Viet Nam-Japan Environmental Week 2021
Information exchange seminar on development of standard for refrigerant management in Viet Nam

Fluorocarbon recovery technology for refrigeration / air conditioning maintenance service technicians

December 17, 2021

Table of contents

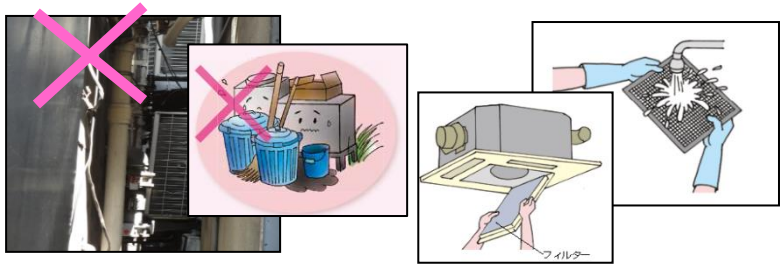
Table of contents

1. Criteria for user judgement

- **In order to prevent leakage of fluorocarbons, users must observe the following (1) to (4) when using refrigeration and air conditioning equipment.**

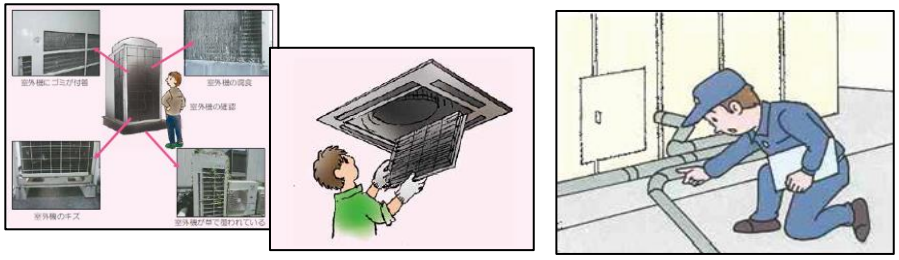
(1) Installation of equipment

- Maintain and secure proper installation and proper usage environment.



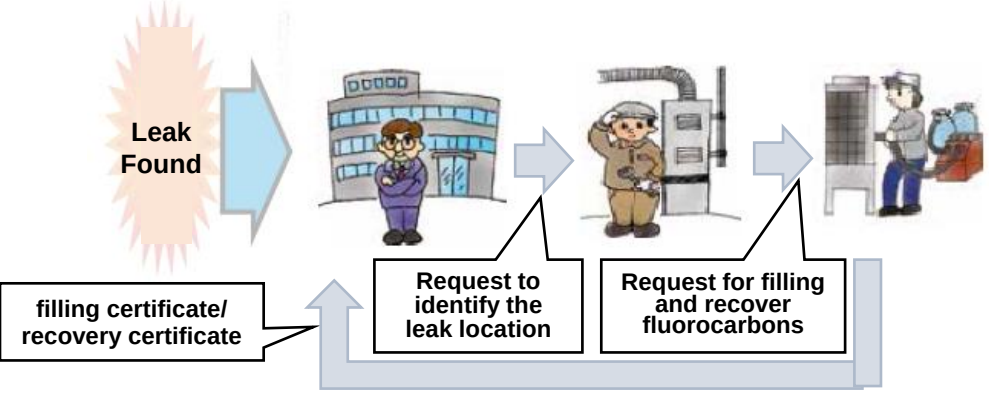
(2) Checkup of Use of Equipment

- Conduct **a simple (daily) inspection** of the equipment at least once every 3 months.
- Request a specialist to conduct **periodic leakage inspections** on a regular basis.



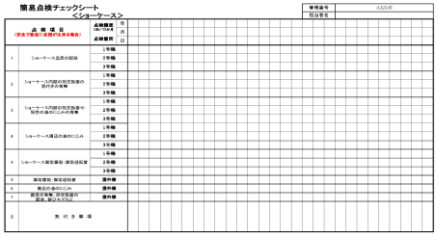
(3) Measures when a leak is found

- Request a specialist to quickly **identify and repair the leak.**
- Filling without repairing the equipment is prohibited.
- Obtain a filling certificate and a recovery certificate from approved business operator.

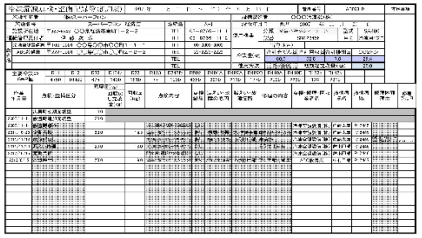


(4) Keeping Records

- **Record and save the history** of inspection, repair, filling, and collection. (3 years after disposing of equipment)
- Records must be disclosed. (Repair Business Operator, On-site Inspection, etc.)



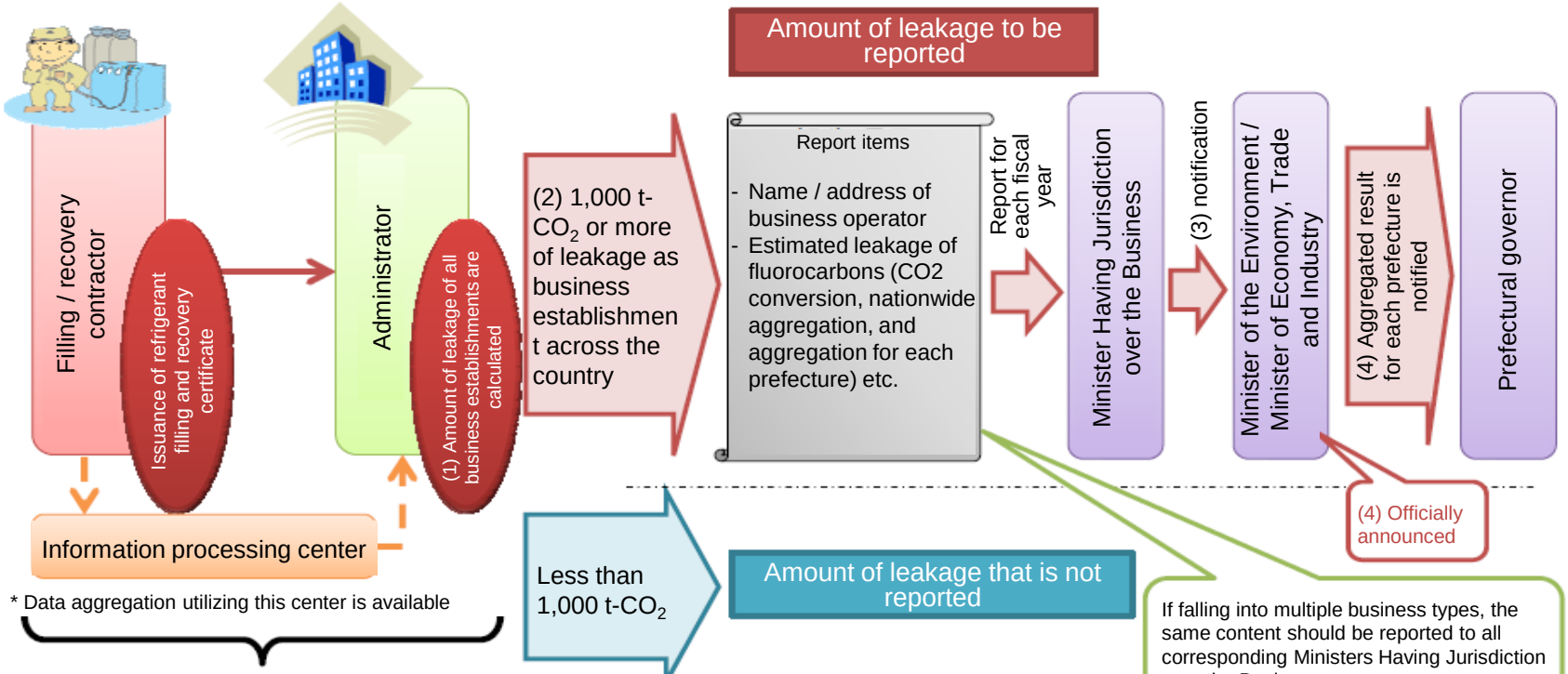
Simple Inspection Check Sheet



inspection record book

2. Report of estimated amount of leakage

- **To promote the proper voluntarily management through comprehension of amount of leakage of fluorocarbons by administrator, if 1,000t-CO2 or more of leakage is caused, it is necessary to report the amount of fluorocarbons leaked from managed equipment to the country.**
- **The information reported to the country will be officially announced after arrangement.**



All business operators need to comprehend the filler content (amount of leakage) and judge the necessity of report

3. Calculation method of estimated amount of leakage

- It is not possible to directly comprehend the amount of fluorocarbon leaked from equipment. The (estimated) amount of leakage is calculated from filling certificate and recovery certificate issued by filling / recovery contractor (excluding the amount that is filled at installation).

Estimated amount of leakage ($t\text{-}CO_2$) = (Σ((filler content (kg) - recovered amount at maintenance (kg)) × GWP for each refrigerant number category)/1000

Nationwide aggregation

Amount of leakage

[Report of calculated amount of leakage]

- Estimated amount of leakage ($t\text{-}CO_2$) etc.

= (Σ

[Filling certificate]

- Type of filled refrigerant (R404A etc.)
- Filler content at maintenance (kg) etc.

−

[Recovery certificate]

- Type of refrigerant that is recovered at maintenance (R404A etc.)
- Recovered amount at maintenance (kg) etc.

