Shimadzu Multitype ICP Emission Spectrometer

ICPE-9000 Hardware
INSTRUCTION MANUAL

Read the instruction manual thoroughly before you use the product.
Keep this instruction manual for future reference.

SHIMADZU CORPORATION
KYOTO JAPAN
ANALYTICAL & MEASURING INSTRUMENTS DIVISION

Before Use

Introduction

Read this manual thoroughly before using the product.

Thank you for purchasing this product.

This manual describes the installation and operation procedures for the product and provides precautionary information and details on accessories and options. Read this manual thoroughly before using the product. Use the product in accordance with the instructions given here. Keep this manual for future reference.

IMPORTANT

- Familiarize yourself with the contents of this manual before using the product.
- If this product is borrowed or changes ownership, provide this manual to the next user.
- If this manual or the warning labels on the product are lost or damaged, promptly contact your Shimadzu representative.
- To ensure safe operation, be sure to read "Safety Precautions" before using the product.
- Installation is performed by Shimadzu-designated service engineers. To ensure safety, do not perform installation yourself or allow anybody other than a Shimadzu-designated service engineer to perform installation.

Warranty and After-Sales Service

Warranty

1. Warranty Period

Contact your Shimadzu representative.

2. Scope

If a fault that can be attributed to Shimadzu occurs during the warranty period, Shimadzu will repair the product or provide the necessary replacement parts free of charge.

3. Limitations

This warranty does not cover faults that can be associated with any of the following:

1) misuse;
2) repairs or modifications made by any company other than Shimadzu or a Shimadzu-designated company;
3) external factors;
4) operation in severe conditions, such as environments subject to high temperatures, high humidity levels, corrosive gases, or vibrations;
5) conditions beyond Shimadzu's control, including fires, earthquakes and other forces of nature, contamination by radioactive or toxic substances, wars, riots, and criminal activity;
6) moving or transporting the product after its initial installation;
7) items or parts that can be regarded as consumable (e.g., parts for which the service life depends on the operation conditions, such as LCDs and program tape);
8) use in combination with hardware or software not designated by Shimadzu;
9) faults in equipment or damage to software, including the OS, or data caused by computer viruses;
10) faults in equipment or damage to software, including the OS, or data caused by power failures, including blackouts and momentary voltage drops;
11) faults in equipment or damage to software, including the OS, or data caused by turning OFF the power to equipment without performing the proper shutdown procedures.

After-Sales Service

If this product does not operate correctly, inspect it and take the appropriate corrective action as described in this manual. If the problem persists, or it is not covered in this manual, contact your Shimadzu representative.

Replacement Parts Availability

Replacement parts will be available for this product for a period of seven (7) years after its discontinuation. Thereafter, replacement parts may cease to be available. Note, however, that the availability of parts not manufactured by Shimadzu shall be determined by the relevant manufacturers.

Safety Precautions

• To ensure safe operation, read these safety precautions thoroughly before using the product.

• Be sure to observe all the safety precautions given here. They are extremely important for ensuring safety.

• In this manual, precautionary information is indicated using the following conventions.

WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or equipment damage.
NOTE	Indicates information provided to improve efficiency or clarify explanations.

■ Safety Precautions Related to Installation Location

WARNING

- **Some of the solvents used for measurement are flammable or toxic. Be sure to ventilate the room properly.**
  Not doing so may result in poisoning or fire.

- **Organic solvents are sometimes used for measurement. Therefore, do NOT use open flames near the product and do NOT install the product in the same room as equipment that generates sparks.**
  Doing so may result in fire.
  As a safety measure, provide a fire extinguisher.

- **A sink is required near the product**
  If solvent gets into your eyes or you come in contact with toxic solvent, you must wash away the solvent immediately. Provide a sink as near the product as possible.

CAUTION

- **Consider the weight of the entire measurement system when installing the product.**
  Install the product on a surface (e.g., a table) that is flat, stable, and easily capable of withstanding the weight of the entire measurement system. Otherwise, the equipment may fall or topple over.

- **Do NOT install the product in locations subject to large amounts of dirt, dust, corrosive gases, or gases containing halides.**
  Otherwise, performance specifications may not be attained or the service life of the equipment may be reduced.

■Safety Precautions Related to Installation Work

WARNING

- **Take steps to ensure that the equipment does not fall over due, for example, to earthquakes.**

  Otherwise, vibrations may cause the equipment to fall over and cause injury.

- **The power supply voltage and power consumption for the product are given below. The power supply voltage is displayed on the label and voltage selector on the back of the product. Connect to a power supply that complies with this voltage.**

  Connecting to a noncompliant power supply may result in fire or electric shock. If the power supply voltage is unstable or if the power supply capacity is insufficient, performance specifications may not be attained. Provide a power supply that complies with the power supply capacity required by the entire system.

- **Ground the product.**

  If the product is not grounded, electric shock may occur when there is faulty operation or current leakage. This is also important for ensuring stable operation.

- **Do NOT insert the adapter's ground wire into, or allow it to make contact with, the power outlet.**

  Doing so may cause fire or electric shock.

- **Do NOT place heavy objects on, or thermal appliances near, the power cord.**

  Otherwise, the cord may break and cause fire, electric shock, or faulty operation. If the cord is damaged, promptly contact your Shimadzu representative.

- **Do NOT modify or stretch the power cord, or bend it excessively.**

  Otherwise, the cord may break and cause fire or electric shock. If the cord is damaged, promptly contact your Shimadzu representative.

CAUTION

- **Be careful not to trap your fingers in gaps in the equipment during installation.**
  Otherwise, your fingers may be injured.

- **Be careful not to trap your fingers when opening and closing doors.**
  Otherwise, your fingers may be injured.

■Safety Precautions Related to Installation Work

WARNING

- **Be sure to take measures for preventing accidents due to static electricity.**
  Otherwise, the sample may catch fire and cause a serious accident involving fire or explosions.

- **Wear protective glasses and gloves when handling solvents and samples.**
  If solvent gets into your eyes, your eyesight may be damaged.
  If solvent does get into your eyes, wash away the solvent immediately, and seek treatment by a medical professional.

- **Wear protective gloves when handling samples that are toxic or that may spread biological contagion.**

- **Do NOT use flammable sprays (e.g., hair sprays or insecticide sprays) near the product.**
  Otherwise, the spray may ignite and cause a fire.

■Safety Precautions Related to Repairs and Maintenance

WARNING

- **Remove the power plug from the outlet before performing inspections or repairs or replacing parts.**

  Not doing so may result in an accident due to an electric shock or short circuit.

- **Do NOT remove the main unit's cover under any circumstances.**

  Doing so may result in injury or faulty operation.

  It is not necessary to remove the main unit's cover for standard repairs and maintenance. Contact your Shimadzu representative to request repairs requiring the removal of the main unit's cover.

- **Replace fuses only with those of the type specified in this instruction manual.**

  Using a different type of fuse may result or fire.

  Contact your Shimadzu representative to inquire about fuses not specified in this instruction manual.

- **If dust adheres to the power plug's pins or pin-side face, remove the power plug and wipe it clean with a dry cloth.**

  Supplying power with dust on the power plug may result in fire.

- **Replace parts only with those specified in this instruction manual.**

  Using other parts may result in damage to those parts and make it impossible to use the product.

- **Do NOT leave the product in a wet state and do NOT clean it using alcohol- or thinner-based solvents.**

  Doing so may result in rust or discoloration.

- **Dispose of waste in accordance with your country's laws and regulations.**

Warning Labels

In order to ensure safety, warning labels are attached in places requiring caution. If a warning label is lost or damaged, obtain a new label through your Shimadzu representative and attach it in the correct position. See "Warning Labels on the Equipment" in this instruction manual for details on the positions where the labels are attached. (See page x ii)

Warning Label Positions

The warning labels shown below are attached to the equipment.

(1) Bottom Left of Outer Casing

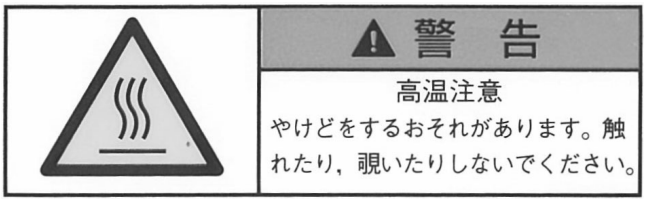
037-72017-10 LABEL, WARN, SA50-017P (Japanese)

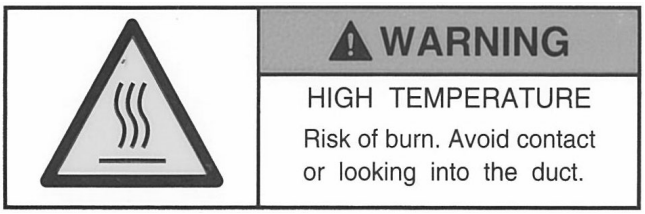
037-72020-10 LABEL, WARN, SA50-020P (English)

(2) Cylindrical Funnel

037-72522-02 LABEL, WARN, SB60-522P (Japanese)

037-72525-01 LABEL, WARN, SB60-525P (English)

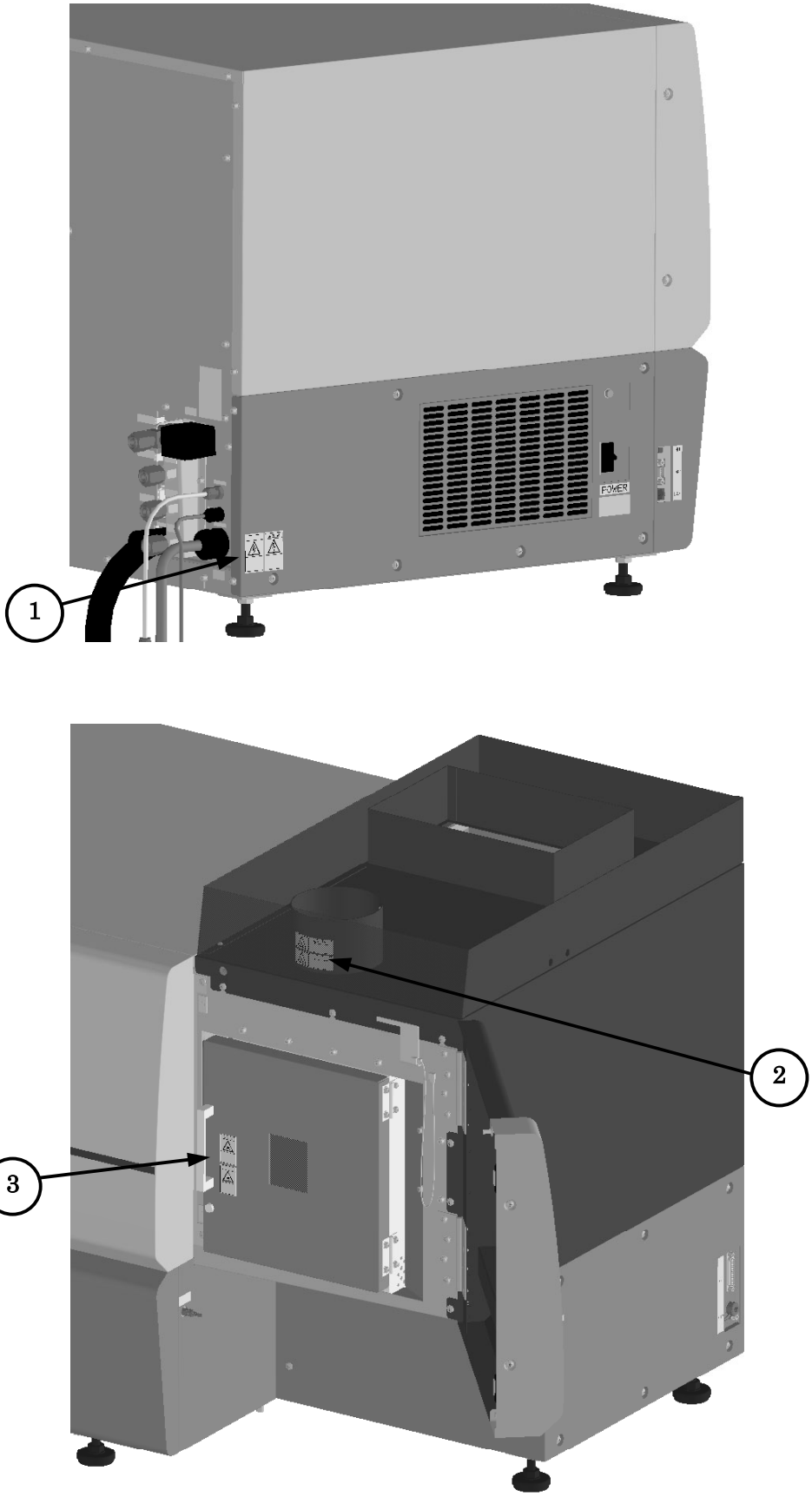




(3) Plasma Stand Door

037-72122-00 LABEL, WARN, SA40-122P (Japanese)

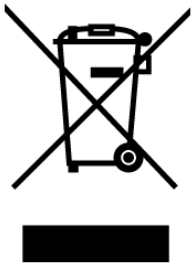
037-72125-00 LABEL, WARN, SA40-125P (English)



Warning Labels

Action for Environment

To all user of Shimadzu equipment in the European Union:
Equipment marked with this symbol indicates that it was sold on or after 13th August 2005, which means it should not be disposed of with general household waste. Note that our equipment is for industrial/professional use only.



WEEE Mark

Contact Shimadzu service representative when the equipment has reached the end of its life. They will advise you regarding the equipment take-back.

With your co-operation we are aiming to reduce contamination from waste electronic and electrical equipment and preserve natural resource through re-use and recycling.
Do not hesitate to ask Shimadzu service representative, if you require further information.

Handling Precautions

Thank you for purchasing the Shimadzu ICPE-9000 multitype ICP emission spectrometer.
Read the following items before using the product.

1. Handling High-Pressure Gas
This product uses argon gas. Read the section entitled "Handling High-Pressure Gas".

2. Use of Radio Frequency
(1) As previously communicated, this product uses a radio frequency (27.120 MHz). In accordance with the Japan's Radio Law, it is necessary to apply for permission to use radio frequencies. Check that the appropriate procedures have been completed. Contact your Shimadzu representative if there are any points requiring clarification.
(2) This product emits a radio frequency that is within the range specified by the Radio Law. If you use a pacemaker, consult a medical professional to confirm that there is no risk of an accident.

3. Analysis Samples
Exercise great care when handling toxic samples.

4. Waste Processing
With this product, most samples generate waste that requires processing. Be sure to process the waste properly.

5. Ventilation
This product uses argon gas and so, if the installation location is poorly ventilated, the ambient environment may become oxygen deficient. Ensure that the installation location is properly ventilated.

6. Chemical Resistance
Due to the nature of the coating and the resin materials used in the outer casing of this product, contact with certain chemicals may cause deterioration of the casing. If chemicals adhere to the casing, promptly remove them.

7. Installation Location and Work Environment
Do not use this product in environments subject to potential hazards, such as corrosive gases.

8. Moving and Disposing of the Product
Contact your Shimadzu service representative before moving or disposing of this product.

9. Handling
Explanations on the methods used to operate and handle this product are covered in the following manuals.

(1) Hardware, English: 305-34043, INSTRUCTION MANUAL, ICPE-9000H/W, E

(2) Software, English: 305-34045, INSTRUCTION MANUAL, ICPE-9000S/W, E

10. You may not reproduce all or any part of the contents of this manual without consent.

11. The contents of this manual are subject to change without prior notice.

12. Contact your Shimadzu representative if you find any errors in this manual.

13. Shimadzu accepts no responsibility for any events that result from the use of this product.

Handling High-Pressure Gas

Thank you for your continuing support of Shimadzu Corporation products.
Many of our products require the use of high-pressure gas. We trust you are already aware of the increasing demand for more stringent levels of safety management with regard to these gases. Although we trust you are already implementing the items listed below, we ask that you review these items and exercise the utmost care in the handling of high-pressure gases.
Note the following points regarding the handling of high-pressure gases in Japan:

1) By law, permission is required to use cylinders containing more than 300 m^3.
2) When using gas of a pressure that exceeds 980.665 kPa (10 kg/cm2) inside the equipment at room temperature, the equipment is regarded as high-pressure gas equipment and, by law, notification of use must be submitted.

We ask that you refer to your government laws and regulations related to high pressure gas control , liquefied petroleum gas control, general high pressure gas control , and fire defense.

Handling Precautions

1. Install the gas cylinder in a well-ventilated outdoor location that is not exposed to direct sunlight and convey the gas indoors via a pipe. Regarding liquefied gases in particular, this setup is required by law in Japan.
2. Ensure that the temperature of the gas cylinder never exceeds 40°C. Also, ensure that there are no open flames within 2 m of the gas cylinder.
3. Ensure that the location where high-pressure gas is used is well ventilated and, as part of initial inspection, check for gas leaks with soapy water.
4. Prevent the cylinder from falling or toppling over by securing it with rope. Be sure not to let liquefied-gas cylinders (e.g., acetylene, propane, or nitrous oxide) topple over into a horizontal position.
5. Be sure to use oil-free decompression valves with oxygen gas cylinders. Also, do not use pipes in which oil adheres to the internal pipe surfaces that oxygen gas comes in contact with.
6. After using the gas, close the cylinder's main valve immediately.
7. Inspect the functional capability of the pressure gauge at least once every three months.
8. Do not use the cylinder until it is empty. Otherwise, the inside of the cylinder will be contaminated.

CONTENTS

1. Introduction

Shimadzu's ICPE-9000 multitype ICP emission spectrometer is a compact, high-performance, tabletop model.

The vacuum-type echelle spectrometer, the two-dimensional semiconductor detector, the photometry system, the ICP RF power supply, and the analysis software were all developed by Shimadzu.

The combination of an echelle spectrometer and a two-dimensional detector brings many advantages. For example, the simultaneous analysis of multiple elements reduces analysis time, the use of a mini-torch reduces running costs, and axial-view plasma observation increases sensitivity.

The software is Windows-compatible and easy to use. It has powerful support functions that provide the user with the information required for analysis and includes a wide variety of application software for ensuring a high level of reliability.

There are also many options that can be attached to this product, including a radial-view observation kit, an ultrasonic nebulizer, and a hydride generator.

2. Parts

The standard ICPE-9000 package consists of the following parts. Check that they are all included.

