) Click Close to close the window.

5) Switch to the window displaying individual channels and perform analysis on individual peaks.

Yellow-colored peaks having intensity ratios not meeting the set value tend to be improperly

peak integration, so check their results and make corrections as needed. After the peak integration is completed, delete peaks with ion intensity ratios that do not meet the criteria, as they are not considered to be DXNs. (The deleted peaks cannot be adopted as measurement results of Dioxins. It is necessary to perform the GC/HRMS measurement again or start all over from sample extraction/clean-up.)

6) Repeat the above operations to integrate and assign all peaks.

End

Appendix 10-4: Japanese Experience of WTE Development

EJEC REPORT

PPP for WTE project
～ The process of forming a MSW treatment project in Japan ～

株式会社 エイト日本技術開発

価値ある環境を未来に

November 26, 2021

Keitaro SHIMAMUNE

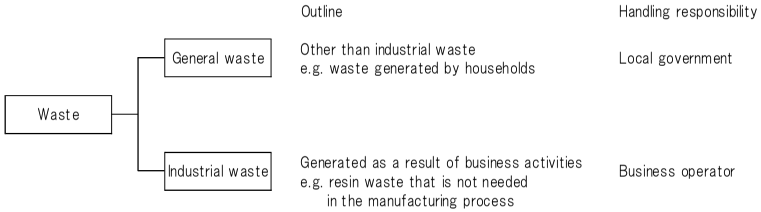
Solid Waste Management Dept.,

Tokyo Branch,

Eight-Japan Engineering Consultants Inc. (EJEC)

Category of Waste

In Japan, waste is mainly classified into “general waste (MSW)” generated by households and “industrial waste” generated by Industries, factories, etc.



Handling Responsibility of General Waste (MSW)

Local governments are responsible for collecting, transporting, treating, and disposing of general waste, either individually or in cooperation with other local governments.

Overall Schedule

Incineration facilities are generally planned to be upgraded based on the service life of the existing facilities. The service life is generally 30-40 years.

Since it will take approx. 10 years to complete the facility construction, the overall schedule is planned backwards.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
Existing Facility	Operation	26	27	28	29	30	31	32	33	34	35		Renewed in 30-40 yrs (e.g. 35 yrs)
New Facility	MSW Treatment Master Plan (MP)		2	3	4	5	6	7	8	9	10	1	Reviewed once every 5 yrs
	Facility Development Conceptual Plan												Decision on renewal & site
	Facility Basic Plan												Decision on processing method
	PFI/PPP Feasibility Study												Decision on business scheme
	Topographic Survey												Reflected in facility basic plan
	Geological Survey												Reflected in facility basic plan
	Environmental Impact Assessment												1.5-4 yrs
	Selection of Winning Bidder												standard 2 yrs
	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

MSW Treatment Master Plan (M/P)

It is a long-term plan for 10 to 15 years, and is defined by law as "the basic plan for municipalities responsible for the overall treatment of general waste (MSW) to manage and ensure the proper treatment of it in their area”, and is required to be revised approximately every five years.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
Existing Facility	Operation	26	27	28	29	30	31	32	33	34	35		Renewed in 30-40 yrs (e.g. 35 yrs)
New Facility	MSW Treatment Master Plan (MP)		2	3	4	5	6	7	8	9	10	1	Reviewed once every 5 yrs
	Facility Development Conceptual Plan												Decision on renewal & site
	Facility Basic Plan												Decision on processing method
	PFI/PPP Feasibility Study												Decision on business scheme
	Topographic Survey												Reflected in facility basic plan
	Geological Survey												Reflected in facility basic plan
	Environmental Impact Assessment												1.5-4 yrs
	Selection of Winning Bidder												standard 2 yrs
	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Appendix 10

Main Contents of MSW Treatment Master Plan (M/P)

It clarifies the basic policy for general waste management in the region from a long-term perspective.

◆ Current Status of Waste

Summarize the current status and issues based on the population and the amount of waste generated (and collected).

Grasp the amount of waste processed and the amount of final disposal, which are the actual results of waste treatment.

◆ Projection of Future Waste Amount

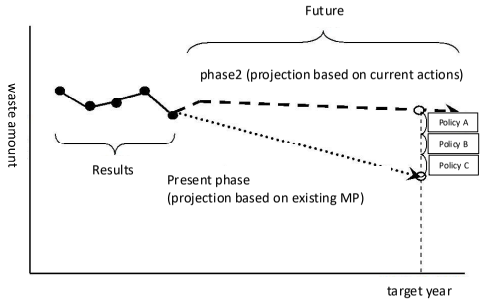
Project the amount of waste to be generated in the future based on future projections of population and waste output.

Consider measures to promote recycling and reduce waste.

◆ Basic Policy of Waste Management

Set numerical targets for future waste volumes and measures how to achieve them.

Examine the direction of collection and transportation, Intermediate treatment (recycling, incineration, etc.), and final disposal of general waste.



Facility Development Conceptual Plan

Based on the MSW Treatment Master Plan (M/P), the principles for the development of facilities will be determined, e.g. applied technology, processing capacity and construction site.

It should be noted that it may take many years to decide on a potential construction site due to local opposition.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
Existing Facility	Operation	26	27	28	29	30	31	32	33	34	35		Renewed in 30-40 yrs (e.g. 35 yrs)
New Facility	MSW Treatment Master Plan (MP)		2	3	4	5	6	7	8	9	10	1	Reviewed once every 5 yrs
	Facility Development Conceptual Plan												Decision on renewal & site
	Facility Basic Plan												Decision on processing method
	PFI/PPP Feasibility Study												Decision on business scheme
	Topographic Survey												Reflected in facility basic plan
	Geological Survey												Reflected in facility basic plan
	Environmental Impact Assessment												1.5-4 yrs
	Selection of Winning Bidder												standard 2 yrs
	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Main Contents of Facility Development Conceptual Plan

It is a basic concept for the development of new facilities.

◆ Decision on Facility Renewal

Decide on the future treatment system and renewal of facilities (new construction) based on the basic waste management plan.

Determine the size of the facility (processing capacity) required for the service area (region).

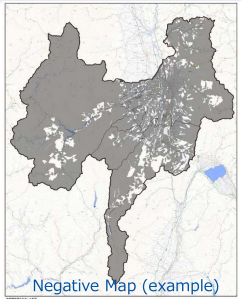
◆ Decision on Planned Construction Site

Set the conditions for the planned construction site, and narrow down the candidate sites from the negative map (areas to be avoided due to laws and regulations).

Evaluate multiple candidate sites from various perspectives (environment, land use, economic efficiency) and decide on a site for construction.

◆ Resident Briefings and Public Comments

Hold resident briefings and public comments on the basic concept (draft) in order to build consensus among residents.



Facility Basic Plan

Determine the specific details of the facility to be upgraded, such as its processing capacity, incinerator type, plant equipment, and basic specifications for civil engineering and construction, as well as the estimated project cost.

In order to determine the conditions for PFI feasibility study and environmental impact assessment, coordination with these related tasks is necessary.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
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	Facility Development Conceptual Plan												Decision on renewal & site
	Facility Basic Plan												Decision on processing method
	PFI/PPP Feasibility Study												Decision on business scheme
	Topographic Survey												Reflected in facility basic plan
	Geological Survey												Reflected in facility basic plan
	Environmental Impact Assessment												1.5-4 yrs
	Selection of Winning Bidder												standard 2 yrs
	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Appendix 10

Main Contents of Facility Basic Plan

It is a basic plan that summarizes the development details and basic conditions of the facilities to be developed.

◆ Decision on Treatment Method

Select the type of furnace to be installed (stoker type or gasification and melting type).

◆ Set Pollution Prevention Standards and Basic Specifications for Plants and Civil Engineering Buildings

Set pollution prevention standards (facility performance) for exhaust gas, noise, vibration, odor, etc. in consideration of laws and regulations.

Examine the processing flow, the number and general specifications of major equipment, the grade of the building, and the need for disaster countermeasures, etc.

◆ Calculation of Estimated Project Cost

Calculate estimated project cost by surveying plant manufacturers.

◆ Holding of the Construction Review Committee including External Experts

Hold committee meetings including external experts since the facility basic plan includes specialized content.

PFI/PPP Feasibility Study

After considering the scope and duration of the project as preconditions, quantitative (Value for Money) and qualitative evaluations are conducted to determine the most appropriate project scheme from PFI, DBO, and public management.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
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	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Main Contents of PFI/PPP Feasibility Study

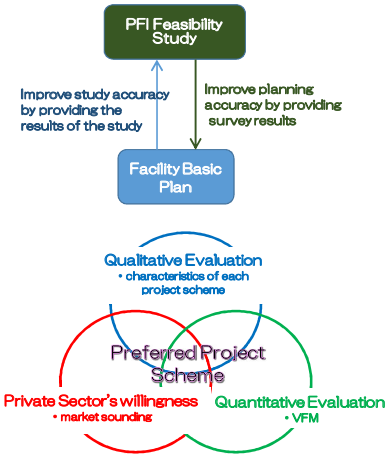
Evaluate the possibility of introducing PFI schemes (BOO, BOT, BTO, DBO, etc.) and determine the project scheme. The survey will be conducted in conjunction with the basic facility plan.