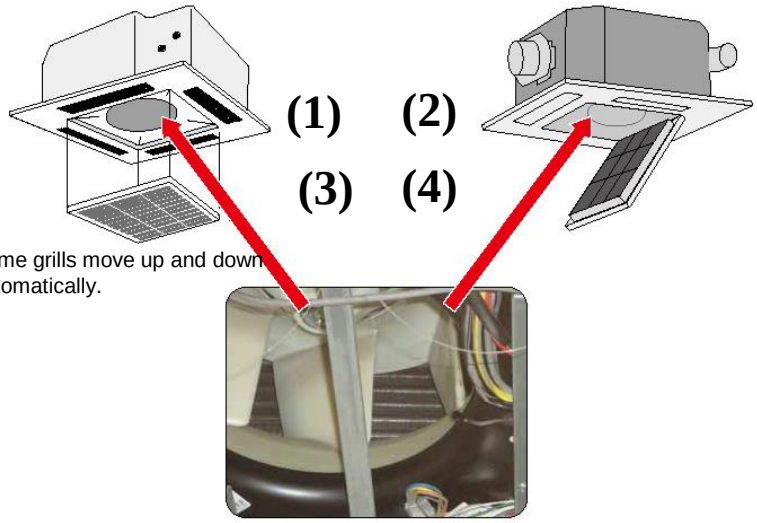
× GWP) /1000

The user here means a company that uses a lot of refrigeration and air conditioning equipment. It refers to grocery supermarkets, etc. that have more than 100 stores nationwide. These users are supermarkets and other establishments that have 100 stores nationwide in Japan.
If you leak about 500 kg of R410A in a year, it will correspond to 1,000 $t\text{-}CO_2$ emission.

4. Simple leak inspection (Example of Air Conditioners)

Inspection locations and Items (if safe and easy to check)

Locations	Inspection Items	
Indoor Unit	(1)	Presence or absence of frost on the heat exchanger
	(2)	Presence or absence of oil bleeding in heat exchangers and pipes
	(3)	Presence or absence of oil bleeding in the surrounding area
	(4)	Abnormal vibration / abnormal driving noise
Outdoor Unit	(5)	Abnormal vibration / abnormal driving noise
	(6)	Presence or absence of oil bleeding in the surrounding area
	(7)	Presence of scratches, corrosion, rust, etc. on the heat exchanger
	(8)	Presence of scratches, corrosion, rust, etc. on the refrigerant piping



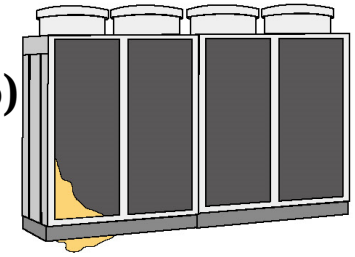
Some grills move up and down automatically.

(5)

The outdoor unit is vibrating abnormally.

There is an abnormal noise from the outdoor unit.

(6)



(7)

Corrosion at the bottom of the heat exchanger

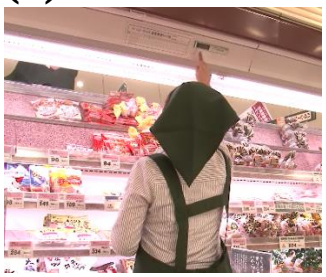
(8)

4. Simple leak inspection (Example of showcase)

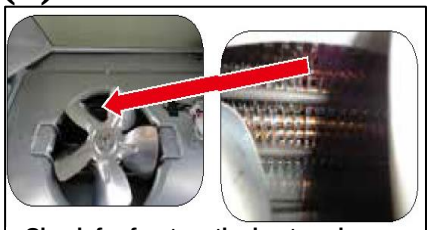
Inspection locations and Items (if safe and easy to check)

Locations	Inspection Items	
Indoor Unit	(1)	Internal temperature (confirm that it is within the set temperature range)
	(2)	Presence or absence of frost on the heat exchanger
	(3)	Presence or absence of oil bleeding in heat exchangers and pipes
	(4)	Presence or absence of oil bleeding in the surrounding area
	(5)	Abnormal vibration / abnormal driving noise
Outdoor Unit	(6)	Abnormal vibration / abnormal driving noise
	(7(	Presence or absence of oil bleeding in the surrounding area
	(8)	Presence of scratches, corrosion, rust, etc. on the heat exchanger
	(9)	Presence of scratches, corrosion, rust, etc. on the refrigerant piping

(1)

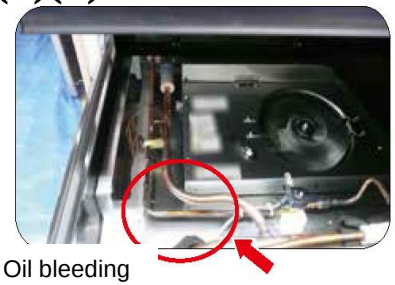


(2)



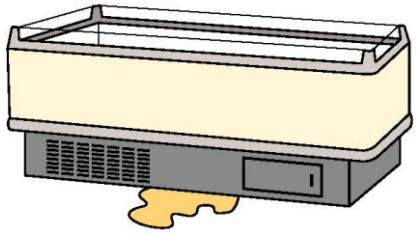
Check for frost on the heat exchanger through the gap in the fan.

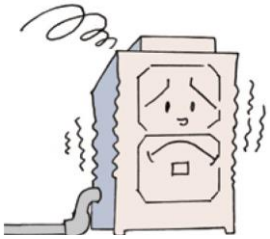
(3)(5)



Oil bleeding

(4)(5)



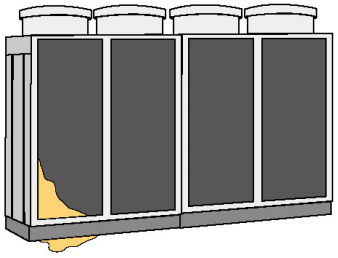


The outdoor unit is vibrating abnormally.

(6)

There is an abnormal noise from the outdoor unit.

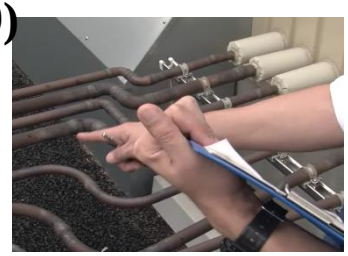
(7)



(8)

Corrosion

(9)



II. Periodic leak inspection

1. Visual inspection, indirect / direct method
2. Flow of periodic inspection
3. Visual leak inspection
4. Indirect leak inspection
5. Direct leak inspection
6. Pressurized leak inspection
7. Judgment of leakage

1. Visual inspection, indirect /direct method

Visual inspection

System leakage inspection is a visual and auditory inspection of the entire refrigerant system prior to direct or indirect inspection.

Direct method

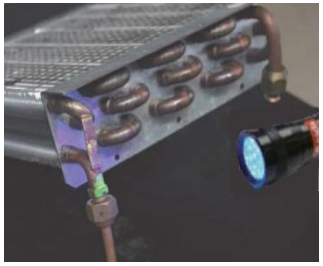
Leakage detector method

A method of detecting fluorocarbons leaking from pipes, etc. using an electronic detector. Depending on the accuracy of the detector, it is possible to detect even a small amount of leakage compared to the other two methods.

Foam method

Suitable for pinpoint leak detection. A foam solution is applied to the place where there is a possibility of leakage, and the blown fluorocarbons are detected.

Fluorimetrical method



A fluorescent agent is injected into the piping, and the leakage point of the fluorescent agent leaked from the leakage point is identified using a lamp such as ultraviolet light.
※Since there is a risk of causing defects in the equipment depending on the components of the fluorescent agent, it is necessary to carry out this with the approval of the equipment manufacturer.

Indirect method

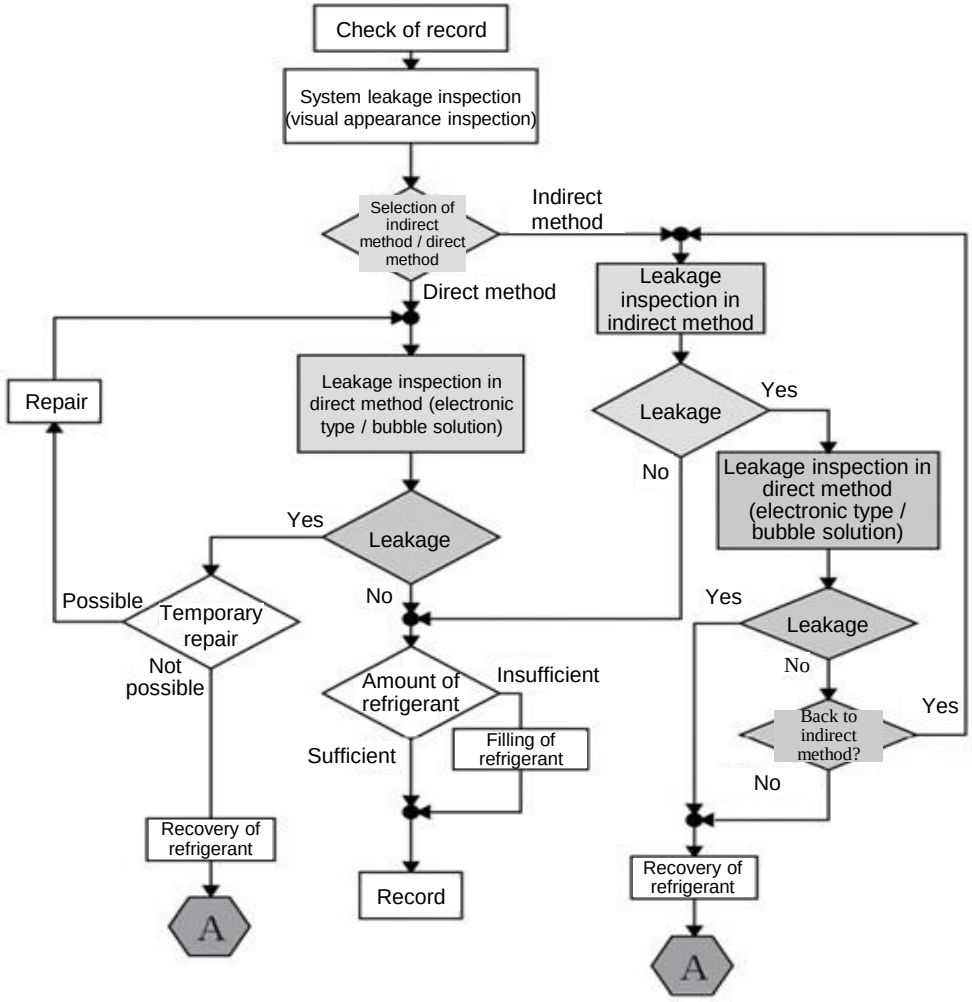
Check the operation value of currently operated equipment is not different from the daily value using the check sheet shown below etc. to diagnose whether there is leakage.