No.	Part number	Part name	Qty.	Notes
1	211-86003-91	ICPE-9000, BODY ASSY	1	Main unit
2	016-31404	VINYL T, R3603, 1/8X1/16	2m	For connecting torch (auxiliary gas) and nebulizer
2	211-85118-91	PLASMA GAS TUBE ASSY	1	For torch (plasma gas) connection
2	016-31409	TYGON TUBE, 1/2X3/8	2m	For connecting drain (main unit)
2	200-30864-24	TYGON TUBE, 7/16X1/16	2m	For connecting leveler (glass)
2	016-43505	PP TUBE, 44-PP, WHITE	5.5m	Piping for argon gas
2	035-65503	HALF UNION, C1N1/4XPT1/4	1	For connecting argon gas inlet
2	035-69703-01	INSERT, B-405-170	3	Insert for swedgelock
2	210-14037	INLINE FILTER, B-4F-7	1	Filter for argon gas
2	046-00426-05	CASE, POLYSTYRENE, 45-066-05	1	Molecular sieve dish
2	228-49750-02	POLYSTYRENE CASE, SQUARE TYPE (K-3A)	1	Dish for catching condensation in utility section
2	211-81448	MINI-TORCH 7500	1	Torch (glass)
2	211-81444	TORCH ADAPTER	1	Attached to outside of torch
2	211-86533	EXTENSION PIPE, L	1	Connects torch and chamber (glass)
2	046-00092-02	NEBULIZER, AR30-1-FC1S	1	Nebulizer (glass)
2	046-00093-02	SPRAY CHAMBER, 808-8881	1	Chamber (glass)
2	046-00093-01	DRAIN TUBE, 808-8214	1	Leveler (glass)
2	210-15508-01	BALL JOINT CLIP, FOR 12	2	Clip for torch and extension pipe
2	037-61113-04	CLAMP, SNP-10	1	Clamp
2	046-00993-01	CLIP, FOR TS-15, D-310-1	1	Clip
2	035-02402-02	CLAMP, 20/25KF, 18342	1	Vacuum clamp
2	037-61028	HOSE CLAMP, HB-1-36	1	Vacuum clamp
2	211-86083-91	EXHAUST VALVE ASSY	1	Attached to vacuum pump
2	088-81104-19	CABLE, LD-CTX/BU5	1	LAN cable for connecting PC (5m)
2	305-34043	INSTRUCTION MANUAL, ICPE-9000H/W, E	1	Hardware instruction manual
2	211-44287-91	DISK, SYSTEM-SPECIFIC, ICPE9000	1	Floppy disk holding system-specific information
2	211-86093-91	TORCH ADJUSTMENT JIG ASSY	1	Torch height adjustment jig
2	022-27602	BOLT, SUS, WITH HOLE, P3, M3X6	1	Bolt for securing torch height adjustment jig
2	211-84742-91	ECHELLE GRATING,GR	1	Echelle grating
2	211-84635	LIGHT-INTERCEPTING PLATE	1	Spectrometer's internal light-intercepting plate
2	022-27617	BOLT, SUS, WITH HOLE, P3, M4X8	3	Bolt for securing spectrometer's internal light-intercepting plate

No.	Part number	Part name	Qty.	Notes
2	206-52224-03	LABEL, VOLTAGE, 200V	1	Voltage label (attached at time of installation)
2	206-52224-04	LABEL, VOLTAGE, 230V	1	Voltage label (attached at time of installation)
2	206-52224-05	LABEL, VOLTAGE, 240V	1	Voltage label (attached at time of installation)
2	206-52224-06	LABEL, VOLTAGE, 220V	1	Voltage label (attached at time of installation)
2	072-60381-02	CLAMP, ULM-18MSG	2	For securing back of leveler exhaust tube
2	022-27045	BOLT, SUS, WITH HOLE, M4X12	2	For securing CLAMP, KCA-64
2	072-60342-04	CLAMP, KCA-64	2	For securing leveler exhaust tube duct
2	016-31428	VINYL T, R36033/16X1/16	2.5m	Leveler exhaust tube
2	211-83697	CONNECTION TUBE	5	For connecting autosampler suction tube
2	211-86547	PLATE, TUBE HOLDER	1	Tube hook on right side of ICPE-9000
2	211-86136-91	TUBE BAND ASSY	1	Block for securing tube on right side of ICPE-9000
2	210-07003-04	MOLECULAR SIEVE	1	Vacuum system
2	017-30813-01	SI GREASE, HIVAC-G 50G	1	Vacuum system
3	211-88096-91	VACUUM PUMP ASSY	1	Vacuum pump

3. Preparation for Installation

3.1 Installation Environment

Before installing the ICPE-9000, the laboratory must be prepared as described in the ICPS-9000 installation guidelines provided separately. Check the following items before installation.

(1) The position of the plasma stand exhaust duct and the exhaust capacity must be appropriate. A damper must also be provided.
An exhaust capacity of 2.5 m^3/min is required for the plasma stand exhaust guide (inner diameter: 118 mm).
An exhaust capacity of at least 6 m^3/min is required for the RF power supply exhaust outlet (inner dimensions: 287 mm × 187 mm).

(2) Air-conditioning equipment that can maintain an ambient temperature in the range 18ºC to 28ºC must be installed. The ambient temperature must not vary more than 2ºC/hour. The humidity must be in the range 20% to 70%.

(3) The equipment must not be directly exposed to the air discharged from the air-conditioning equipment.

(4) The equipment must not be directly exposed to sunlight.

(5) The equipment must not be installed in a location subject to shocks or vibrations.

(6) The respective distances between the equipment and the walls must satisfy the following conditions.
Back of equipment: 200 mm min
Right side of equipment: 400 mm min. normally, 600 mm min. during maintenance
Left side of equipment: 200 mm min. normally, 600 mm min.during maintenance

(7) There must be no high-capacity heat-generating sources near the equipment.

(8) Voltage fluctuations of the power supply must not exceed ±10%. The voltage must not exceed 250 V.

(9) There must be no devices incorporating CPUs (e.g., computers) less than 2 m from the equipment.

(10) The purity of the argon gas must be at least 99.95% and the gas pressure at the inlet to the equipment must be in the range 450±10 kPa.

(11) The temperature of the cooling water for the RF coil and the cooling jacket must be in the range 5°C to 30°C, the flow rate must be at least 1 L/min, and the pressure must be in the range 100 to 300 kPa.

(12) A cooling water circulation system must be provided separately to provide coolant for the CCD.
Provide a cooling water circulation system with the specifications given below. Alternatively, use the cooling water circulation system recommended by Shimadzu (option).
Pumping signals are output from the main unit. Ensure that cooling water is pumped to the main unit only while pumping signals are being output.

Cooling water circulation system:

Temperature setting range:	0ºC to room temperature
	(standard operating temperature: 10ºC)
Temperature control precision:	±0.1ºC
Cooling capacity:	200 W min.; Liquid temperature: 10ºC
Pumping capacity (maximum pump head):	
	2.1 m min. at 50 Hz, 2.4 m min. at 60 Hz
Pumping signals:	24 VDC, 0.5 A

3.2 Installing and Handling the Data Processing Unit

General points to note regarding the installation and handling of the data processing unit are given below.

3.2.1 Operating Environment and Storage

(1) Do not install the unit in a location where the display screen will be directly exposed to sunlight or light emitted by lighting fixtures in the ceiling.

(2) Do not install the unit in a location where it will be exposed to direct sunlight or near heating equipment, such as stoves.

(3) Do not install the unit in a location subject to large amounts of moisture or dust.

(4) Do not install the unit in a location subject to shocks or vibrations.

(5) Do not install the unit on a slope.

3.2.2 Maintenance

(1) If the main unit becomes dirty, wipe it with a soft, dry cloth. If the dirt is particularly difficult to remove, dip a cloth in some diluted neutral detergent, wring out the cloth, and use it to wipe off the dirt. Finally, wipe the unit with a dry cloth. Do not use benzene or thinner as this may cause discoloration.

(2) Wipe the display screen with a dry cloth.

3.2.3 Other Points

Be careful not to subject the computer to shocks when carrying it. Otherwise, faults may occur. Also, disconnect the power plug and connecting cable before moving the computer.

CAUTION

If nothing appears on the screen or if there is an unusual sound or smell, turn OFF the power immediately. It is dangerous to continue operation in this state.

4. Basic Principles

ICP (inductively coupled plasma) emission spectrometry is a method used to perform emission spectrometry using inductively coupled plasma as the light source. In order to facilitate a deeper understanding of ICP analysis, this section describes the fundamentals of measurement performed with emission spectrometry.

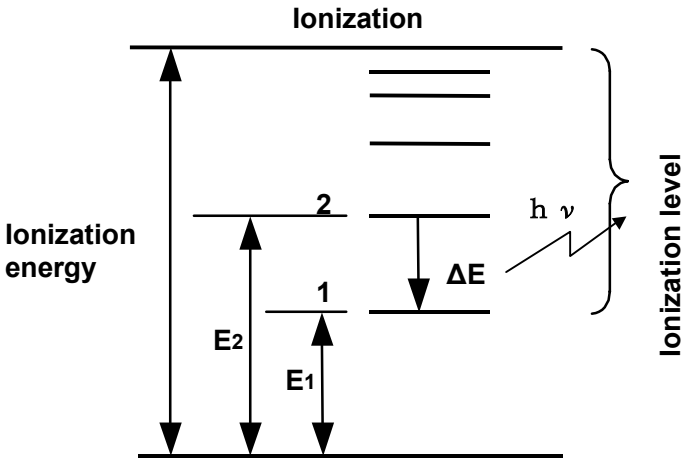
4.1 Fundamentals and Principles of Emission Spectrometry

4.1.1 Definition of Emission Spectrometry

Emission spectrometry is an analysis method in which a sample is electrically or thermally excited, causing it to emit light. The emitted light is divided into element-specific spectral lines with a spectrometer and the qualitative and quantitative analysis of the elements contained in the sample is performed by investigating the presence and intensity of these spectral lines. It is said that this method was first developed when Bunsen, who is credited with the development of the Bunsen burner, put different kinds of solvent into the burner and observed the colors of the flames.

4.1.2 Principles of Emission Spectrometry

An atom consists of an atomic nucleus and electrons that move around the nucleus with specific orbits. If energy is applied to the atom by some method, the atom absorbs the energy and an orbital electron moves from the steady state to an orbit with a higher energy level (E2). Within a very short time (of the order of 10^{-7} to 10^{-8} s), however, this electron moves back to the orbit with the lower energy level (E1). At this time, the energy difference, ΔE, is radiated as light.



If the frequency of the light is "ν", the energy difference can be expressed as follows:

$\Delta E = E_2 - E_1 = h\nu$ h: Planck's constant

The frequency, ν, and the wavelength, λ, of the light satisfy the following relationship:

$\lambda = c/\nu$ c: Speed of light (3×10^{10} cm/sec)

The emitted light is directed into a spectrometer, where it is divided by a prism or a diffraction grating, and the element-specific atomic spectral lines are observed.

The number of spectral lines normally observed in the ultraviolet, visible, and infrared regions varies from a few dozen (e.g., alkali metals) to a few thousand (e.g., rare-earth elements and uranium). The spectral lines can be divided into two types depending on the state of the light-emitting atom, neutral atomic lines (arc lines) and ion lines (spark lines). The part used to excite the sample and thereby generate these spectral lines is called the "light source".

If a substance is caused to emit light and spectral lines corresponding to the atoms or ions of a certain element are discovered in the light, this confirms the presence of that element in the substance. This is the principle of qualitative spectrometry.

If the amount of an element contained in a substance changes, then the intensity of the corresponding emission lines in the spectrum for that substance also changes. The line intensities for multiple standard samples (i.e., samples of known concentrations) of different concentrations are measured and the relationship between the intensities and concentrations is expressed in the form of a calibration curve. The line intensity of a sample with an unknown concentration is measured and the concentration is calculated from the calibration curve. This is the principle of quantitative spectrometry.

4.1.3 Intensity Method (Time Integration Method) and Intensity Ratio Method (Internal Standard Method)

A calibration curve is created by obtaining the emission intensities of multiple standard samples with different concentrations by integrating over a fixed time period, plotting the results on a graph with concentration represented by the horizontal axis and emission intensity represented by the vertical axis, and obtaining a relationship in terms of linear, quadratic, and higher-order expressions. This method is called the "intensity method".

Another method is the "intensity ratio method" or "internal standard method". With this method, a spectral line (the internal standard line) for an element of which a fixed amount is contained in (added to) the standard sample and analytical sample are selected, and a calibration curve is created with the vertical axis representing the ratio of the emission intensity of the target element to the emission intensity of the internal standard element. With this intensity ratio method, even in cases where sample introduction is unstable due to differences in sample viscosity in the nebulizer, this can be corrected by obtaining the ratio, thereby improving precision and accuracy.

Although better results can be obtained by selecting, as the internal standard element, an element that exhibits similar properties to the analytical element in terms of ionization energy, excitation energy, and distribution within the plasma, making an incorrect selection can lead to large errors. It is therefore necessary to perform thorough preparatory experiments.

4.1.4 Self Absorption

In general, the light source used for the emission spectral analysis has temperature distribution, higher in the center and lower in the peripheral area. If the density of an atom in the plasma is high, the light emitted in the center will be absorbed by the atom existing in a lower-temperature area. This phenomenon is called "self absorption" and it is often observed in the resonance lines used in atomic absorption spectrometry. As the concentration of a sample increases, because of self absorption, the intensity does not increase in proportion to the concentration, and the linear calibration curve starts to bend. ICP is donut-shaped with a higher temperature at the periphery than in the center and can therefore be used as a light source with minimal self absorption. Depending on the element, there are cases where it can yield a 5 or 6-digit linear concentration range.

4.1.5 Background Equivalent Concentration (BEC) and Limit of Detection (LOD)

The background equivalent concentration (BEC) and limit of detection (LOD) are used as representations of analysis sensitivity. They are respectively defined as follows:

BEC: The concentration giving a signal intensity equal to the background intensity (i.e. intensity at zero concentration)

LOD: Lowest detectable concentration

They can be obtained with the following formulas:

BEC = Intensity at y-intercept of calibration curve without background-correction × Inclination of calibration curve (concentration/intensity)

LOD = 3 × Standard deviation (σ) of repeatedly measured concentration of blank sample

Note that the intensity is not equal to the background-corrected value (= Intensity of target spectral line - Background intensity in neighborhood of this target spectral line).

4.2 Fundamentals, Principles, and Characteristics of Inductively Coupled Plasma

4.2.1 Definition of Plasma

In the field of physics, an American physical chemist Langmuir in the 1920's gave the name "plasma" to a region where electric charges of ions and electrons are balanced. This was the first time for the word plasma appeared in this field. In short, the plasma means ionized gases such as gases ionized in the central emission area of a vacuum discharge tube, gas between arc discharge electrodes, ionosphere, corona, etc.

4.2.2 Principles of ICP

"Fig. 4-1" shows the plasma generation process. A magnetic field, H, is formed by an RF current, I, flowing through an inductive coil, and an electric field of a strength proportional to the rate of change of the RF magnetic field is generated. The electric field accelerates electrons and ions, and as a result of collisions between high-speed electrons and argon atoms, the argon atoms are ionized. The rate at which electrons are generated exceeds the rate at which they are destroyed, and plasma is formed. The plasma is maintained in a state where the generation and destruction (i.e., due to rebonding, dispersion, or gas flow) of ions and electrons balances. The current density in a cross section of the conductor in which the RF current flows becomes as large as the current density at the surface. This phenomenon is called the "skin effect".

The higher the frequency or the conductivity of the plasma, the more heat is concentrated in the periphery. With the introduction of the carrier gas, the temperature at the center of the tube decreases even more and a donut-shaped ring of plasma is formed.

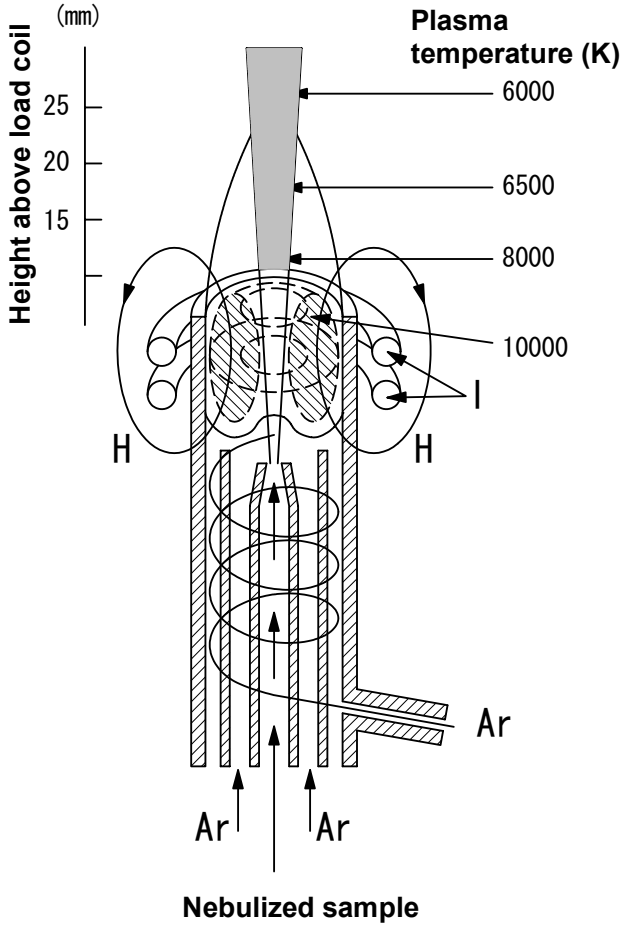


Fig. 4-1 Plasma

4.2.3 Features of ICP

(1) The introduction of a solution sample makes it easier to prepare a standard sample as compared with a solid sample. It also improves the analysis accuracy.

(2) Extremely high sensitivity and a low detection limit to various elements are realized.

(3) Very few chemical interference as occurred with the conventional flame (chemical flame) due to high plasma temperature and a doughnut- shaped hole where a sample is placed for a comparatively long time.

(4) Less self absorption and extremely wide dynamic range with the linear range of the calibration curve extending over 5 to 6 digits.

(5) Various elements can be excited under the same conditions. Major, medium, and minor component elements can be quantitatively analyzed at the same time .

(6) Various elements can be excited under the same conditions. Major, medium, and minor component elements can be quantitatively analyzed at the same time .

(7) There is no danger of explosion due to the use of inert argon gas.

4.3 Fundamentals of Spectrometers

The spectrometers used for emission spectrometry must be able to separate very large numbers of atomic spectral lines and must therefore have greater resolution than the spectrometers used for atomic absorption spectrometry.

A diffraction grating is used as the spectrometer's dispersive element. This is because relatively large diffraction gratings can be produced, making it possible to create bright spectrometers, and also because they enable the creation of spectrometers that attain a high resolving power, either by having a large number of grooves (e.g., sequential ICP spectrometers) or by using higher order spectra (e.g., echelle ICP spectrometers). A diffraction grating is created by ruling a large number of parallel, equally spaced grooves in the surface of glass onto which metal has been vapor deposited.

4.3.1 Basic Equations for Diffraction Gratings

When light strikes a diffraction grating from a certain direction, light of a certain wavelength is intensified in a certain direction due to diffraction. The overall effect is that a spectrum is formed. If α is the angle the incident light makes with the perpendicular to the surface of the diffraction grating (incident angle), β is the angle the diffracted light makes with the perpendicular, d is the grating constant, and λ is the wavelength, then the following equation holds:

$$n\lambda = d(\sin\alpha + \sin\beta) \quad \cdots\cdots (1)$$

n: Order of diffraction

Here, n is the order of diffraction, n = 0 corresponds to the direct image, and n = 1, n = 2, n = 3... correspond to diffraction images of order 1, 2, 3... Echelle diffraction gratings use high orders, ranging from approximately 30 to 130.

If we assume that the incident angle is constant, then (1) gives the following:

$$d\beta / d\lambda = n / d\cos\beta \quad \cdots\cdots (2)$$

This is the angular dispersion. It varies in proportion to the order, n, and increases as the grating constant decreases.

If light dispersed by angle $\Delta\beta$ forms an image consisting of two lines, and if the distance between these two lines in the focal plane is ΔL, $\Delta L / \Delta\lambda$ ($dL / d\lambda$) is called the "linear dispersion".

$$dL / d\lambda = \frac{f}{\sin\varepsilon} \times \frac{d\beta}{d\lambda} \quad \cdots\cdots (3)$$

Here, f is the focal length of the spectrometer and ε is the angle of inclination between the focal plane and the optical axis. In practice, the reciprocal of this, the "reciprocal linear dispersion" is often used, and is expressed in units of nm/mm.