◆ Examination of Project Scheme

Examine the scope of the project, project period, and risk sharing.

◆ Evaluation of Project Scheme

The project will be evaluated comprehensively through quantitative evaluation (economic evaluation) based on the private sector's willingness to participate and VFM, and qualitative evaluation (merits and demerits of each project scheme) based on the characteristics of the project scheme at the business entity selection and implementation stages.



Major Project Schemes used in WTE in Japan

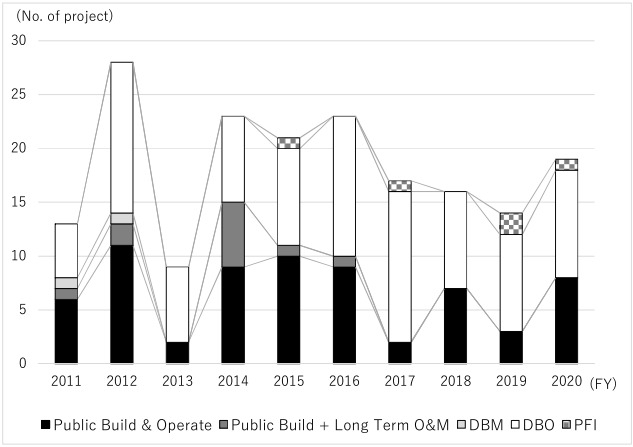
Item		Role: Construction: Design	Construction	Finance	Operation	Maintenance	Owner of Facility: Construction period	Operation period	After operation period	Outline
PFI	BOO	Private	Private	Private	Private	Private	Private	Private	Private	Schemes in which the private sector raises funds, and designs, constructs, and operates the facility. BOO：Ownership will not be transferred to the public even after the operation period. BOT：Ownership will be transferred to the public at the end of operation period. BTO：Ownership will be transferred to the public after completion of the facility.
	BOT	Private	Private	Private	Private	Private	Private	Private	Public	
	BTO	Private	Private	Private	Private	Private	Private	Public	Public	
Others	DBO	Public	Public	Public	Private	Private	Public	Public	Public	The public sector raises funds through bonds and grants, and comprehensively outsources the design, construction, operation of the facility to the private.
	DBM	Public	Public	Public	Public	Private	Public	Public	Public	The public sector raises funds through bonds and grants, and comprehensively outsources the design, construction, maintenance of the facility to the private.
	Public Build + long term O&M contract	Public	Public	Public	Private	Private	Public	Public	Public	The public sector designs and constructs the facility, and the private is entrusted with the operation for multiple years.

Points of Emphasis in the Selection of WTE's Project Scheme in Japan

In the selection of the project scheme for incineration plants (WTE) in Japan, economic efficiency is taken into consideration, but not pursued excessively, only to the extent of confirming that VFM is achieved. Rather, the following points are emphasized in the selection of the project scheme.

- **Handling Responsibility of General Waste (MSW)**
  As stated in Law, municipalities are responsible for the handling of general waste, and the project scheme should be such that municipalities can fulfill their responsibilities in any case.
- **Gaining Understanding from Residents**
  In the development and operation of a waste treatment facility, it is important to have a relationship of trust with the local residents, so the project scheme should be in harmony with the local community and surrounding environment.
- **Long Term Use**
  The project scheme must be able to use the facility safely and stably over the long term.
- **Efficiency**
  Efficient project scheme should be used for the development and operation of waste treatment facilities.
- **High Reliability**
  Highly reliable project scheme should be used for the construction and operation of waste treatment facilities.

Changes in Project Scheme of WTE over the past 10 years in JP



Topographic & Geological Survey

Conduct topographic survey and geological investigations of the proposed construction site to determine the conditions that will affect the construction cost. The results of these surveys are used as prerequisites for surveys of construction costs, etc. to plant manufacturers for the Basic Facility Plan.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
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	Selection of Winning Bidder												standard 2 yrs
	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Environmental Impact Assessment

Conduct environmental surveys (air quality, noise, vibration, odor, water quality) in the vicinity of the proposed construction site to predict and evaluate the impact of the facility on exhaust gas, noise, vibration, and odor. Since the procedures vary depending on the capacity of the facility, the survey period takes 1.5 to maximum 4 years in Japan.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
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	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Appendix 10

Selection of Winning bidder

Select construction and/or operation companies for PFI and DBO etc. “Comprehensive Evaluation Method” is generally applied to select the business entity, which involves a comprehensive evaluation of technology and price.

		2021 (1)	2022 (2)	2023 (3)	2024 (4)	2025 (5)	2026 (6)	2027 (7)	2028 (8)	2029 (9)	2030 (10)	2031 (11)	Remarks
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	Construction Work							Construction					standard 3-4 yrs
	Operation											Start	

Main Contents of Selection of Winning Bidder

Bidding documents are prepared, evaluation criteria are set, and private business entity is selected through comprehensive evaluation method (Final selection criteria = technical point + financial point).

In the past, projects were selected by bidding on price alone, although design documents were reviewed in advance. However, with the increase of PPP projects, the comprehensive evaluation method has become the mainstream for selecting contractors, and is now widely used not only for PPP projects but also for public projects. This is due to the fact that the comprehensive evaluation bidding method was recommended from the perspective of ensuring transparency and fairness in the selection of business operators for PFI projects.

The following is an example of a comprehensive evaluation bidding system in the DBO that is becoming mainstream.

◆ **Planning Stage**

In order to allocate the budget for the project, the budget is determined based on the preliminary requirements.

Quotations will be collected from plant manufacturers, but the budget will be assessed by using the unit price of orders for similar projects.

◆ **Bidding Documents Preparation Stage**

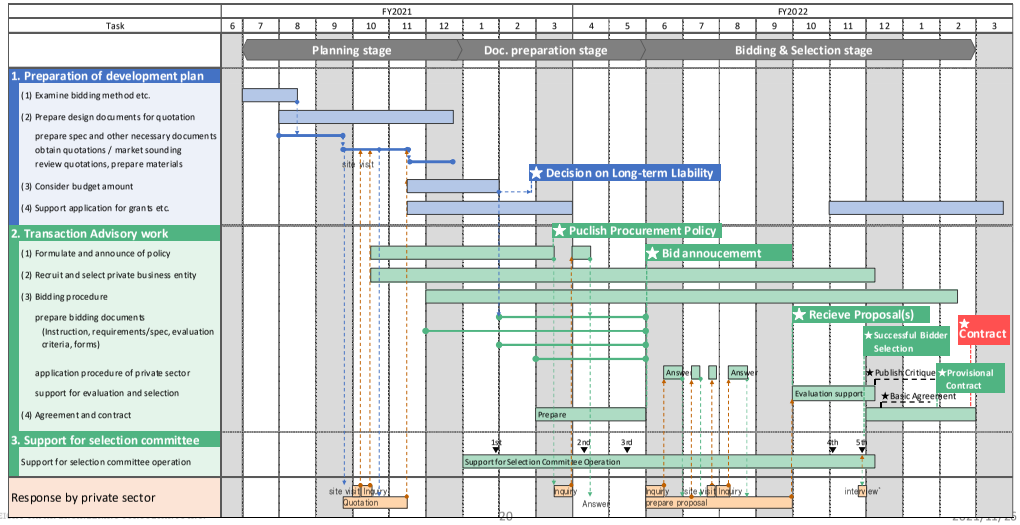
To publicize the project widely, prepare and publish an implementation policy.

Prepare bidding documents (bid explanatory documents, requirements, criteria for determining successful bidders, contract documents, etc.)

◆ **Bidding & Selection of Business Entity Stage**

Issue a public notice for bidding, evaluate the proposals, and select the successful bidder.

After that, contract negotiations will be held with the successful bidder and a contract will be concluded.