	Status value (cycle parameter)		Symbol (Note 1)	Unit	Normally estimated value (Note 2)	Measurement value	Focus point	Not one of the following phenomenon (Note 3)	Judgment
a	Low pressure (evaporating pressure)		Pe	(MPa) (gauge pressure)			It should not be too low	Change by control	
	High pressure (condensation pressure)		Pc	(MPa) (gauge pressure)			It should not be too low	Change by control	
b	Discharge gas temperature			(℃)			It should not be too high	Clogging of refrigerant system, failure of expansion valve	
c	Motor of compressor	Rotational frequency		(Hz)			Whether the operation status is stable in case of inverter equipment	Change by control	
		Voltage		(V)			It should not be too low	Change by control	
		Current		(A)			It should not be too low	Change by control	
	Supercooled liquid temperature		Td	(℃)					
	Intake gas temperature		Ts	(℃)					
	Evaporation saturation temperature		Te	(℃)					
	Condensation saturation temperature		Tc	(℃)					
d	Degree of superheat		Ts-Te	(K)			It should not be too large	Clogging of refrigerant system, failure of expansion valve	
e	Degree of supercooling		Tc-Td	(K)			It should not be too small		
f	Overheating of compressor			(℃)			It should not be too high	Clogging of refrigerant system, failure of expansion valve	
	Intake air temperature			(℃)					
	Discharge air temperature			(℃)					
	Cooling water inlet temperature			(℃)					
	Cooling water outlet temperature			(℃)					
g	Temperature differential between intake and discharge air			(K)			It should not be too small	The thermal load is extremely small	
	Temperature differential between inlet and outlet cooling water			(K)			It should not be too small	The thermal load is extremely small / flow rate is extremely large	
h	Vibration of piping in equipment						It should not vibrate abnormally	Change by control	
i	Flowing status of refrigerant liquid (sight glass)						Air bubbles should not be generated	The thermal load is extremely large	
j	Number of air steam extractions (low-pressure refrigerant turbo freezing machine)						Number of times should not be large		
	Fluid level of refrigerant (low-pressure refrigerant turbo freezing machine)						The liquid level should not be extremely low		

As for the inspection method, it is important to carry out the inspection by an appropriate method in accordance with the refrigerant leak inspection guidelines established by JARAC.
http://www.jarac.or.jp/business/cfc_leak/dl/JRC_GL-01-20170731.pdf

2. Flow of periodic inspection

The person in charge of periodical inspection should check the leakage inspection record book, and then carry out the system leakage inspection (visual appearance inspection) and select indirect method or direct method and carry out the inspection referencing the flow shown below. If the result is A, it is evaluated as leakage and the person in charge starts the repair work.



3. Visual leak inspection

Visual inspection is an external inspection of the entire refrigerant system by visual inspection, auditory sensation, etc., prior to leakage inspection by indirect method or direct method. The inspection points and judgment criteria are shown.

Oil leakage and stain

Inspection to determine if oil leaks or traces of oil leaks locally to the brazing parts, flare joints, condensers, drain pans, and heat insulation covers of piping where liquid refrigerant flows.

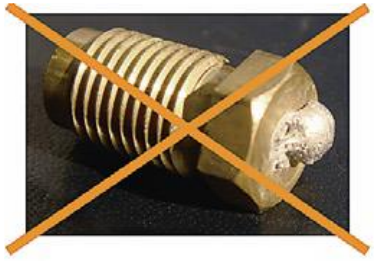
Partially frozen, frosted, condensed

Piping, etc., where liquid refrigerant flows around capillary tubes and is inspected for freezing, dew condensation, etc., in places that are not normally cooled

Equipment damage

Inspecting damage to entire equipment, especially pipes, heat insulation, cracks, dents, etc.

Deformation of a fusible plug



Check for deformation of molten metal in the fusible plug

Decrease in refrigerant level

Check if the refrigerant level during operation and shutdown is lower than the specified line

4. Indirect leak inspection

The leakage at the inspection point that cannot visually checked cannot be found only in the direct method. Select the indirect method (however, only when there is sufficient load).

Status value		Symbol	Unit	Normally estimated value (Note 2)	Measurement value	Focus point	Not one of the following phenomenon	Judgment
Low pressure (evaporating pressure)		Pe	[MPa]			It should not be too low	Change by control	
High pressure (condensation pressure)		Pc	[MPa]			It should not be too low	Change by control	
Discharge gas temperature			[°C]			It should not be too high	Clogging of refrigerant system, failure of expansion valve	
Motor of compressor	Rotational frequency		[Hz]			Whether the operation status is stable in case of inverter equipment	Change by control	
	Voltage		[V]			It should not be too low		
	Current		[A]			It should not be too low	Change by control	
Supercooled liquid temperature		Td	[°C]					
Intake gas temperature		Ts	[°C]					
Evaporation saturation temperature		Te	[°C]					
Condensation saturation temperature		Tc	[°C]					
Degree of superheat SH		Ts-Te	[K]			It should not be too large	Clogging of refrigerant system, failure of expansion valve	
Degree of supercooling SC		Tc-Td	[K]			It should not be too small		
Overheating of compressor			[°C]			It should not be too high	Clogging of refrigerant system, failure of expansion valve	

4. Indirect leak inspection

Status value	Symbol	Unit	Normally estimated value (Note 2)	Measurement value	Focus point	Not one of the following phenomenon	Judgment
Intake air temperature		[°C]					
Discharge air temperature		[°C]					
Cooling water inlet temperature		[°C]					
Cooling water outlet temperature		[°C]					
Temperature differential between intake and discharge air		[K]			It should not be too small	The thermal load is extremely large	
Temperature differential between inlet and outlet cooling water		[K]			It should not be too small	The thermal load is extremely large / flow rate is extremely large	
Vibration of piping in equipment					It should not vibrate abnormally	Change by control	
Flowing status of refrigerant liquid (sight glass)					Air bubbles should not be generated	The thermal load is extremely large	
Fluid level of refrigerant (when there is a receiver tank)					The liquid level should not be low		

Note 2: For the normally estimated value, use the value in stable operation status.
Note 3: If "**Not one of the** following phenomenon" can be demonstrated, the status is judged as leakage.
Note 4: The pressure should be described as gauge pressure.

5. Direct leak inspection (Electronic Leakage Detector)

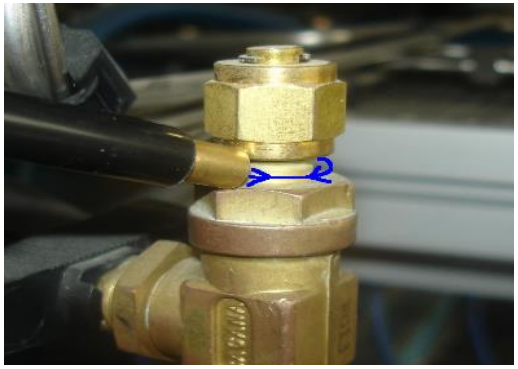
High-performance sensors such as semiconductor sensors, heated semiconductor sensors, and infrared sensors are used to identify the presence or absence of leaks and the location of leaks in refrigeration and air conditioning equipment. It has excellent detection sensitivity. Precautions are shown below.

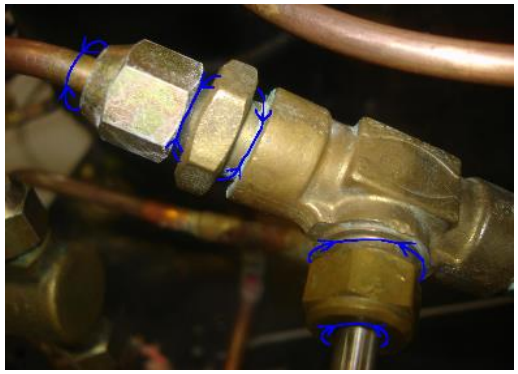
- **Under high humidity and dust, the sensor and suction pump may be damaged by sucking moisture.**
- **Depending on the type of detector, there are advantages and disadvantages.**
- **When a large amount of refrigerant leakage is considered, a foaming liquid method or the like is desirable.**
- **To periodically perform sensitivity check in a reference leak.**
- **Leak detector sensitivity of 5g/year or more is recommended.**
- **Ensure that the equipment contains sufficient refrigerant.**
- **The low-pressure side during operation may not be detectable.**

5. Direct leak inspection (Electronic Leakage Detector)

High-performance sensors such as semiconductor sensors, heated semiconductor sensors, and infrared sensors are used to identify the presence or absence of leaks and the location of leaks in refrigeration and air conditioning equipment. It has excellent detection sensitivity. Precautions are shown below.

