VOC Emission Control

Manual of Voluntary Measures Regarding Industrial Cleaning

Ministry of the Environment
Japan Industrial Conference on Cleaning
Asahi Research Center Co., Ltd.

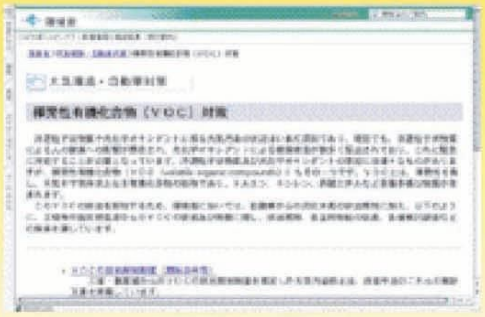
VOC Emission Control by cutting costs and work environment improvement activities

Voluntary measures manual regarding industrial cleaning

contents

Websites with related information

Japan Industrial Conference on Cleaning
http://www.jicc.org



Ministry of the Environment, VOC related website
http://www.env.go.jp/air/osen/voc/voc.html

Ministry of Economy, Trade and Industry VOC related website
http://www.jemai.or.jp/japanese/tech/voc/index.cfm

Why VOC emission control is necessary / Outline of this manual

Reasons why VOC emission control in industrial cleaning is needed

In the Amended Air Pollution Control Law implemented in April, 2006,

1) Facilities larger than a certain size come under the regulation and are required to make reports to the prefectural government
2) Facilities that come under the VOC emission control regulation are required to comply with the emission concentration standard at exhaust vents
3) Facilities too small to come under the VOC emission control regulation are entrusted to take voluntary measures

This is based on the idea of effective VOC emission control by a proper combination (Best Mix) of legal regulation and voluntary measures by the industry.

In particular, many of small and mid size business offices with industrial cleaning sites are exempt from the regulation as is shown in 3), therefore it is crucial to take wide measures for VOC emission control and to conduct voluntary VOC emission control measures.

The target time limit for achieving the figures of VOC emission control in the Amended Air Pollution Control Law is in FY2010, business offices (fixed sources) are to reduce VOC emission by 30% from the figures in FY2000.

Amendment of the law is planned whether if this aim has been achieved in FY2010 or not. Depending on the result of amendment, facilities subject to the regulation can be reviewed.

Outline of this manual

This book is a manual of VOC emission control measures in industrial cleaning and is both as quantitative and as simple as possible. The aim is to put concrete VOC emission control measures into practice based on this chart.

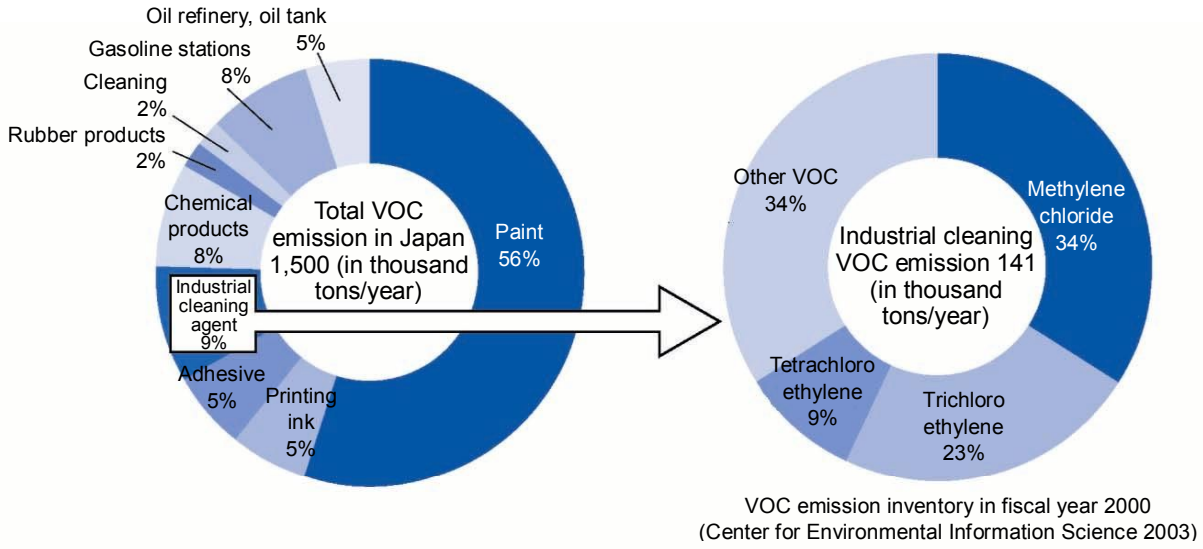
Compiled chart of VOC emission control measures in industrial cleaning

Type of measures		Concrete method	VOC emission control effect (Note: confirm details)		Initial cost required for the measures	Samples of cost cutting (by reducing cleaning agent)
Cleaning process improvement	Operation improvement	・Procedure of start-up/stop	-		Zero	-
		・Reduction of airstream around the cleaning equipment	Quantitative measurement experiment data	Approx. 60 – 90% (refer to model cleaning equipment data p.9)	About ¥100,000	¥27,000 – 44,000/month
		・Examination of Dwell method		Approx. 15– 80% (refer to model cleaning equipment data p.11)	Zero	¥2,000 – 18,000/month
		・Reduction of amount of liquid taken out by the items being cleaned		Approx. 80% (refer to model cleaning equipment data p.12)	About ¥10,000	¥10,000/month
	Cleaning equipment improvement	・Change of local emission method		Approx. 70 – 85% (refer to model cleaning equipment data p.10)	0 - ¥1milion	¥22,000/month
		・Installation of lids/cover		Approx. 80% (refer to model cleaning equipment data p.13)	¥10,000 – 500,000	¥15,000/month
		・Proper cooling effect		Approx. 10 – 30% (refer to model cleaning equipment data p.14)	¥100,000 – 1million	¥1,400/month
		・Securing free board ratio		Approx. 20% (refer to model cleaning equipment data p.15)	Less than ¥1million	¥1,000/month
Introduction of alternative cleaning agent		・Water type, semi-aqueous type, hydrocarbon type, halogen (fluoride, bromide), etc, cleaning agent	100% (emission of alternative substance not included)		Several tens of million yen (replacing equipment)	
Introduction or retrieval/recycling equipment		・Activated carbon adsorption method ・Cryogenic condensation method	60 – 80%		Several million - 20million yen	
Airtight equipment		・Depressurized steam cleaning system ・Airtight cleaning equipment	70 - 80%		Several million – 20million yen	

How to use this manual

Full scale environmental policy on VOC emissions control has started (implemented on April 1, 2006).

VOC emission control in industrial cleaning from the viewpoint of air pollution prevention sets its target at non-water type cleaning agents, of which chloride cleaning agent makes up 70% (fig.1). These non-water type cleaning agents, especially chloride solvent, are required to come under chemical substance management including legal regulation on cleaning for not only air pollution but also work environment, waste, underground penetration, water pollution (reference material). This manual organizes VOC emission control technology mainly for chloride cleaning agent, and gives explanation to ease voluntary VOC emission control measures matching the actual situation for business offices.



VOC emission inventory in fiscal year 2000
(Center for Environmental Information Science 2003)

Cost cutting

Work environment improvement

VOC Emission Control

VOC emission control measures in industrial cleaning are generally organized in the “VOC emission control organization chart” (P.1). While introducing retrieval/recycling equipment of cleaning agent vapor is an effective measure, low-cost technology measures for improvement of cleaning process (improvement of operation, modification of cleaning equipment) are also effective as well as being simple.

In addition, VOC emission control measures are environmental measures, **at the same time they directly lead to emission control in cleaning process/reduction of cleaning agent purchase amount by retrieval and recycling, resulting in cost cutting measures in the process. Also VOC emission control measures improve the working environment.**

Improvement of cleaning process means low-cost technology measures. Depending on the method of improvement used, a considerable emission control effect can be attained. Synergy can also be expected by combining improvements.

Your creative ways and means can achieve VOC emission control resulting in cost cutting and work environment improvement.

Quantitative measurement experiment to indicate emission control effect

Quantitative measurement experiment data to indicate the effect

In “Improvement of cleaning process” in this manual, there is quantitative measurement experiment data on each type of emission control technology from actual measurement and analysis at a model cleaning equipment actually using methylene chloride.

The experiment was conducted over a period of one year. The result is modified after measurement in consideration for conditions such as outside temperature, etc, as much as possible. However the cleaning equipment used in each individual facility varies greatly. Therefore use the data and figures of this model cleaning equipment as a quantification of relative evaluation, not as the absolute value of effect.

Specification and measurement condition of model cleaning equipment for quantitative measurement experiment

	Height (mm)	width (mm)	Depth (mm)	
Soak cleaning tank (first tank)	350	370	340	Cleaning agent in use: methylene chloride (dichloromethane) Amount of cleaning agent in the equipment: approx. 150kg VOC emission rate is measured by the liquid surface in the stable steam cleaning tank in operation. The rate is calculated according to the rise and fall of cleaning agent in liquid form. The published data is modified as values in room temperature of 20°C and standardized.
Rinsing tank (second tank)	380	370	340	
Steam cleaning tank (third tank)	-	370	340	
Vapor zone	520	1360	420	
Model cleaning equipment outer dimensions	**1210**	**1940**	**950**	

VOC emission control effect of each item in “Improvement of cleaning process” is based on the quantitative measurement experiment data. The cost-cutting effect in the graph (yen/month) is calculated on the assumption of operating 8 hours/day, 25days/month, with the unit price of methylene chloride assumed as ¥200/kg.

Appearance of model cleaning equipment for quantitative measurement experiment

Transport equipment with model cleaning equipment for quantitative measurement experiment
(Source: Industrial Cleaning VOC Manual Committee WG)

Column

What is VOC?

VOC (volatile organic compound) is a general term for organic compounds which are volatile and evaporate into gaseous form in the air.

In the definition of Article 2 of the Air Pollution Control Law, it states “organic compounds which are in gaseous form when emitted or dispersed into the air from the emission vent”. It does not give a clear answer to “Is the substance we use in our company legally classified as VOC or not?” As for the 8 excluded methane and Freon compounds which are considered to have little or no photochemical effect, their names are indicated in a separate government ordinance (May 27, 2005, Government Ordinance No.189, Article 2-2).

The main VOCs are used in paint, printing ink, adhesives, cleaning agents, etc, and can be generally considered as “organic solvents”. Typical VOCs actually used in factories in Japan include toluene, xylene, ethyl acetate, methanol, methylene chloride, etc. Approximately there are 200 substances. In the industrial cleaning field, most cleaning agents are defined as VOC such as chloride type, hydrocarbon type, glycol ether, alcohol, etc. However, surfactant is not VOC, nor is water type cleaning agent.

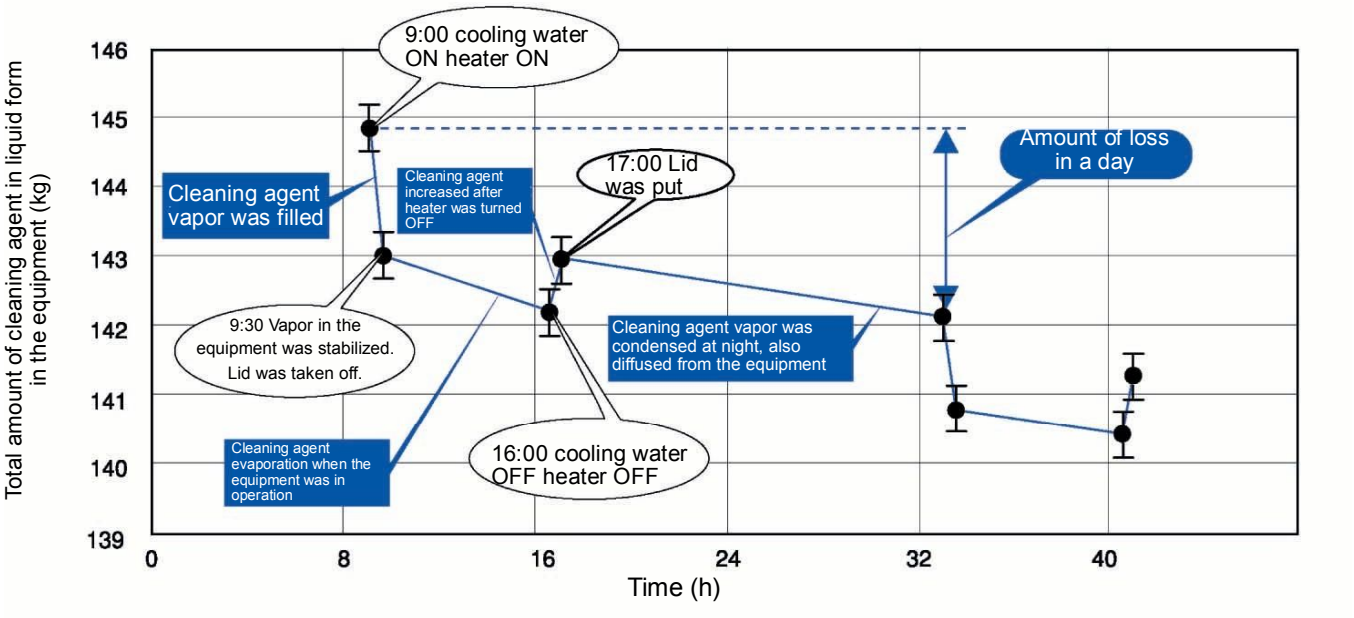
Substances designated as non-VOC excluded substances

1) methane
2) chlorodifluoromethane (HCFC-22)
3) 2-chloro-1,1,1,2-tetrafluoromethane (HCFC-124)
4) 1,1-dichloro-1-fluoroethane (HCFC-141b)
5) 1-chloro-1,1-difluoroethane (HCFC-142b)
6) 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca)
7) 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)
8) 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-1 0mee)

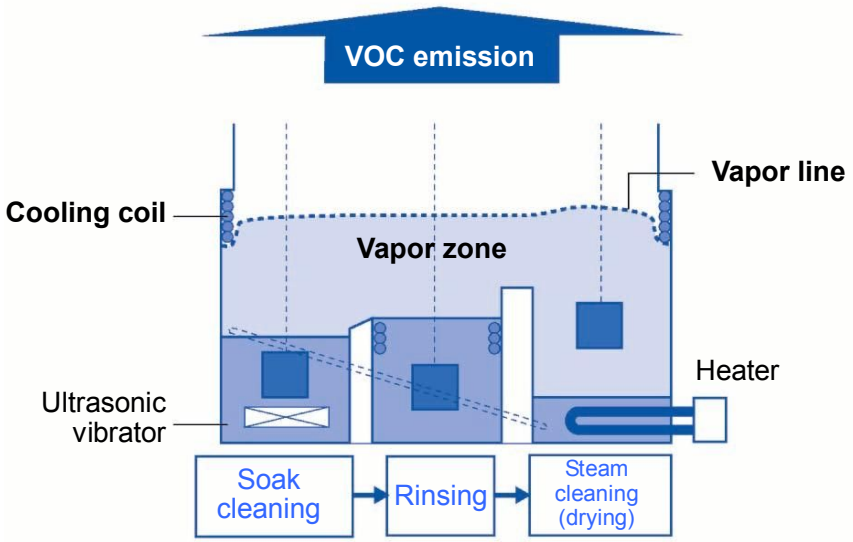
Why does loss of cleaning agent (solvent) occur?