Documents of Bid Announcement (in case of DBO)	Main Contents
Instruction to Bidder	Matters related to bidding procedures, etc.
Requirements/ Specifications	Conditions for design, construction and operation, etc.
Evaluation Criteria	Method of determining the successful bidder, etc.
Forms	Format, specification of content, number of pages, etc
Draft Basic Agreement	Various draft contracts to be concluded with the successful bidder or SPC (Other draft contracts will be added depending on the project scope, e.g. Ash handling/disposal agreement, etc.)
Draft Basic Contract	
Draft Construction Contract	
Draft Operation Contract	

Appendix 10

Main Contents of Instruction to Bidder

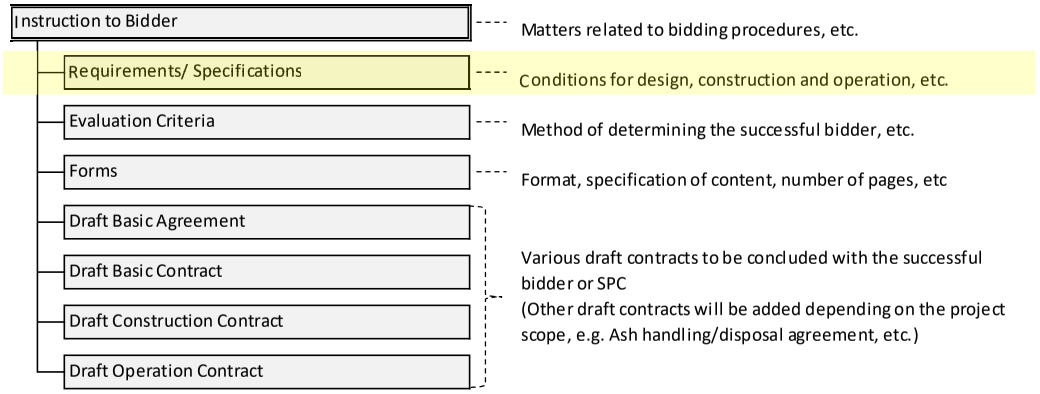
- ◆ Project Scope
  - Whether ash recycling is mandatory, etc.
- ◆ Bidding Schedule
- ◆ Qualification Criteria
  - Track record of construction company
  - Track record of operation company, etc.
- ◆ Classification and Method of Payment
- ◆ Framework of Incentives and Penalties

Table: Classification of Payment

Classification		Item	Contents
Construction cost		Design cost Construction cost	All costs related to construction
Operation cost	Variable cost	Fuel Chemicals Utility	Costs that vary depending on the amount of waste
	Fixed cost	Labor Maintenance Basic electricity charges Repair costs	Costs that do not vary depending on the amount of waste

※In principle, the revenue from electricity sales becomes the revenue of the local government.

Documents of Bid Announcement (in case of DBO) — Main Contents



Positioning of Requirements/Specifications

The requirements/specifications indicate the level of facility specifications and services that the client (local government) requires from bidders.

It does not preclude the proposals that demonstrate originality and ingenuity, or that exceed them.

Part I Common Items	
Chapter 1 Positioning of this requirements/specifications **Chapter 2 Definitions** **Chapter 3 Outline of the Project**	
Part II Design and Construction	
Chapter 1 General **Chapter 2 Overall Plan** **Chapter 3 Mechanical equipment**	**Chapter 4 Electrical instrumentation equipment** **Chapter 5 Civil engineering and building** **Chapter 6 Civil engineering and building**
Part III Operation	
Chapter 1 General **Chapter 2 Operational structure** **Chapter 3 Operation management** **Chapter 4 Operation and Maintenance** **Chapter 5 Environmental management**	**Chapter 6 Effective utilization** **Chapter 7 Information management** **Chapter 8 Disaster management** **Chapter 9 Related tasks** **Chapter 10 Municipality's tasks**

Main Contents of Requirements/Specifications

- ◆ Matters related to Planned Project Site
  - Site boundary, geology, planned ground elevation, land use regulations, greening standards, etc.
- ◆ Facility Size and Object to be Treated
- ◆ Pollution Control Standards
- ◆ Performance Guarantee Items
  - Since WTF development utilizes the plant manufacturer's own patents and know-how, the performance-based ordering system is adopted to let the contractor perform both design and construction. The performance guarantee sections describes the testing items/procedures and pass/fail criteria for the preliminary performance test as well as the performance test to be conducted in final phase of the construction work to confirm the performance guarantee.
- ◆ Specifications for Plant, Civil and Building works,
- ◆ Contents of Operation Work,

Appendix 10

Flow from Facility Development to Operation

Documents of Bid Announcement (in case of DBO)

	Main Contents
Instruction to Bidder	Matters related to bidding procedures, etc.
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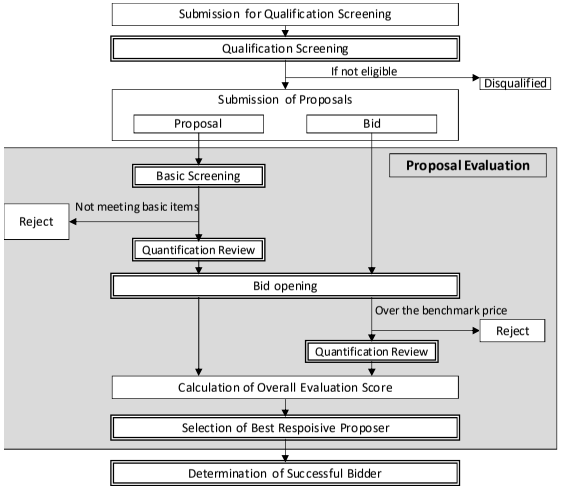
Flow from Facility Development to Operation

Successful Bidder Selection Process in Comprehensive Evaluation Method



Keys to a Fair Evaluation System

1. Complete separation of technical review and price bid opening procedures
2. Ensuring transparency in selection procedures
3. Technical evaluation (scoring) by a neutral committee members
4. Explanation of assessment results

Flow from Facility Development to Operation

Successful Bidder Selection Criteria in Comprehensive Evaluation Method

Evaluation items			Score
Item		Contents	
1. Design, construction, operation and maintenance			40
1) Environment friendly facility			11
	Environment conservation	(1) Efforts to satisfy pollution prevention standards	4
		(2) Global warming measures	1
	Education	(1) Visitor support & environmental learning plan	3
	Landscape	(1) Landscape	3
2) Facility that considers resource recycling			7
	Efficient use of energy	(1) Amount of power generation	4
	Resource recycling & final disposal	(1) Amount of residue	3
3) Facility designed to ensure safety and stable operation			22
	Layout and flow planning	(1) Outdoor layout flow planning	3
		(2) Indoor layout flow planning	3
	Safety	(1) Ensuring safety during disasters	2
		(2) Fire and explosion prevention	2
	Stable operation	(1) Reliability of handling system	4
		(2) Maintain basic performance	4
		(3) Prevention of problems and post-problem measures	2
		(4) Carry-in and carry-out management	2
2. Business plan			20
1) Organization structure			4
	Structure	(1) Organization structure, staffing plan	4
2) Management plan & Business balance plan			6
	Business balance plan	(1) Opproach to formulation of plans	3
		(2) Security for business continuity	3
3) Risk management			3
	Risk management and handling	(1) Risk management & self-monitoring	3
4) Community contribution			7
	Local economy and community	(1) Utilization of local companies and local employment	5
		(2) Contribution to community	2
3 Bidding price			40
1) Bidding price			40

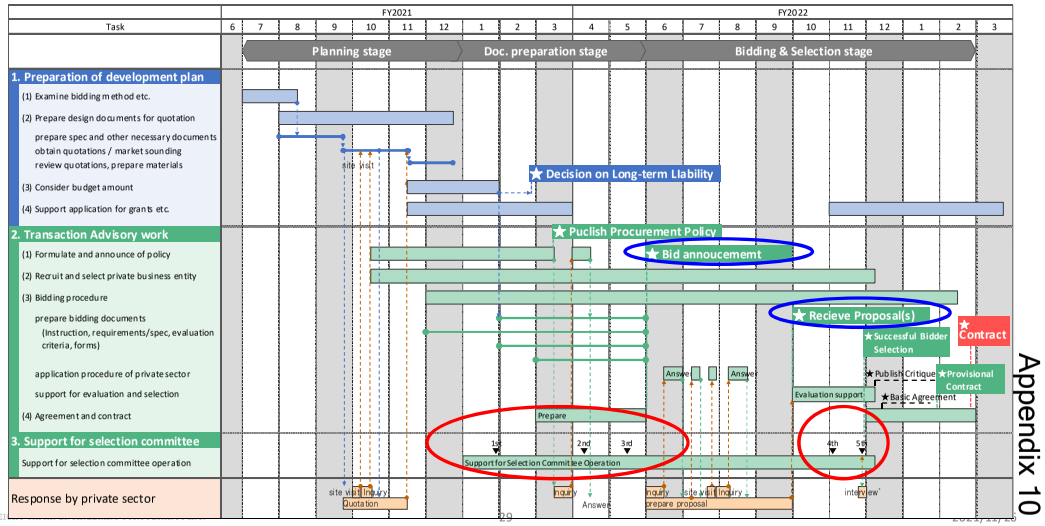
In the quantitative evaluation, the ratio of technology scores and price scores should be set to avoid "cheap but shoddy" facility.

The evaluation items are set with reference to those set as the concept of facility development in the facility basic plan, etc.