The ability to separate two closely neighboring wavelengths into two distinct lines is called the "resolution". If λ is the average wavelength of two separable spectral lines and $\Delta\lambda$ is the difference in wavelength, then the resolution, R, can be expressed as follows:

$$R = \lambda / \Delta\lambda \quad \cdots\cdots (4)$$

If N is the total number of grooves and n is the order, then the resolution, R, can also be expressed as follows:

$$R = \lambda / \Delta\lambda = nN \quad \cdots\cdots (5)$$

Therefore, the resolution increases as the total number of grooves, N, increases or the diffraction order, n, increases.

4.3.2 Mounting of Spectrometer

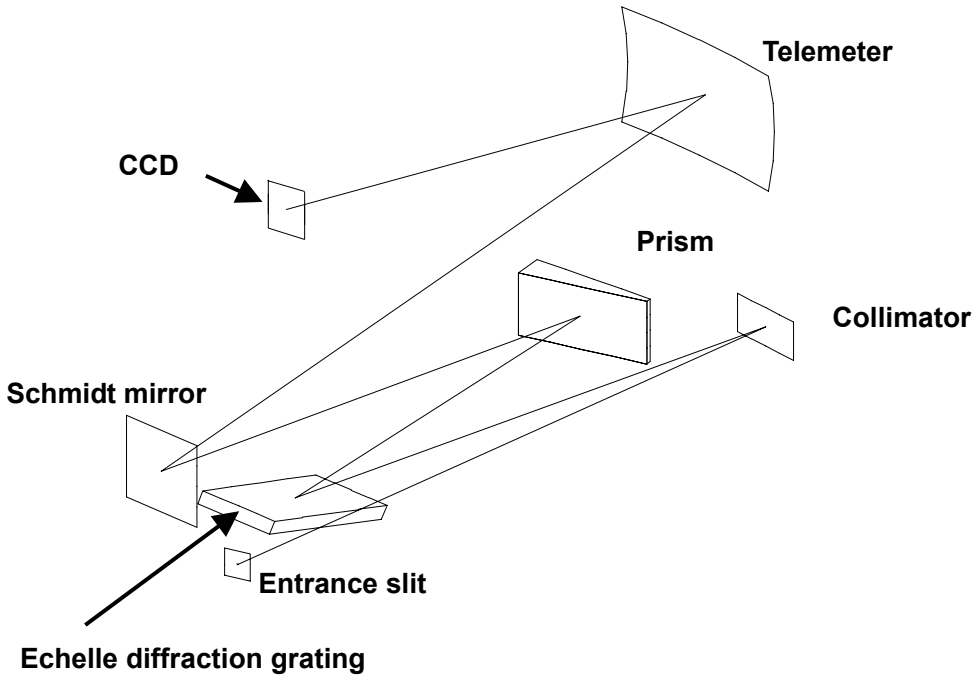


Fig. 4-2 Spectrometer Incorporating Echelle Diffraction Grating

The arrangement of a spectrometer's optical elements is called a "mounting". "Fig. 4-2" shows the mounting for an echelle spectrometer incorporating an echelle diffraction grating.

The divergent light through the entrance slit is converted to parallel light by the collimator. It is then diffracted and divided by the diffraction grating and the prism, it undergoes aberration correction at the Schmidt mirror, and an image is formed by the telemeter mirror at the exit slit. With the ICPE-9000, a two-dimensional semiconductor detector is used instead of an exit slit.

The echelle spectrometer is designed to improve resolution by increasing the order of diffraction , as shown in equation (5) in "4.3.1 Basic Equations for Diffraction Gratings", and to improve the angular dispersion by increasing the diffraction angle, β (i.e., reducing the value of cosβ), as shown in equation (2). In general, the order is in the range 30 to 130 and the diffraction angle is in the range 60° to 70°. When light is divided with an echelle spectrometer, all light for which the product of the order and wavelength is the same will be radiated in the same direction and so an order-dispersive element is required in order to isolate light of the target wavelength. In light divided with an echelle spectrometer, if λ and λ' are wavelengths of two consecutive orders that appear at the same position in the spectrum, then the difference in the wavelength, Δλ, is called the "free spectral range", and represents the wavelength range measured for each order.

Applying $\alpha \cong \beta$ to equation (1) gives the following:

$$n\lambda = (n+1)\lambda' = 2d\sin\beta \quad \cdots\cdots (6)$$

$$\Delta\lambda = \lambda - \lambda' = \lambda'/n \quad \cdots\cdots (7)$$

In general, the range is from the 30th to the 130th order and from 1 to 10 nm.

The prism divides the light so that it radiates in a direction perpendicular to the direction in which the light is dispersed by the diffracted grating. The light is separated according to order and all the wavelengths are dispersed onto a two-dimensional plane. "Fig. 4-3" shows the echelle pattern.

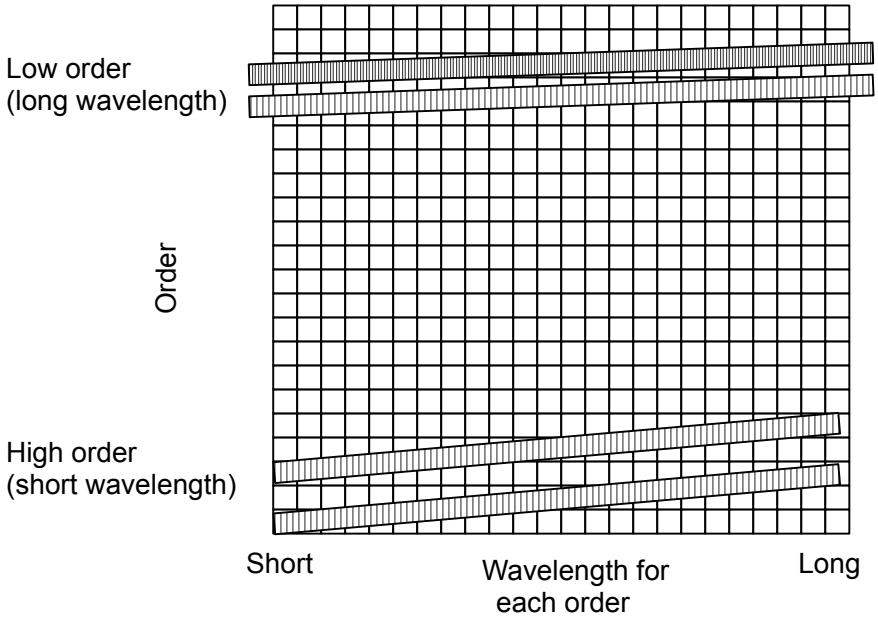


Fig. 4-3 Echelle Pattern

4.4 Detector

Light can be converted to electrical signals using a photomultiplier tube or a semiconductor detector.

A photomultiplier tube uses the fact that electrons are generated when light strikes a photoelectric surface. It accelerates the electrons in a vacuum and amplifies the signal and detects them as current from an anode. A semiconductor detector uses the fact that electrons are generated in a solid-state element (Si) by incident photons. It accumulates electrons and performs detection by measuring the amount of electric charge.

In order to measure two-dimensional spectra, the echelle spectrometer uses a semiconductor detector. Approximately one million (1,024 × 1,024) independent elements (pixels) with vertical and horizontal dimensions of a few tens of microns are arranged within an area of one square inch. After accumulation time elapses, the amount of electric charge is read (i.e., measured) for each pixel. The spectral intensity of the target element is obtained as the amount of electric charge that accumulated in the pixel a certain number along and a certain number up.

Semiconductor detectors come in CCD (charge coupled device) and CID (charge injection device) types. Repeated reading is possible with a CID but all the pixels are read in one operation with a CCD. The ICPE-9000 uses a CCD.

The sensitivity of a photomultiplier tube is adjusted by changing the applied voltage. With a semiconductor detector, however, the sensitivity adjustment is not possible for individual pixels. Also, there is a limit to the amount of charge that can accumulate in a pixel. If a pixel is irradiated with light of an intensity that exceeds this amount, an overflow occurs. In this case, the accumulation time is decreased to prevent an overflow and the number of repetitions is increased. On the other hand, if the light intensity is relatively low, the accumulation time is increased and the number of repetitions is decreased.

4.5 Principle of RF Power Supply

4.5.1 Outline

The energy used to generate ICP is applied to the plasma in the form of RF electric power. This RF electric power is generated by an RF power supply, which is configured as shown in "Fig. 4-4".

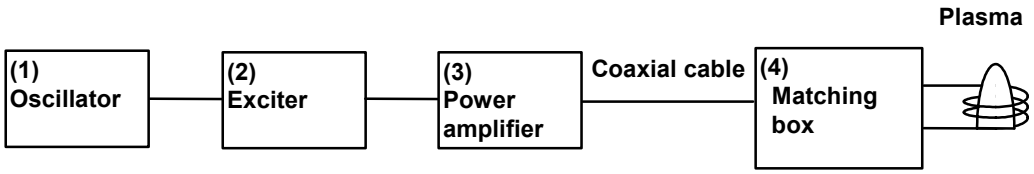


Fig. 4-4 Configuration of RF Power Supply

(1) Oscillator

This unit sets the frequency of the RF output. Fluctuations in the frequency affect the analysis precision and so many ICP power supplies use a crystal oscillator because of the high level of frequency stability.

(2) Exciter

This unit amplifies the radio frequency generated by the oscillator to the magnitude enough to excite the PA (power amplifier (3)).

(3) Power Amplifier

This unit amplifies the power from the exciter to the output of kW order enough to ignite and maintain the ICP.

(4) Matching Box

The power amplified by the PA is allowed to the plasma through a coaxial cable with the characteristic impedance Z0. However, because the impedance of the plasma and the characteristic impedance of the cable are different, a matching circuit is required. The box incorporating the matching circuit is called the "matching box".

4.5.2 Principle of Matching Box

When the RF power reaches the load (impedance Zr) via the cable (characteristic impedance Z_0), the reflection expressed by the following equation occurs.

$$P_r = P_f \left(\frac{Z_0 - Z_r}{Z_0 + Z_r} \right)^2$$

Pr: Reflected power

Pf: Incident power

As shown by this equation, the reflected power, Pr, is zero only when the impedance of the load, Zr, is equal to characteristic impedance of the cable, Z_0.

5. Configuration and Operating Principle of the ICPE-9000

5.1 Block Diagram

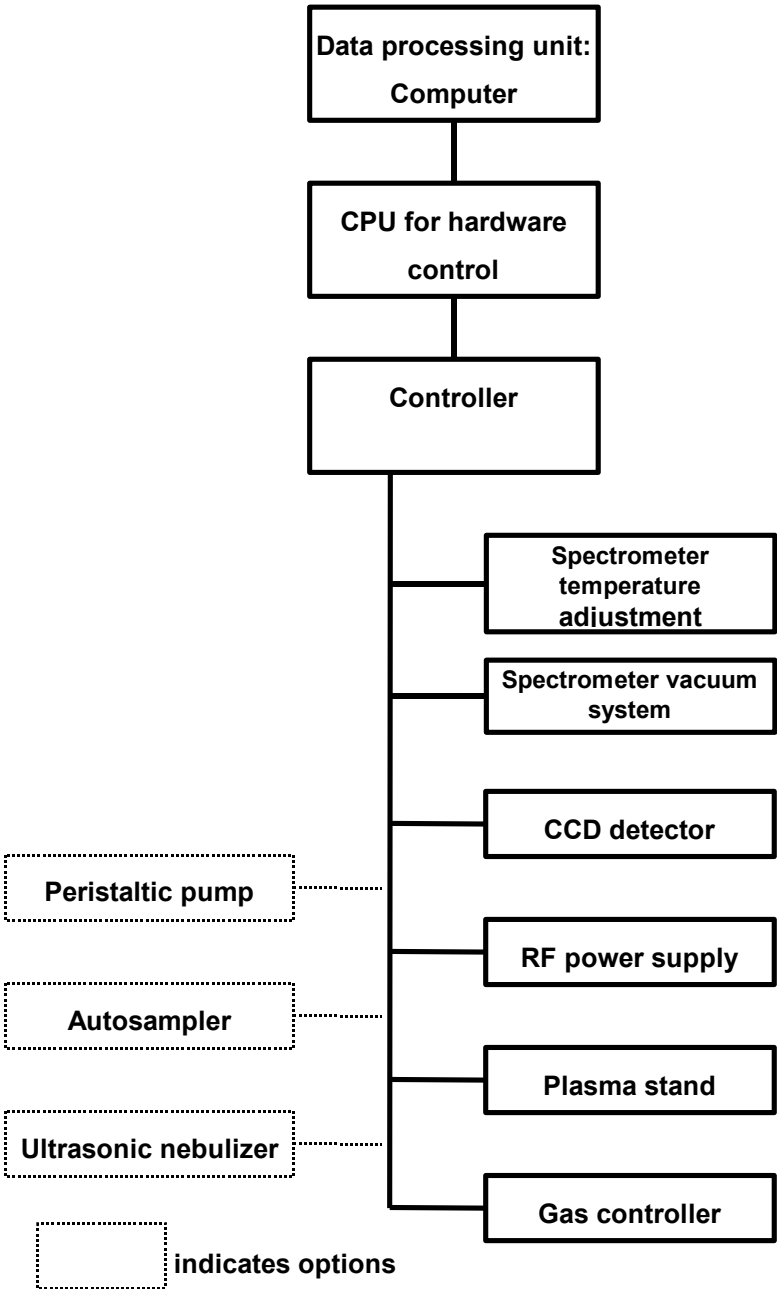
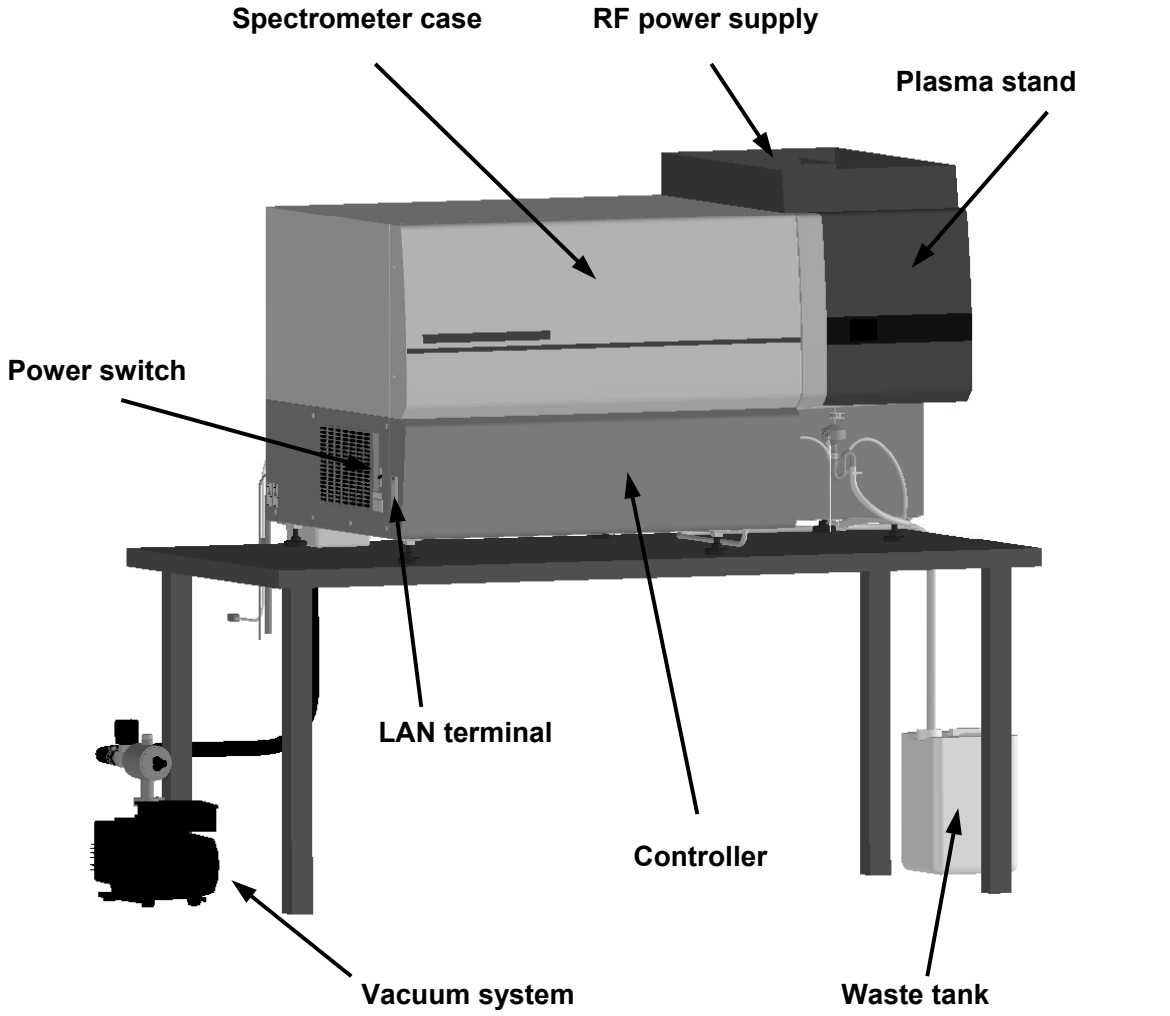


Fig. 5-1 Block Diagram

5.2 Appearance and Configuration

The ICPE-9000 basically consists of the spectrometer case, the plasma stand, the RF power supply, the controller, and the vacuum system. Inside the spectrometer case, the echelle spectrometer is contained in a temperature-controlled bath. The controller incorporates the gas controller and the control power supply.



(Table and waste tank not provided.)

Fig. 5-2 Appearance of ICPE-9000

NOTE

Do NOT install the ICPE-9000 in a position where it is difficult to turn OFF the power switch.

5.3 External Connection of Power Supply, Argon Gas, and Coolant

The ICPE-9000 requires a single-phase, 200/220/230/240-V, 50/60-Hz, 30-A power supply, a ground, argon gas, and coolant.

The coolant is used to cool the cooling jacket, the RF coil, and the CCD. The coolant for the cooling jacket and the RF coil is provided from the same system. Either mains water or a cooling water circulation system is used. The coolant for the CCD is provided separately from a cooling water circulation system. (See item (12) under "3.1 Installation Environment".)

Argon gas is supplied to the plasma torch, the nebulizer, the cooling jacket (for purge gas), and the CCD at independently adjusted flow rates.