Evaporation and condensation

Cleaning agent in the cleaning equipment repeatedly evaporates (in gaseous form) and condenses (in liquid form). The chart shown below is a record of change of the total amount of the cleaning agent in the cleaning equipment (without any items being cleaned, in static condition) actually measured in the model cleaning equipment for a quantitative measurement experiment. Loss of cleaning agent occurs even while the cleaning operation is stopped. Cleaning agent vapor, which is heavier than air, diffuses from the opening of the top of the cleaning equipment. Generally speaking, factors of loss in cleaning agent are this vapor diffusion, leaking from the equipment, and being taken out by the items being cleaned. In particular, measures for vapor diffusion are important VOC emission control measures.



The above chart shows the amount of cleaning agent in the cleaning equipment in an actual day without items being cleaned in a model cleaning equipment for a quantitative measurement experiment. Cooling water and heater is turned ON and the lid was taken off at 9:00 in order to operate the cleaning equipment at 9:30. Operation was stopped at 16:00, cooling water and heater turned OFF. The lid was put at 17:00 to finish the work of the day. The vapor diffused and the liquid amount decreased during the night. This is repeated every day.



VPC emission image by vapor diffusion from the cleaning equipment

Role of cooling coil

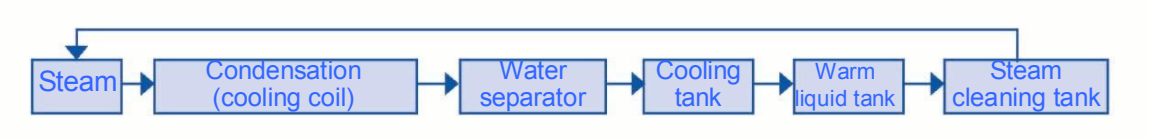
When cleaning is done with a cleaning agent without flash point such as methylene chloride, generally steam cleaning is done at the end. The purpose of steam cleaning is listed below:

1) To give a final rinsing with the evaporated, purest cleaning agent
2) To heat up the items being cleaned to boiling point to reduce cleaning agent taken out and shorten the drying time
3) To distil the cleaning agent in the cleaning equipment and to circulate pure cleaning agent

Therefore steam cleaning is an indispensable process in cleaning. For steam cleaning , the cleaning agent is heated to boiling point in the steam cleaning tank. Some of the generated vapor is condensed on the surface of items being cleaned to be used for so-called steam cleaning. Most of the rest of the vapor is not condensed and remains as vapor. A cooling coil is installed above the vapor zone to cool, condense, and liquefy the vapor.

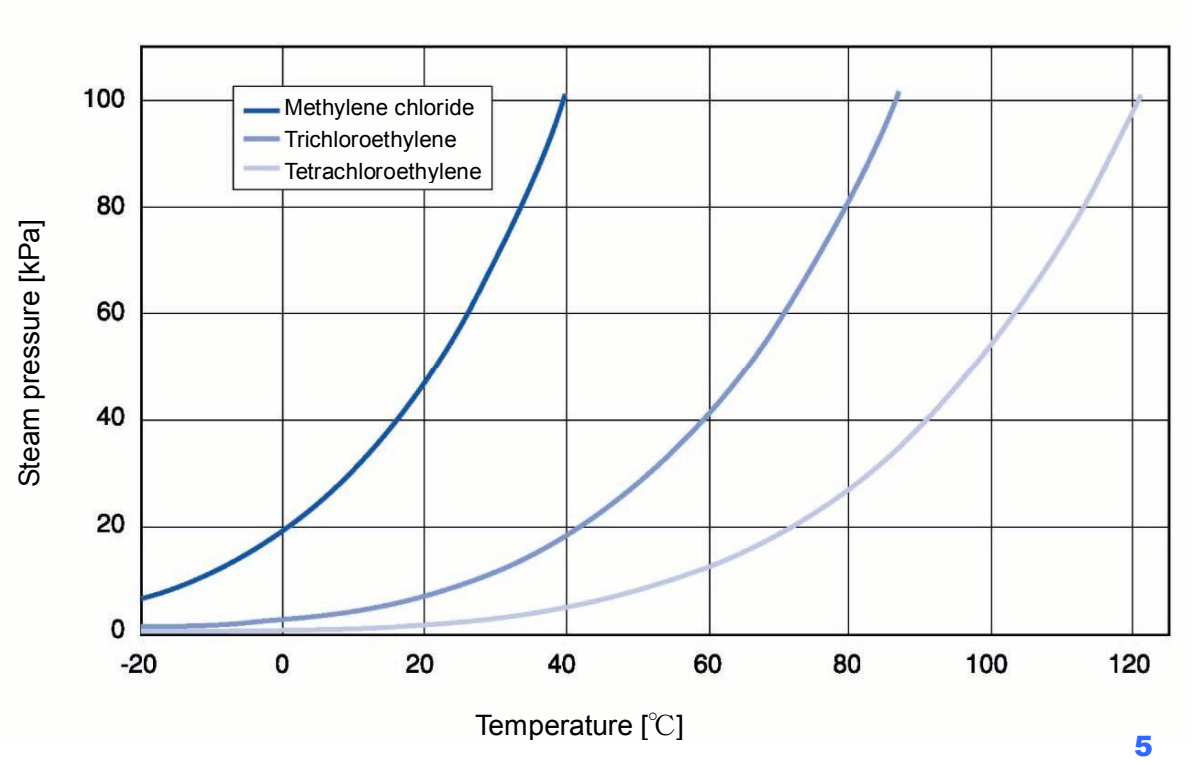
Cooling coils are long enough to cool a certain height in the vapor zone. The space above the vapor zone surrounded by the cooling coils is called the cooling zone. Items being cleaned which have finished steam cleaning are temporarily placed in the right direction in the cooling zone to let the cleaning agent attached on the surface evaporate and dry.

The most important role of the cooling coil is to cool and condense the vapor generated in the steam cleaning tank. By condensing the vapor with the cooling coil, the cleaning agent in the cleaning equipment is condensed as shown below.



By this circulation, contaminants such as oil, etc, dissolved in the cleaning agent are transferred to the solvent in the steam cleaning tank for condensation, maintaining the purity of the cleaning agent in the cool liquid tank.

As we have seen, the important effect of the cooling coil is to reduce the amount of cleaning agent which leaks outside the equipment, by condensing the vapor. Reduction of cleaning agent leakage leads to reduction in running costs, lowered VOC concentration in the work environment, and less environmental impact.

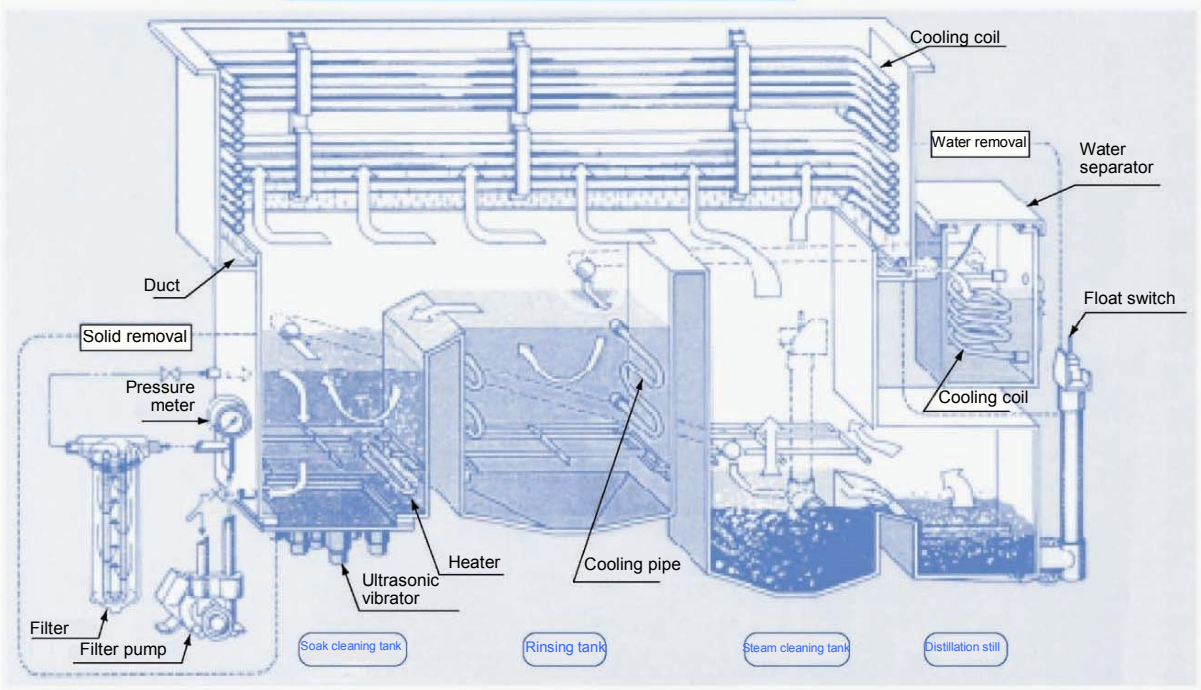


3-tank type cleaning system

The basics of industrial cleaning are 1) washing – 2) rinsing – 3) drying.

1) Washing: dirt on the items being cleaned is removed by the chemical solution force of the solvent and the physical force of ultrasonic wave, etc.
2) Rinsing: Solvent used in the washing process is removed, and any dirt which was not removed in the previous tank is removed
3) Drying: Let the solvent used in the rinsing evaporate at a temperature in a range which does not have an adverse effect on the items being cleaned for removal

Typical wet type open style 3-tank type cleaning system



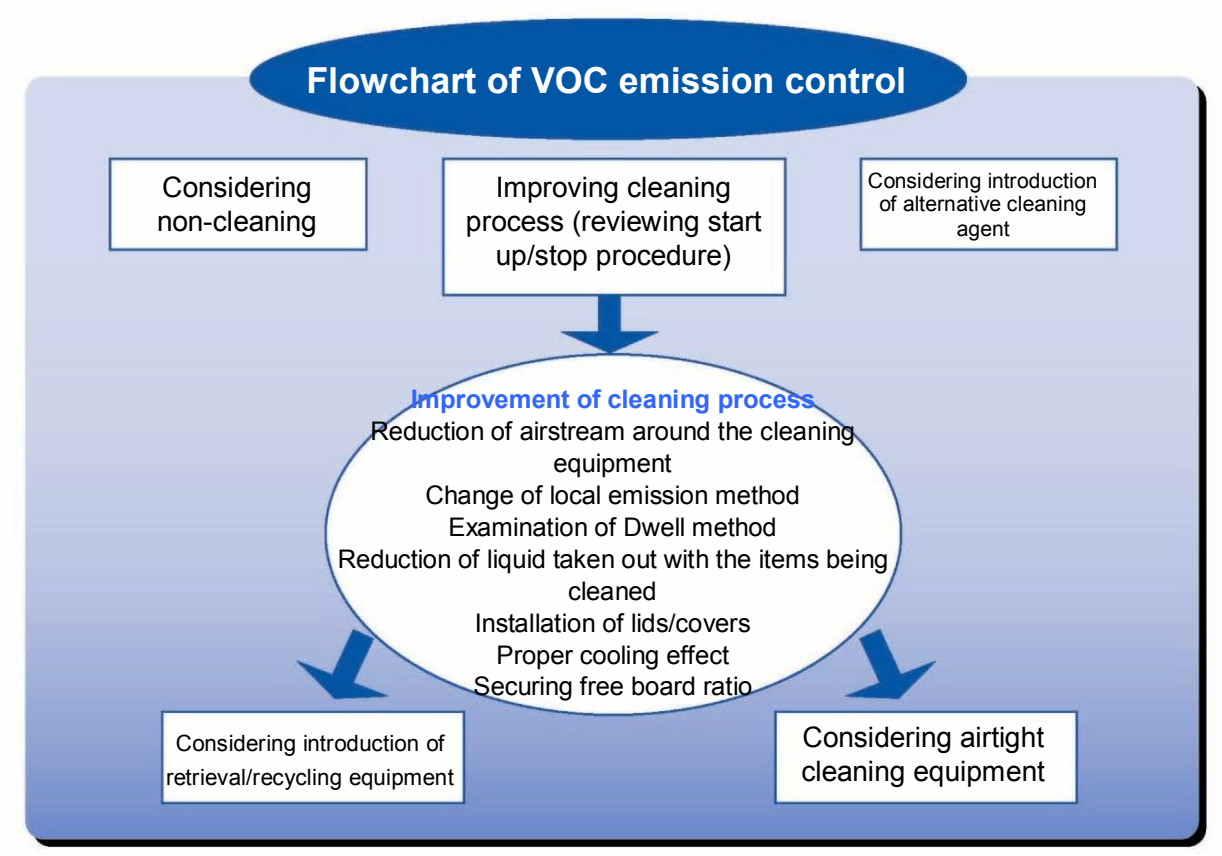
Key measures for emission amount reduction in the industrial cleaning process