Higher points will be given to items that the client emphasizes in the development of facilities.

The evaluation items are designed to make it easy for the private sector to submit proposals and for the evaluation committee members to score them.

Flow from Facility Development to Operation



Appendix 10

Construction Work

The contractor selected through the selection process will carry out the construction work in accordance with the construction contract and specifications/requirements in the bidding document.

Construction work will generally take 3 to 4 years, depending on the processing capacity and site conditions. At the end of the construction work, a performance test is conducted to confirm that the performance specified in the requirements document has been secured.

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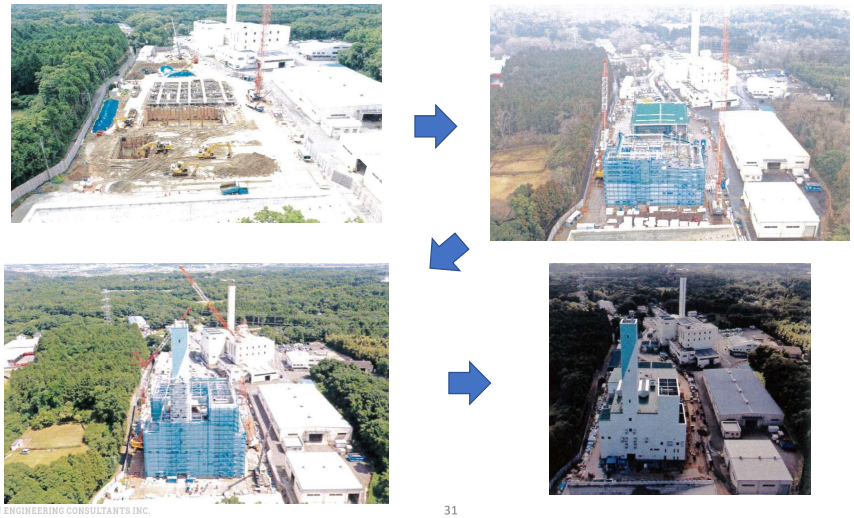

Operation Work

After construction is completed, the operator selected through the selection process (in case of DBO) is responsible for operation and maintenance of the facility in accordance with the O&M agreement and specifications/requirements in the bidding document.

The local government, as the client, monitors the implementation status of the operation every month during the operation period.

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EJEC

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Appendix 10

EJEC REPORT

Outline of Waste to Energy (WtE)* Technology and Requirements for WtE Project

Note: WtE in this document intends WtE-ACC (Appropriately Controlled Combustion) which is Incineration Technology.

December 10, 2021

Manabu ETO

Solid Waste Management Dept., Tokyo Branch,
Eight-Japan Engineering Consultants Inc. (EJEC)

株式会社 エイト日本技術開発

価値ある環境を未来に

Agenda

1. Outline of WtE project
(1) Characteristics of WtE project (WtE Plant) in Japan
(2) Procedure of WtE Project Development

2. What are the requirements in WtE Project?
(1) Input Conditions
(2) Output Conditions
(3) Plant Conditions

3. How to succeed in WtE project?
(1) Is the contents described in the *Employer's Requirement* feasible?
(2) Can they be executed as requested?

1. Outline of WtE project

(1) Characteristics of WtE project in Japan

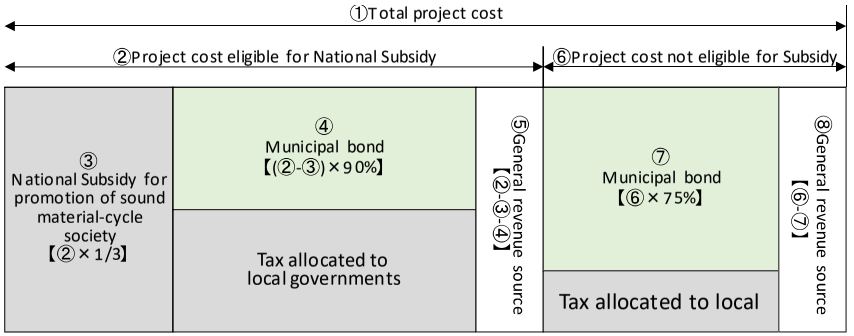
① Out of 1,067 incineration plants in Japan, **384 (36%)** are WtE plants (power generation plants).
② Scale of WtE plants varies from **less than 100t/d to Max. 1,800t/d.**
③ The average efficiency of power generation is 13.74%. The National Government (NG) hopes to raise the efficiency by increasing the scale of facilities.
④ **There are generous national subsidy programs;**
- ✓ The National Government supports **40-50%** of the cost of facility construction, including both subsidies and local allocation of taxes.
- ✓ Even Local Governments (LGs) with weak financial base can construct WtE plants by this.

⑤ Because of ④, Design-Build (DB) or Design-Build-Operate (DBO) schemes are the mainstream in Japan, with a minority of municipalities choosing Build-Operate-Transfer (BOT) or BOT*.
⑥ Most of the facilities have been in operation for **more than 30 years (or are about to be)** by conducting appropriate inspections and repairs.
⑦ The WtE plant is a facility that is in charge for "(thermal) Recycle" among the 3Rs (Reduce, Reuse, Recycle).

Note: Design-Build (DB) or Design-Build-Operate (DBO) schemes where LG shall raise the fund while Build-Own-Operate (BOO) or Build-Operate-Transfer (BOT) schemes where let private partner finance the capital expenditure.

1. Outline of WtE project

(1) Characteristics of WtE project in Japan/ Generous National Subsidy programs



- The gray area is the portion subsidized by NG, which corresponds to about 40-50% of the total construction cost.
- The municipal bond portion (in green) is also lent by NG at ultra low interest rates, so the interest burden on LGs is low.
  => Municipalities that choose DB and DBO are blessed with financial resources, so BOT and BOO with private funding are less likely to be chosen in Japan.

Appendix 10

1. Outline of WtE project

(2) Procedure of WtE Project Development

Since the Law clearly stipulates that "Local government is responsible for Waste treatment", even if LG contracts some parts to private, LG is still primarily responsible for waste treatment. Thus, WtE Project shall be led by local governments.
=> Throwing the whole part of waste treatment to the private sector is not an option.

MSW Treatment Master Plan (MP), Facility Development Conceptual Plan

■ What to be decided by LG

•	Ideal state of waste management	⇒ Set Political Priority for recycling or power generation...
•	Setting the service provision area	⇒ Single municipality or wide-area union (clustering)
•	Current and future waste volumes	⇒ Target volume of WtE, handling of plastics,
•	Sett up capacity of the WTE facility	⇒ Target volume of WtE ÷ Operating days (t/day)
•	Development Timeline	⇒ For EIA ( ) yrs, Bidding ( ) yrs, Construction ( ) yrs, ...
•	Appropriate Site Selection	⇒ Urban or Suburb, next to landfill, etc.

Application for National Subsidy
(Called as Regional Plan for Circular Economy)

■ Approximate Cost will be estimated based on MP and Facility Conceptual Plan. (Basic application document for national government shall be formulated.)

Facility Basic Plan

■ What to be decided by LG

•	Treatment method	⇒ Stoker or fluidized bed or gasification & melting or...
•	Project scheme	⇒ BOT or BTO or DBO or...
•	Exhaust gas standard value	⇒ Dust, SOx, NOx, HCL, Hg, DXNs
•	Treatment flow	⇒ Handling of bottom ash and fly ash,
•	Approx. project cost	⇒ Total cost, amount of funds to be procured ...

1. Outline of WtE project

(2) Procedure of WtE Project Development (Cont.)

Selection of Business Entity

■ What to be specified in **"Employer's Requirement"*** by LG

•	Selection method	⇒ Comprehensive evaluation method, Price competition
•	Instruction to Bidder (ITB)	⇒ Qualification criteria, Terms of payment, etc.
•	**Employer's Requirement*** Document	⇒ Conditions of input, output, plant (Detailed in next page afterward)
•	Evaluation criteria	⇒ Stability, economy, safety
•	Contract documents	⇒ Draft basic agreement, construction/operation contract

After the business entity is selected, it is necessary to confirm that the facility is being designed, constructed and operated as desired by LG.
=> In many cases, employ the consultants to check the conformity.