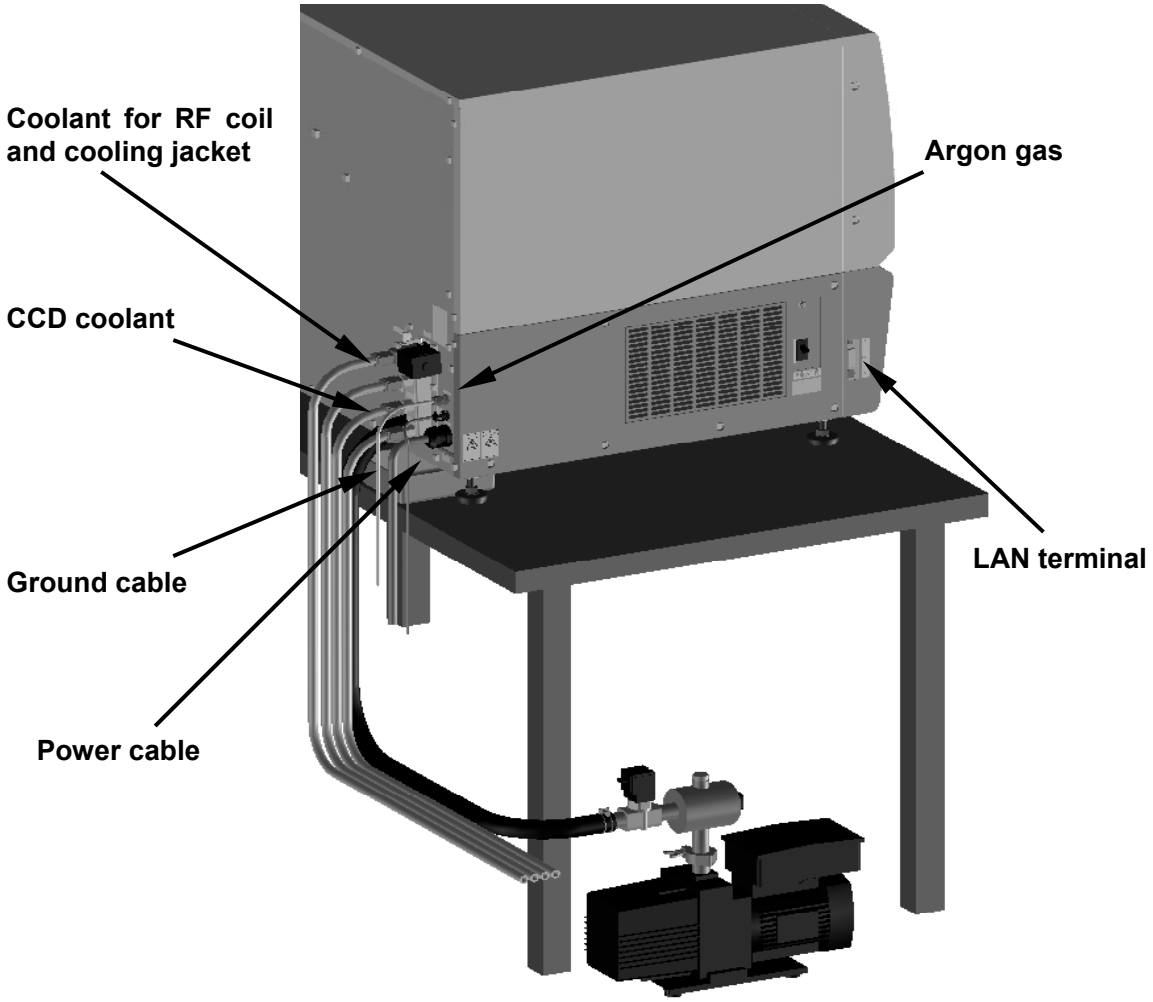


Fig. 5-3 External Connection of Power Supply, Argon Gas, and Coolant

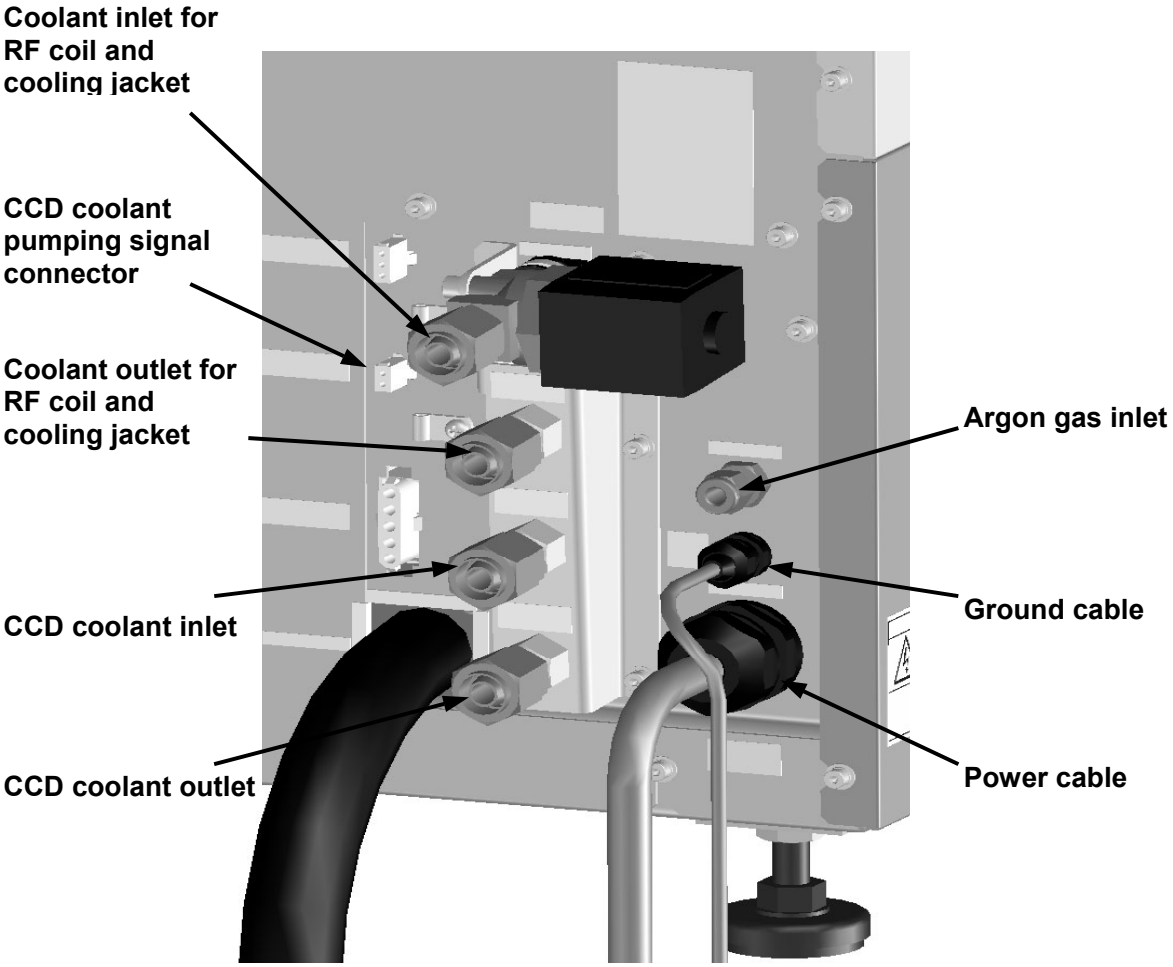


Fig. 5-4 Connection Panel for Power Supply, Argon Gas, and Coolant

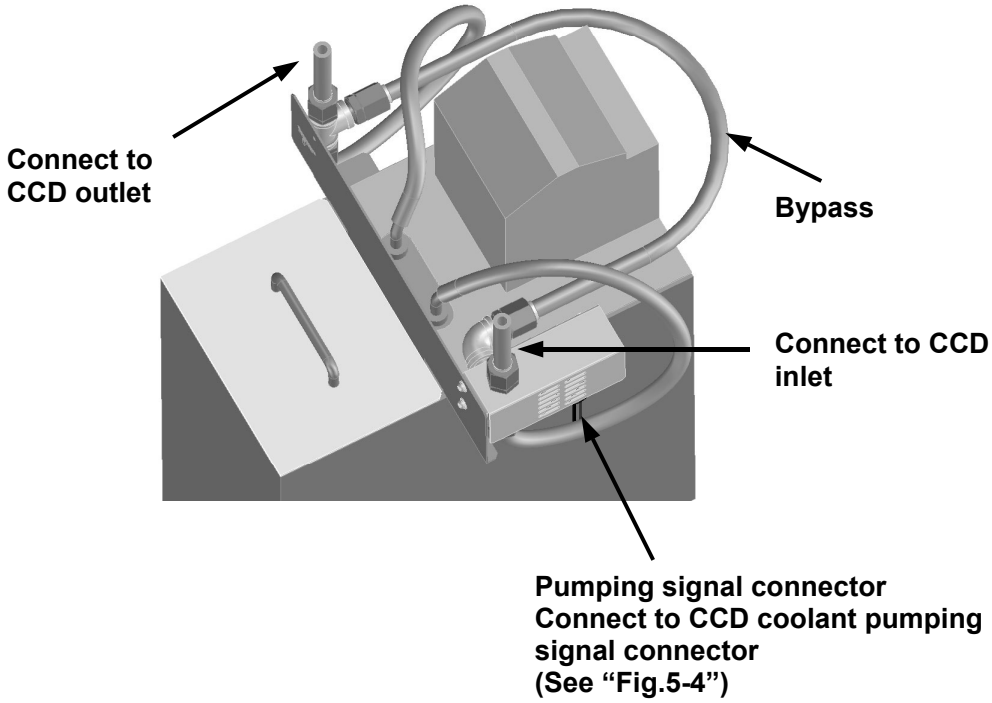


Fig. 5-5 Piping and Wiring for CCD Cooling water circulation system (Option)

5.4 Connecting the Data Processing Unit to the ICPE-9000

Connect the ICPE-9000 LAN terminal and the LAN card terminal on the data processing unit with the LAN cable provided. (See "Fig. 5-3".)

5.5 Spectrometer and Light-Focusing System

In axial-view observation, light from the ICP is bent 90° by the back-reflect mirror in the cooling jacket, it passes through the glass window in the section joining the spectrometer and the cooling jacket, and it is reflected by the toroidal mirror and the plane mirror to form an image at the entrance slit.

In the echelle mounting, the spectrometer mount uses an echelle diffraction grating with 79 grooves/mm and a blaze angle of 63.4°.

Light that passes through the pinhole (rectangular) entrance slit is converted to parallel light by the collimator mirror (parabolic mirror), and is divided (in a vertical direction) according to wavelength by the echelle diffraction grating. Then the light is divided (in a horizontal direction) according to order by the prism, it is reflected off the Schmidt mirror in order to correction aberrations, and it is reflected off the telemeter mirror (concave mirror) to form an image at the CCD detector.

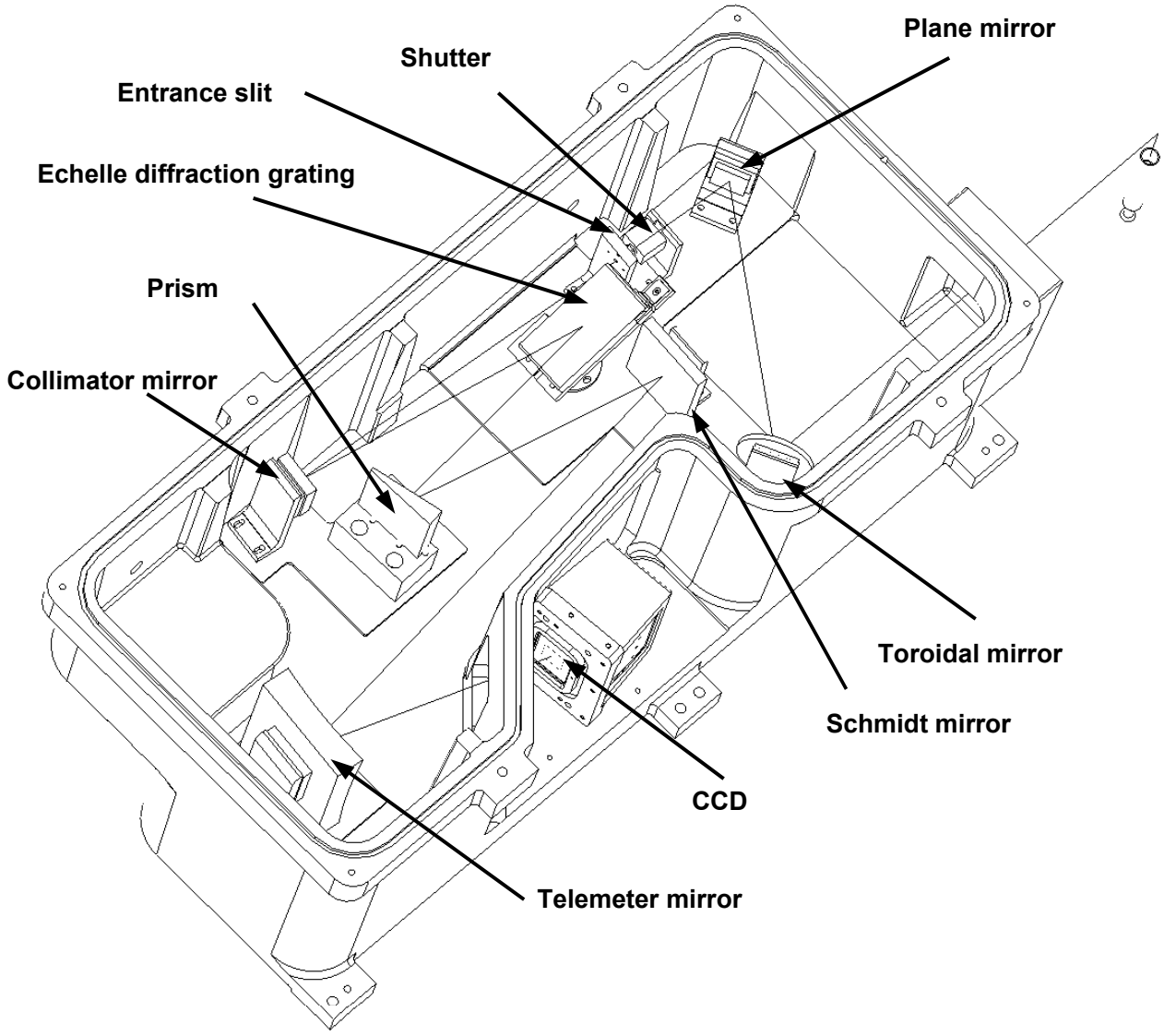


Fig. 5-6 Optical System

5.6 CCD Detector

The CCD detector's light-receiving surface consists of 1,024 × 1,024 pixels and the size of each individual pixel is 20 μm × 20 μm.

The dark current (output signal with no light input) decreases as the temperature of the light-receiving surface decreases and so the detector is cooled with a peltier element. Coolant is required for this purpose. (Check the specifications.)

Also, in order to facilitate the detection of spectra in the vacuum ultraviolet region, gaps in the spectrometer and CCD are purged with argon gas. It is delivered at a high flow rate when the plasma is first ignited and then continuously at a low rate after that. This gas also prevents condensation on the detector.

Control is performed with the data processing unit.

High flow rate: 4.5 L/min

Low flow rate: 0.5 L/min

5.7 Shutter

At the CCD detector, light in the entire spectral region is accumulated for the constant time, and then the electric charge is read for each pixel. During reading, however, the light from the plasma must be blocked. In order to facilitate blocking control, a shutter is positioned in front of the entrance slit.

The shutter repeatedly opens and closes at a minimum interval of 0.1 sec. For example, for 5 sec. of accumulation, the accumulated value for 0.1 s is measured 50 times, and the values are added, and then the accumulated value for 1 sec. is measured 5 times, and the values are added. This completes one analysis. This is controlled with signals from the computer. The CCD dark current is measured with the shutter closed. This is also controlled with signals from the computer.

5.8 Temperature Control

The spectrometer is housed in a thermally insulated case. The temperature of the spectrometer is kept constant by circulating air at a constant temperature in the space between the case and the spectrometer. The spectrometer temperature is set to 38°C and is regulated by ON/OFF heater control. There is no cooling function and so proper control may not be possible if the ambient temperature is high (e.g., higher than 28°C).

ICPE-9000 performance is greatly affected by the stability of the spectrometer temperature. Therefore, do not turn OFF the power supply to the main unit under normal circumstances as this will also turn OFF temperature control. Stability is maintained in momentary power interruptions but approximately half a day is required for recovery if the power supply to the main unit is turned OFF for a few hours or more.

5.9 Vacuum System

Spectra for short wavelengths of 190 nm or less are attenuated due to absorption by oxygen and water vapor and so the air in the spectrometer is evacuated by a vacuum pump.

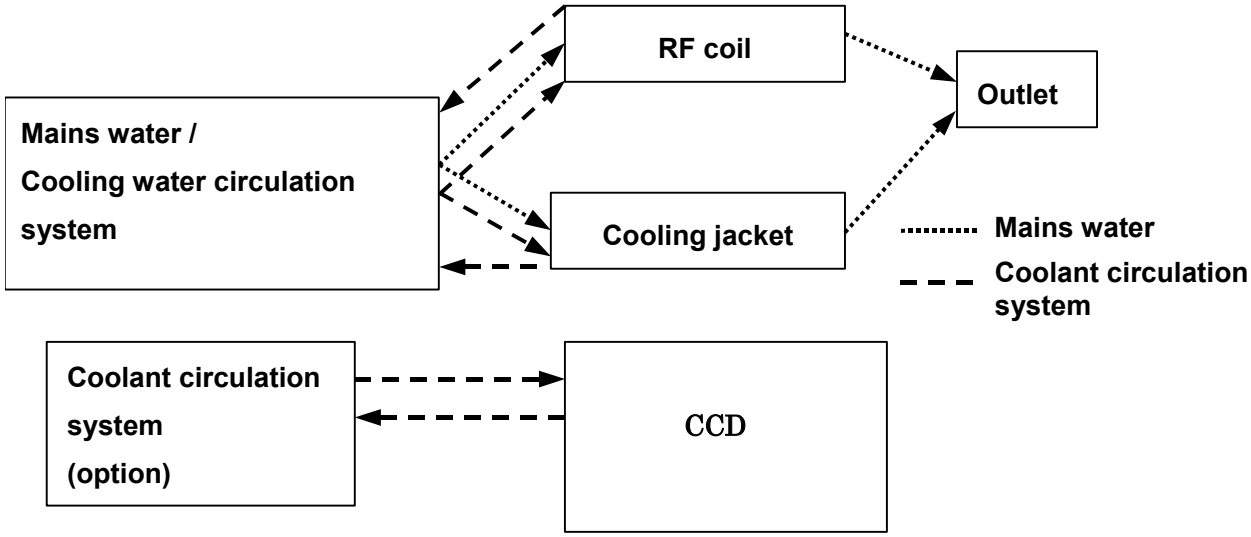
The solenoid valve separates the spectrometer and the vacuum system and closes automatically when pump operation stops. If the pump is restarted, the valve opens automatically after approximately one minute.

In order to prevent pump oil mist reaching the spectrometer from the vacuum pump, a very small amount of air is injected from the leak valve. If the vacuum level does not reach 20 Pa or less approximately 20 minutes after the pump starts, there is a possibility of a leak and so the vacuum pump stops automatically. Check the vacuum level reached by viewing the data processing software's [Instrument Control] window.

5.10 Cooling System

The cooling system consists of the two systems shown below.

When the plasma is ignited, the valve opens automatically and coolant flows. The flow of coolant is monitored with the flow switch. If it detects that coolant is not flowing, the plasma is not ignited. If the plasma is already ignited, it is automatically extinguished.



5.11 Argon Gas System

The argon gas passes through an in-line filter before entering the ICPE-9000.

The gas pressure at the ICPE-9000 inlet (argon gas inlet shown in "Fig. 5-4") is set in the range 450±10 kPa. If the pressure is less than 300 kPa, the pressure sensor detects this and automatically extinguishes the plasma.

NOTE

While the carrier gas is flowing, do NOT perform any operation that will cause the source pressure of the argon gas to drop below 100 kPa (such as replacing the argon gas cylinder).

5.12 Sample Introduction System (Including Plasma Stand Interior)

"Fig. 5-7" shows the plasma light source.

The parts are shown in "Fig. 5-8" and "Fig. 5-9".