Types of measures		Concrete method	VOC emission control effect (Note: confirm details)	Initial cost required for the measures
Cleaning process improvement	Operation improvement	・Procedure of start-up/stop	-	Zero
		・Reduction of airstream around the cleaning equipment	Approx. 60 – 90% (refer to model cleaning equipment data p.9)	From about ¥100,000
		・Examination of Dwell method	Approx. 15– 80% (refer to model cleaning equipment data p.11)	Zero
		・Reduction of liquid taken out by the items being cleaned	Approx. 80% (refer to model cleaning equipment data p.12)	About ¥10,000
	Cleaning equipment improvement	・Change of local emission method	Approx. 70 – 85% (refer to model cleaning equipment data p.10)	0 - ¥1milion
		・Installation of lids/cover	Approx. 80% (refer to model cleaning equipment data p.13)	¥10,000 – 500,000
		・Proper cooling effect	Approx. 10 – 30% (refer to model cleaning equipment data p.14)	¥100,000 – 1million
		・Securing free board ratio	Approx. 20% (refer to model cleaning equipment data p.15)	Less than ¥1million
Introduction of alternative cleaning agent		・Water type, semi-aqueous type, hydrocarbon type, halogen (fluoride, bromide), etc, cleaning agent	100% (emission of alternative substance not included)	Several tens of million yen (replacing equipment)
Introduction or retrieval/recycling equipment		・Activated carbon adsorption method ・Cryogenic condensation method	60 – 80%	Several million - 20million yen
Airtight equipment		・Depressurized steam cleaning system ・Airtight cleaning equipment	70 - 80%	Several million – 20million yen

Checking factors of VOC generation

Process flow and check point chart

Process flow	Check point	Factors of VOC emission in the air	Aim of VOC generation rate
Preparation	• Is there no over-washing? • Is the start-up/stop procedure of cooling equipment and heater correct? • Is the cooling water flowing? Is the temperature appropriate? • Are the items being cleaned placed correctly? • Is cleaning agent leaking when filled/replaced?	Volatilization of cleaning agent when poured in	About 30%
Cleaning/drying	• Is there airstream around the cleaning equipment? • Is the local emission aspirated too highly? • Can the local emission form be changed? • Is the free board ratio correct? • Are the items being cleaned put in/taken out slowly? • After washing, is the moisture removed? Are they allowed to dry in the upper layer of the vapor zone? • Is there a lid or a cover on the cleaning tank? • When the lid is put on, is the lid below the local emission aspiration vent? • Can alternative cleaning agent be used? • Can VOC processing equipment be fitted at the emission opening?	Volatilization of cleaning agent	About 70%
Storage	• Is the temperature controlled in the storage area? • Are the cans shielded from direct sunlight? • Are the lids of solvent always closed tightly when not in use?	Volatilization of cleaning agent in storage	Less than about 5%



Procedure of start-up/stop

◎Important point◎
Emission loss can be reduced by proper start up/stop procedure of water cooling equipment (chiller) and heater.

◎Comments◎
If the temperature of the cleaning agent is raised while the temperature at the cooling zone of the cleaning tank is not fully lowered, VOC emission in the air will increase. Follow the procedure described below to start up/stop the cleaning system.

Let it rest a while after start up until the temperature/flow of cooling water becomes stable (about 10 minutes) before turning on the heater switch. Also check if the work is done properly following this procedure with a work check list, etc.

Procedure of start up/stop of cleaning system

Start up

1) Cooling water ON (wait for a while, about 10 minutes)
↓
2) Open the lid slowly
↓
3) Heater, etc, ON
↓
4) Confirm that it is in stable condition (set temperature)
↓
5) Start cleaning operation

Stop

1) Heater, etc, OFF
↓
2) Close the lid
↓
3) Confirm that the temperature in the cleaning tank is lowered to room temperature
↓
4) Cooling water OFF (constant flow is preferred)

(Made based on “Handbook for a proper use of chlorocarbon” 2000, Japan Association for Hygiene of Chlorinated Solvents)

Reduction of airstream around the cleaning equipment

◎Important point◎
To reduce airstream generation around the cleaning equipment
When airstream blows onto the cleaning equipment from outside, diffusion of cleaning agent vapor is promoted, becoming a huge factor affecting VOC emission increase.

VOC emission control effect	▲60 – 90% (Reduce the airstream in the environment to 0.25m/s – 0m/s from 1.25m/s. Installation of screen board, covering with sheet)
Initial cost	from about ¥100,000 (detail: installation of screen board, covering with sheet, etc.)
Running colt	none

◎Comments◎
In the normal type of cleaning equipment with the opening on the top, it is inevitable for the cleaning agent vapor generated in the cleaning tank to diffuse from the opening. If an airstream is blowing where cleaning equipment is situated, diffused vapor is blown away quickly, promoting more diffusion, resulting in a greater VOC emission level. If there is a door or window near the cleaning equipment, and outside air is blown in at the opening/closing, this phenomenon happens. According to a report, compared with the no-airstream condition, approx. 0.3 – 0.5m/s of airstream (faintly perceptible airstream velocity) multiplies emission by 2 to 3 times, and 1m/s airstream multiplies it by 10 times. VOC emission amount due to this factor has a larger impact than emission by other factors, therefore it needs to be dealt with.

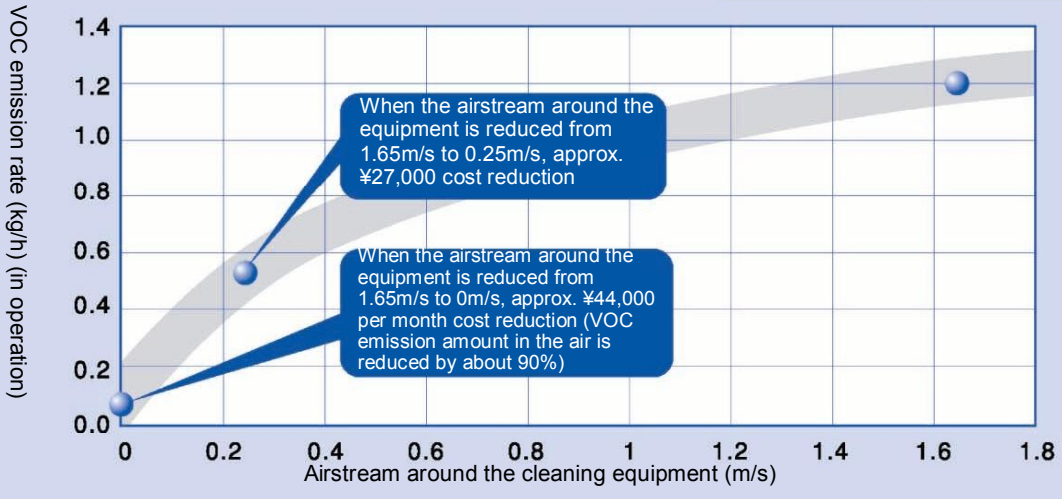
Examples of airstream around the cleaning equipment are1) open window in the workroom to alleviate odor or heat, 2) cleaning equipment is placed near a door facing outside, 3) operation of a local cooling device or fan toward the workers to alleviate heat in the summer, etc.

It is preferable if these issues can be solved, however, at the very least it is necessary to properly install screens to effectively protect against airstream.

Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

[Experiment condition]

Airstream velocity around the cleaning equipment	0 0.25 1.65m/s
Free board ratio	1.13
Cooling water amount	50.0L/min
Local emission velocity	0.0m/s



(Airstream velocity around the cleaning equipment is measured right in front of the equipment [place where operator stands is assumed])

Change in local emission method

◎Important point◎
To review the local emission equipment to optimize the volume of airstream
VOC emission can be controlled by optimizing the airstream volume of local emission. Also the form of local emission equipment alters the wind flow around the cleaning tank. Changing the form of the hood, etc, can control VOC emission.

VOC emission control effect	▲70-85% (airstream volume in the closed type local emission is reduced from 0.8m/s to 0.4 – 0.6m/s)
Initial cost	0-¥1million (detail: change of local emission equipment costs around ¥1million)
Running colt	none

□Comments□
There are two types of local emission equipment; the side attachment type and the closed type. In cleaning equipment, the latter has much less VOC emission than the former since there is no airflow blowing into the cleaning equipment. Therefore it is preferable to set up a slit type sucking gate all around the opening of the cleaning equipment to control the level of sucking velocity at around 0.4m/s.

* Supplementation (Regulation of legally controlled airstream velocity in the Labor Safety and Sanitation Law)

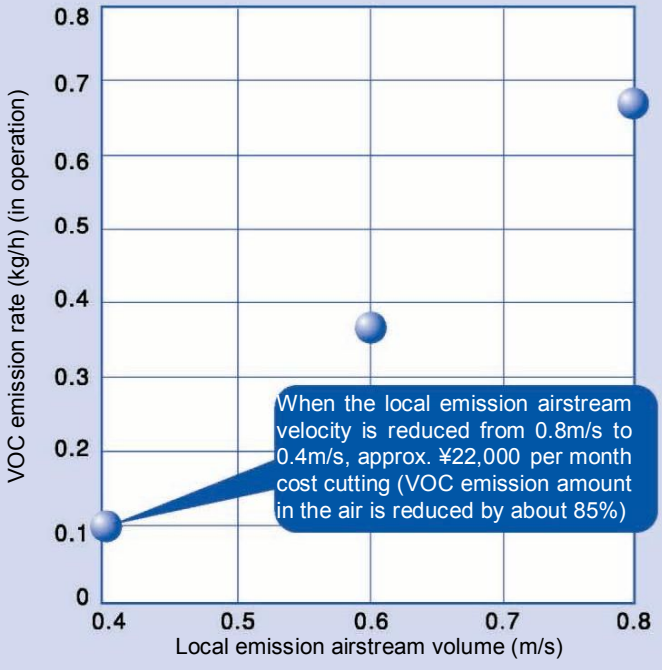
According to the regulation dealing with organic solvent poisoning prevention in the Labor Safety and Sanitation Law, it is mandatory to install local emission equipment for work environment safety when chloride cleaning agent is used. The legally controlled airstream velocity is regulated at the sucking gate (For the hood in the closed type, a controlled velocity of no less than 0.4m/s).

Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

Sucking duct for local emission

[Experiment condition]

Local emission airstream velocity	0.4 0.6 0.8m/s
Free board ratio	1.13
Cooling water temperature	15℃
Cooling water flow rate	50.0L/min



Examination of Dwell method (let the items being cleaned dry above the vapor zone)

◎Important point◎
To conduct Dwell (let the items being cleaned dry above the vapor zone)
After steam cleaning, temporarily store the items being cleaned above the vapor zone as long as possible to allow the attached solvent to evaporate well. After it is condensed and retrieved by the cooling coil, take out the items being cleaned.

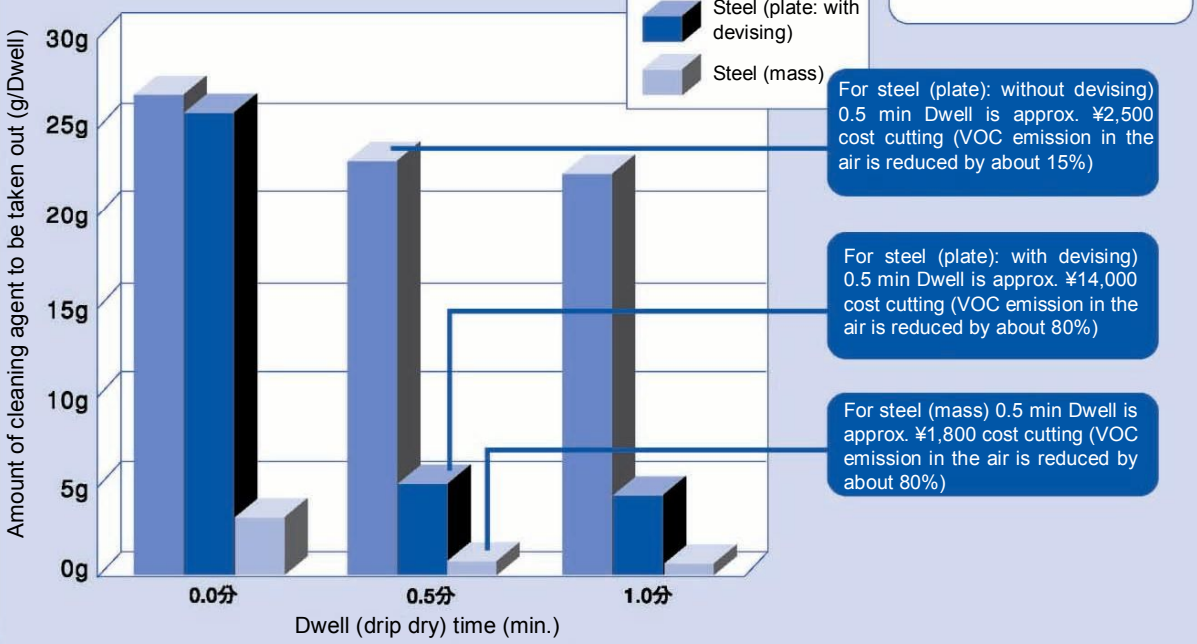
VOC emission control effect	▲15 – 80% (from no Dwell to 30 seconds Dwell)
Initial cost	none
Running colt	none

◎Comments◎
Place the items being cleaned so that the bottom of them will come to about 5cm above the borderline of vapor zone generated by cooling. Also, it is preferable if most of the items are surrounded by the cooling coil.
Allow the cleaning agent which is wetting the items to evaporate by Dwell. About half of it is condensed and retrieved by the cooling coil. If the items are placed higher than the upper end of the cooling coil, attached cleaning agent cannot be retrieved. Most of it will be emitted as VOC.
Good results can be obtained when proper placement is done and do Dwell for about 30 seconds while considering the through put (work time).

Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

[Experiment condition]

Dwell time	none	0.5min	1min
Iron (board, without devising)	26.49g	22.73g	22.11g
Steel (plate, with devising)	25.64g	4.69g	4.20g
Steel (mass)	3.24g	0.54g	0.48g
Batch amount (takt/day)	160	137	120



30 seconds of Dwell is effective in reducing the amount of cleaning agent to be taken out. Dwell is effective in mass form also.

For steel (plate): without devising) 0.5 min Dwell is approx. ¥2,500 cost cutting (VOC emission in the air is reduced by about 15%)

For steel (plate): with devising) 0.5 min Dwell is approx. ¥14,000 cost cutting (VOC emission in the air is reduced by about 80%)

For steel (mass) 0.5 min Dwell is approx. ¥1,800 cost cutting (VOC emission in the air is reduced by about 80%)

Reduction in amount of liquid taken out by items being cleaned

◎Important point◎
To reduce the amount of cleaning agent taken out by the items being cleaned as much as possible.
When they are taken out of the cleaning tank, arrange them in the basket in such a way that the liquid is not pooled, or that they are not piled up.

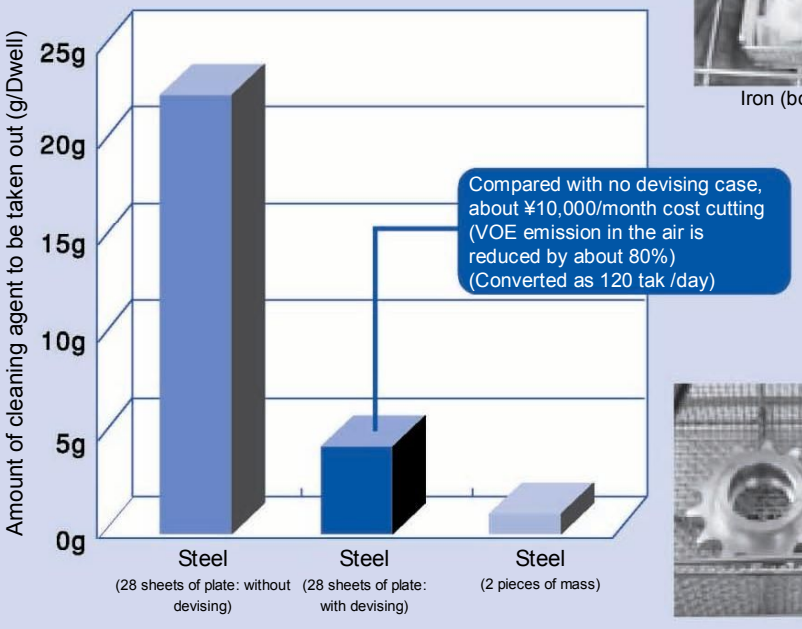
VOC emission control effect	▲80% (from laying plate-like items horizontally to vertically) *Not applicable for mass form
Initial cost	about ¥10,000 (detail: modifying baskets)
Running colt	none

◎Comments◎
After soak cleaning, vapor cleaning is done. When the temperature of the items being cleaned rises due to the heat of vapor until it is the same as that of vapor heat, no more condensation is generated, finishing vapor cleaning. After that, the items are taken out from the vapor zone. Depending on the form of the items (dented which makes solvent form pools, hollow, layered parts, etc,) or the arrangement in the basket, cleaning agent, besides wetting the surface of items, can become pooled at piled-up parts, etc. without flowing down.
Taken out of the equipment this condition, extra VOC emission is generated for the amount of taken out liquid. Therefore consider ways so that there is minimum liquid pooling in the items when they are taken out of the cleaning tank, or arrange them in the basket without piling them up.

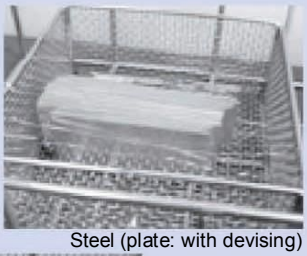
Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

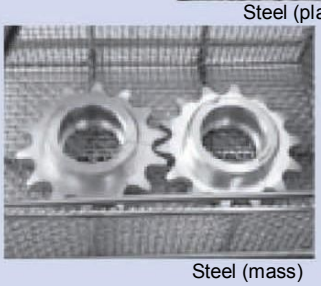
[Experiment condition]

Dwell time	1min
Steel(plate, without devising)	22.11g
Steel (plate, with devising)	4.20g
Steel (mass)	0.48g




Iron (board: without devising)


Steel (plate: with devising)


Steel (mass)

Installation of lids/cover

◎Important point◎
When there is airstream around the equipment, installation of lids/cover on the cleaning tank can prevent cleaning agent vapor diffusion from the cleaning tank, reducing VOC emission..

VOC emission control effect

▲ 80% (Tight-fitting lid is used below the sucking gate)
Some offices reduced cleaning agent (methylene chloride) by 27%, another cleaning agent (trichloroethylene) by 14% by encouraging lid installation. (Federation of Electro Plating Industry Association, Japan, Voluntary measures data)

Initial cost

¥10,000 - ¥500,000 (detail: building airtight lid, automatic open/close lid costs about ¥500,000)

Running colt

none

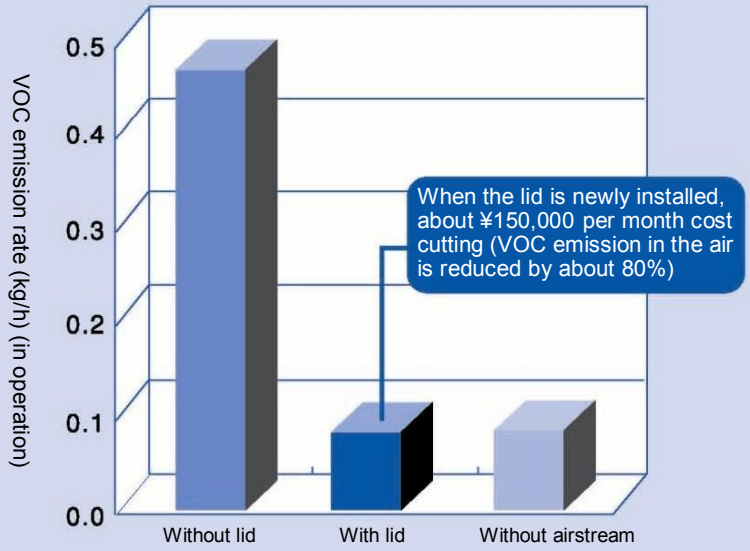
◎Comments◎
To install a lid/cover with a high degree of tightness to prevent vapor diffusion when the cleaning equipment is not in use. Lids are highly effective especially when cooling water is stopped with the equipment not in use, such as at night. For equipment installed with closed type local emission equipment, the lid should be under the sucking gate to be effective.
Also in automatic conveyer type cleaning equipment, modification by installation of a sliding type automatic shutter which opens the lid when the items being cleaned go into/out of the cleaning tank can achieve effective VOC emission control.

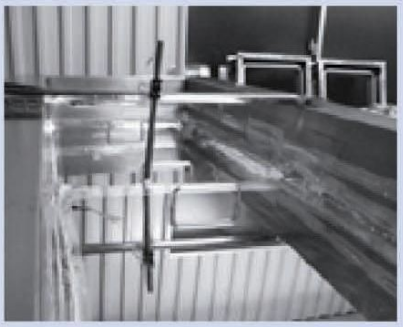
Actual equipment data of quantitative measurement experiment indicating Voc emission control effect

[Experiment condition]

	Without lid	With lid	Without lid /without airstream
Free board ratio	1.13	1.13	1.13
Cooling water temperature (℃)	15	15	15
Cooling water flow rate (L/min)	50	50	50
Local emission airstream velocity (m/s)	0.0	0.0	0.0
Airstream around the equipment (m/s)	1.65	1.65	0
Emission rate during operation (kg/h)	0.4751	0.00896	0.0898

If an unnecessary lid is installed in a no-airstream condition, the emission loss on opening/closing the lid has a large impact.




Lid on top of the cleaning equipment

Proper cooling effect

◎Important point◎

To lower temperature of cooling coil cooling water on the upper part of the cleaning tank, or to adjust to proper cooling water flow rate.
By lowering the temperature of cooling coil cooling water, diffusion of cleaning agent vapor is controlled, which results in reduction of VOC emission.

VOC emission control effect	▲10-35% (Change cooling water temperature from 25℃to 15℃, 10℃) An office reduced the cleaning agent (trichloroethylene) usage by 47% by the improvement of water cooling equipment (chiller). (Federation of Electro Plating Industry Association, Japan, Voluntary measures data)
Initial cost	¥100,000 - ¥1 million (detail: attaching and augmenting water cooling equipment (chiller))
Increased running colt	about twice as much (detail: electricity consumption by the water cooling equipment (chiller), water cost, etc.)

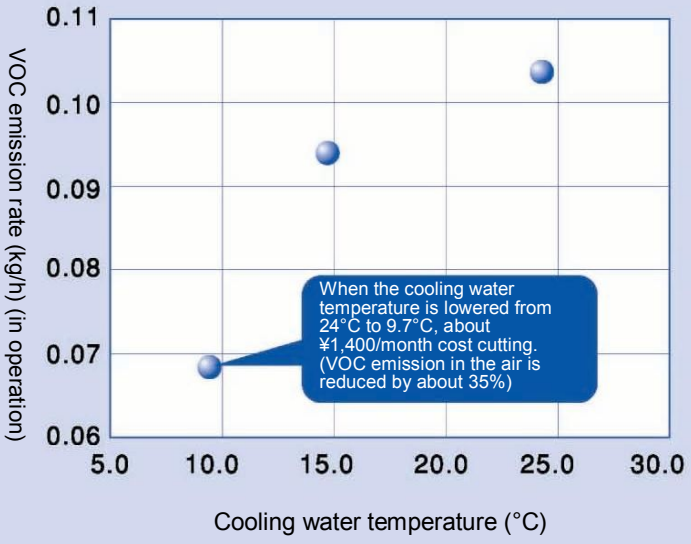
◎Comments◎

Methylene chloride has a lower boiling point (40°C) compared with trichloroethylene. Therefore the diffused amount of cleaning agent vapor increases when the water temperature in the cooling coil is high. For this reason, the cooling water temperature should be set at 5-15°C when using methylene chloride. If low temperature cooling water cannot be supplied from other equipment, etc, an exclusive cooling water equipment (chiller) should be attached.
When using trichloroethylene (boiling point 87°C) or tetrachloroethylene (boiling point 121°C), the cooling water temperature at the entrance should basically be set to under 25°C.
When humidity is high, such as in the rainy season, use of excessively cold cooling water (under 10°C), means moisture in the room tends to condense, causing water to enter the cleaning liquid. Attention should be paid not to lower the temperature too much.

Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

[Experiment condition]

Cooling water temperature	9.7 14.6 24.4℃
Free board ratio	1.13
Cooling water flow rate	50.0L/min
Local emission airstream velocity	0.0m/s



Remarks

In a quantitative measurement experiment, it was observed that a vapor line was not formed and VOC emission by the cleaning agent increased drastically when the cooling water flow rate was decreased to 10L/min. At the same time, no significant change was observed over 25L/min. Therefore it is important to maintain the cooling water flow rate over a certain volume.

Securing free board ratio

◎Important point◎
Free board ratio secures a proper size. When the free board ratio is small, the cooling agent vapor in the cleaning tank is not cooled enough, so un-condensed vapor diffuses from the cleaning tank, resulting in increased VOC emission. By enlarging the free board ratio, loss of cleaning agent by diffusion can be minimized.