Construction

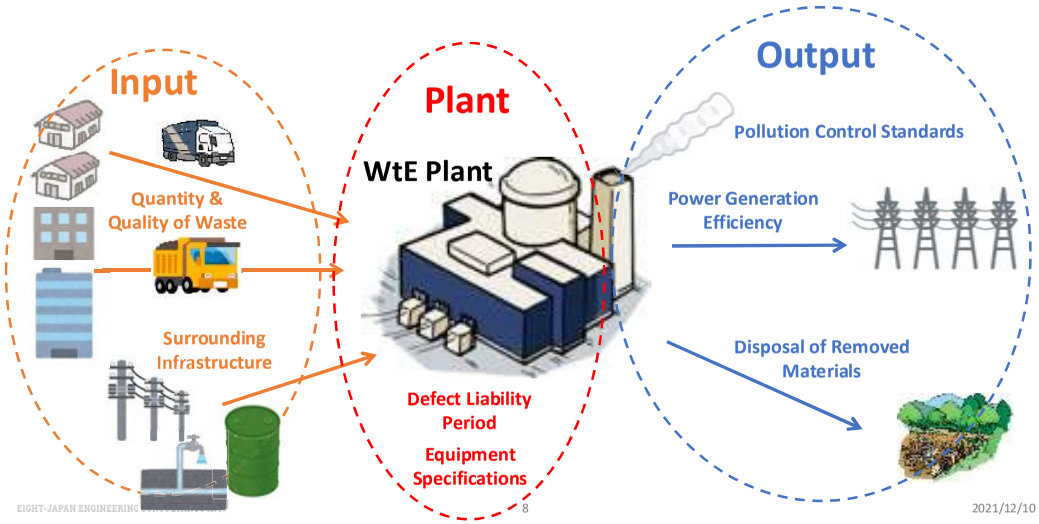
•	Design Supervision (SV)	⇒ Review drawings for building & plant equipment
•	Construction Supervision (SV)	⇒ Checking progress, witness to the inspections and/or tests incl. performance test

Operation

•	Compliance Status with **Employer's Requirement***	⇒ Power generation/transmission amount, Pollution control standards, etc.
•	Facility maintenance status	⇒ Visual inspection, check self-inspection records, etc.

***Employer's Requirement (ERQ)** is defined as the document specifies the purpose, scope, and/or design and/or other technical criteria for the execution of the Works in FIDIC general conditions. It is used as "Technical Specification" in the Design-Build ordering system where the Employer specifies only some output/input conditions and let contractor to propose their best options.

2. What are the requirements in WTE Project?



2. What are the requirements in WTE Project?

(1) Input conditions

Main contents of "Employer's Requirement" in Bidding Document

(A) COMMON	(B) CONSTRUCTION	(C) OPERATION
1. Capacity of the Facility, Project scheme	1. Quantity and quality of waste	1. Project implementation structure
2. Construction Site, Area	2. Performance Guarantee Matters;	2. Development of manuals and plans
3. Project period, time schedule	(1) Power generation efficiency	3. Operation and maintenance contents;
4. Topography and geology conditions	(2) Pollution control standards, etc.	(1) Operation management
5. Surrounding infrastructure, city planning related matters	3. Performance guarantee method	(2) Inspection, testing, repair and renewal
	4. Defect Liability Period	(3) Disposal of removed materials
	5. Equipment specifications	(4) Information management
	(1) Mechanical equipment specifications	4. Handling after the Project Period
	(2) Electrical instrumentation equipment specifications	
	(3) Civil engineering and building works specifications	

Appendix 10

2. What are the requirements in WTE Project?

(1) Input conditions; Quantity & Quality of Waste

Quantity & quality of waste are the quantity and quality of "fuel" for WTE plant.
=> WTE plant runs trouble-free when the quality of fuel is good.
=> WTE plant generates more power if the fuel quantity is high.

■ Quantity of waste;

• Setting Service Area	⇒ Within LG's jurisdiction, or with other LGs (how extensive can be?)
• Setting Target Waste	⇒ Domestic/business, combustible, sludge, medical waste, etc. (Possibility to collect waste which less unsuitable matter with higher calorific value?)

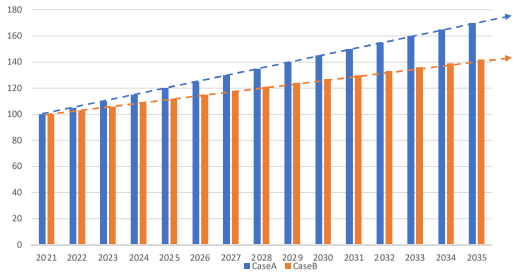
■ Quality of waste;

• Physical Composition	⇒ Papers, Plastics, Woods, Kitchen waste, Incombustibles, Others
• 3 components (Proximate Analysis)	⇒ Moisture, Combustible, Ash
• Ultimate Composition	⇒ Carbon(C), Hydrogen(H), Oxygen(O), Sulphur(S), Nitrogen(N), Chloride(Cl)
• Unit volume weight	⇒ Bulk density
• Calorific value	⇒ Net Calorific Value (NCV) or Low Calorific Value (LCV)

2. What are the requirements in WTE Project?

(1) Input conditions; Quantity of Waste

- In order to receive government subsidies, the amount of waste needs to be reduced from the current level.
  ⇒ The national and prefectural governments have set targets for waste generation unit rate, recycling rate, final disposal rate, etc., and Local governments need to strive to meet those target values.
- Only waste after 2R (Reduce, Reuse) is delivered to the WtE plant.



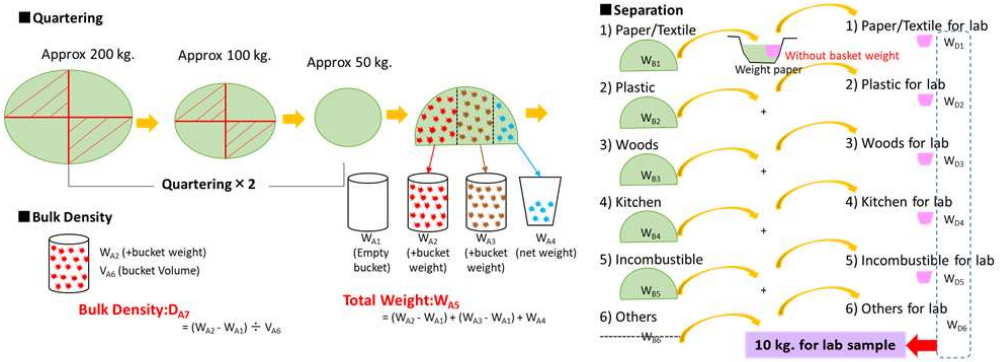
Items	NG's Target (as of 2025)
MSW Generation Unit Rate	440g/person-day
Recycling Rate in MSW*	28%

* Recycling Rate in MSW (%) = $\frac{\text{Recycled Material Quantity}}{\text{Total Waste Quantity}}$ x 100

2. What are the requirements in WTE Project?

(1) Input conditions; Quality of Waste

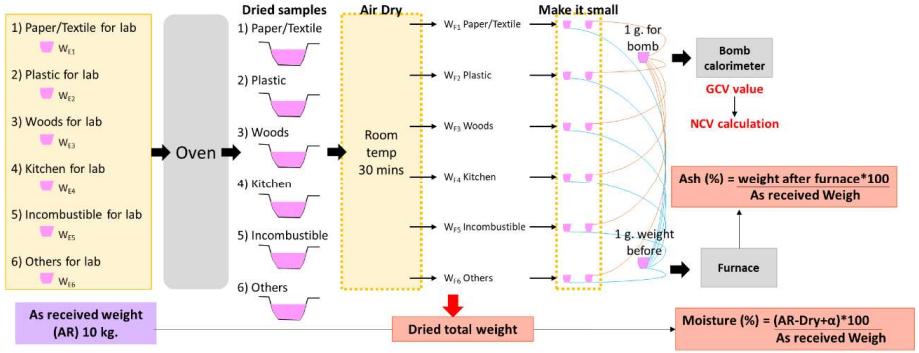
- Waste quality surveys are conducted at least 4 times/year at all facilities.
- Reduction of the sample by Quartering and measure Bulk Density and Physical Composition.



2. What are the requirements in WTE Project?

(1) Input conditions; Quality of Waste

- 3 Components (Moisture, Ash and Combustible), Elemental Composition and Calorific Value are measured from the sample after physical composition survey.



Appendix 10

2. What are the requirements in WTE Project?

(1) Input conditions; Quality of Waste

- Present 3 components, Elemental composition, LCV and Bulk density of Target Waste for WtE Plant.
- Ratio of Higher limit and Lower limit of LCV range of Target Waste (H/L ratio) is generally less than 2.5.

			Low	Standard	High
3 Components	Moisture	(%)	59.69	50.06	40.43
	Ash	(%)	5.79	6.54	7.29
	Combustible	(%)	34.52	43.40	52.28
Elemental Composition	Carbon	(%)	19.10	24.16	29.22
	Hydrogen	(%)	2.20	2.73	3.25
	Oxygen	(%)	12.00	15.22	18.44
	Sulfur	(%)	0.01	0.01	0.01
	Nitrogen	(%)	1.20	1.27	1.35
	Chlorine	(%)	0.01	0.01	0.01
Lower Calorific Value (LCV) or Net Calorific Value (NCV)	NCV	(kcal/kg)	1,460	2,250	3,040
	NCV	(kJ/kg)	L 6,100	9,400	H 12,700
Bulk Density	Bulk density	(t/m3)	0.234	0.220	0.205

H/L＜2.5

2. What are the requirements in WTE Project?

(1) Input conditions; Surrounding infrastructure, City planning related matters

If possible…we want to select a location where the surrounding infrastructure is as good as possible.
If possible…we want to select a location with few restrictions of city planning, and also to gain the understanding of residents.
=> Constraints on the location of the WtE plant are one of the factors that determine the success or failure of the project.