WARNING

Risk of Burn Injury

There is a risk of burn injury. When checking the plasma stand, do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

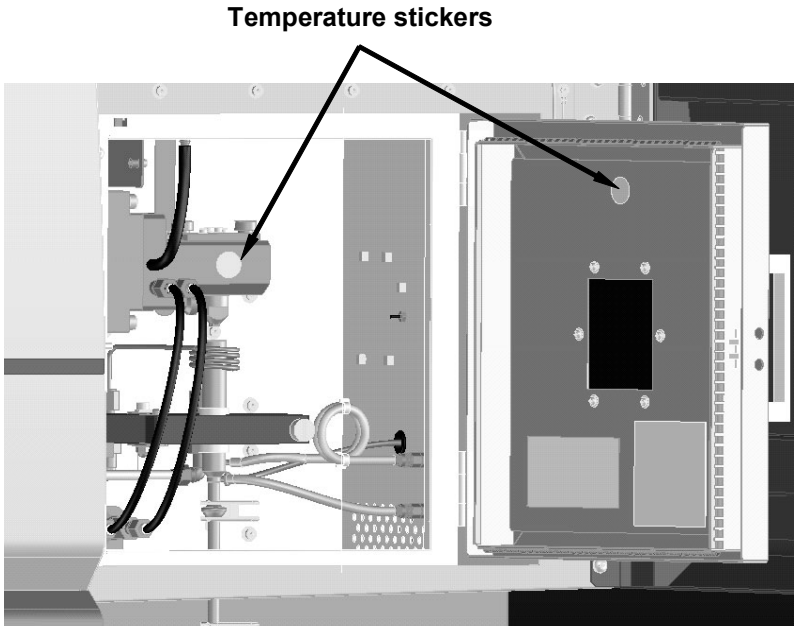


Fig. 5-7 Plasma Light Source

WARNING

Risk of Burn Injury

If "50" is displayed on a temperature sticker, it means that the temperature at and around that sticker is 50°C or higher. In this case, do NOT touch any point in the vicinity of the sticker.

(1) Plasma Torch

The plasma torch is made of quartz and has a threefold structure in which plasma gas (coolant gas), auxiliary gas, and carrier gas flow (from the outside).

(2) Plasma gas

For the plasma gas (coolant gas), argon gas is delivered at a standard rate of 8 to 10 L/min.

(3) Auxiliary gas

The auxiliary gas is delivered at a standard rate of 0.6 L/min. The function of this gas is to lift up the plasma slightly to protect the quartz tube in the middle.

(4) Carrier gas

The carrier gas introduces nebulized sample solution particles into the center of the plasma at a standard rate of 0.6 to 0.8 L/min.

The flow rate of carrier gas is not only related to the sample introduction rate. If it is too high, the plasma is cooled excessively, the retention time of the sample in the plasma is reduced, and the sensitivity is lowered. For this reason, precise adjustment is required. (The maximum possible flow rate of the carrier gas depends on the nebulizer.)

(5) Purge gas

For the purge gas, argon gas is circulated in the area between the light-focusing lens and the plasma to prevent dirt from the plasma or the sample adhering to the lens or the mirror. In the plasma ignition sequence, after approx. 10 sec. of purging at a high flow rate, purging is continued at a low flow rate. Approx. 1 hour is required to stabilize before performing measurement in the vacuum ultraviolet region.

(6) Nebulizer and Chamber

The nebulizer has a coaxial structure. It nebulizes samples so that they can be introduced into the plasma.

The chamber sorts the nebulized sample particles and introduces them into the plasma. Large particles adhere to the internal wall and are drained away. Only small particles are introduced into the torch.

(7) Leveler

Keeps the chamber's internal capacity at a constant level and prevents the carrier gas escaping to the drain side.

(8) Sample Introduction Tube

Introduces the sample into the nebulizer.

(9) Orifice ASSY L

This reduces the argon background light intensity, improves the effectiveness of the emission spectrum from the measurement elements, and guides it into the spectrometer.

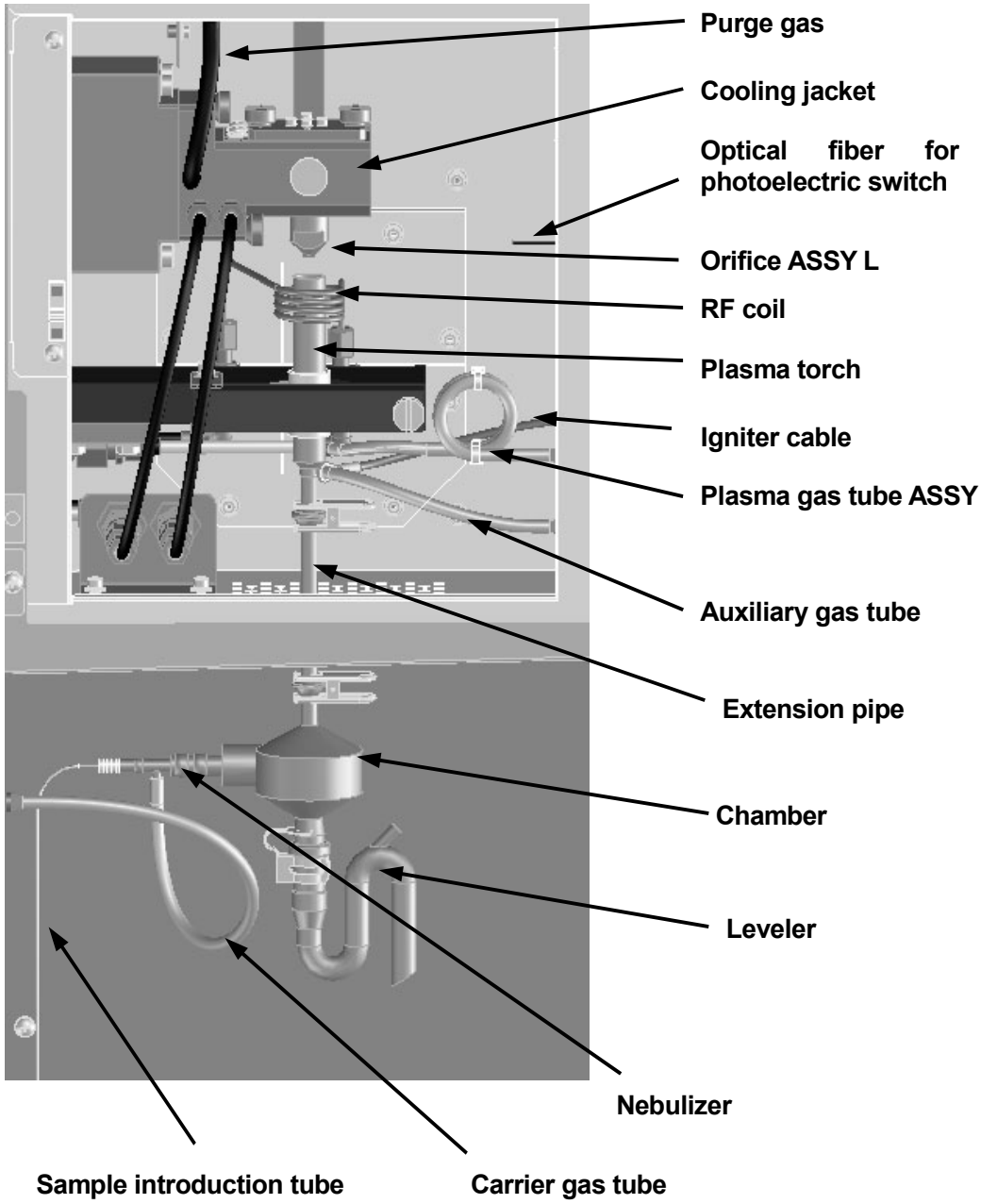


Fig. 5-8 Sample Introduction System, Argon Gas System, and Cooling Jacket (Plasma Stand Interior)

(10) RF Coil

A 27-MHz RF current is applied to the RF coil, the argon gas is heated and ionized by the induced current generated between the coil and the plasma, and the plasma is thereby maintained. The plasma is ignited by the igniter.

The RF coil is tubular and coolant flows through the interior.

(11) Optical Fiber for Photoelectric Switch

Guides the light from the plasma to the photoelectric switch, which detects whether or not the plasma is ignited.

(12) Leveler Drain Tube

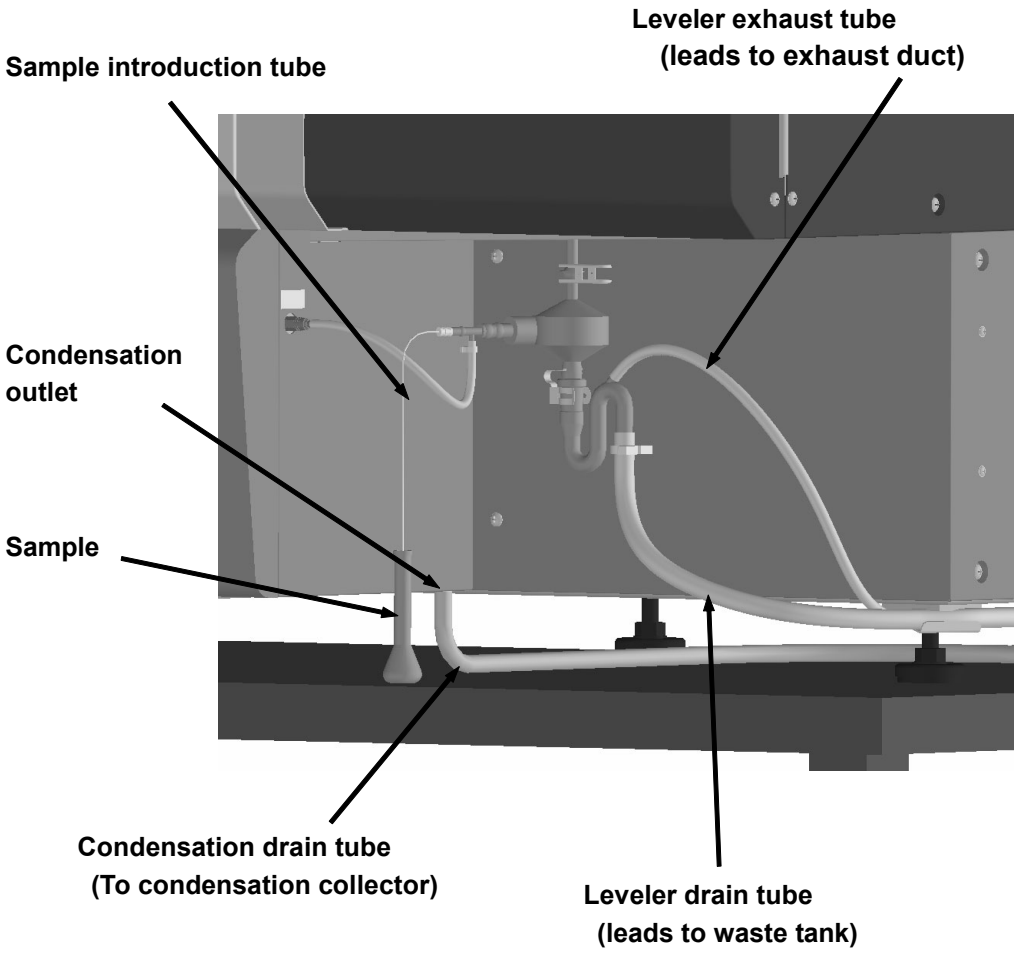
Drains the waste from the leveler to the waste tank.

(13) Condensation Drain Tube

Condensation flows into the condensation collector when condensation occurs inside the instrument.

(14) Leveler Exhaust Tube

Draws the gas given off by the sample in the leveler to the exhaust duct.



(The condensation collector and waste tank are not included.)

Fig. 5-9 Sample Introduction and Waste System (Plasma Stand Exterior)

NOTE

Do not insert the condensation drain tube into the waste tank. Corrosion inside the unit may result from the condensation drain tube, depending on the analysis sample.

5.13 Cooling Jacket

In axial-view observation, the plasma makes contact with the cooling jacket. The cooling jacket is cooled with water and prevents damage to the orifice and the emission of light by the metal elements that make up the orifice. The purge gas flows through the cooling jacket towards the plasma and prevents sample particles contaminating the optical system. Also, in order to facilitate analysis of the vacuum ultraviolet region, the area between the plasma and the spectrometer septum is purged.

Light passes through the center of the orifice, it is reflected off the back-surface mirror, it passes through the entrance window, and it is focused by the dual light-focusing mirrors to form an image at the entrance slit.

If no cooling water is flowing, the safety switch operates and the ICP is not ignited.

"Fig. 5-10" shows the optical system inside the cooling jacket.

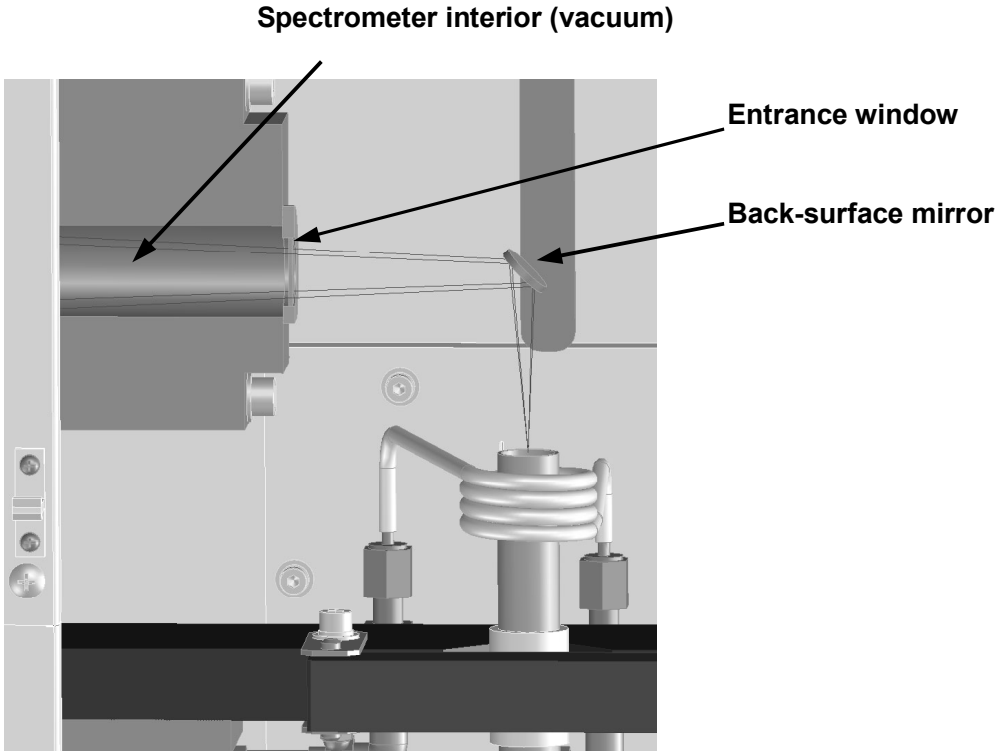


Fig. 5-10 Optical System inside Cooling Jacket

NOTE

Purge gas flows continuously when the plasma is ignited.
Do NOT turn OFF the purge gas when the plasma is ignited.

5.14 Radial-View Observation Kit (Option)

This optional unit is installed inside the plasma stand and enables radial-view observation. Switching between axial-view observation and radial-view observation is possible from the software. The observation points at the top and bottom set in radial-view observation can also be switched from the software. At the time of installation, the points 9 and 15 mm (for the optional plasma torch) above the RF coil are set but these can be changed with the observation position setting knobs. (Setting range: 7 to 22 mm.)

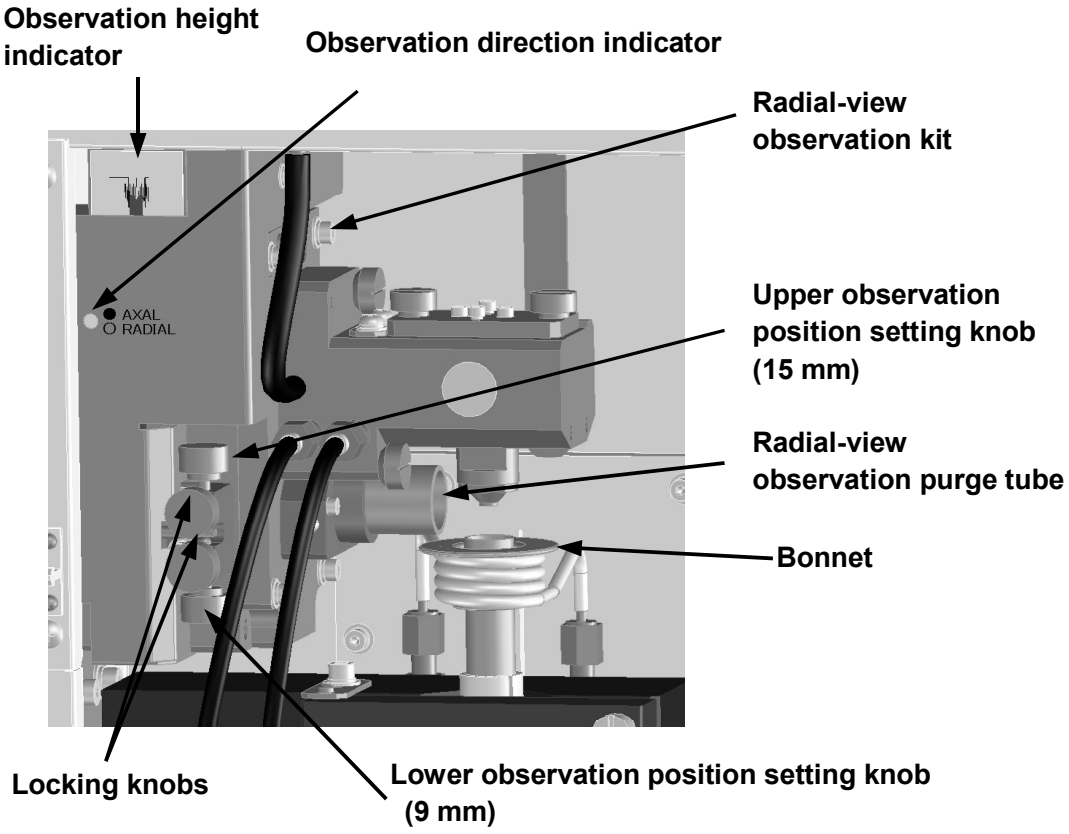


Fig. 5-11 Radial-View Observation Kit

WARNING

Risk of Burn Injury

There is a risk of burn injury. When checking the plasma stand, do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

(1) Switching Observation Direction

The observation direction is switched using the software. When igniting the plasma, perform the switching operation from the software's [Instrument Control] window and check that the observation direction has been switched properly. The mark shown below is displayed in the observation direction indicator.

Axial-view observation: ●

Radial-view observation: ○

(2) Switching Radial-View Observation Height

The observation height is switched using the software. The measurement position is indicated by the observation height indicator.

The observation height for radial-view observation (i.e., the position above the RF coil) is indicated by the observation height indicator.

(3) Changing Radial-View Observation Height

The observation height is changed using the upper and lower observation position setting knobs.

To adjust the upper observation position, loosen the locking knob with [Up] set in the software's [Instrument Control] window, and turn the upper observation position setting knob while viewing the observation height indicator scale. Tighten the locking knob when the position on the scale is aligned with the desired setting.

To adjust the lower observation position, loosen the locking knob with [Down] set in the software's [Instrument Control] window, and turn the lower observation position setting knob while viewing the observation height indicator scale. Tighten the locking knob when the position on the scale is aligned with the desired setting.