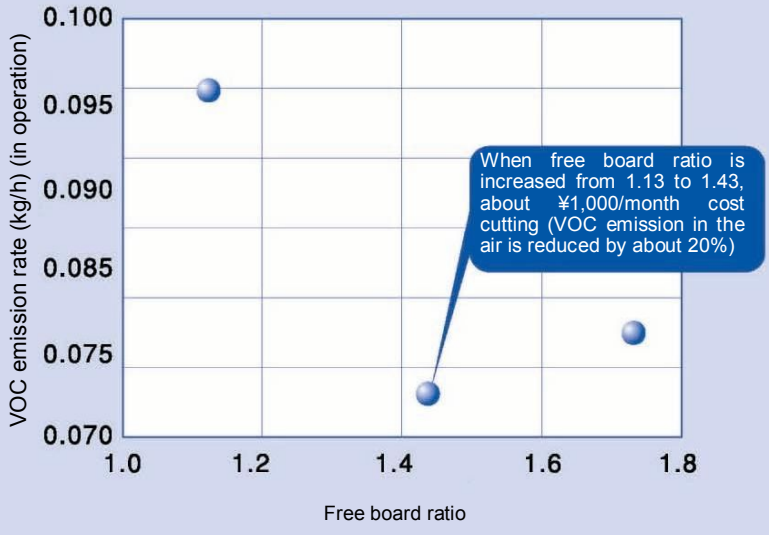
VOC emission control effect	▲20% (when free board ratio is secured from 1.1 to more than 1.4)
Initial cost	less than ¥1 million (detail: augmenting walls of the cleaning tank and cooling coil, installation of steps for work, etc.)
Running colt	none

◎Comments◎
The distance between the surface of vapor condensation and the top of the cooling coils is called free board. When the steam cleaning tank is in idling condition (not in cleaning process) and when there is no airstream on the cleaning tank, the height of free board has a large effect on the diffusion of cleaning agent vapor.
Even with the same free board height, the difference in the size of opening of the tank of the actual cleaning equipment makes a difference in the solvent loss. Therefore the height of free board is standardized by dividing it by the shorter width of the tank, i.e. free board ratio. The minimum standard free board ratio is not less than 0.7 for trichloroethylene with a high boiling point, not less than 1.0 for methylene chloride with a low boiling point. Modification of equipment is necessary to secure at least the minimum standard free board ratio.

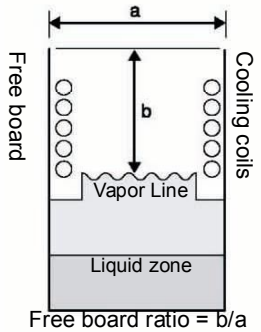
Actual equipment data of quantitative measurement experiment indicating VOC emission control effect

[Experiment condition]

Free board ratio	1.13	1.43	1.73
Cooling water temperature	15℃		
Cooling water flow rate	50.0L/min		
Local emission airstream velocity	0.0m/s		



<Free board ratio>



Free board ratio = b/a
free board ratio: ratio of distance between the solvent liquid surface and the top end of the cleaning tank (b) to the shorter length of the opening of the cleaning tank (a)

Hydrocarbon type cleaning system

◎Important point◎

Hydrocarbon type cleaning agent with a high boiling point generates relatively low VOC emission when the cleaning is conducted at room temperature.
By the way, hydrocarbon type cleaning agent is classified as one of the VOCs. VOC emission is controlled by installation of depressurized drying equipment and distilling retrieval equipment. Hydrocarbon cleaning agent is a highly flammable substance, therefore explosion preventive measures are required. VOC emission control in this system varies according to the drying system.

VOC emission control effect	▲60 – 99% (attaching depressurized distilling recycling equipment achieves over 95%)
Initial cost	¥8million to ¥14million (detail: soak cleaning, drying system, distilling recycling equipment, explosion preventive measures)
Increased running colt	¥40,000 - ¥80,000 (detail: electricity, maintenance of the equipment)

◎Comments◎

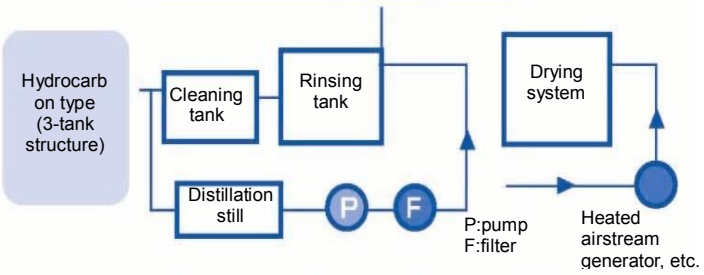
Various drying systems in the hydrocarbon type cleaning system make a difference to the degree of VOC emission.

1) heated airstream drying
   Cleaning agent is evaporated dry by a heated airstream. Emission concentration is low, making retrieval difficult. Therefore all cleaning agent taken out to the drying process by the items being cleaned is emitted to the air, which results in large VOC emission.
2) sucked dry
   In the drying process, lots of air goes through to dry the cleaning agent. Cleaning agent taken out to the drying process by the items being cleaned is retrieved in the retrieval mechanism. However, the sucked drying process is not completely airtight, so cleaning agent is emitted to the air from a large wind sucking system with a retrieval mechanism. There is VOC emission.
3) Vacuum steam heating + vacuum drying
   Steam cleaning and drying is done in a sealed vacuum space. (Thermal energy is given to the items being cleaned by vacuum steam cleaning)
   When the vacuum degree is increased, attached cleaning agent evaporates and dries rapidly. There are two types of retrieval mechanism; physically adsorbing and retrieving, and cooling and retrieving in liquefied form. Since the vacuum drying process is done in a completely airtight space, most of the cleaning agent taken out by the items being cleaned is retrieved by the retrieval mechanism, resulting in low VOC emission.

(Example) Grease removal cleaning of machine processing part

Rough cleaning	General cleaning	Precise cleaning
Soak and shaking, soak and shaking	Soak ultrasonic x 2	Soak ultrasonic, shower
Heated airstream drying	Heated airstream drying	Depressurized vapor
Distilling recycling, augmented security/explosion prevention, foam fire extinguisher	Distilling recycling, augmented security/explosion prevention, foam fire extinguisher	Distilling recycling, augmented security/explosion prevention, foam fire extinguisher
Initial cost: ¥8.3 million	Initial cost: ¥11.8 million	Initial cost: ¥13.5 million
Running cost ¥35,000	Running cost ¥81,000	Running cost ¥60,000
Electricity ¥27,000 Maintenance ¥8,000 Industrial waste ¥0	Electricity ¥67,000 Maintenance ¥14,000 Industrial waste ¥0	Electricity ¥43,000 Maintenance ¥17,000 Industrial waste ¥0

Structure of hydrocarbon type cleaning system



***Supplementation**
Among the hydrocarbon type cleaning systems, “depressurized steam cleaning + vacuum drying” system conducts all the procedure(cleaning, rinsing and drying) in an airtight container. Therefore most of consumed cleaning agent comes from waste liquid (hydrocarbon type cleaning agent + processing oil, etc.) discharged from the attached depressurized distilling recycling equipment. In this system, emission to the air is very little from the vacuum pump.
This will be described in the “depressurized steam cleaning system” in airtight cleaning equipment section.

Semi-aqueous type cleaning system

◎Important point◎

Semi-aqueous type cleaning agent can be rinsed with water. It has a strong cleaning force against organic dirt, at the same time ionic dirt can be removed by rinsing with water. Semi-aqueous type cleaning agent mainly consists of glycol-ether mixture (surfactant, water). It also includes N-methylpirrolidone type, terpene type, and alcohol type. VOC emission is close to zero apart from the N-methylpirrolidone type and alcohol type.
Standard semi-aqueous cleaning system is 4-tank type (washing – pre-rinsing – finish rinsing – drying). Since it uses water for rinsing, drying is required. Generally pure water recycling equipment is attached.

VOC emission control effect	▲95 – 100% (100% when glycol-ether type cleaning agent is used and rinsed with water)
Initial cost	¥6 million - ¥13million (detail: 4-tank type cleaning equipment (with dryer), pure water recycling equipment)
Increased running colt	¥50,000 - ¥140,000 (detail: activated carbon replacement, industrial waste, electricity, equipment maintenance)

◎Comments◎

VOC emission from the semi-aqueous type cleaning system varies according to the type of cleaning agent and rinsing agent.

1) Glycol-ether type cleaning agent hardly evaporates at all, therefore VOC emission is zero as long as it is rinsed with water.
2) When the alcohol type is used for rinsing, alcohol taken into the drying tank at drying is emitted as VOC.
3) Inflammable cleaning agent evaporates when it is heated in the cleaning process, and is emitted as VOC, but it can be kept to a minimum by the use of retrieval equipment and airtight procedure. If the water content is replaced with alcohol for drying, the alcohol taken out becomes VOC emission. Efficient drying equipment should be used and water should be used for rinsing if possible.

Standard use of semi-aqueous type cleaning agent

1) Washing procedure (ultrasonic, shower, JET in the liquid, etc.) cleaning temperature (60 - 70°C)
2) Pre-rinsing (tap water or pure water, room temperature - 40°C) – replacing liquid once to twice a month
3) Finish-rinsing (pure water at room temperature - 50°C) Discharged water can be sealed watertight by recycling using pure water recycling equipment (activated carbon, ion exchange resin)
4) Drying (heated airstream 70°C - 90°C)

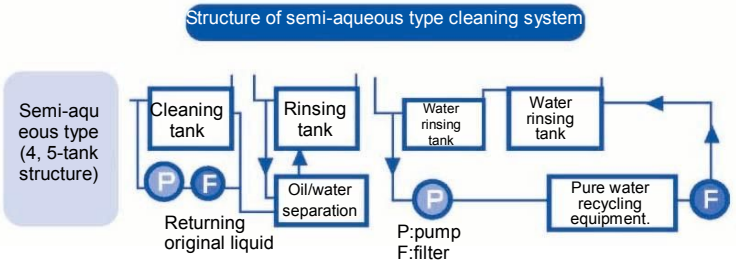
Types of semi-aqueous cleaning agent

1) non-flammable (non-hazardous substance)
   1) glycol – ether mixture (surfactant, water)
   2) hydrocarbon + glycol –ether mixture (surfactant, water)
   3) N-methylpyrrolidone (NMP) mixture (surfactant, water)
2) flammable (hazardous substances)
   4) terpene type solvent mixture (surfactant)
   5) N-methylpyrrolidone mixture (surfactant)
   6) glycol – ether mixture (surfactant)
   7) alcohol type cleaning agent (IPA, denatured alcohol)

(Example) Printed circuit board /electronic parts (flux removal) cleaning

Rough cleaning (3-tank type)	General cleaning (4-tank type)	Precise cleaning (4-tank type)
Soak ultrasonic 1 set	Ultrasonic 2 sets, jet flow	Ultrasonic 3 sets
Tap water rinsing	Pure water rinsing x 2, pure water recycling equipment	Pure water rinsing x 2, pure water equipment, rinsing purification equipment
Heated airstream drying	Heated airstream drying	Heated airstream drying
Initial cost equipment: ¥6 million	Initial cost equipment: ¥10 million	Initial cost equipment: ¥130million
Running cost total: ¥91,000	Running cost total: ¥144,000	Running cost total: ¥177,000
Cleaning agent 30kg ¥36,000 Industrial waste 334kg ¥20,000 Recycling cost ¥0 Electricity ¥27,000 Maintenance cost ¥8,000	Cleaning agent 30kg ¥36,000 Industrial waste 234kg ¥14,000 Recycling cost ¥45,000 Electricity ¥33,000 Maintenance cost ¥16,000	Cleaning agent 30kg ¥36,000 Industrial waste 234kg ¥14,000 Recycling cost ¥55,000 Electricity ¥48,000 Maintenance cost ¥24,000

Structure of semi-aqueous type cleaning system



*RC: monthly running cost (total of industrial waste, electricity, maintenance, and recycling costs)
Condition for calculating running cost
○ procedure consists of washing – pre-rinsing – finish-rinsing- drying
○ cleaning equipment operates manually
○ each cleaning tank can contain 100L
○ cleaning agent is ¥1,200/kg, entire agent is replaced every 3 months
○ monthly supplemented cleaning agent is 30kg, industrial waste cost of cleaning agent and rinse 1 water is ¥60/kg
○ rinse 2 is recycled by pure water recycling equipment, 25L each of activated carbon, ion exchange R, operation condition 10hours/day x 22/month

Water type cleaning system

◎Important point◎
When water type cleaning agent (alkali cleaning agent, surfactant type cleaning agent, acid type cleaning agent, and mixture of alkali and surfactant cleaning agent) is used, there is no VOC emission. Discharged water neutralization treatment and water purification (recycling) becomes necessary. In this system, separate consideration for discharged water is necessary.

VOC emission control effect	▲100% (when all the cleaning agent is converted to water type)
Initial cost	¥5 million to ¥20 million (detail: ultrasonic cleaning equipment, drying equipment, pure water recycling equipment)
Increased running colt	¥50,000 - ¥230,000/month (detail: electricity, waste treatment cost, water recycling equipment cost)

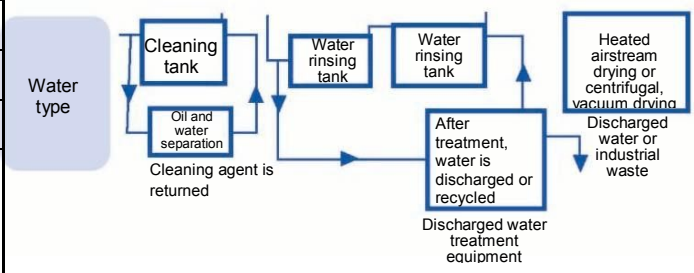
◎Comments◎
Water type cleaning agent does not include flammable or volatile substances, also it is safe. At the same time, consideration for discharged water is necessary. There is a way to use water type cleaning agent without newly installing a large scale discharged water treatment facility.