- **Move the sensor at a speed of 2.5mm-5 mm/sec without separating 5 mm or more from the detection point.**
- **Blow air on the suspected leak to blow off the surrounding gas.**
- **In the case of a large equipment, the bottom of the equipment is inspected first.**
- **Minimize air flow to increase detection sensitivity.**
- **When inspecting the evaporator, it is preferable to inspect the gas in the condensed drain pipe.**





5. Direct leak inspection (Foaming Solution)

- **Pinpoint leaks can be detected regardless of the type of refrigerant. Detection is possible with nitrogen gas, etc. without using a refrigerant.**
- **Since it is an observation with the naked eye, the concealed part cannot be examined.**
- **The detection sensitivity depends on the skill of the inspector and the selection of the foaming solution.**
- **The detection sensitivity is about 120g/year (reference value).**

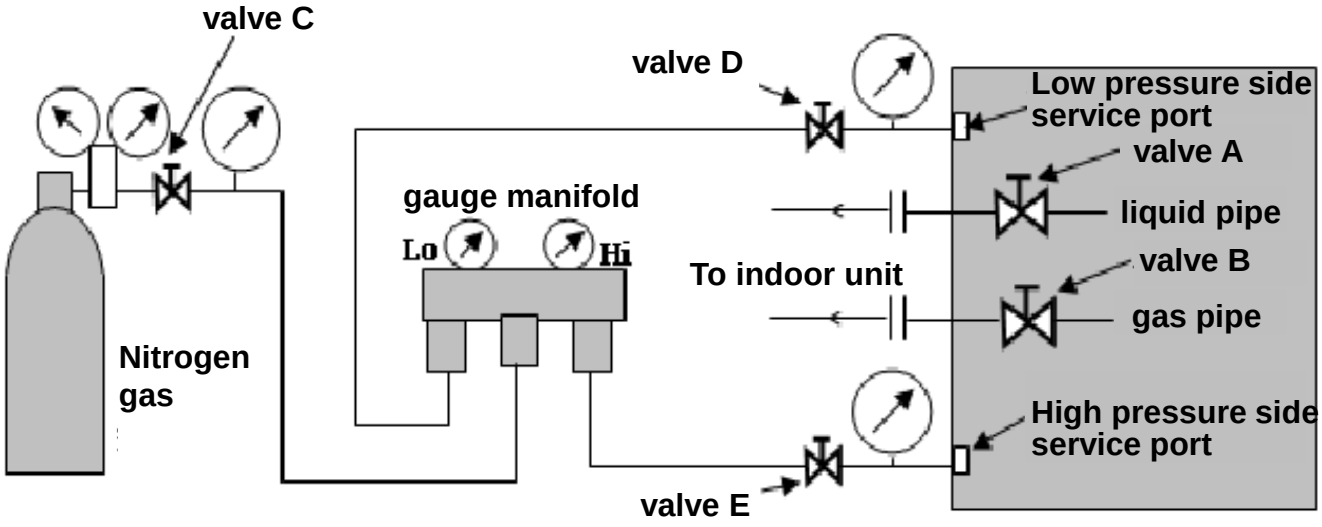
- **The foam leakage test method (JIS Z 2329) is recommended. Do not use household detergent.**
- **When the amount of leakage is very small, it does not foam if it is sprayed too much.**
- **Since it is water-soluble, it is not applied to the electrical part.**
- **Since the foaming force becomes weak at low temperatures, the foaming liquid for low temperatures is used.**
- **After inspection, cleaning is performed. If possible, perform water washing.**

6. Pressurized leak inspection and Vacuum Inspection

- Pressurize with nitrogen gas and inspect for leaks by movement of the needle of the pressure gauge.
- Pressurize slowly up to the test pressure in two steps and check for leaks.
- After the third pressurization, close valves D and E, remove the gauge manifold, leave it for the specified time, and observe the pressure change.
- Pressure correction is performed by the following formula.

$$\text{Absolute pressure during measurement} = \frac{(\text{absolute pressure during pressurization}) \times (\text{Temperature during measurement} + 273)}{(\text{Temperature during pressurization} + 273)}$$

- Exhaust the pressurized nitrogen with a vacuum pump.
- Since even a minute leakage can be detected in the vacuum state, final confirmation of the leakage is performed.



7. Judgment of leakage

- "No leakage" should be judged not only by system leakage inspection, but by indirect method or direct method. With the visual inspection, you may passing it over due to hidden part or overlooking etc.
- Select the indirect method wherever possible. In the following cases, carry out the direct method and exercise judgment.
  - When the point of leakage can be identified in some degree based on system leakage inspection and history data etc.
  - When the actual machine cannot be operated
  - When there is no sufficient operation history data and the judgment in indirect method cannot be exercised
  - When the leakage is found in indirect method
- Judgment of leakage
  a) If all judgment results of indirect method, pressurized leak test, and direct method are "No leakage", the judgment result should be "No leakage".
  b) If the judgment results of indirect method and pressurized leak test are "There is leakage", continue the inspection until the point of leakage is found.

	Indirect method or pressurized leak test	Direct method	Only direct method	Judgment	Description
a	No leakage	No leakage		No	Follow a)
b	There is leakage	Identify the point		Yes	Check it again after repair work
c	No leakage	Identify the point		Yes	Indirection method is not appropriate
d	There is leakage	No leakage		Not available	Refer to the note
e			No leakage	No	Check it in indirect method again when the operation is available
f			Identify the point	Yes	

Note: Check it again. If the judgment result is a, b, or c after the recheck, follow the judgment. In case of d, follow b).

III. Examples of Fluorocarbons Leakage (1) - (12)

III. Examples of Fluorocarbons Leakage (1), (2)

(1) Closing valve and ball valve

cause of leakage	countermeasures
✧ Seal between valve and spindle shaft shrink and wear due to aging and use	✧ Make sure the sheet surface is smooth
✧ Overheating during installation	✧ When the valve is made of brass, cool it with a wet rag, etc.
✧ Aging of internal seals	✧ Cover the valve with a cap

(2) Valve with Bulge

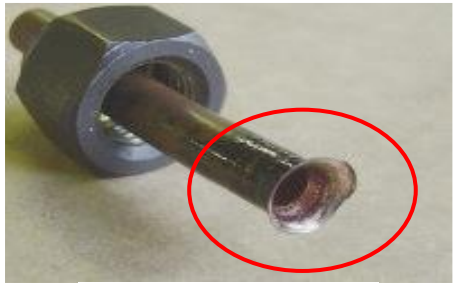
cause of leakage	countermeasures
✧ Damaged valve core during brazing	✧ Remove the valve core when brazing the fitting
✧ Core is not properly tightened during replacement	✧ Make sure the valve body is cold when replacing the core
✧ Not covered with a cap	✧ Replace regularly

III. Examples of Fluorocarbons Leakage (3)

(3) Flare Joint

cause of leakage	countermeasures
✧ Loosening of flared nut due to thermal expansion /shrinkage due to wide temperature changes, especially at the outlet of the expansion valve	✧ When using flares, use flare adapters (factory-processed flares) as much as possible.
✧ Improper fitting ✧ Due to a leakage from the initial construction	✧ Make sure the valve body is cold when replacing the core. ✧ If flares need to be machined, cut the pipe with a pipe cutter and expand the pipe using the correct tool. ✧ Use a flare tool and make sure the proper pipe length comes out of the flare block .
✧ Overtightening, undertightening	✧ Use a torque wrench to tighten the flare nut to the specified torque so that it is not overtightened or undertightened.
✧ About oil application	✧ If the manufacturer specifies oil application, follow the instructions. ✧ When coating for improving sealing performance, apply lightly only inside the flare

clean flare without scratches



deformed flare

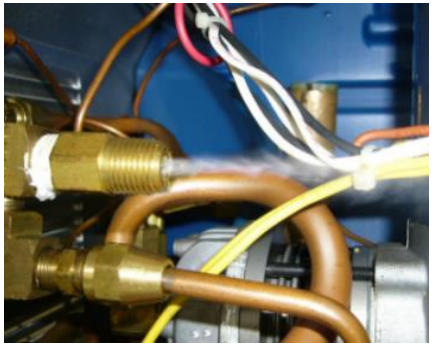
III. Examples of Fluorocarbons Leakage (4), (5)

(4) Mechanical joints and flanges

cause of leakage	countermeasures
✧ Poor fitting repair ✧ Did not replace the gasket	✧ Replace the flange gasket. Remove all old gaskets and make sure they are not scratched before inserting new ones.
✧ One-sided bolt tightening	✧ Tighten the bolts evenly so that the diagonal positions are alternately tightened until the flanges are properly connected.
✧ Use improper gasket	✧ For HFC refrigerant, use a special gasket for the material. ✧ use a proper sealant
✧ Insufficient tightening torque for bolts	✧ Check the final tightening force of the flange bolts using a torque wrench.