NOTE

Tighten the locking knob securely after adjusting the observation position. If the locking knob is loose, the reproducibility of analytical values may be adversely affected.

(4) Attaching Entrance Window Cover

NOTE

Remove the cooling jacket when analyzing organic solvent samples or hydrofluoric acid samples. Otherwise, the cooling jacket may be damaged.

Attach the entrance window cover (provided) when performing radial-view observation with the cooling jacket removed.

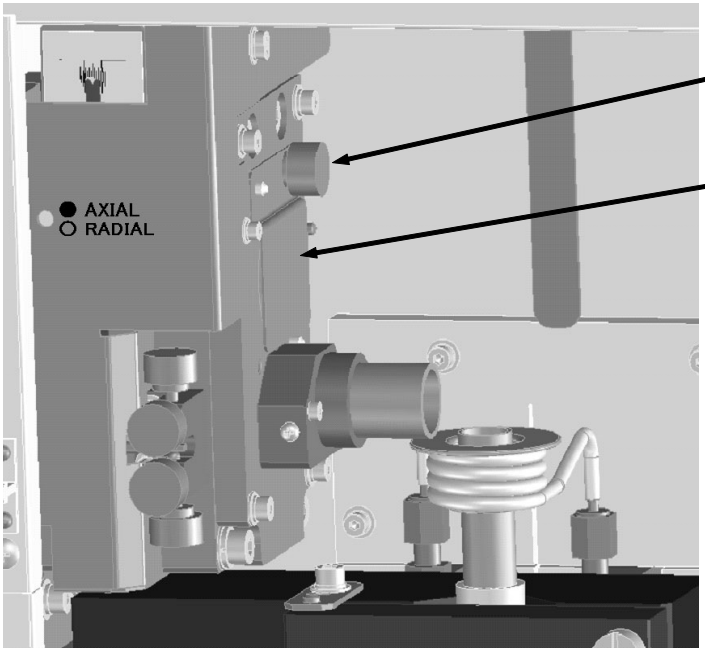


Fig. 5-12 Entrance Window Cover

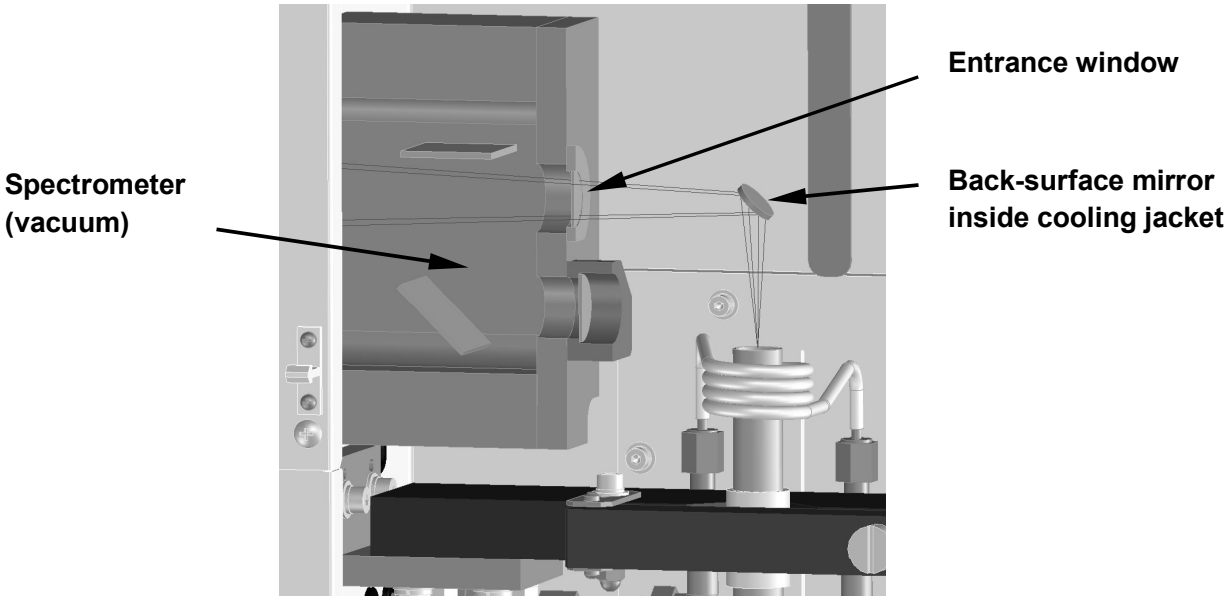


Fig. 5-13 Cooling Jacket Optical System with Radial-View Observation Kit (Option) Attached

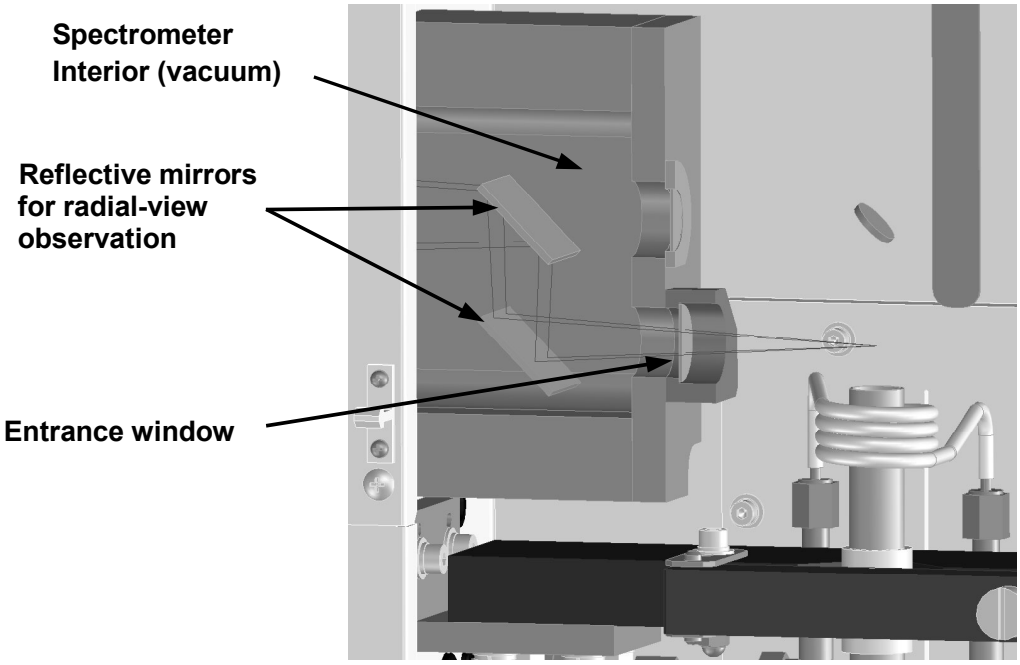


Fig. 5-14 Optical System for Radial-View Observation with Radial-View Observation Kit (Option) Attached

5.14.1 Lists of Maintenance Parts and Consumable Items for Radial-View Observation Kit

Maintenance Parts List

P/N	Part name	Notes
036-10202	O-RING, 1A P4	O-ring for shaft
036-10218	O-RING, 1A P18	O-ring for axial-view observation window
036-10222	O-RING, 1A P22	O-ring for radial-view observation window
036-12002	O-RING, 1A G30	O-ring for light-guiding pipe
036-12015	O-RING, 1A G90	O-ring for lid
017-30813-01	SI GREASE, HIVAC-G 50G	Vacuum grease
017-27023-01	GREASE, HP-300-100G	Grease for cylinder drive unit
211-86211-91	CYLINDER, LOWER MIRROR, ASSY	Cylinder for lower mirror
211-86212-91	CYLINDER, UPPER MIRROR, ASSY	Cylinder for upper mirror
211-86034-92	STOP VALVE, PURGE GAS	Valve for purge in radial direction
016-43285-23	PO TUBE, TPS0604B-20	Tube for purge in radial direction
211-86038-93	CAPILLARY ASSY, PURGE 0	Resistance tube for purge in radial direction
211-88158-91	CYLINDER, 4KA1 ASSY 14	Cylinder drive valve for upper mirror
211-88158-92	CYLINDER, 4KA1 ASSY 15	Cylinder drive valve for lower mirror
211-86128-91	TUBE ASSY, PURGE	Tube for purge in radial direction
211-86129-91	TUBE ASSY, AIR CYLINDER 1	Cylinder piping and resistance tube
211-86129-92	TUBE ASSY, AIR CYLINDER 2	Cylinder piping and resistance tube
211-86129-93	TUBE ASSY, AIR CYLINDER 3	Cylinder piping and resistance tube
211-86129-94	TUBE ASSY, AIR CYLINDER 4	Cylinder piping and resistance tube
072-60040-27	GROMMET, G-97	Part for cylinder piping
016-37515	TUBE, 9003-2.0X4.0WH	Cylinder piping
016-37515-03	TUBE, 9003-2.0X4.0YE	Cylinder piping
016-37515-04	TUBE, 9003-2.0X4.0GN	Cylinder piping
016-37515-05	TUBE, 9003-2.0X4.0Bk	Cylinder piping
631-40282	ELBOW, VITON, 6X6	Joint for purge in radial direction
211-86207-92	MIRROR UPPERSIDE	Reflective mirror of upper side
211-86210-92	MIRROR LOWERSIDE	Reflective mirror of lower side
211-86491	WINDOW COVER	Entrance window cover
211-86490-91	COVER LOCKING SCREWS M5	Entrance window cover locking screws

Consumable Items List

P/N	Part name	Notes
211-86218-91	PURGE PIPE, ADHESIVE	Quartz tube for purge in radial direction
211-84356	BONNET,STD TORCH	

5.15 RF Power Supply

The RF power supply includes the output unit, which is configured with transistors, the matching circuits for the output unit and the RF coil, and control system for external control. This power supply is designed specifically for use with plasma and improved for the use of digital control instead of analog control.

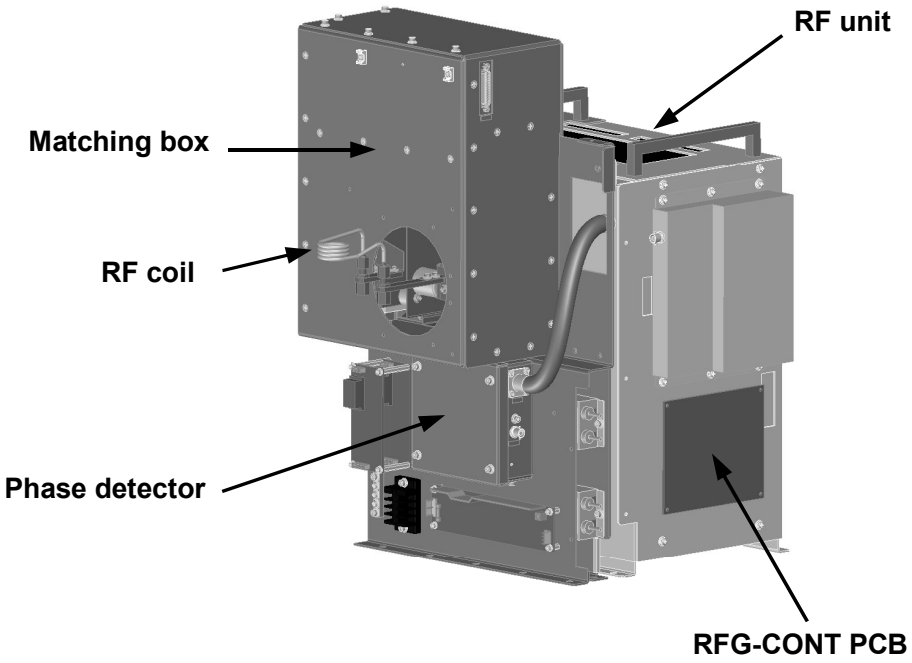


Fig. 5-15 Names of RF Power Supply Parts

(1) RFG-CONT PCB

Controls each part of this power supply. It has the following three functions.

* Exchange of signals with the CPU
* Control of autotuning
* Safety checks

(2) RF Unit

Produces a maximum output of 1.6 kW at a frequency of 27.12 MHz.

(3) Phase Detector Unit

Detector for RF power.

5.16 Purpose and Operating Principles of Safety Devices

The ICPE-9000 incorporates the following safety devices: a temperature fuse in the plasma stand, a plasma stand door switch, a coolant flow switch, a temperature fuse in the RF power supply, an argon gas pressure switch, a photoelectric switch, and a CCD condensation sensor. See "7.2 Checking Operation of Safety Devices" for details on the procedures used to check the operation of safety devices.

WARNING

Risk of Electric Shock or Burn Injury

Do NOT use the equipment with the safety devices disabled. Doing so may result in electric shock or burn injury.

(1) Argon Gas Pressure Sensor

Monitors the argon gas pressure. If the pressure drops to 300 kPa or less, a safety circuit operates and interrupts RF output.

(2) Plasma Stand Door Switch

Ensures that RF output is not applied to the coil when performing maintenance checks inside the plasma stand. If the plasma stand door is opened, a safety circuit operates and interrupts RF output.

(3) Coolant Flow Switch

Monitors the coolant. If no coolant is flowing, a safety circuit operates and interrupts RF output to prevent burning of the RF coil and overheating of the cooling jacket.

(4) Temperature Fuse in RF Power Supply

Monitors the power amplifier's DC power supply unit in the RF power supply. If the radiator temperature of any part increases to 60°C or higher, a safety circuit operates and interrupts RF output.

(5) Temperature Fuse in Plasma Stand

Monitors the temperature inside the plasma stand. If the temperature inside the plasma stand increases to 60°C or higher, a safety circuit operates and interrupts RF output.

(6) Photoelectric Switch

Detects whether or not the plasma is ignited. If the plasma is extinguished, a safety circuit operates and interrupts RF output.

(7) Spectrometer Temperature Switch

Monitors the temperature of the spectrometer's temperature-controlled bath. If the temperature of the temperature-controlled bath reaches 60°C, a buzzer sounds and the power supply to the heater turns OFF.

(8) CCD Condensation Sensor

The CCD detector is cooled at a water temperature of approx. 10°C. If the water temperature is too low or if the humidity level of the installation location is too high, condensation may occur on the internal radiator plate and possibly result in damage to the CCD. If the humidity level inside the CCD detector becomes too high, the sensor operates and automatically extinguishes the plasma and turns OFF the CCD power supply.

5.17 Connector Panel

The connector panel is used to connect to optional units.

* PUMP
  Terminal used to connect to a peristaltic pump (option).

* ASC
  Terminal used to connect to the ASC-6100F autosampler (option).

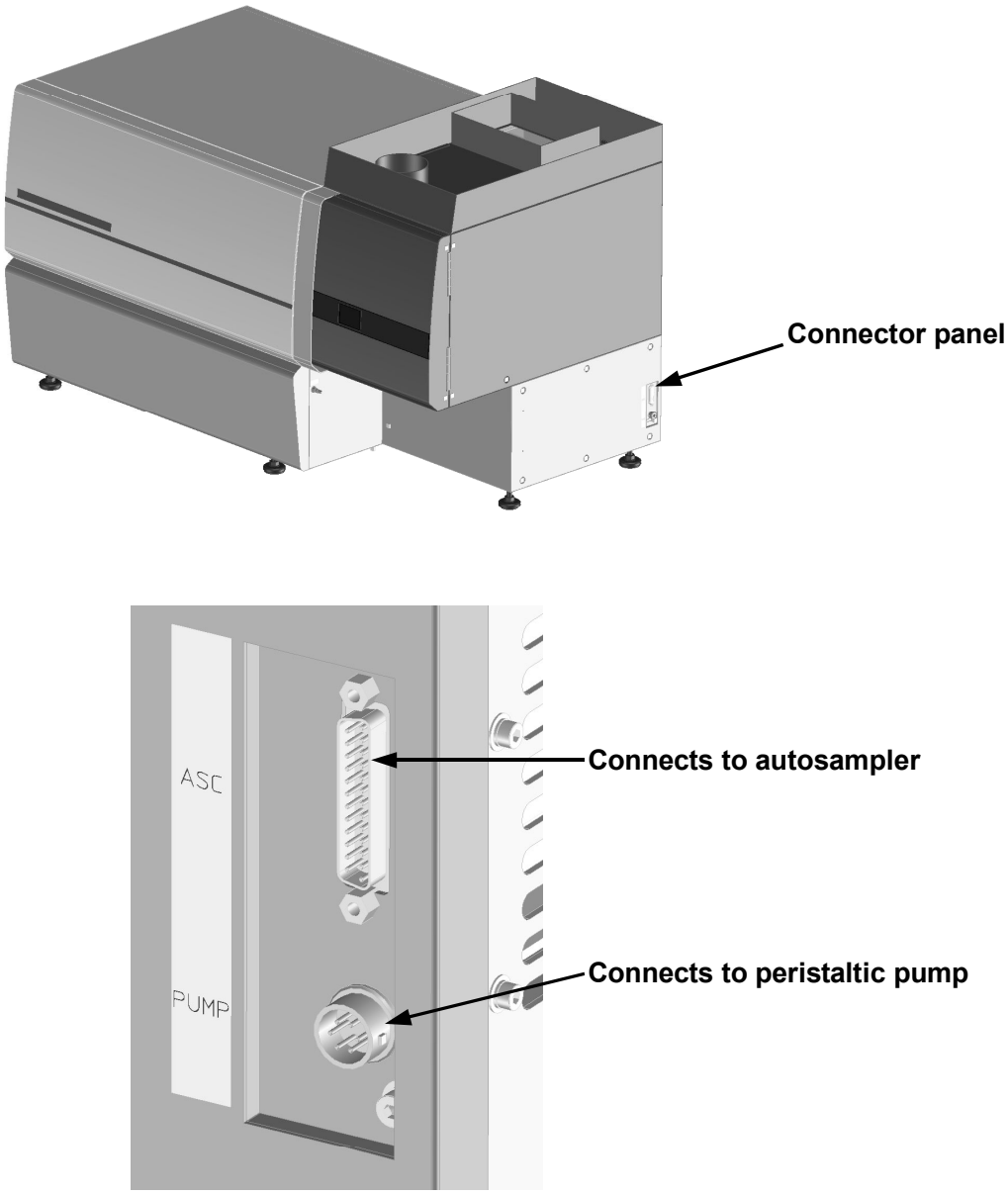


Fig. 5-16 Connector Panel

5.18 ASC-6100F Autosampler (Option)

5.18. 1 Connection

(1) Connect the control signal cable connector provided with the autosampler to the autosampler and the ICPE-9000's connector panel. (See "5.17 Connector Panel".)

(2) Connect the nebulizer's sample introduction tube (see "Fig. 5-8") and the autosampler's suction tube to the connection tube (P/N 211-83687) provided with the ICPE-9000.
Cut the nebulizer's sample introduction tube and the autosampler's suction tube to appropriate lengths before connecting them.

(3) Connect the autosampler's power cable to the extension cable.

(4) Turn ON the autosampler's power switch.

Refer to the instruction manual provided with the ASC-6100F autosampler for further details.

5.18.2 Consumable Items

The part detailed below is a consumable item required when using the ASC-6100F autosampler for the ICPE-9000.

Refer to the instruction manual provided with the ASC-6100F autosampler for details on other consumable items and maintenance parts specific to the ASC-6100F autosampler.

P/N	Part Name	Approximate Replacement Period	Material
211-83697	CONNECTION TUBE	1 month (*1)	Made by Cole-Parmer (U.S.): P-95609-30

(*1) Although the above connection tube is resistant to acids, alkalis, and many types of solvents, check that it can be used beforehand.