- Rinsing water recycling system
  In this system, discharged water from the rinsing process is recycled in the attached equipment. Discharged water from the rinsing process is distilled in the distilling equipment, and the collected distilled water is used again as rinsing water. Or in the case of precise cleaning when ion exchanged water is required for rinsing, the distilled water is put through ion exchange equipment to be used again.
  Also there are cases to use microfiltration membrane, ultrafiltration membrane, etc.
- Oil and water separating system
  Oil and water separating type cleaning agent is long lasting as well as requiring less frequent replacement. Also, some systems promote oil and water separation by working on the cleaning equipment or using attached equipment. In the cleaning equipment, reservoir tank is enlarged in the cleaning agent circulation line. This enables stabilization of the cleaning agent to non-moving status as much as possible, which floats the mixed-in oil. Also there are methods to install oil and water separating equipment as the attached equipment in the circulation line of cleaning agent to actively remove the mixed-in oil (oil and water separating membrane type, pressurized floatation type, and electrostatic separation type).
- Non-rinsing system
  This is used in rough cleaning. In this cleaning equipment it is necessary to suppress re-attachment of dirt mixed in the cleaning agent onto the items being cleaned, requiring oil and water separation system, cleaning agent filtering system, etc. Since this cleaning process requires only a cleaning tank and a drying tank, there is an advantage of smaller cleaning equipment compared with general water type cleaning equipment.

(Example) Metal parts (grease removal) cleaning

Rough cleaning	General cleaning	Precise cleaning (4-tank)
Soak ultrasonic x 2	Soak ultrasonic x 2 Core lesser	Soak ultrasonic x 3 Membrane separation
Heated airstream drying	Heated airstream drying	Depressurized vapor
Initial cost: ¥5.5 million	Initial cost: ¥9.5 million	Initial cost : ¥17.5 million
Running cost ¥53,000	Running cost: ¥143,000	Running cost : ¥229,000
Electricity ¥26,600 Maintenance cost ¥8,000 Industrial waste ¥18,000 Cylinder ¥0	Electricity ¥33,400 Maintenance cost ¥583,000 Industrial waste ¥6,000 Cylinder ¥45,000	Electricity¥100,000 Maintenance cost ¥71,600 Industrial waste ¥12,000 Cylinder ¥45,000

Structure of water type cleaning system



Retrieval/recycling equipment by cryogenic condensation

◎Important point◎
When cleaning agent vapor concentration is high, retrieval equipment by cryogenic condensation can be attached. In the retrieval equipment by cryogenic condensation, cleaning vapor is sucked, condensed and cooled for retrieval. This method is good when cleaning agent vapor concentration is relatively high and airstream is slight. It is effective for the process of retrieval very near the generator of cleaning agent vapor.

VOC emission control effect	▲50 – 80%(depends on the condition of cleaning equipment)
Initial cost	¥8 million - ¥12.5 million (detail: retrieval equipment, duct, water separator, installation work cost, etc.)
Increased running colt	¥10,000 - ¥100,000/month (detail: electricity, cooling water cost)

◎Comments◎
Retrieval equipment by cryogenic condensation consists of compressor which can suck and pressurize, condensing part to condense pressurized gas, and water separator to separate retrieved VOC and water.

1) Sucking process: High concentration gas is directly sucked in from near the vapor line in the cleaning tank
2) Pre-condenser: The gas at about -30°C discharged from the cryogenic condenser passes through the inner cylinder, exchanging heat with the sucked in vapor which passes through the outer cylinder. Part of it is liquefied and condensed.
3) Pressurizing process: Pressurized by compressor, apparent concentration becomes higher.
4) Water cooling condensing process: Part of the pressurized gas is liquefied and condensed by the cooling water supplied from outside.
5) Cryogenic condensing process: Vapor which cannot be liquefied in the water cooling condenser is chilled to -30°C to -40°C to liquefy and condense (cryogenic condensation). Most of the vapor is liquefied here. In the cryogenic condenser, moisture in the air becomes frozen over time. After a certain period, the vapor defrosts itself by halting the flow.

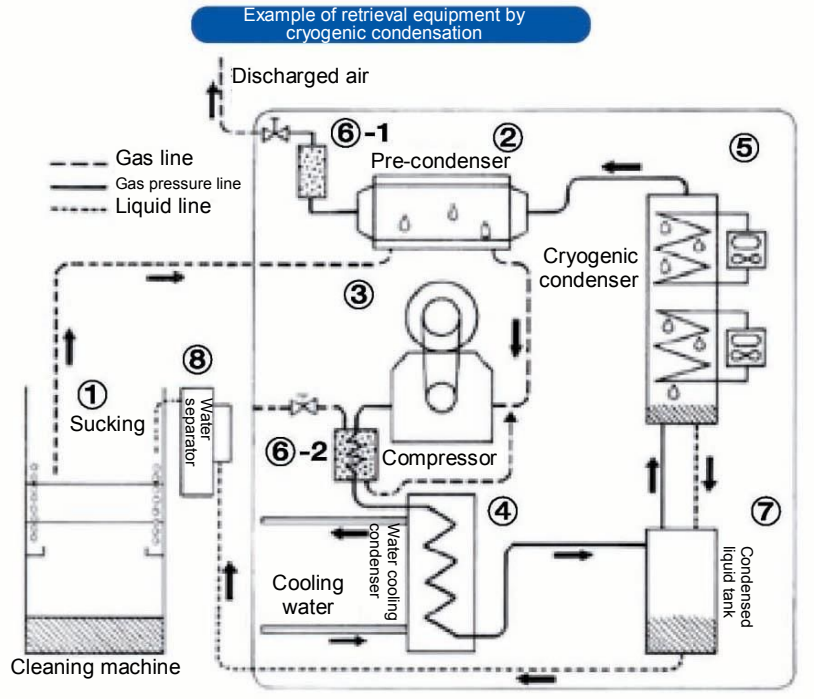
6)-1 Activated carbon adsorption process: vapor which cannot be liquefied in the cryogenic condenser is adsorbed by the activated carbon.

6)-2 Activated carbon desorption process: Vapor adsorbed on the activated carbon is desorbed by indirect heating and sucking desorption, i.e., thermal pressure swing method, and is returned to the entrance of compressor.

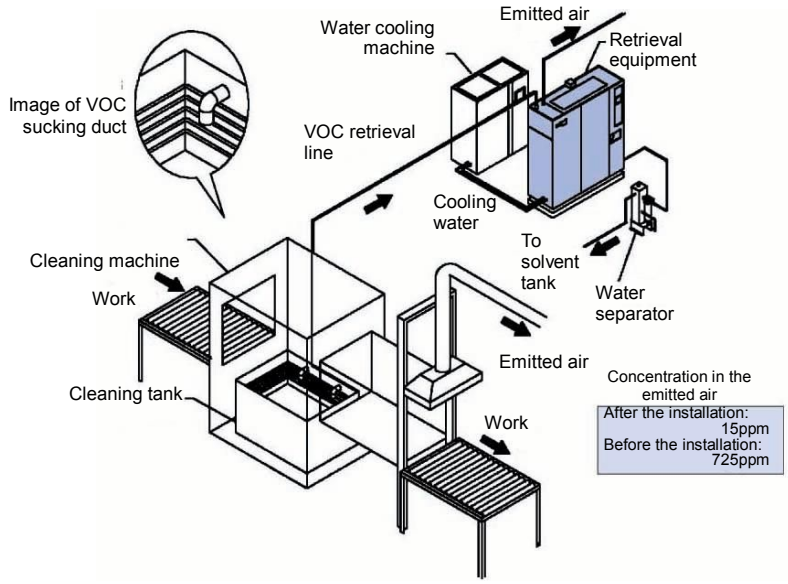
7) Condensed liquid tank: Cleaning agent liquefied in the water cooling condenser and cryogenic condenser is collected in the condensed liquid tank, and is regularly discharged by the inner pressure.
8) Water separation process: Retrieved cleaning agent discharged from the condensed liquid tank goes to a water separator where water is separated, then is returned to cleaning equipment, liquid tank, etc.

In combination with cleaning equipment, diffusion is controlled by sucking a small amount of gas from the vapor zone in the cleaning equipment. VOC concentration near the local emission opening on the upper part of the cleaning equipment becomes extremely low by installing the sucking part of the retrieval equipment about 10cm from the top of the vapor line, which results in in reduction of VOC emission.

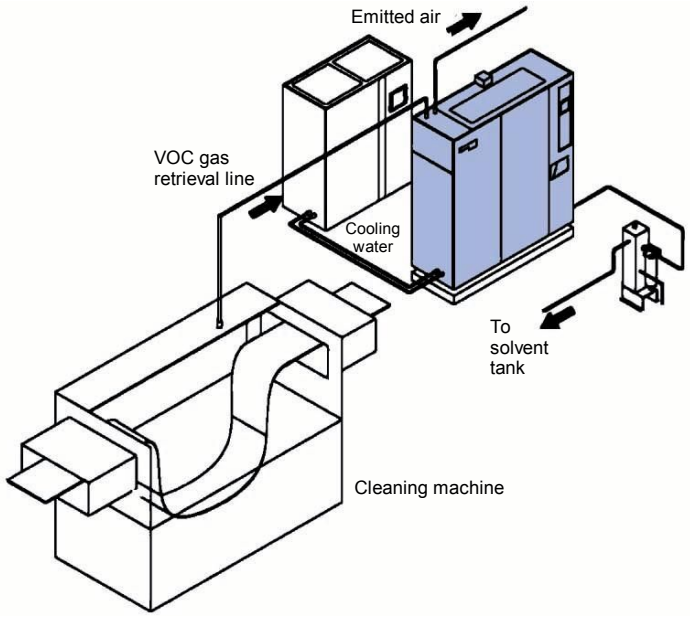
Example of retrieval equipment by cryogenic condensation



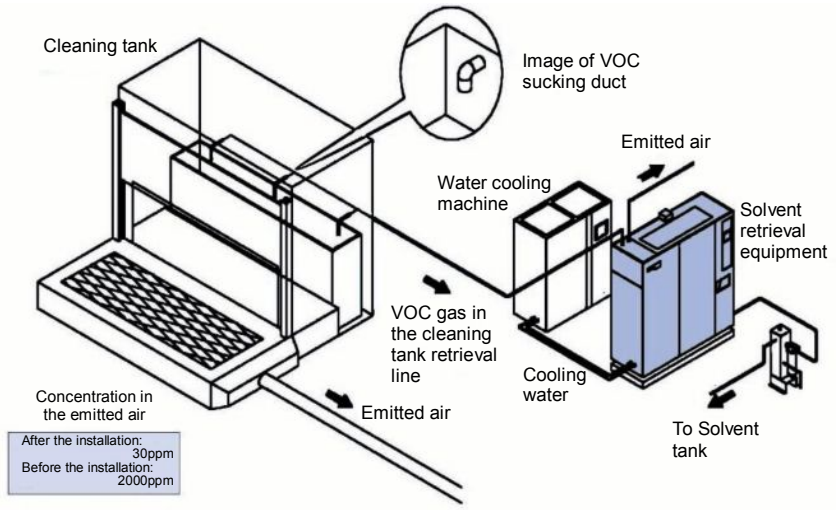
Actual case of retrieval/recycling equipment by cryogenic condensation No.1

1	Industry type	Transportation machinery/parts manufacturing	
2	Items to be cleaned	Heat treated parts	
3	Amount of items to be cleaned	approx. 100kg/batch	
4	Outline of emission facility	Emission facility	Closed type single tank automated cleaning machine
		Size of liquid surface in the cleaning tank	approx. 1.9 x 1.5(m)
		Airstream amount of local emission	approx. 40m³/min
		Operating hours	24 hours/day, 22days/month
5	VOC generating condition	Substance	Methylene chloride (dichloromethane)
		Generating condition	Flow-out of VOC volatilized in the cleaning tank
6	Aim of measures	Reduction of concentration in the emitted air (responding to prefectural regulation)	
7	Method of measures	Installation of retrieval/recycling equipment (cryogenic condensation type)	
8	Emission control measures (flow)	 1) VOC emission is reduced and retrieved liquid is recycled by collecting VOC and mist volatilized from the cleaning tank, which used to be discharged into the air, by solvent retrieval equipment. 2) Concentration in the work environment is reduced under the standard.	
9	Effect	Reduction effect	**▲ 65%, ¥324,000/month cost cutting** (Solvent usage before the installation: 2.5t/month Solvent usage after the installation: 0.88t/month)
		Emission concentration before the installation	725ppm
		Emission concentration after the installation	15ppm
		Others	Solvent retrieved in the retrieval equipment is recycled
10	Cost for the measures	Facility cost	¥11million (retrieval equipment)
		Construction cost	¥2million (duct, transportation, installation, test running and adjustment, etc.)
		Others	¥1million (water separator, attached equipment, materials, etc.)

Actual case of retrieval/recycling equipment by cryogenic condensation No.2

1	Industry type	Metal products manufacturing	
2	Items to be cleaned	Rolled metal sheet	
3	Amount of items to be cleaned	-	
4	Outline of emission facility	Emission facility	Hoop type cleaning machine
		Size of opening part in the cleaning tank	approx. 0.8 x 1.2(m)
		Airstream amount of local emission	approx. 5m³/min
		Operating hours	10 hours/day, 25 days/month
5	VOC generating condition	Substance	Methylene chloride (dichloromethane)
		Generating condition	Diffusion of VOC volatilized in the cleaning tank
6	Aim of measures	Reduction of usage amount	
7	Method of measures	Installation of retrieval/recycling equipment (cryogenic condensation type)	
8	Emission control measures (flow)	 VOC emission is reduced by collecting VOC volatilized from the cleaning tank which used to be discharged into the air by retrieval equipment.	
9	Effect	Reduction effect	▲ **85%, ¥340,000/month cost cutting** (Solvent usage before the installation: 2.0t/month Solvent usage after the installation: 0.3t/month)
		Emission concentration before the installation	- ppm
		Emission concentration after the installation	10ppm
		Others	Solvent retrieved in the retrieval equipment can be recycled
10	Cost for the measures	Facility cost	¥6 million (retrieval equipment)
		Construction cost	¥1.2 million (duct, transportation, installation, test running and adjustment, etc.)
		Others	¥300,000 (water separator, materials, etc.)