(5) Fusible plug and Safety Valves (High Pressure Protection)

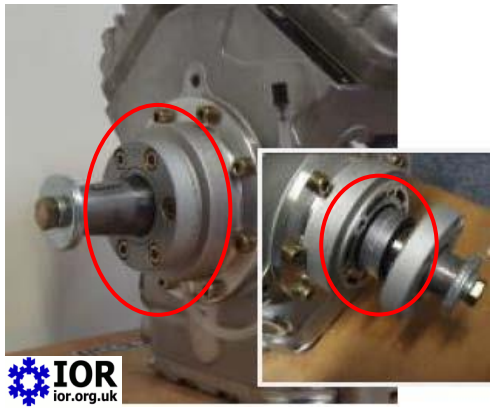
cause of leakage	countermeasures
✧ Wide temperature and pressure fluctuations weaken the adhesion between the molten metal and the body	✧ Avoid using fusible plugs in hot areas as much as possible ✧ Fusible plugs should be inspected for leaks as appropriate.
✧ Release the pressure and set the valve seat when the pressure is low. ✧ Leakage through the valve seat of the safety valve	✧ Leakage inspection at the safety valve outlet as appropriate. ✧ If it leaks from the safety valve, repair or replace. ✧ Do not cap the safety valve.



III. Examples of Fluorocarbons Leakage (6), (7)

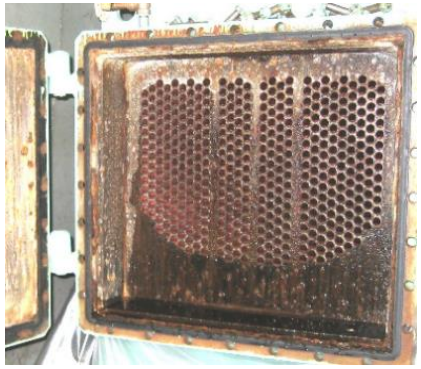
(6) Shaft seal (open compressor)

cause of leakage	countermeasures
✧ General aging wear	✧ Regularly observe oil leaks on the shaft seals to check for wear on the shaft seals.
✧ Oil leak from a shaft seal ✧ Poor lubrication ✧ Fluorocarbons dissolved in oil leaks	✧Stop the compressor and check for leaks from the shaft seal.
✧ Improper incorporation of new shaft seals ✧ Poor shaft centering	✧ When replacing the shaft seal, use a proper shaft seal and follow the procedure.
✧ Bearing damage	✧ Bearing replacement



(7) Shell and Tube (Condenser)

cause of leakage	countermeasures
✧ Corrosion occurs if the water circulating in the pipe is not properly treated.	✧ Make sure that proper corrosion prevention equipment such as a chemical injection device is equipped.
✧ Corrosion of tube plate	✧ Regularly open and inspect the water chamber.
✧ Corrosion in the pipe is invisible and it is difficult to identify the location of the leak.	✧ Regularly open and inspect the water chamber. ✧ Periodic inspection of corrosion condition - Overflow flaw detection inspection - Endoscopy ✧ Regular maintenance and monitoring ✧ If a leak occurs in a bundle of pipes, not only replace the leaked pipe, but it is highly possible that other pipes are in the same state.



III. Examples of Fluorocarbons Leakage (8), (9)

(8) Air-cooled condensers

cause of leakage	countermeasures
✧ Occurrence of corrosion	✧ Repair or replace unbalanced fans ✧ Check the fin rows for signs of oil seeping
✧ Impact damage due to foreign matter in the air flow	✧ When replacing the condenser, pay attention to the usage environment such as salt-damaged environment or near the coast, and select appropriate condenser considering the environment.
✧ Damage to the tube bundle fixing part due to vibration	✧ Always install the condenser horizontally.

(9) Pressure Switches

cause of leakage	countermeasures
✧ Vibration causes the joint of the pressure switch to come off or damage the pressure switch	✧ Make sure that the pressure switch joint does not rub against other parts or other vibrating surfaces. ✧ Make sure the pressure switch is properly supported or secured.
✧ The pressure detector tube of the pressure switch is rubbing	✧ A flare adapter is used for a pressure switch where a copper pipe is used.
✧ Damage to the switch bellows due to vibration or fluid pulsation	✧ Use a double bellows switch if possible.
✧ Poor flare connection of pressure switch	✧ Install the pressure switch to minimize vibration propagation to the pressure switch.
✧ Poor support or fixing of pressure switch body	✧ Always check the inside of the pressure switch for leaks (be careful of electric shock during operation)

III. Examples of Fluorocarbons Leakage (10), (11)

(10) O-ring, gasket

cause of leakage	countermeasures
✧ Abrasion, swelling, hardening and flattening when exposed to high or low temperatures.	✧ Check for changes in shape and flexibility ✧ Do not reuse the existing O-Ring ✧ Apply refrigerator machine oil to the seal surface prior to mounting (according to manufacturer standards) ✧ Apply sealant as needed before mounting according to manufacturer standards
✧ When the refrigerant is converted (retrofitted), leakage occurs due to not fitting to the new oil.	✧ Make sure the replaced gasket replaced is compatible with the system oil and refrigerant.

(11) Capillary tube

cause of leakage	countermeasures
✧ Due to uncertain fixing, the capillary tube is damaged by rubbing etc. ✧ Excessive stress or poor brazing due to vibration of capillary tube connection	✧ Secure with a protective spiral tube or binding band, etc. ✧ Take measures against vibration. ✧ Replacing the capillary tube.

III. Examples of Fluorocarbons Leakage (12)

(12) U-bend part of evaporator and condenser

cause of leakage	countermeasures
✧ Corrosion due to chemical action in the U-bend (curved tube) of the evaporator or air-cooled condenser ✧ Since the U-bend part of the heat exchanger is thin, corrosion leads to leakage in a relatively short period of time.	✧ Sufficient U-bend leak inspection ✧ If leaks are likely to occur from the U-bend of the evaporator or condenser, replace with a material which is hardly damaged such as a coated or electroplated heat exchanger.
✧ Damage is accelerated in severe environments (salt damage or acidic atmosphere) leading to leakage.	✧ When the atmosphere is severe (for example, salads are washed with chlorine water in food factories, vinegar is produced, or the installation location is close to the coast) ✧ When chemical cleaning is performed, be sure to neutralize it and then treat it appropriately in accordance with local regulations.

IV. Recovery of Fluorocarbons

1. Criteria for recovery
2. Recovery device
3. Recovery procedure
4. Efficient recovery
5. Safe recovery
6. Important points regarding the regeneration of recovered fluorocarbons

1. Criteria for recovery

- Depending on the pressure and filling amount of fluorocarbons filled in the commercial refrigeration and air conditioning, suck the fluorocarbons so that the pressure at the refrigerant recovery port shall be below the specified pressure. In addition, after a certain period of time has passed, suction should be performed so that the pressure is below the pressure listed in the table below.
- A person who has sufficient knowledge about the properties of fluorocarbons and the method of recovering fluorocarbons (engineer handling refrigerant fluorocarbons, etc.) shall perform or witness by themselves.

Reference pressure for recovery

Pressure classification of fluorocarbons	Pressure (Absolute Pressure)		Pressure (Ref.) (Gauge Pressure)
Low Pressure Gas (Pressure at a normal temperature is less than 0.3MPa)	0.03MPa		-0.07MPa
High Pressure Gas (Pressure at a normal temperature is 0.3MPa or more and less than 2MPa, and the filling amount of fluorocarbons is less than 2kg)	0.1MPa		0 MPa
High Pressure Gas (Pressure at a normal temperature is 0.3MPa or more and less than 2MPa, and the filling amount of fluorocarbons is 2kg or more)	0.09MPa		-0.01MPa
High Pressure Gas (Pressure at a normal temperature is 2MPa or more)	0.1MPa		0 MPa