5.19 Optional Plasma Torch and Orifice Assembly

If axial view observations are performed using the optional plasma torch (P/N 204-70272) or high TDS torch (P/N 204-77296), the optional orifice assembly (P/N 211-43740) is required. Replace the orifice assembly L attached to the cooling jacket with the orifice assembly (P/N 211-43740).

Cleaning of the orifice assembly (P/N 211-43740) is the same as for cleaning of the axial-view observation orifice assembly L in section 8.8.

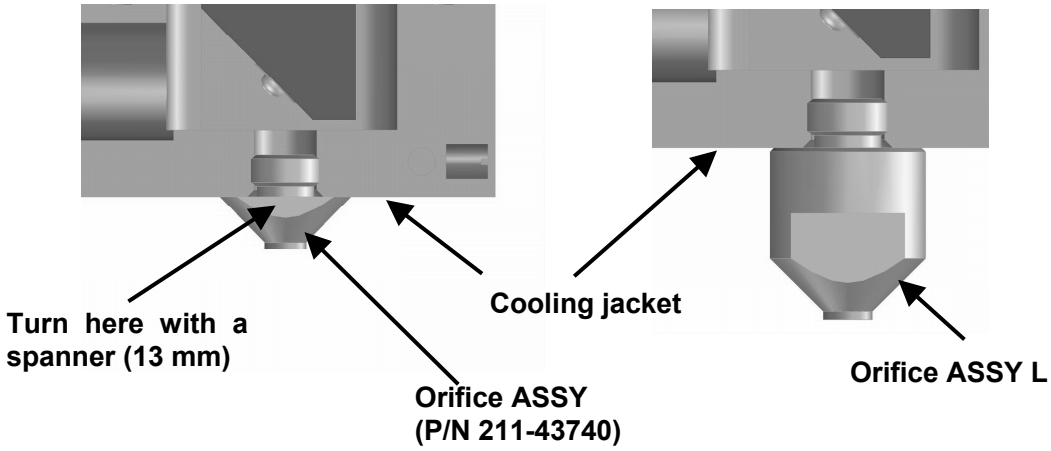


Fig. 5-17 Orifice ASSY and Orifice ASSY L

NOTE

The orifice assembly L will deteriorate rapidly if the plasma is ignited using the plasma torch (P/N 204-70272) or high TDS torch (P/N 204-77296) with the orifice assembly L installed.

6. Specifications

6.1 Plasma Light Source

(1)	Torch unit	Axial-view observation with argon gas purge function
(2)	Spray chamber	Cyclone chamber made of Pyrex glass
	Plasma torch	Mini-torch made of quartz
	Nebulizer	Coaxial type made of Pyrex glass
(3)	RF power matching system	Automatic matching
(4)	Gas controller	Automatic control of gas flow rate from CPU
		Three flow lines for plasma
		Flow rate setting ranges
		Plasma gas (coolant gas) 0 to 20 L/min
		Auxiliary gas 0 to 1.5 L/min
		Carrier gas 0 to 1.5 L/min
		Purge gas for cooling jacket 0.5 and 4.5 L/min
		Purge gas for CCD 0.5 and 4.5 L/min

6.2 RF Power Supply

(1)	Oscillator	Crystal oscillator
(2)	Frequency	27.12 MHz
(3)	RF output	1.6 kW max.
(4)	Output stability	Within ±0.3%
(5)	RF circuit element	Transistor
(6)	Control system	CPU control
(7)	Ignition method	Completely automated
(8)	Loading matching function	Automatic matching supported
(9)	Safety functions	Overheating/overload detected

6.3 Spectrometer

(1)	Optical system	Echelle mounting
(2)	Wavelength range	167 nm to 800 nm
(3)	Dispersive elements	Echelle diffraction grating with 79 grooves/mm
		Prism
(4)	Reciprocal linear dispersion	0.27 nm/mm (200 nm)
		0.82 nm/mm (600 nm)
(5)	Spectrometer temperature	Equipped with temperature control
(6)	Vacuum system	Rotary pump with leak valve control
		Pressure: 10 Pa max.

6.4 Measuring Unit

Two-dimensional CCD semiconductor detector

- Effective light-receiving surface 20.48 mm × 20.48 mm
- Effective number of pixels 1,024 × 1,024 pixels
- Pixel size 20 μm × 20 μm
- Equipped with peltier cooling device
- Equipped with condensation sensor

6.5 Data Processing Unit Software: ICPEsolution

6.5.1 Measurement Samples

1 data file, 300 samples max.

6.5.2 Qualitative Analysis

- Analysis using internal database
- Automatic selection of qualitative-analysis wavelength for each sample
- Database correction function

6.5.3 Quantitative Analysis: Calibration Curve Method / Standard Addition Method

- Measurement wavelength:
  Possible to set multiple measurement wavelengths for each element
  Automatic selection of quantitative-analysis wavelength for each sample
- Correction methods:
  Background correction, inter-element correction, internal standard correction, drift correction, weight/dilution correction
- Calibration curve:
  1st to 3rd order expressions
- Printing:
  Setting of printing items
  Automatic printing of analysis results after measurement
  Batch printing (analysis conditions, calibration curves, analysis results, etc.)
- Saving data:
  Echelle mode (all data saved)
  Analysis wavelength save mode (only data for selected wavelengths saved)
- Recalculation functions:
  Addition and recalculation for analysis elements and wavelengths
  Recalculation of intensity after changing intensity calculation information, such as the accumulation interval, the background point, or the internal standard element
  Changing of calibration curve conditions, such as the calibration curve order
- QA/QC functions (optional):
  Evaluation and recorrection of calibration curve and inter-element correction coefficients
  Evaluation, recorrection, and remeasurement of drift during measurement
  Recovery test, dilution test, remeasurement test
- Copying of display contents:
  Analysis values, profiles, and calibration curves can be copied to other applications using the Windows clipboard function.

6.5.4 User Support

- Development assistant
- Diagnosis assistant

6.5.5 Instrument Control

- Monitor display of instrument status
- Control of vacuum pump
- Automatic igniting/extinguishing of plasma
- Automatic extinguish function that operates when analysis completed
- Automatic control of autosampler

6.6 Utilities

6.6.1 Power Supply Requirements

Single phase,200/220/230/240 V ±10% (upper limit: 250 V), 50/60 Hz, 30 A

6.6.2 Ground

30 Ω max., independent ground

6.6.3 Argon Gas

Purity	99.95% min.; Pressure: 450±10 kPa

6.6.4 Cooling water

Mains water	Pressure: 100 kPa to 300 kPa; Flow rate: 1 L/min min.
CCD cooling water	Temperature setting range: 0°C to room temperature
	Temperature control precision: ±0.1°C
	Cooling capacity: 200 W min.; Liquid temperature: 10°C
	Pumping capacity (maximum pump head): 2.1 m min. at 50 Hz, 2.4 m min. at 60 Hz
	Coolant may be pumped to the main unit only while pumping signals are being output from the main unit.
	Pumping signals: 24 VDC, 0.5 A

6.6.5 Installation Conditions

Temperature	18°C to 28°C (temperature must not fluctuate more than 2°C/hour)
Humidity	20% to 70% (with no condensation)

6.6.6 Dimensions and Weight

Dimensions	1,380 mm (width) × 740 mm (depth) × 760 mm (height)
	(not including plasma stand exhaust guide)
Weight	270 kg

6.6.7 Options

Autosampler

Radial-view observation kit (option)

Hydrofluoric acid sample introduction system

Ultrasonic nebulizer

Peristaltic pump

Hydride generator

NOTE

The PC used for data processing with the ICPE-9000 must satisfy the following specifications.

1)	CPU	Intel® Celeron D300 2.66 GHz min. or equivalent
2)	RAM	768 MB min.
3)	HDD	80 GB min.
4)	FDD	3.5", 1 min.
5)	CD-ROM	1 min.
6)	Display	Resolution of 1,280 × 1,024 dots min.
7)	OS	Windows XP
8)	LAN interface	100BASE-T
9)	Mouse	
10)	Printer	Page printer compatible with Windows XP

7. Operation

This section describes the procedures used to start and stop the ICPE-9000. Refer to the software instruction manual for details on the analysis operations.

7.1 Starting the ICPE-9000

7.1.1 Starting the ICPE-9000 at Installation

(1) Connect the main unit and the PC with the LAN cable.

(2) Connect the power cable, the argon gas piping, and the coolant piping.

(3) Supply power to the ICPE-9000.

Turn ON the power switch. (Raise the lever.)

Switch Indication

I : ON

○ : OFF

(4) Turn ON the CRT power switch

(5) Turn ON the printer power switch.

(6) Turn ON the computer power switch.

(7) Perform the operations described below under "7.1.2 Starting the ICPE-9000 in Daily Use".

7.1.2 Starting the ICPE-9000 in Daily Use

(1) Supply coolant to the ICPE-9000.

If mains water is used, open the main valve of the mains water supply.

If a cooling water circulation system is used, start the system.

(2) Supply argon gas to the ICPE-9000.

Open the main valve of the argon gas supply. The pressure of the argon gas supplied to the ICPE-9000 is in the range 450±10 kPa.

(3) Turn ON the exhaust duct that you attached above the plasma stand exhaust guide.

WARNING

Risk of Oxygen Deficiency

There is a risk of oxygen deficiency. Be sure to operate the exhaust duct.

(4) Open the plasma stand and check that the cooling jacket, glassware, and other items are set properly.

NOTE

Check that the water-cooled tube and the argon gas purge tube are connected.
If they are not connected, the cooling jacket may be damaged when the plasma is ignited.

(5) Start the software and perform the necessary operations.

NOTE

If an irregularity is observed during the startup procedure, turn OFF the power switch and other power supply equipment, stop the supply of coolant and argon gas, and contact your Shimadzu representative.

NOTE

During vacuum pump operation, exhaust from the exhaust outlet contains oil mist.
Use the following oil mist trap to trap this mist. (purchased separately)
P/N 042-00125-25 OIL MIST TRAP, OMT-050A

NOTE

If a vacuum error occurs after the vacuum pump has been operating for 20 minutes, turn ON the vacuum pump again. (Select [ON] in the "Vacuum Pump ON/OFF" window on the [Instrument] menu, and click [OK].)
If the same error re-appears, replace the molecular sieve.
(See 8.12 Replacing the Molecular Sieve (Oil Absorbent) in the Vacuum Pump)
If the error continues to occur, please contact your Shimadzu representative.

7.1.3 Stopping the ICPE-9000 in Daily Use

(1) Quit the software.

(2) Stop the supply of coolant.

(3) Turn OFF the printer power switch.

(4) Turn OFF the monitor power switch.

(5) Turn OFF the computer power switch.

(6) Turn OFF the exhaust duct.

NOTE

If the power switch is turned OFF, the spectrometer temperature-control circuit stops operating.

The time required for the spectrometer to stabilize varies with the external temperature but, if it has been OFF for 24 hours, 6 hours is required. It soon recovers, however, after a momentary power interruption.

In consideration of this point, then, leave the power switch ON if continuous temperature control is required. Turn OFF the power switch only when stopping the equipment for a long time.

7.1.4 Leak Valve Operation (After vacuum pump is stopped)

NOTE

When stopping the vacuum pump, release the molecular sieve case to atmospheereic pressure.

(1) After stopping the vacuum pump, open the leak valve.
(Viewed from above, turn the valve counter-clockwise 2 complete turns.)
(2) After the air-leak sound disappears, close the leak valve.

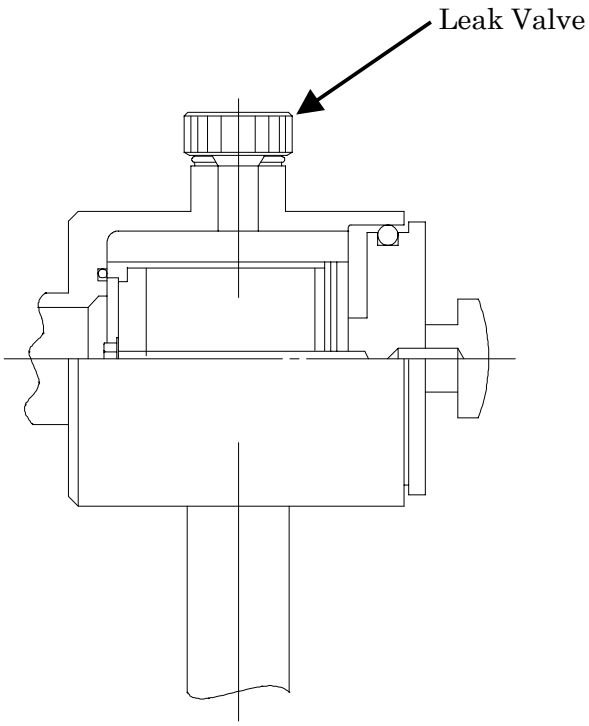


Fig. 7-1 Molecular Sieve Case

NOTE

Do NOT turn OFF the power switch before exiting the software. Otherwise, an error will occur.

NOTE

If the cooling water circulation system is not going to be used for a long time, remove the water from the tank.
Also, replace the water in the tank at least once a month.

7.2 Checking Operation of Safety Devices

The ICPE-9000 is equipped with safety devices. The plasma cannot be ignited if the safety devices are not operating properly. See "8.16 Checking Operation of Safety Devices" for details on the checking procedures. Check the operation of the safety devices on a regular basis (every one month)

7.3 Response in Emergency

In the event of an emergency situation, such as a fire or an earthquake, if there is not enough time to stop the ICPE-9000 in the usual way, turn OFF the ICPE-9000's power switch. The power supplied to the ICPE-9000 is interrupted.

Stop the supply of argon gas to the ICPE-9000 by closing the main valve of the argon gas supply.

Stop the supply of coolant to the ICPE-9000.

NOTE

If there is enough time, stop the ICPE-9000 as described in "7.1.3 Stopping the ICPE-9000 in Daily Use".

7.3.1 Recovery after Emergency Stop

After stopping the ICPE-9000 by turning OFF the power switch, perform the following recovery procedure.

(1) Turn OFF the computer power switch.

(2) Turn ON the power switch.

(3) Start the ICPE-9000 as described in "7.1 Starting the ICPE-9000".

7.3.2 Response to Power Failure

In the event of a power failure, perform the following procedure.

(1) Turn OFF the breaker of the power supply line.

(2) Turn OFF the ICPE-9000's power switch and the computer power switch.

(3) When power is restored, start the ICPE-9000 as described in "7.1 Starting the ICPE-9000".

8. Maintenance

NOTE

Extinguish the plasma at least once a day to perform, for example, maintenance of the glassware and to check that there is no condensation on the parts.

8.1 Replacing and Inspecting Glassware

The glassware inside the ICP stand must sometimes be cleaned or replaced. The approximate replacement period and the replacement procedure are given below.

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

CAUTION

The glassware is fragile. Handle it with care.

8.1.1 Replacing the Torch

Replace the torch in the following cases.

* If the torch melts (periphery)
* If samples adhere to the torch's center orifice
* If, after analyzing high-concentration boron (B), a trace amount of another element is to be analyzed
* If the torch's center orifice melts or is damaged in some other way

NOTE

Even if the internal diameter of the tip of the torch's center orifice becomes smaller, this cannot be checked with the torch installed. If the spectra for an element do NOT appear or if the intensity weakens, it is possible that the tip of the torch's center orifice has melted or the internal diameter has changed. Remove the torch and check the tip of the torch's center orifice.

8.1.2 Nebulizer

Deposits adhere to the tip of the nebulizer when analyzing alkali solvents. Be sure to use a water bubbler (option) when analyzing this kind of sample. If there is clogging in the tip of the nebulizer, the sample suction speed may reduce significantly and sample suction may even stop. In this case, the nebulizer must be replaced or cleaned.

8.1.3 Replacing the Chamber

Replace the chamber in the following cases.

* If a conspicuous amount of dirt accumulates
* If there is a crack or some other damage that causes gas to leak and adversely affect operation

8.1.4 Cleaning Glassware

Clean the glassware with hydrochloric acid (HCl) 2 standard solution.

NOTE

Do NOT perform ultrasonic cleaning on the glassware.

8.2 Removing Glass Parts

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

CAUTION

Glass parts break easily and may cause injury if they are damaged. Handle them with care.

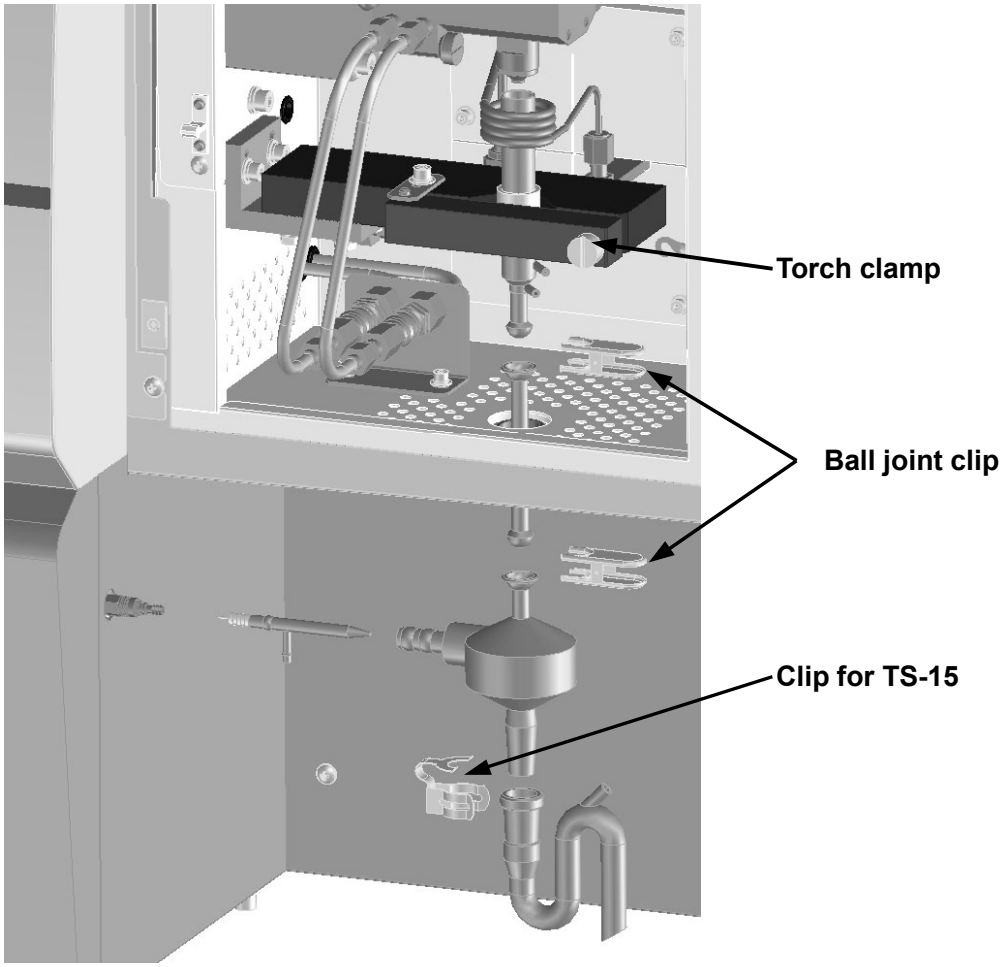


Fig. 8-1 Removing Glassware

8.2.1 Removing the Chamber and Extension Pipe

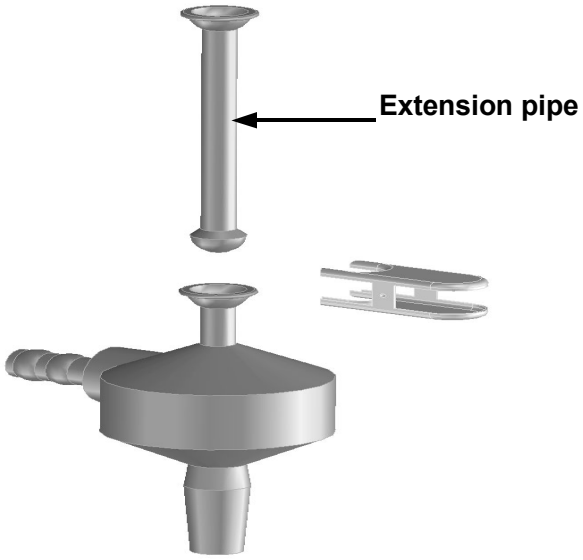


Fig. 8-2 Removing the Chamber

* Remove the ball joint clip that connects the chamber and the extension pipe and remove the chamber.
* Remove the ball joint clip that connects the extension pipe and the torch and remove the extension pipe.