Actual case of retrieval/recycling equipment by cryogenic condensation No.3

1	Industry type	Metal products manufacturing	
2	Items to be cleaned	Stainless pipes	
3	Amount of items to be cleaned	400 kg /batch	
4	Outline of emission facility	Emission facility	Closed type double tank automated cleaning machine
		Size of opening part in the cleaning tank	approx. 4.5 x 1.0(m)
		Airstream amount of local emission	approx. 15m³/min
		Operating hours	8 hours/day, 20 days/month
5	VOC generating condition	Substance	Trichloroethylene
		Generating condition	Flow-out of VOC volatilized in the cleaning tank
6	Aim of measures	Reduction of concentration in the emitted air (voluntary measures for ISO14001) Reduction of concentration in the work environment	
7	Method of measures	Installation of retrieval/recycling equipment (cryogenic condensation type)	
8	Emission control measures (flow)	 VOC emission is reduced by collecting VOC flown out from the cleaning tank which used to be discharged into the air by direct sucking of retrieval equipment.	
9	Effect	Reduction effect	**▲ 59%, ¥100,000/month cost cutting** (Solvent usage before the installation: 875kg/month Solvent usage after the installation: 400kg/month)
		Emission concentration before the installation	2000ppm
		Emission concentration after the installation	30ppm
		Others	Solvent retrieved in the retrieval equipment can be recycled
10	Cost for the measures	Facility cost	¥11million (retrieval equipment)
		Construction cost	¥1.5 million (duct, transportation, installation, test running and adjustment, etc.)
		Others	¥1million (water separator, attached equipment, materials, etc.)

Retrieval/recycling equipment by activated carbon adsorption

◎Important point◎

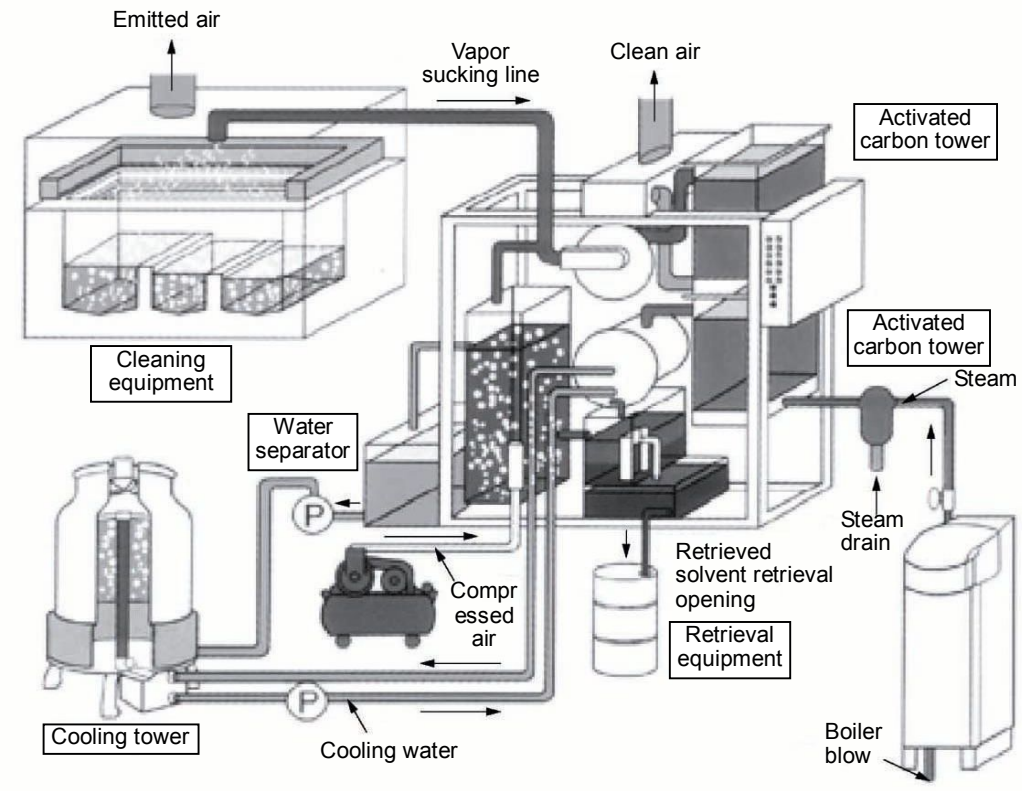
When there is a large diffusion of cleaning agent vapor or low concentration of cleaning agent vapor, vapor is collected with large amount of airstream, adsorbed on the activated carbon for higher concentration, and then the cleaning agent is removed. Retrieval equipment using this method is called retrieval equipment by activated carbon adsorption.

VOC emission control effect	▲About 65% (depending on the condition of cleaning equipment used)
Initial cost	¥6 million - ¥20 million (detail: retrieval equipment, duct, discharged water treatment facility, installation construction, etc.)
Running cost	¥300,000/year (detail: electricity, replacement cost of activated carbon)

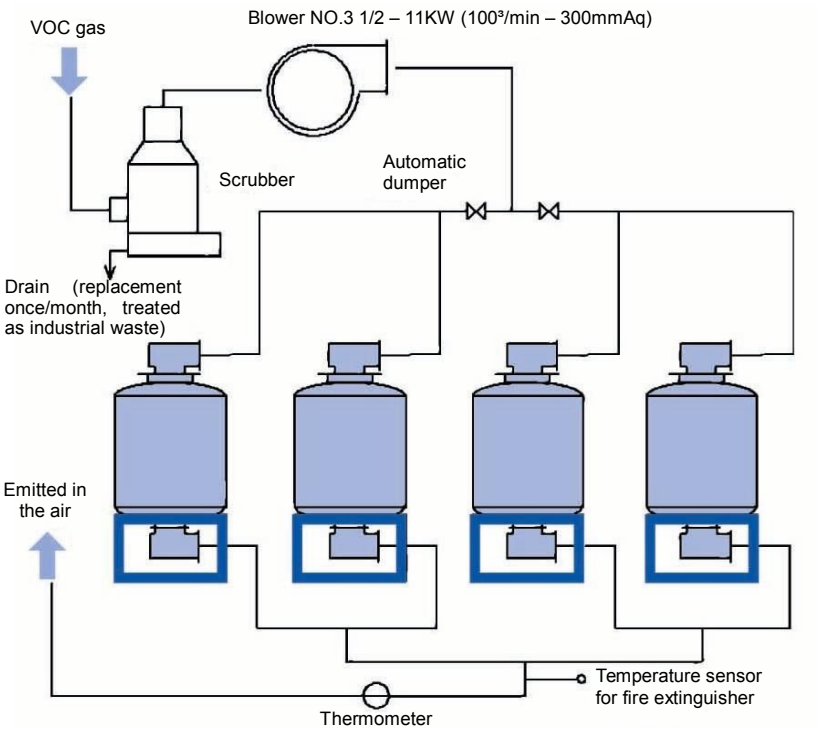
◎Comments◎

Among the retrieval equipment by activated carbon adsorption, fixed-bed activated carbon adsorption type retrieval equipment usually consists of 2 towers of activated carbon. The air containing VOC sucked in the sucking blower is adsorbed on the activated carbon in the process of going through the tower of activated carbon, to discharge clean air. Meanwhile heated steam is blown in from the bottom of another activated carbon tower, pushing out the VOC adsorbed on the activated carbon. Steam and VOC are liquefied through the condensing duct, and are retrieved by gravity separation in the water separator. Separated water goes through the discharged water treatment equipment and is discharged under the discharged water standard. Water in the activated carbon tower desorbed by steam is further removed by the heated airstream, improving and reviving the adsorption amount.
Also, there is the separation and transportation type (exchange type) activated carbon adsorption method where only an activated carbon adsorption tower is installed in the cleaning factory. The adsorption tower is exchanged when it is saturated, and transported to the desorption factory for reviving (desorption).

Example of retrieval equipment system by fixed-bed activated carbon adsorption



Actual case of retrieval/recycling equipment by separation and transportation type activated carbon adsorption

1	Industry type	Precision optical parts processing	
2	Items to be cleaned	Copy drums, etc.	
3	Amount of items to be cleaned	-	
4	Outline of emission facility	Emission facility	coating removal equipment
		Size	-
		Airstream amount of local emission	100m³/min
		Operating hours	24 hours/day, 20 days/month
5	VOC generating condition	Substance	methylene chloride (dichloromethane)
		Substance temperature	22°C
		Generating condition	continuous emission
6	Aim of measures	Reduction of concentration in the emitted air (responding amended air pollution control law, ISO 14001 and PRTR)	
7	Method of measures	Installation of retrieval/recycling equipment (separation and transportation type activated carbon adsorption)	
8	Emission control measures (flow)		
9	Effect	Reduction effect	**▲ 65%, ¥108 million/month cost cutting** (Solvent usage before the installation: 8t/month Solvent usage after the installation: 2.8t/month)
		Emission concentration before the installation	600ppm
		Emission concentration after the installation	30ppm

Airtight cleaning equipment

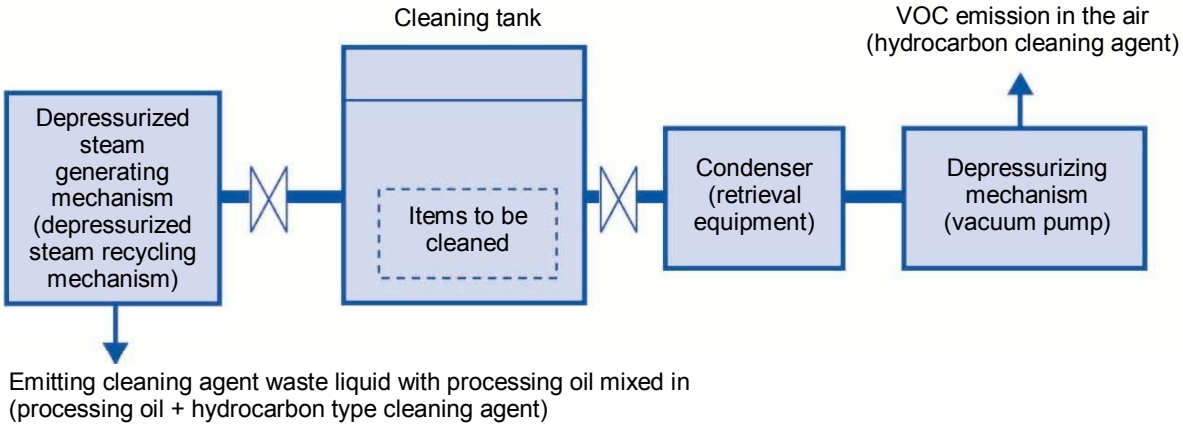
Depressurized steam cleaning system

◎Important point◎
In the depressurized steam cleaning system, all of the processes (washing – rinsing – drying) are conducted in an airtight container. Therefore solvent usage is reduced to 1/2 – 1/10. Most solvent consumption comes from waste liquid (hydrocarbon type cleaning agent, processing oil, etc.) emitted from the attached depressurized steam recycling equipment. Only a small amount of cleaning agent VOC emission comes from the vacuum pump.

VOC emission control effect	▲50 – 90% (depending on cleaning system)
Initial cost	from about ¥20 million (detail: exclusive cleaning equipment, depressurized steam recycling mechanism, vacuum drying equipment,
Running cost	several tens of thousand yen (detail: vacuum pump operation cost, etc.)

◎Comments◎
The depressurized steam cleaning system consists of a heating mechanism to heat cleaning agent, steam generating tank connected to the depressurizing mechanism via condenser (retrieval equipment) to enable continuous depressurization, and cleaning tank connected to depressurizing mechanism via condenser to enable continuous depressurization. Those are connected via a control valve.

Basic structure of depressurized steam cleaning system using hydrocarbon type cleaning agent



Depressurized steam cleaning system features:
1) Improved safety since work is done in an airtight container
2) Compared with the heated airstream drying method, cleaning agent emission in the air is 1/17 – 1/34, which reduces environmental burden. Compared with the heated airstream drying method, running cost is reduced, too.
3) Cleaning performance is stabilized since the depressurized steam recycling mechanism is attached as a standard.
4) Cleaning performance is improved since the attached ultrasonic mechanism enables cleaning by deaeration and ultrasonic wave.