■ Surrounding infrastructure

Electricity	Status of transmission lines, availability of reverse power flow
Water	Water supply, groundwater, rainwater
Waste water	Domestic wastewater, plant wastewater, Discharge to river, sewerage, or treated water discharge not allowed (close-type: no wastewater discharge)
Fuel	City gas grid, kerosene, heavy oil

■ City planning matters

Building coverage ratio	Ratio of building area to site area
Floor area ratio	Ratio of total floor area to site area
Height restriction	Height restriction of building and chimney
Residents' understanding	Development of compensation facilities to the community, holding the explanatory meetings for residents

2. What are the requirements in WTE Project?

(2) Output conditions

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2. What are the requirements in WTE Project?

(2) Output conditions: Power generation efficiency

Conditions to obtain National Subsidy on Energy Recovery Ratio (Revised every year)

Facility size x (t/d)	Energy recovery rate (%)
x ≦100	17.0
100＜x≦150	18.0
150＜x≦200	19.0
200＜x≦300	20.5
300＜x≦450	22.0
450＜x≦600	23.0
600＜x≦800	24.0
800＜x≦1,000	25.0
1,000＜x≦1,400	26.0
1,400＜x≦1,800	27.0
1,800＜x	28.0

Energy recovery ratio
＝Power generation efficiency＋Heat utilization rate

■ Power generation efficiency
[power generation output×100%]
÷[input energy (waste + external fuel)]

■ Heat utilization rate
[effective calorific value×0.46×100%]
÷[input energy (waste + external fuel)]

[Example] In case if facility size 600t/d, waste LCV is 9,000kJ/kg,
Energy recovery ratio shall be 23.0% or more.

23% = [power generation output(kW)×3,600(KJ/kWh)×100%]
÷[9,000(kJ/kg)×600(t/d)×1,000(kg/t)÷24(h/d)]
[power generation output(kW)] = 14,375(kW)
Turbine generator rated output of 14,375 (kW) or more is required. (when no heat is used)

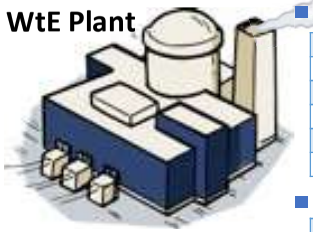
Appendix 10

2. What are the requirements in WTE Project?

(2) Output conditions: **Pollution control standards**

As a means of gaining the understanding of nearby residents, WtE owners often voluntarily impose regulatory values that are stricter than legal standards.

WtE Plant



■ **Exhaust gas standards;**

Particulate matter	Less than 0.04g/Nm3 (depending on facility size)
Hydrogen chloride	Less than 430 ppm
SOx	K-value regulation (depending on chimney height and exhaust gas volume)
NOx	Less than 250 ppm
Dioxins	Less than 0.1ng-TEQ/Nm3
Mercury	30μg/Nm3

■ **Effluent standards;**

Standards for hazardous substances	28 items
Standards related to living environment items	16 items

■ **Noise standards;**

Set standards in Daytime, Morning & Evening, Night (divided into 4 types of land use categories)

■ **Vibration standards;**

Set standards in Daytime, Morning & Evening (divided into 2 types of land use categories)

■ **Odor**

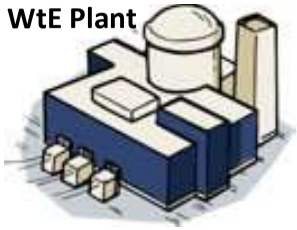
Standards at site boundaries, outlets and drainage

2. What are the requirements in WTE Project?

(2) Output conditions: **Disposal of removed materials (Bottom / fly ash)**

The unburned component must be sufficiently low for both landfill disposal and conversion to cement raw materials.

WtE Plant



Landfill disposal

Cement raw materials

Acceptance conditions

■ **Bottom ash;**
- Ioss of Ignition
- DXNs Contents

■ **Treated fly ash;**
- DXNs Contents
- Heavy metals leakage

■ **Both bottom/fly ash;**
- Moisture
- Removal of bulky items,
- Removal of metals

2. What are the requirements in WTE Project?

(3) Plant conditions

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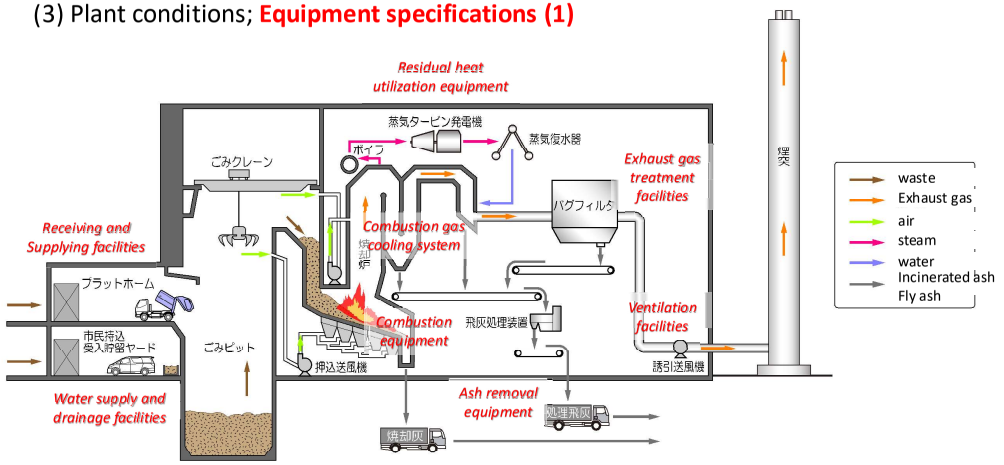
2. What are the requirements in WTE Project?

(3) Plant conditions; **Equipment specifications (1)**



Appendix 10

2. What are the requirements in WTE Project?

(3) Plant conditions; **Equipment specifications (2)**

Name of Equipment	Main Items as Example	Major purpose
Receiving and supplying facility	Weighing bridge, garbage crane, garbage pit	Weight measurement, storage and homogenization
Combustion equipment	Waste feeder, Combustion chamber	Constant supply, complete combustion
Combustion gas cooling system	Boilers, steam condensers	Cooling for exhaust gas treatment, and heat recovery
Exhaust gas treatment facilities	Dust collection equipment, hazardous gas removal equipment	Removal of hazardous components
Residual heat utilization equipment	Steam turbine	Heat recovery, power generation, hot water use
Ventilation facilities	Forced Draft Fan, Induced Draft Fan, Chimney	Air supply for combustion, exhaust gas induction
Ash extraction equipment	Ash pit, ash crane	Ash storage, stabilization of fly ash
Water supply and drainage facilities	Cooling water cooling tower, wastewater treatment equipment	Equipment cooling, water quality improvement
Electrical equipment	Power transforming equipment, emergency power generation equipment	Stable power supply in normal and emergency situations
Instrumentation equipment	DCS, ITV, pollution monitoring display panel	FB control, SQ control
Architecture	Plant/administration building plan, interior/exterior	Worker/visitor flow line efficiency
Building machineries/electrics	Air conditioning, ventilation, lighting, fire alarm	Fire prevention, odor prevention, work environment improvement
Civil engineering and exterior structures	Parking lot, gate, fence	Vehicle flow line efficiency

2. What are the requirements in WTE Project?

(3) Plant conditions; **Defect Liability Period**

- During the first few years after the completion of facility construction, it is easy for basic performance to be underachieved or for equipment to malfunction due to defective construction or unfamiliarity with operation.
- A certain period of time is set as the defect liability period (2-3 years).
  => During this period, EPC contractor shall be responsible for improvement of the equipment.