2. Recovery device

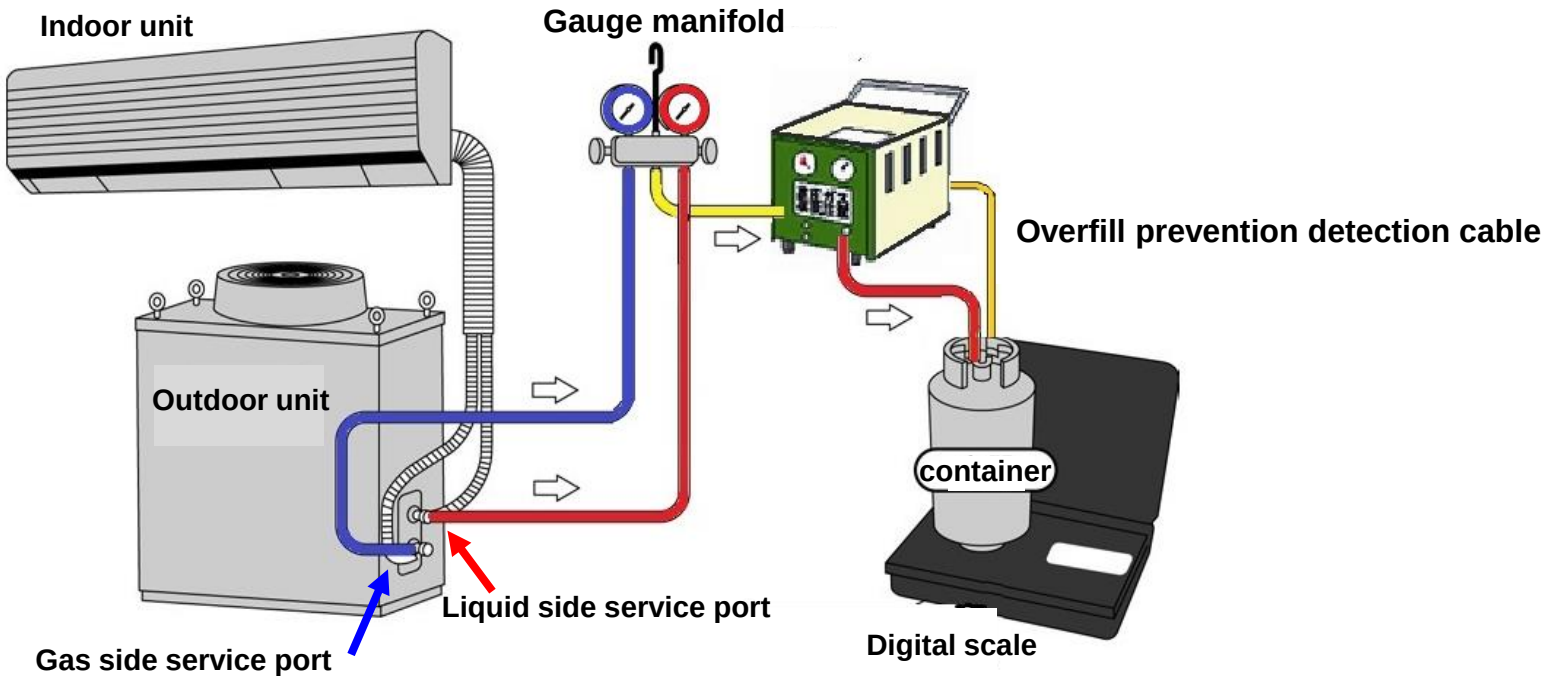
① The recovery device shall be a recovery device that corresponds to the type of recovery fluorocarbons. Also, check whether the recovery capacity (g/min) is suitable for the equipment to be recovered.

② Avoid using a combination of a large recovery device and a small cooling equipment (small ice maker, etc.) because the recovery efficiency will be significantly reduced due to piping resistance.

③ The recovery device determines the type of refrigerant that can be recovered. Use the one self-certified by the recovery device manufacturer.

3. Recovery Procedure (Example of Recovery Device Connection)

(1) Connect the red hose to the liquid side service port and the blue hose to the gas side service port.
(2) The yellow hose at the central port connects to the suction port on the recovery device.
(3) Connect the red hose to the discharge port of the recovery device and the recovery container.
(4) Connect the recovery device and the recovery container with the overfill prevention detection cable.



Connection example when recovering packaged air conditioners for buildings

3. Recovery Procedure
(Evacuation of recovery container and empty containers)

Recovery container

(1) Determine the type and number of recovery containers, taking into consideration the type and total amount of fluorocarbons to be recovered, the transportation method, and the space of the installation location.

(2) The amount of refrigerant (kg) that can be recovered per container varies depending on the type of refrigerant and the recovery temperature in order to avoid overfilling. JARAC shows the following estimated values in the **"Guideline for preventing overfilling of fluorocarbons".**

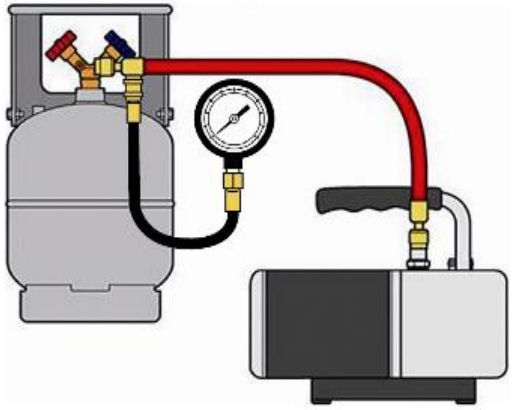
(estimated value; kg)

Recovery Container Cylinder	10ℓ	12ℓ	21ℓ	24ℓ	40ℓ	107ℓ	117ℓ
R12	9	-	20	22	38	100	-
R22, R134a, R502	9	-	19	21	36	97	-
R407C, R410A R404A, R507A	-	9	16	19	-	-	92

Evacuate empty container

(1) Attach a compound gauge (or vacuum gauge) to the gas side valve (blue) of the empty container and check the degree of vacuum.

(2) If the degree of vacuum is less than -0.1MPa, connect a vacuum pump and completely exhaust the non-condensable gas such as nitrogen and air remaining in the container to **-0.1MPa**.



3. Recovery Procedure (Recovery Operation)

(1) After connecting to the equipment to be recovered, select the following (a), (b), and (c) to operate the recovery device.

(1) Liquid recovery

Set the recovery device to liquid recovery or push-pull, and recover the liquid from the high-pressure side of the refrigeration and air conditioning equipment. At this time, pay attention to the liquid compression in the compressor of the recovery device.

(2) Gas recovery

Set the recovery device to gas recovery, and recover gaseous fluorocarbons from the low pressure side of the refrigeration and air conditioning equipment. Be careful of low temperature condensation on the equipment side due to sudden decompression.

(3) Liquid/Gas recovery

The most common method for recovering from small and medium-sized equipment is to set the recovery device to liquid recovery and simultaneously recover liquid/gaseous from the high-pressure side and low-pressure side of the equipment.

(2) For large equipment, chillers, and turbo chillers, recover them according to the instructions given by the equipment manufacturer's manual.

3. Recovery Procedure (Estimated end of recovery)

Recovery of high-pressure gas

(1) Check the lamp or pressure gauge display to confirm that the recovery device has automatically stopped due to the low pressure cut of the recovery device.
(2) Restart after about 5 to 15 minutes in the stopped state.
(3) After the recovery device has automatically stopped again, stop the recovery Close the valve on the recovery device side, and monitor the change in the pressure (suction pressure) of the refrigerant recovery port for a certain period of time.
(4) If the filling amount is less than 2 kg, hold it for about 10 minutes.
(5) If the filling amount is 2 kg or more, the remaining refrigerating machine oil is large and the temperature is low, or the outside air temperature is low, the holding time is further extended.
(6) If the recovery device capacity is excessive compared to the capacity of the recovery equipment, the reference pressure will be reached quickly, but the pressure rise during the holding time also will be large.

Recovery of low-pressure gas

(1) After the gas recovery to about 0.02 MPa (-0.08MPaG) for a reference pressure (suction pressure) of 0.03 MPa (-0.07MPa) in the service port, the valve on the recovery device side is closed, and monitor the pressure.
(2) If the suction pressure exceeds the reference pressure, repeat the recovery operation. If it is confirmed that the pressure is kept below the reference pressure, the recovery is completed.

4. Efficient recovery
(Refrigerant stagnation due to low temperature condensation)

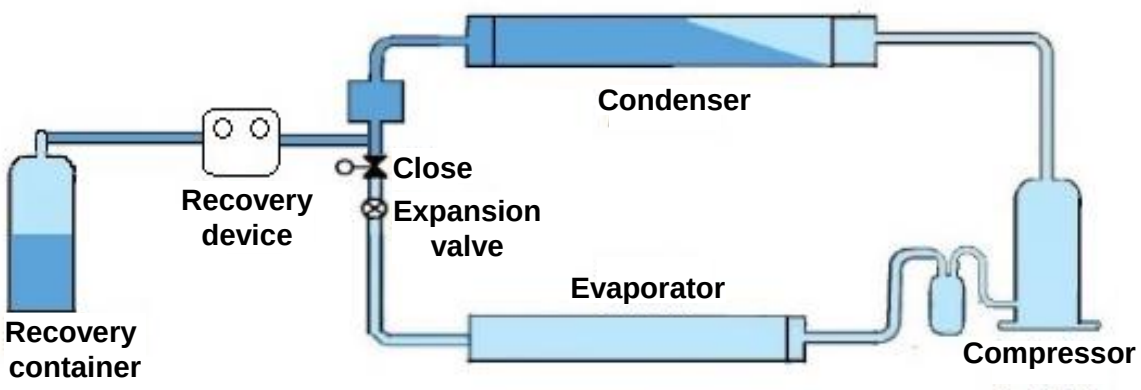
Condition

In a refrigerating and air-conditioning equipment where refrigerant cannot be pumped down, if recovery is performed from both the high-pressure and low-pressure ports at the same time, the pressure inside the equipment drops even though the liquid refrigerant remains, and the recovery speed drops sharply.

Countermeasures

(1) Only the liquid refrigerant is first recovered, and then the gas is recovered from both the high and low pressure ports.
(2) If possible, push-pull recovery is efficient.
(3) Equipment that can be warmed up should be operated for about 5 to 15 minutes.
(4) Recover after energizing the heaters of each part.
(5) Remove the worm valve at the service port and use a large diameter hose.
(6) Heat using a heat gun.

If pump-down operation is possible, collect the refrigerant in the condenser and then efficiently recover the liquid refrigerant.