Completely airtight cleaning equipment

◎Important point◎

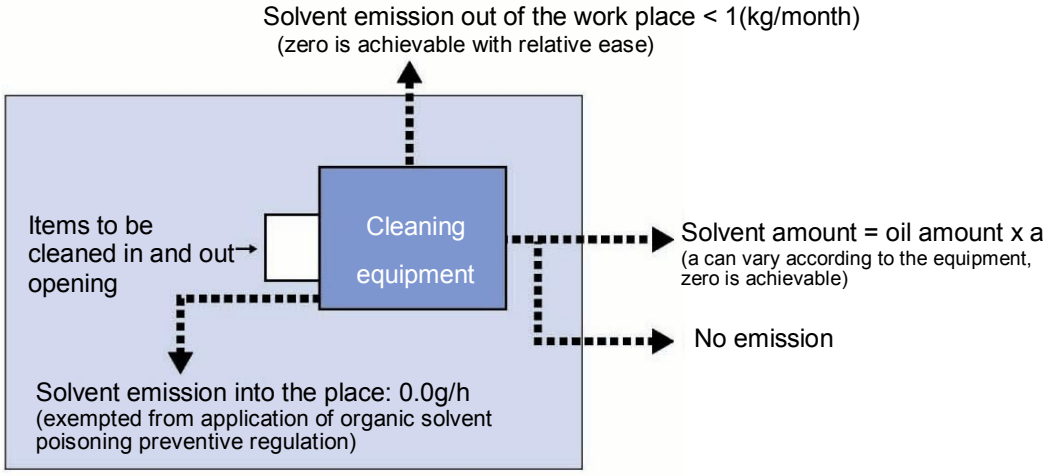
In completely airtight cleaning equipment, volatile solvent including hydrocarbon type cleaning agent can be used, involving airtight equipment and solvent recycling.
There is no water discharge, causing no environmental problem by discharged water and is exempted from legal regulation. Operation is in dry condition in the cleaning tank, which does not cause hydrolysis of cleaning agent, etc. Also a slight supply of nitrogen ensures maintenance of a nonflammable atmosphere. Therefore it can be used in temperatures above flash point.

VOC emission control effect	▲About 99% (cleaning agent emission is almost zero. Cleaning agent in the waste liquid only.)
Initial cost	¥6 million - ¥17 million (detail: when chloride type cleaning agent is used in vacuum style completely airtight single tank automated cleaning equipment)
Running cost	¥40,000 - ¥70,000 (detail: mainly electricity)

◎Comments◎

All the equipment is connected and sealed completely airtight via pipes to prevent the air from entering the cleaning equipment system or to prevent the cleaning agent vapor from emitting. A flexible gas holder is connected to respond to the change of gas amount in the equipment. The whole equipment is constantly kept at a minute positive pressure. There is no internal gas leak or ingress of air from outside.
Also it is devised not to let air come in or cleaning agent vapor go out of the system when items to be cleaned are put in and taken out. Air coming with the items being cleaned is expelled out of the system by the vacuum pump before the items are brought into the cleaning system. Also cleaning agent vapor is retrieved into the system by the vacuum pump before the items to be cleaned are taken out. When inflammable cleaning agent is used, space within the system where cleaning agent exists is replaced by nitrogen, maintaining oxygen concentration under the combustible point.

Concept of completely airtight cleaning equipment



* Cleaning tank capacity = 55 L (420 x 300 x 430mm)
* Tact time = 3 minutes
* Cleaning agent = methylene chloride

Reference

Air pollution

Emission standard (at outlet)
(Air Pollution Control Law)

Environmental Quality Standard Concerning Air Pollution (Basic Environment Law)

Applicable Volatile Organic Compounds (VOC)
- methylene chloride
- trichloroethylene
- tetrachloroethylene

Designated substance emitting facilities and designated substance control standard cleaning facilities (over 3m²is exposed to the air)
- trichloroethylene existing 500mg/m² new 300mg/²
- tetrachloroethylene existing 500mg/m² new 300mg/²

Labor Safety and Sanitation

Division of organic solvent
(Ordinance on Prevention of Organic Solvent Poisoning)

Controlled concentration
(in the work place)
(Labor Safety and Sanitation Law)
Work Environment Evaluation Standard (Controlled Concentration)
- methylene chloride 50ppm
- trichloroethylene 25ppm
- tetrachloroethylene 50ppm

Environmental risk measures for chemical substances

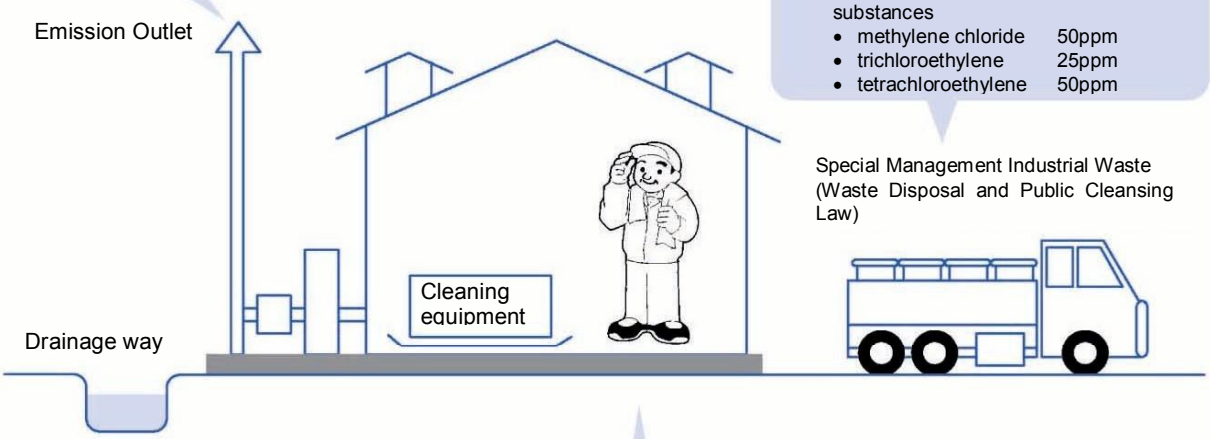
PRTR Law
Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof

Class 1 designated chemical substances
- methylene chloride
- trichloroethylene
- tetrachloroethylene

Industrial Waste

Special Management Industrial Waste
(Waste Disposal and Public Cleansing Law)

Class 1 designated chemical substances
- methylene chloride 50ppm
- trichloroethylene 25ppm
- tetrachloroethylene 50ppm



Underground water pollution

Underground permeation prohibiting
Effluent standard (acceptable limit)
Order of Measures concerning Underground Water Purification
(Water Pollution Control Law)

Environmental quality standard concerning Water Pollution
(Basic Environment Law)

Effluent standard (acceptable limit)
- methylene chloride no more than 0.2mg/l
- trichloroethylene no more than 0.3mg/l
- tetrachloroethylene no more than 0.1mg/l

Soil pollution

Order of Soil Pollution Removal Measures
(Soil Contamination Countermeasures Law)

Environmental quality standard concerning Soil Pollution
(Basic Environment Law)

Designated area
- methylene chloride no more than 0.02mg/1l tested liquid
- trichloroethylene no more than 0.03mg/1l tested liquid
- tetrachloroethylene no more than 0.01mg/1l tested liquid

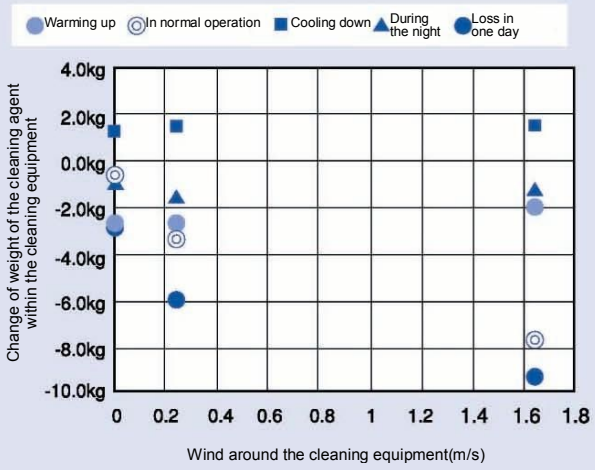
Key regulations applied on chloride solvents

Appendix:Actual quantitative measurement experiment raw data

Experiment on actual machine on airstream velocity around cleaning equipment

(Site photo)

Appearance of the cleaning equipment installation site including a window



(Experiment condition)

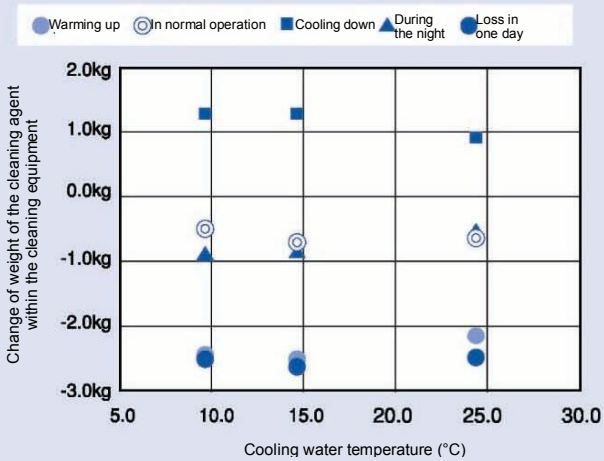
	Velocity around the cleaning equipment (m/s)	0	0.25	1.65
Change of total weight of liquid within the equipment	Warming up (kg)	-2.57	-2.69	-2.07
	In normal operation (kg)	-0.62	-3.337	-7.748
	Cooling down (kg)	1.27	1.46	1.63
	During the night (kg)	-0.773	-1.437	-1.093
	Loss in one day (kg)	-2.69	-6.00	-9.28

Mainly the loss during the normal operation is analyzed

Experiment on actual machine on proper cooling effect

(Site photo)

Appearance of chiller (cooling equipment)



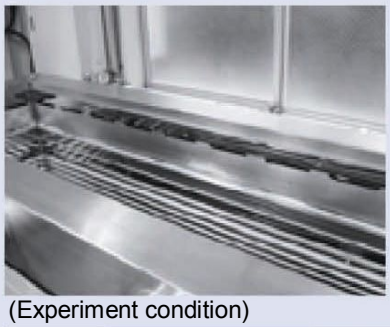
(Experiment condition)

	Cooling water temperature (°C)	24.4	14.6	9.7
Change of total weight of liquid within the equipment	Warming up (kg)	-2.17	-2.57	-2.49
	In normal operation (kg)	-0.68	-0.62	-0.45
	Cooling down (kg)	0.899	1.27	1.27
	During the night (kg)	-0.570	-0.773	-0.870
	Loss in one day (kg)	-2.52	-2.69	-2.54

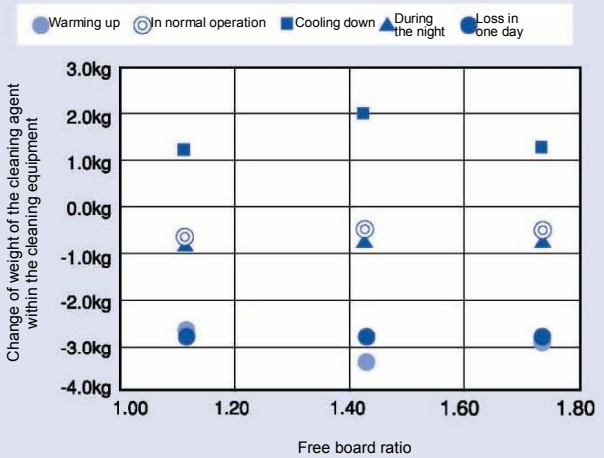
Mainly, the loss during normal operation is analyzed

Experiment on actual machine on securing free board ratio

(Site photo)



Increasing volume of cooling coil in order to raise free board ratio



(Experiment condition)

	Free board ratio	1.13	14.3	1.73
Change of total weight of liquid within the equipment	Warming up (kg)	-2.57	-3.42	-2.94
	In normal operation (kg)	-0.62	-0.475	-0.506
	Cooling down (kg)	1.27	1.89	1.34
	During the night (kg)	-0.773	-0.726	-0.710
	Loss in one day (kg)	-2.69	-2.73	-2.82

Mainly, the loss during the normal operation is analyzed

Appendix:Actual quantitative measurement experiment chart, committee members register

Quantitative measurement cleaning equipment for experiment on emission control effect

Liquid surface measurement part of vapor tank

Committee for Creating and Examining Voluntary Measures Manual at Industrial Cleaning for VOC Emission Control by Cutting Down Cost and Work Environment Improvement Activities
Members Register

	Name	Affiliation	Remarks
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WG Chairman	安藤　英一	SPC Electronics Corporation	Cleaning equipment manufacturer *
Committee member	小田　重男	Tokuyama Corporation	Cleaning agent manufacturer *
Committee member	北村　裕夫	Just Co., Ltd	Cleaning equipment peripheral equipment manufacturer
Committee member	高橋　幹晴	Taisei-Chemical Co., Ltd.	Cleaning agent manufacturer
Committee member	武田　光史	Federation of Electro Plating Industry Association	Cleaning user organization
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Committee member	土井　潤一	Daiwa Chemical Industries Co., Ltd.	Retrieval equipment manufacturer *
Committee member	長田　和己	Nissin Seiki Inc.	Cleaning equipment manufacturer *
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Committee member	渕野　哲郎	Tokyo Institute of Technology, Graduate School of Engineering, Department of Chemical Engineering	Associate Professor (academics) *
Committee member	的場　弘二	The Japan Electrical Manufacturers' Association	Cleaning user organization
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Committee member	山口　弘造	Japan Metal Heat Treatment Association	Cleaning agent user organization
Committee member	山本　保夫	Japan Association for Hygiene of Chlorinated Solvents	Cleaning agent user organization
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Observer	藤井　洋	Ministry of the Environment, Environmental Management Bureau, Air Environment Division, Chief	
Office	小田切　力	Japan Industrial Conference on Cleaning	Industrial Cleaning Business Organization
Office	内田　志郎	Japan Industrial Conference on Cleaning	Industrial Cleaning Business Organization
Office	山田　晃	Japan Industrial Conference on Cleaning	Industrial Cleaning Business Organization
Office	三木　真一郎	Asahi Research Center Co., Ltd.	Japan Industrial Conference on Cleaning Member
Office	新井　喜博	Asahi Research Center Co., Ltd.	Japan Industrial Conference on Cleaning Member

(No titles, members in alphabetical order, * also serves as WG (experiment on actual machine working group) committee member)

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