	1st year from COD*	2nd year	3rd year	4th year	5th year
Equipment (A)	Underachieved to the performance	Remedied			
Equipment (B)		Strange noise	Remedied		
▲ Completion of Construction					

COD: Commercial Operation Date

Performance Test at the end of Defect Liability Period (In case of 3 years of DLP)

2. What are the requirements in WTE Project?

Case Study (1)

Major Items in WTE Planning	Unit	A city	B city	C city	D city
Project Scheme	-	DBO	DBO	DBO	DBO
Quantity of Waste (=Capacity of facility)	t/d	600	420	330	339
Quality of Waste	H/L ratio	2.0	2.0	1.86	2.03
Higher Limit	KJ/kg	12,000	12,800	12,100	13,200
Standard	KJ/kg kcal/kg	9,000 2,142	9,600 2,285	9,300 2,214	9,900 2,357
Lower Limit	KJ/kg	6,000	6,400	6,500	6,500
Power Gen. Efficiency	%	26.5	25.8	25.3	24.0
Power Gen. Capacity	kW	16,800	10,640	9,550	8,400
Steam conditions	MPa	6.0	4.8	4.85	3.9
	dC	450	425	415	445

2. What are the requirements in WTE Project?

Case Study (2)

Major Items in WTE Planning		Unit	A city	B city	C city	D city
DLP* for Building		Year	3	2	2	2
DLP for Plant		Year	3	3	2	2
Discussion for post concession		-	3 years before	N/A	N/A	N/A
O&M Concession Period		Years	20	15	20	15
Target Durable Years		Years	> 30	> 30	> 30	> 30
Exhaust gas PM	0.04**	g/Nm3	0.01	0.01	0.01	0.01
SOx	depends	ppm	100	20	30	20
NOx	250	ppm	150	50	50	50
HCL	430	ppm	40	30	50	20
DXNs	0.1	ng-TEQ/Nm3	0.1	0.01	0.1	0.05
Mercury	30	mg/Nm3	30	30	N/A	N/A

* DLP: Defect Liability Period

** National exhaust gas emission standards regulated by Air Pollution Prevention Act.

Appendix 10

3. How to succeed in WtE project?

(1) Is the content of the Employer's Requirement feasible? - Don't make it armchair plan

Embody the product image through Q&A and dialogues with private partner + have a common understanding
*=**Don't leave everything up to the business entity!***

- Employer's Requirement for quotation
  - LG presents at the time of **quotation collection (at Facility Basic Plan formulation phase)**
  - LG examines the contents through **Q&A sessions** with the business entities
- Employer's Requirement (draft)
  - LG presents at the time of **publication of the project implementation (procurement) policy**
  - LG examines the contents through **Q&A sessions** with the business entities
- Employer's Requirement
  - LG presents at the time of **bid announcement**
  - LG examine the contents through **Q&A sessions** and **dialogues** with the business entities

- Basic Design Documents
  - Bidders submit as **a part of proposal by the bidders**
  - LG determines whether or not to accept the proposal after **Q&A sessions** with the bidders
- Execution Design Documents
  - EPC contractor submits **after the discussions based on approved Basic Design Document**
  - LG finalize the design values after **Q&A sessions** with the business entity
- As-built Documents
  - EPC contractor submits upon **completion of facility construction.**
  - Contains finalized **detailed design docs** and the specifications of the delivered equipment.

3. How to succeed in WTE project?

(2) Can the contents of Employer's Requirement be executed as requested?

A system to ensure that Employer's Requirement are implemented is necessary
=> Make a good use of experts (consultants)!

Design & Construction Phase

- Schedule Supervision
  - **Monitor** the progress of design and construction through monthly and weekly meetings,
  - Identify bottlenecks and input management resources to relieve them,
- Design Supervision
  - **Check if** the contents proposed by the bidder is reflected in their design,
  - Check the appropriateness of design values e.g. capacities of the facility, power generation and exhaust gas treatment,
- Construction Supervision
  - **Check if** construction is being carried out based on the detailed design,
  - Inspections are conducted at each stage of construction to check progress,

Operation Phase

- Operation Monitoring
  - **Check if** the quantity of treated waste and elec. generation is in accordance with the Employer's Requirement as well as the proposals,
  - Introduction of a system to impose **a penalty (reduction of fee)** depending on the Key Performance Indicator compliance situation,
- Financial Monitoring
  - **Check** the financial appropriateness of SPC by examine financial statements and improper expenditure,
  - Introduction of a system for additional investment or shareholders' loan in the event of deterioration in financial conditions,
- Environmental Monitoring
  - **Check** the compliance with pollution prevention standards.
  - Introduction of a system to impose **a penalty (reduction of fee)** depending on the situation,

Sample description of "Employer's Requirement" for Garbage Pit

7. Garbage pit (included in civil engineering and construction work)
   (a) Form : watertight reinforced concrete
   (b) Quantity : 1 unit
   (c) Main items (per line)
   a Capacity : 3,010m3 or more (7 days or more of the rated capacity)
   b Dimensions : Width [ ] m× depth [ ]m× depth [ ]m
   c Main material : Watertight reinforced concrete
   (d) Accessories Faller rescue device
   (e) Special Notes
   a. Ensure both the length and width of the pit does not interfere with the stable operation of the waste crane.
   b. The reference level for calculating the effective capacity of the pit shall be less than or equal to the horizontal line on the lower level of the input gate (in the case of the 2 pits method, only the first pit (receiving pit) side shall be subject to this condition.) In addition, do not calculate the chute, etc. into capacity after considering the angle of repose.
   c. The depth of the garbage pit should be 2.5 times or more in principle with respect to the opening dimensions of the crane bucket in consideration of autonomous driving.
   d. The chute of the inlet is fitted with a 12 mm steel plate as a countermeasure against wear.
   e. For lighting, provide a high side light or top light as necessary.
   f. Each pit bottom illuminance shall be 150 lux or more.
   g. For lighting, an energy-saving type such as LED equipment is adopted. Lighting fixtures attached to high places shall be in a position that can be safely replaced.
   h. Provide an appropriate water gradient and bottom shape so that wastewater is discharged quickly. In addition, the screen is made of stainless steel and has an easy-to-clean structure.
   i. Set up a typed garbage level display scale on the three-way sidewall of the inner wall of the pit.

Sample description of "Employer's Requirement" for Garbage Pit

7. Garbage pit (included in civil engineering and construction work)
   (e) Special Notes (CONT.)

   j. Even when the furnace is stopped from operation, deodorization measures shall be taken to prevent odor leakage to the platform, visitor passage, etc.
   k. Install a combustion air intake to keep the pit chamber at a negative pressure. Regarding the position of the intake, sufficient consideration should be given to preventing blockage due to scattered dust.
   l. Plan an infrared fire detection system that can detect the occurrence of a fire at an early stage in the entire range of the pit to be installed, and install the required number of water cannon devices that can extinguish the detected fire at an early stage. The water cannon device will allow remote and field operation.
   m. The reinforcing bar cover thickness at inner surface of the pit should be thick enough to protect it from wastewater and the collision of the crane bucket.
   n. Since the pit has a humid atmosphere, the equipment in the pit should be considered for corrosion prevention.
   o. The skeleton of the garbage pit shall be steel-framed reinforced concrete or reinforced concrete up to a height higher than the garbage crane receiving beam. Since it is mass concrete, control temperature cracks. For steel-framed parts, consider wall thickness (thick panel in the case of ALC), moisture penetration, and pollution control measures when confirming seismic performance and selecting wall materials.
   p. Install a fallen rescue device in the pit.
   q. From the viewpoint of preventing the vehicle from falling into the pit, the structure is such that the tailgate of the garbage-carrying vehicle does not go out to the pit side as much as possible when it is put in.