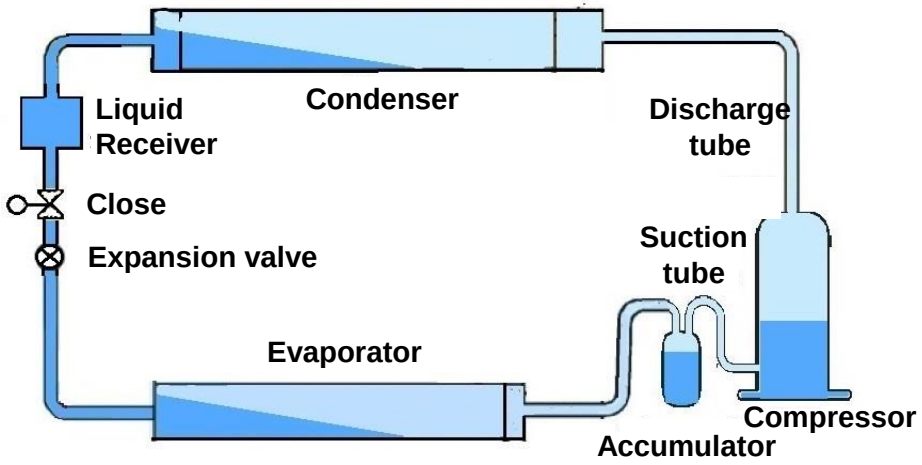
4. Efficient recovery (Refrigerant dissolved in refrigerating machine oil)

Condition

Even if the recovery reference pressure is reached, the pressure inside the refrigeration and air conditioning equipment will rise immediately, and recovery may not be completed easily.

Countermeasures

(1) Perform warm-up operation.
(2) Perform pump down operation.
(3) First, only the liquid refrigerant is recovered, and then the gas is recovered from both the high-pressure and low-pressure service ports.
(4) Recover after energizing the heaters of each part.
(5) Recovery is performed once up to the vacuum region, left until the pressure rises, and then recovery is performed again.



Refrigerant in refrigerating and air-conditioning equipment left for a long time

Fluorocarbons stagnation

4. Efficient recovery
(Precautions when recovering HFC mixed refrigerants)

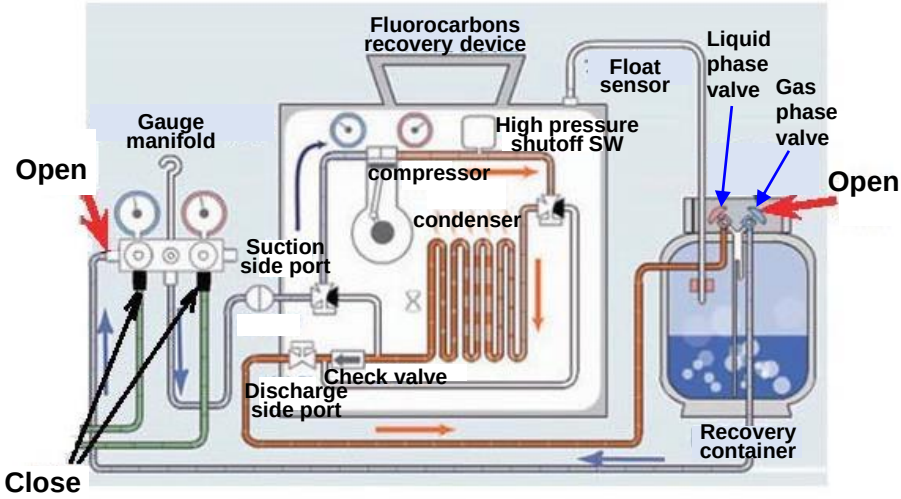
Condition

Recovery speed becomes very slow due to the high pressure in the recovery container, and the recovery device may stop due to high pressure shutoff during recovery.

Countermeasures

(1) Separate the recovery container and recovery device from the floor by about 0.5 m.
(2) Recover using a recovery container that is larger than usual.
(3) First, only the liquid refrigerant is recovered, and then the gas is recovered from both the high-pressure and low-pressure service ports.
(4) Cool air is blown.
(5) Wrap a wet towel around the recovery container.
(6) Adjust the suction pressure of the recovery device to "0.3MPa to 0.5MPa" (gauge pressure).
(7) Remove the worm valve at the service port.
(8) Use a large diameter hose.
(9) Perform a cylinder cooling operation to reduce the pressure in the recovery container.

Cylinder cleaning is a method of sucking refrigerant gas from the gas phase valve of the recovery container into the recovery device, recondensing and returning the liquid refrigerant to the recovery container, and cooling the container.



4. Efficient recovery (when refrigerant accumulates in equipment)

Condition

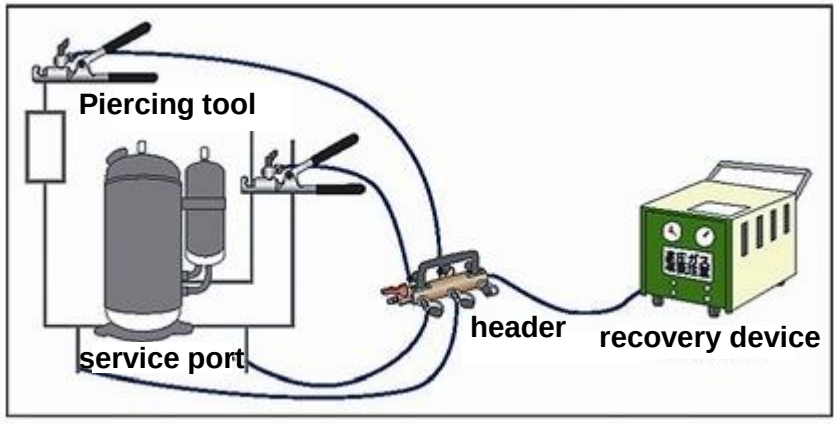
In the case of having an accessory such as a liquid receiver or a sub tank, low temperature condensation may occur in that part during recovery, and as a result, recovery speed may decrease.

Countermeasures

(1) When a heater is installed in a liquid receiver, a sub tank, etc., recovery is performed after heating (perform when warming up is possible).

(2) A plurality of piercing tools are used for a copper pipe under a liquid receiver and a sub tank, and the lower copper pipe is connected with a header to directly recover the liquid.

Piercing plier



Recover with piercing pliers and headers

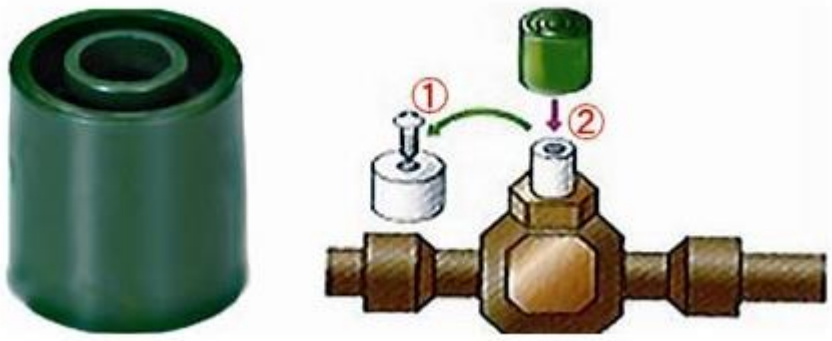
4. Efficient Recovery (Forced Release of Solenoid Valves)

Condition

Refrigerant may be ejected when recovery is performed at the site where the power was turned off and the refrigerating and air-conditioning equipment and piping are removed.
Solenoid valves are attached to various parts inside the refrigerating and air-conditioning equipment, and if the power of the refrigerating and air-conditioning equipment is turned off, the refrigerant in the refrigerating cycle closed by the solenoid valves cannot be recovered.

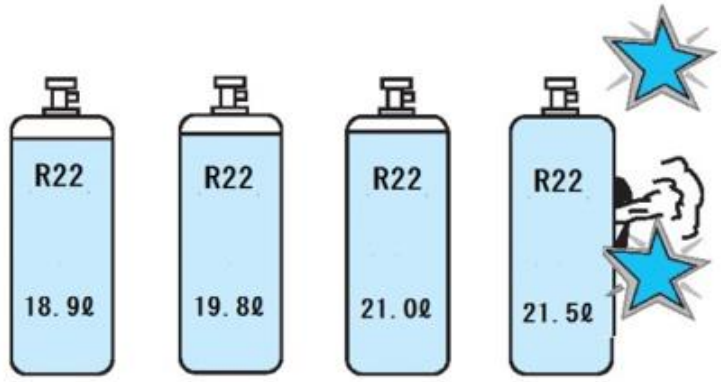
Countermeasures

Forcibly open all solenoid valves using a solenoid valve opener or the like that can forcibly open the solenoid valves even when they are not energized.
By forcibly opening the solenoid valve, the non-recoverable part can be eliminated, and push-pull recovery and liquid recovery can be performed in the refrigerating and air-conditioning equipment that uses a large amount of refrigerant.

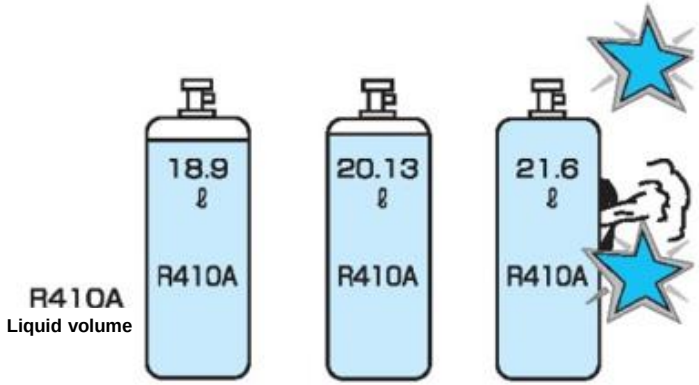


Solenoid valve opener

5. Safe recovery (Container rupture due to overfilling)



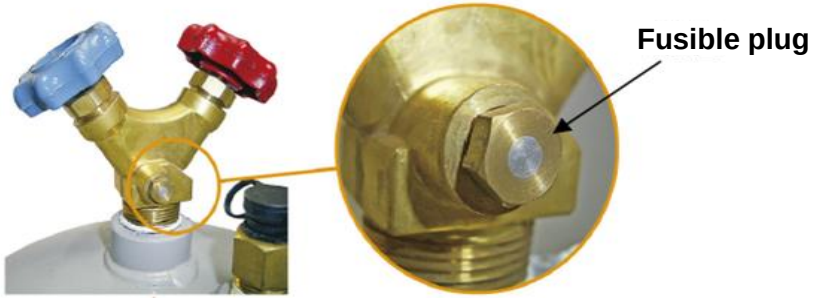
Temperature	16°C	30°C	45°C	50°C
Pressure	0.71MPa	1.09MPa	1.63MPa	1.84MPa
Liquid filling ratio	90.0%	94.2%	99.9%	102.2%
Mass of refrigerant	23.2kg	23.2kg	23.2kg	23.2kg
Specific volume (liquid)	8164ℓ/kg	0.8541ℓ/kg	0.9042ℓ/kg	0.9240ℓ/kg



Temperature	16℃	30℃	42℃
Pressure	1.29MPa	1.88MPa	2.54MPa
Liquid filling ratio	90.0%	95.9%	102.9%
Mass of refrigerant	20.9kg	20.9kg	20.9kg
Specific volume (liquid)	0.9044 ℓ/kg	0.9634 ℓ/kg	1.032 ℓ/kg

"explosive sound"
"Plosive before fusible plug elutes"

[Caution]
According to the law, it is to be handled at 40 ℃ or lower.



5. Safe recovery (air mixing)

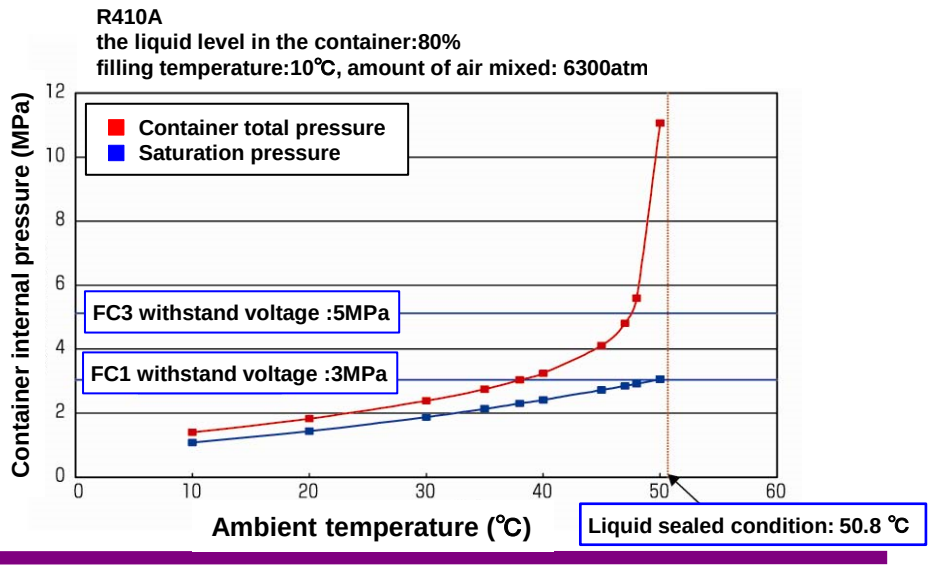
Condition

During recovery, the internal pressure of the recovery container rose sharply, making it impossible to recover. Air was mixed into the recovery container due to insufficient evacuation of the recovery container, deterioration of the hose, loosening of the hose joint, and the like.

Countermeasures

(1) Leakage inspection of hose coupling etc.
(2) Make sure to evacuate the recovery container.
(3) Measure the pressure and temperature with a gauge manifold, etc., and monitor the operating condition.
(4) In case of abnormally high pressure, perform air purge.

If air gets into the recovery container, the temperature inside the container will rise and the pressure inside the container will become abnormally high, resulting in a dangerous condition.
The figure on the right shows the case where air is mixed in R410A, and the total pressure of the container rises sharply as it approaches the liquid-sealed condition.



5. Safe recovery (oxygen deficiency accident)

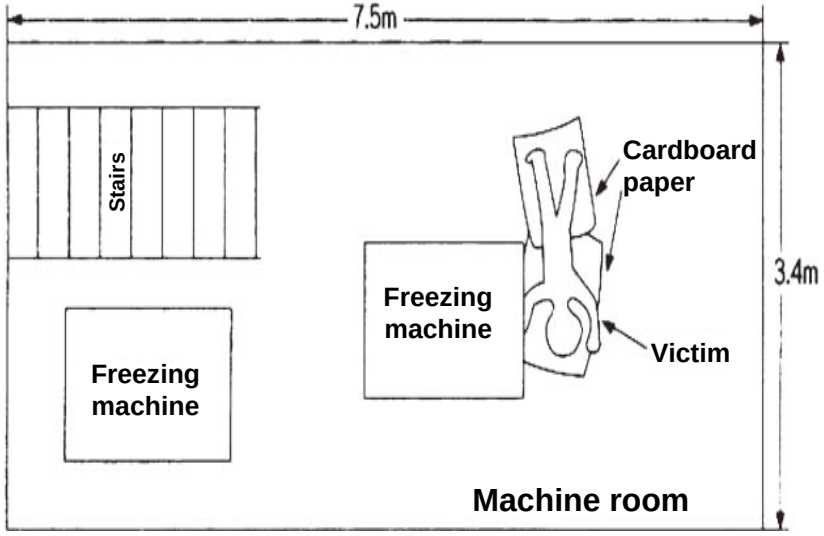
The specific gravity of freon gas is about triple that of air. If it leaks, it remains near the floor. For the recovery of fluorocarbons where it may remain, pay attention to the following.

(1) Ventilation of working place (natural / forcible)
(2) Prevent leakage of fluorocarbon
(3) Don't leave the field during work
(4) Monitor the oxygen concentration

Oxygen meter

Oxygen concentration	Symptom etc.
21%	Usual air state
18%	Safety limit, but continuous ventilation is necessary
16%	Headache, sick feeling
12%	Dizziness, loss in muscle strength
8%	Blackout, fainting, death within 7 to 8 minutes
6%	Fainting instantaneously, arrest of breathing, death

Quoted from document of Ministry of Health, Labour and Welfare



Situation of the accident

5. Safe recovery
(Generation of toxic gas due to thermal decomposition of fluorocarbons)

Fluorocarbons

Heat → **Fluorocarbons**

Hazardous gas such as phosgene ($COCl_2$), chlorine (Cl_2), hydrogen fluoride (HF)

$$\underset{\text{R11}}{CFCl_3} + \underset{\text{Water}}{H_2O} \rightarrow \underset{\text{Hydrogen Fluoride}}{HF} + \underset{\text{Hydrogen Chloride}}{HCl} + \underset{\text{Phosgene}}{COCl_2}$$

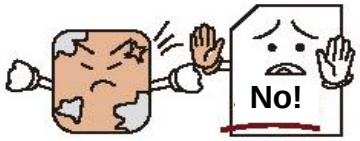
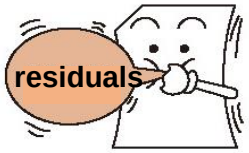
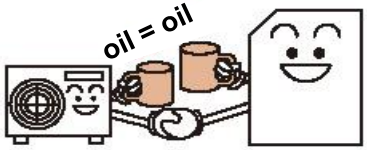
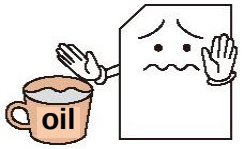
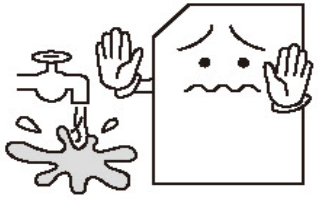
$$\underset{\text{R22}}{2CHCF_2} \rightarrow C_2F_4 + \underset{\text{Hydrogen Chloride}}{2HCl}$$

Asymptomatic incubation period / breathing difficulty

Smoking prohibited, pay attention to use of fire such as burner

6. Important points regarding the regeneration of recovered fluorocarbons

- When regenerating fluorocarbons, the recovery device, gauge manifold, and charging hose, etc. shall be dedicated to each refrigerant type.
- Use a cleaned recovery container. In addition, it is recommended that the inner surface of the container be rust-proofed.
- Keep in mind the following table.

	Please be careful when the refrigerant is contaminated by damage to the compressor and water intrusion.		When recovering a refrigerant different from the previous one, completely remove the residual refrigerant.
	Use the same oil for the lubricating oil in the recovery device and the lubricating oil for the refrigerant to be recovered.		Do not recover or fill different refrigerants in the same recovery container.
	Do not allow large amounts of oil to be absorbed into the recovery device.		Do not recover water, mud, etc. other than the specified refrigerant.

Thank you for listening.

Sources and Information

- **Office for Promotion of Ozone Layer Protection, Ministry of Economy, Trade and Industry**
  http://www.meti.go.jp/policy/chemical_management/ozone/index.html

- **Office for Promotion of Measures against Fluorocarbons, Etc., Ministry of the Environment**
  http://www.env.go.jp/earth/ozone/cfc/law/kaisei_h27/index.html

- **Japan Federation of Refrigeration and Air Conditioning Equipment Manufacturers**
  http://www.jarac.or.jp