Appendix 10

Appendix 10-5:
Examples of WTE in Tokyo

10-5-1 December 3, 2022
10-5-2 December 6, 2022

Appendix 10-5:
Clean Authority Tokyo

10-5-1 December 3, 2022

Online Tour
Suginami Incineration Plant

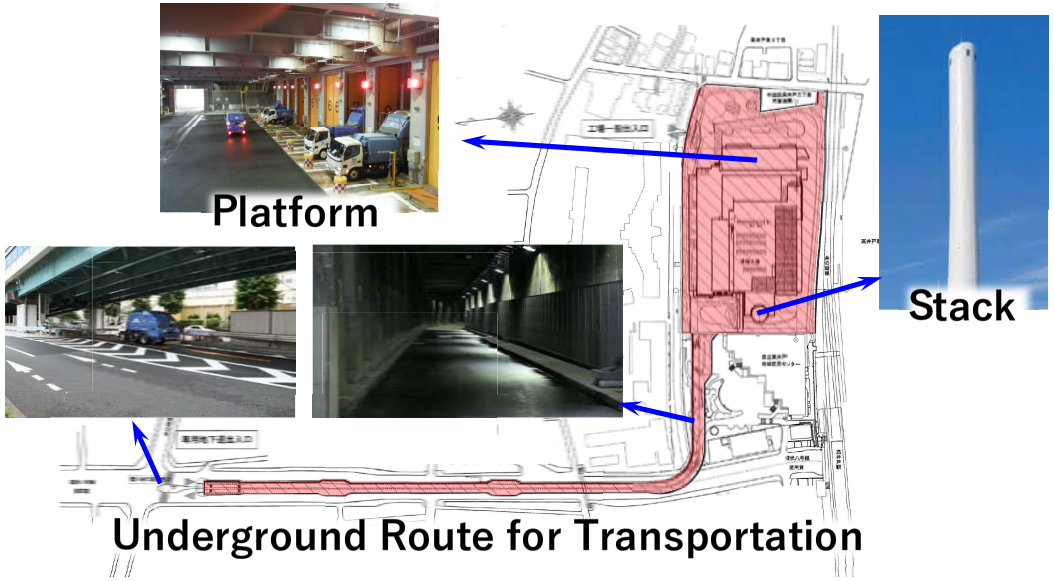
Clean Authority of TOKYO

Suginami Incineration Plant

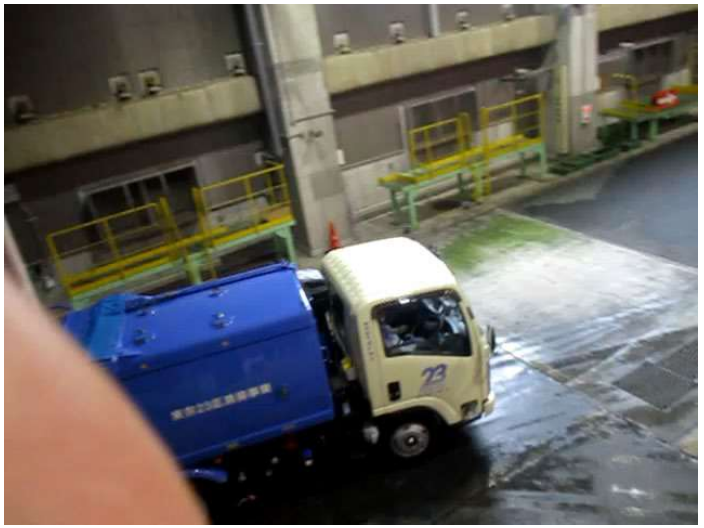
Promenade

Biotope

Underground Route for Transportation

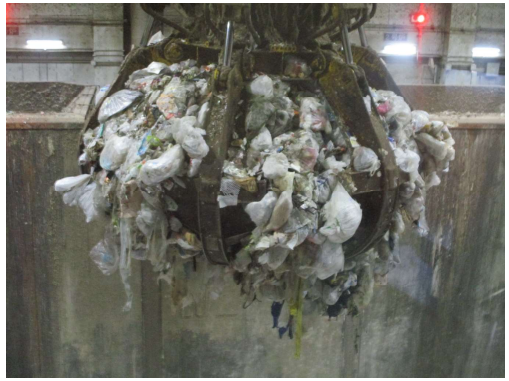


Platform



Platform
Video

Waste Bunker



Waste Crane

Waste Crane Video

Boiler

Inside the Incinerator

Inside the Incinerator Video

Central Control Room

Steam Turbine Generator

A Place for Environmental Education

Environmental Paintings
by Elementary School Student

Top the Stack

Inside the Stack

View from the Stack

Thank you

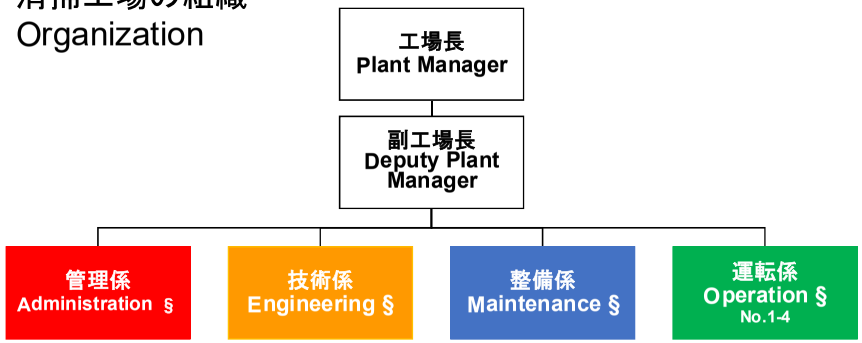
Environmental measures surrounding Suginami Incineration Plant

Clean Authority of Tokyo
Kobayashi Tomoki

自己紹介
Self-introduction

目黒清掃工場は建替えに伴い、平成29年2月から稼働停止
江戸川清掃工場は建替えに伴い、令和2年9月から稼働停止

清掃工場の組織
Organization



- Office clerks
- Mechanical, Electrical, Chemical engineers
- Facilities management technicians

Environmental measures in incineration plant

1. Construction of facilities and installation of equipment with structures that conform to technical standards
2. Prevention of hazardous substances generation through combustion control
3. Detoxification by each processing facility
4. Compliance evaluation through monitoring and measurement, and improvement of treatment processes

1 : Studied at the construction planning stage
2 & 3: Monitoring, operation, and inspection by operation staff
4 : Conducted by technical staff (chemical engineers)

Compliance evaluation through monitoring and measurement, and improvement of treatment processes

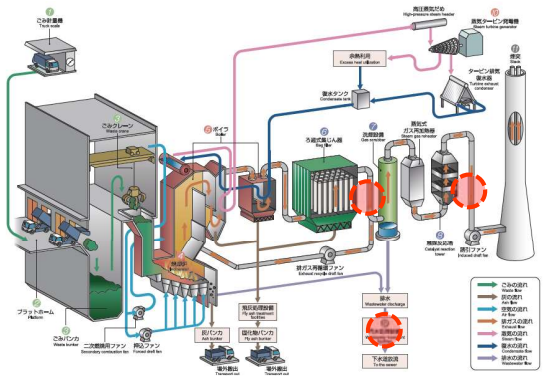
Measurement by continuous analyzer

Monitoring & Self-analysis of treatment process

Analysis and measurement by third-party organization

Measurement by continuous analyzer

- Periodic calibration and inspection
- Responding to equipment problems



Monitoring & Self-analysis of treatment process

- Checking the mixing of fly ash and chemicals

Monitoring & Self-analysis of treatment process

- Checking the coagulation and sedimentation of wastewater

Analysis and measurement by third-party organization

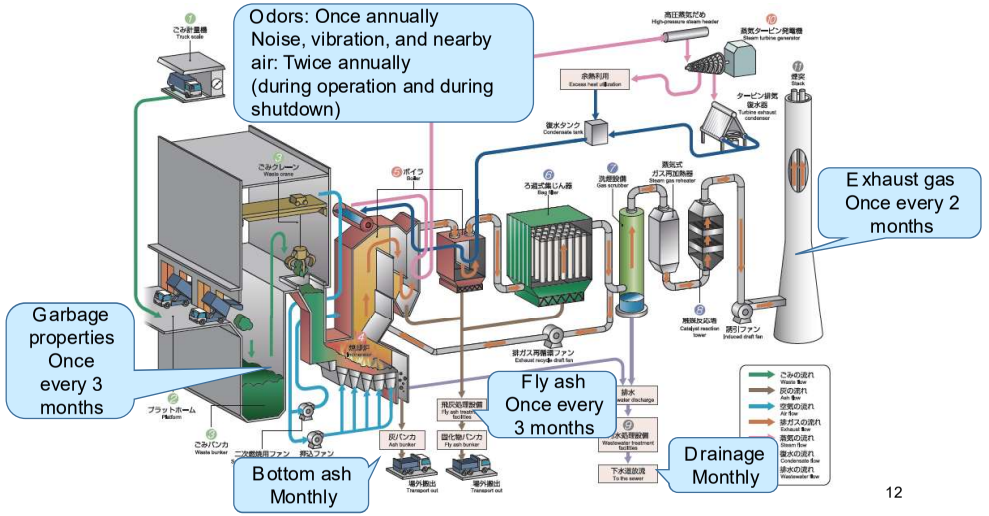
- Analysis by a registered measurement certification operator based on the Measurement Act

Exhaust gas

Drainage

Properties of waste

Analysis and measurement by third-party organization



Notifications and report to competent authorities

• Application for plant installation approval (environmental protection ordinance)	Suginami City
• Notification of establishment of waste processing facility (Waste Management and Public Cleansing Act)	Tokyo Metropolitan Government
• Notification of establishment of soot and smoke-generating facility (Air Pollution Control Act)	Tokyo Metropolitan Government
• Notification of establishment of mercury-discharging facility (Air Pollution Control Act)	Tokyo Metropolitan Government
• Notification of establishment of Specified Facility	
(Noise Regulation Act/Vibration Regulation Act)	Suginami City
(Water Pollution Prevention Act)	Tokyo Metropolitan Government
(Sewerage Act)	Tokyo Metropolitan Government
(Act on Special Measures against Dioxins)	Tokyo Metropolitan Government
Others	

Conclusion

As part of environmental measures taken at incineration plants, chemical engineers...

- Regularly check the treatment of exhaust gas and wastewater to prevent pollution and maintain public health;
- Strive to improve treatment processes to ensure legal compliance and cost effectiveness; and
- Fulfill their obligation to be accountable as government personnel (civil servants).

Thank you!

Do you have any question?

Appendix 10