8.2.2 Removing the Nebulizer

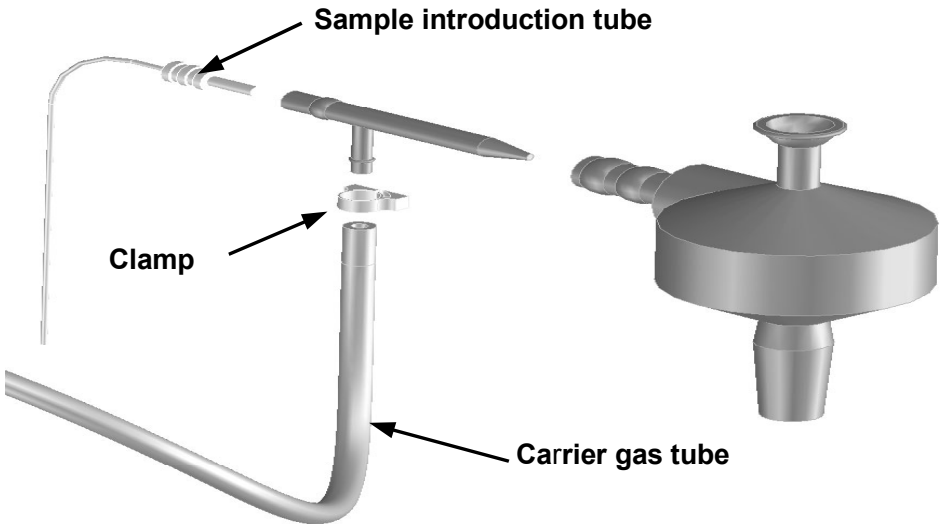


Fig. 8-3 Removing the Nebulizer

(1) Remove the nebulizer from the chamber.

* Hold the part connecting the chamber and the nebulizer with one hand and hold the nebulizer with the other hand.
* Pull the nebulizer out of the chamber.

(2) Remove the carrier gas tube's clamp.

* Slide the clamp's hook up and down to remove it.

(3) Remove the carrier gas tube.

* Hold the nebulizer's carrier gas inlet with one hand and, with the other hand, pull and turn the carrier gas tube to remove it.

(4) Remove the sample introduction tube.

* Hold the part connecting the nebulizer's sample introduction tube with one hand and, with the other hand, pull the sample introduction tube to remove it.

8.2.3 Removing the Leveler

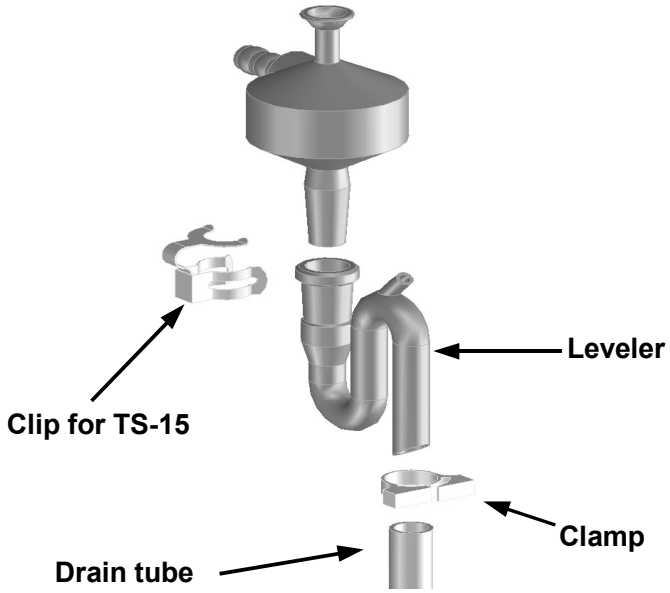


Fig. 8-4 Removing the Leveler

(1) Remove the clip for TS-15.

* Hold the part connecting the chamber and the leveler with one hand and, with the other hand, pull the clip for TS-15 to remove it.

(2) Remove the part connecting to the leveler exhaust tube.

(3) Remove the leveler.

* Hold the chamber with one hand and, hold the leveler with the other hand, and pull and turn the chamber to remove the leveler.

(4) Remove the liquid in the leveler.

(5) Remove the drain tube.

* Slide the clamp's hook up and down to remove it.
* Hold the part connecting to the leveler drain tube with one hand, hold the drain tube with the other hand, and pull the leveler away from the drain tube.

8.2.4 Removing the Torch

(1) Remove the torch from the torch mount.

* Turn the torch clamp to loosen it and remove the torch. (If the chamber is set, remove the chamber first.)

(2) Remove the plasma gas tube assembly and the auxiliary gas tube.

* Hold the plasma gas inlet of the torch with one hand, hold the end of the tube with the other hand, and pull and turn the tube to remove it.
* Remove the auxiliary gas tube in the same way.

(3) Remove the igniter cable from the torch.

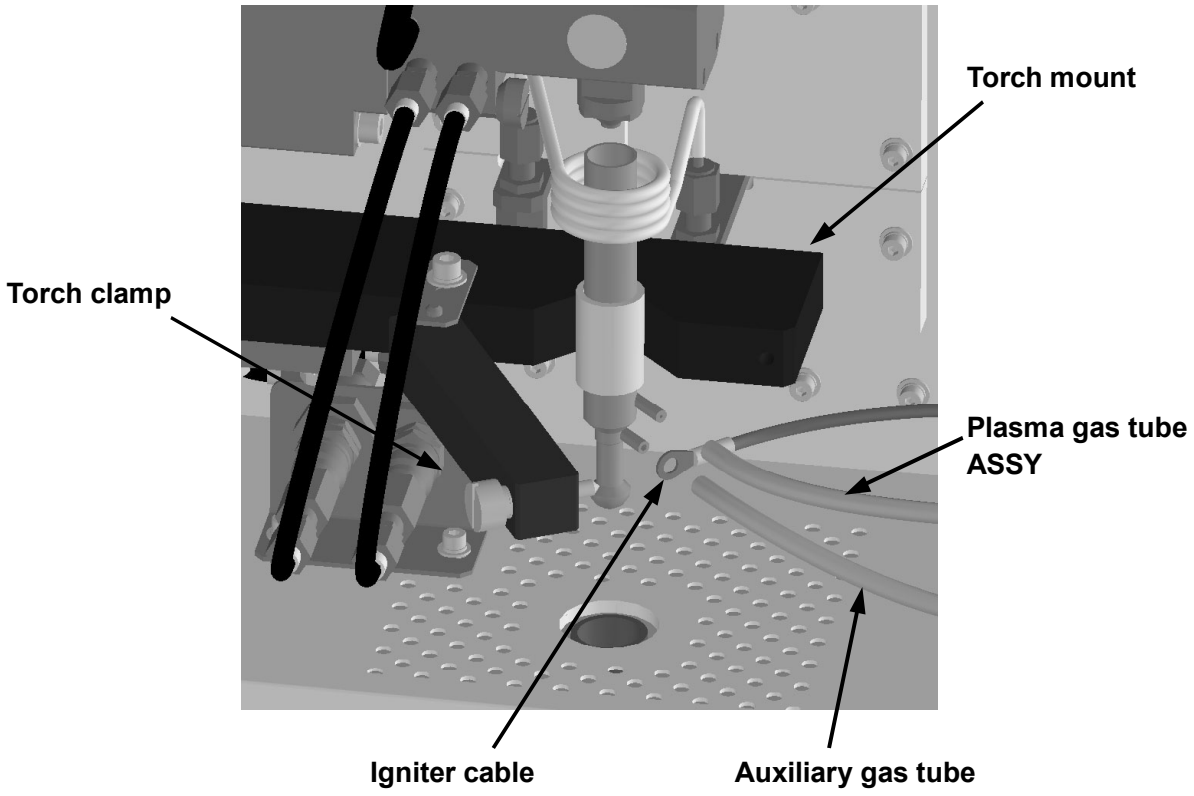


Fig. 8-5 Removing the Torch

8.3 Attaching the Glassware

CAUTION

Glass parts break easily and may cause injury if they are damaged. Handle them with care.

8.3.1 Attaching the Torch

(1) Connect the igniter cable to the auxiliary gas inlet of the torch.
(2) Push the igniter cable through the hole shown in Fig. 8-6 Igniter Cable Installation, until there is no slack.

NOTE

Check that the igniter cable is securely connected to the auxiliary gas inlet of the torch.

If the igniter cable is positioned near the electrode that is connected to the high-frequency induction coil, electrical discharges can damage the cable.

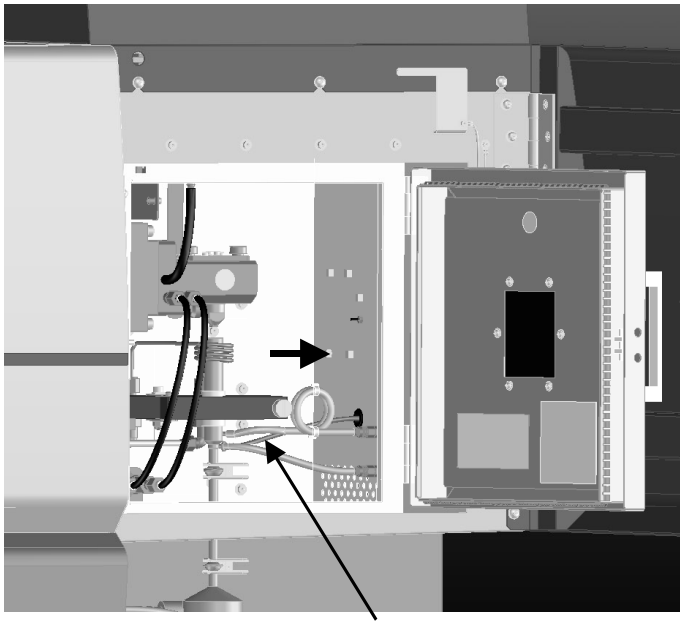


Fig. 8-6 Igniter Cable Installation

(3) Insert the plasma gas tube assembly and the auxiliary gas tube in the torch.

* Insert approx. 10 mm of plasma gas tube assembly into the plasma gas inlet of the torch.
* Insert approx. 10 mm of tube into the auxiliary gas inlet of the torch.
* Attach the Teflon ring at a position 46 mm from the end of the torch. This Teflon ring is not required for the optional plasma torch.

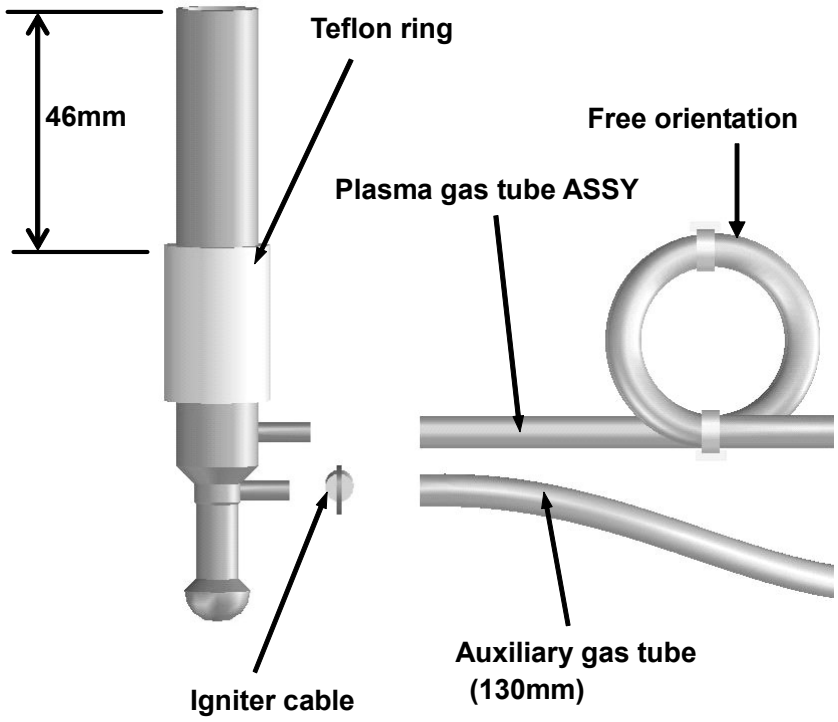


Fig. 8-7 Attaching Gas Tubes, Igniter Cable, and Teflon Ring

(4) Secure the torch to the torch mount.

* Insert the torch in the torch mount and turn the torch clamp to lightly secure the torch.

(5) Adjust the torch position.

* Stand the torch position adjustment jig on the torch mount.
* Move the torch to the position where the protruding section of the torch position adjustment jig makes contact with the end of the torch and, in this position, turn the torch clamp to secure the torch.

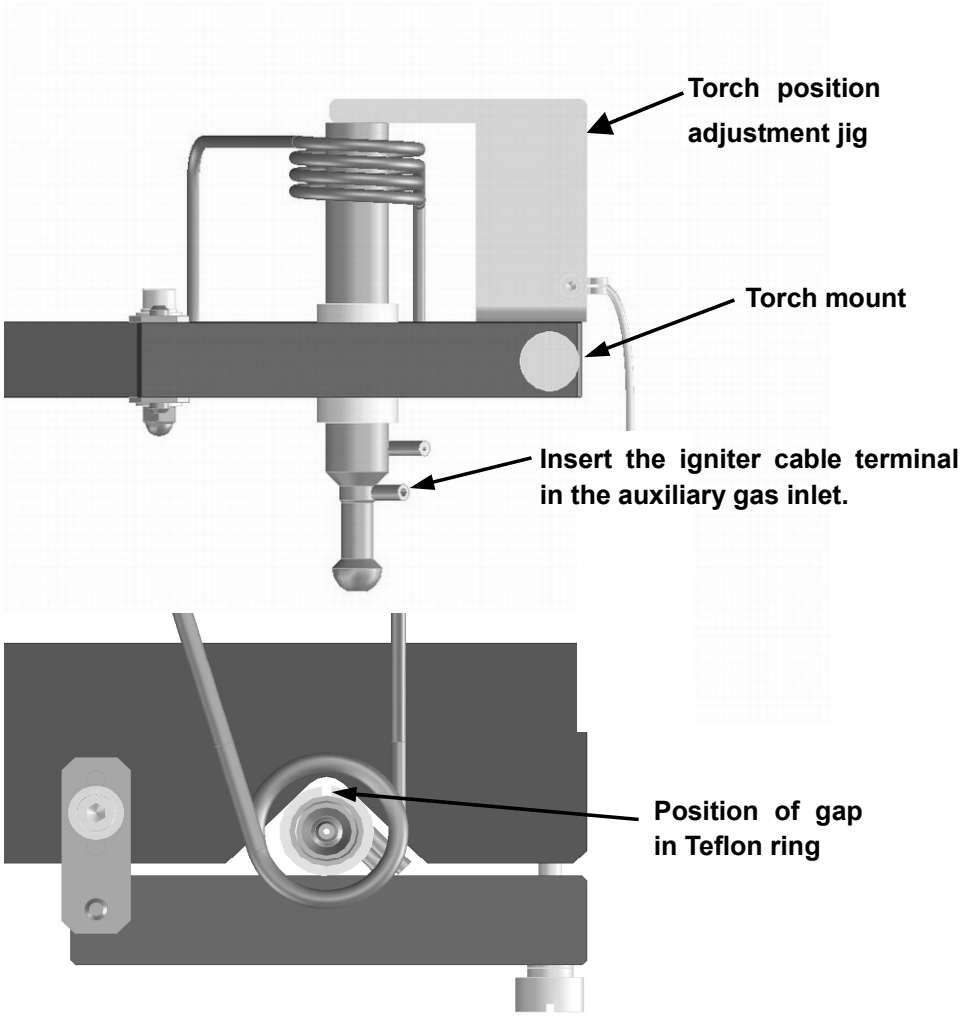


Fig. 8-8 Attaching the Torch

(6) Remove the torch position adjustment jig and return it to the original position. At this time, pull the chain protruding from the torch position adjustment jig outside the plasma stand door.

NOTE

Do NOT tighten the clamp with a driver or some other tool. Tightening the clamp forcefully with a tool may cause the torch to break.

NOTE

Be sure to remove the torch position adjustment jig before igniting the plasma. Igniting the plasma with the torch position adjustment jig standing on the torch mount may cause damage to the torch, RF coil, or torch position adjustment jig.

8.3.2 Attaching the Leveler

(1) Attach the drain tube.

* Insert approx. 20mm of drain tube into the bottom end of the leveler.
* Secure the drain tube with the clamp.

(2) Attach the leveler to the chamber.

* Insert the leveler into the bottom end of the chamber.
* Attach the clip for TS-15.

(3) Connect the leveler exhaust tube.

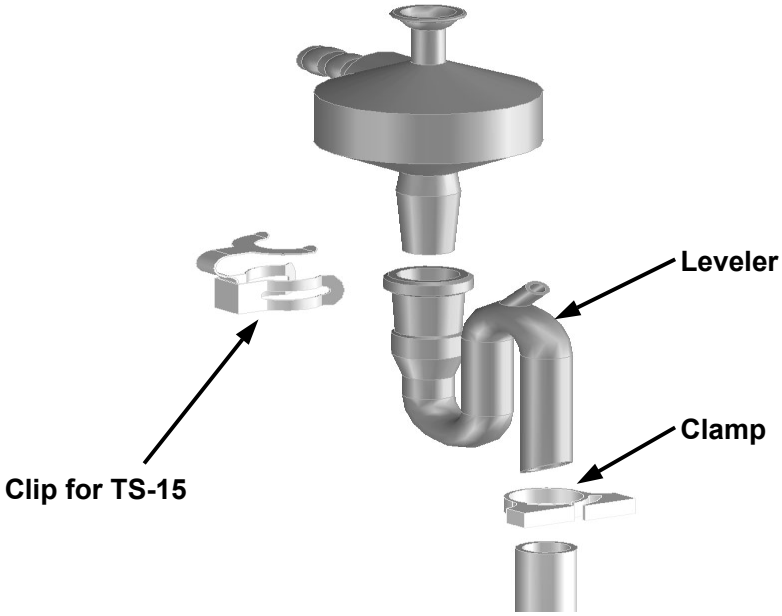


Fig. 8-9 Attaching the Leveler

8.3.3 Attaching the Nebulizer

(1) Attach the carrier gas tube.

* Hold the nebulizer's carrier gas inlet with one hand and, with the other hand, insert approx. 10 mm of the carrier gas tube into the carrier gas inlet.

* Attach the clamp.

(2) Attach the sample introduction tube.

* Insert the sample introduction tube up to the end of the nebulizer's sample introduction tube insertion port.

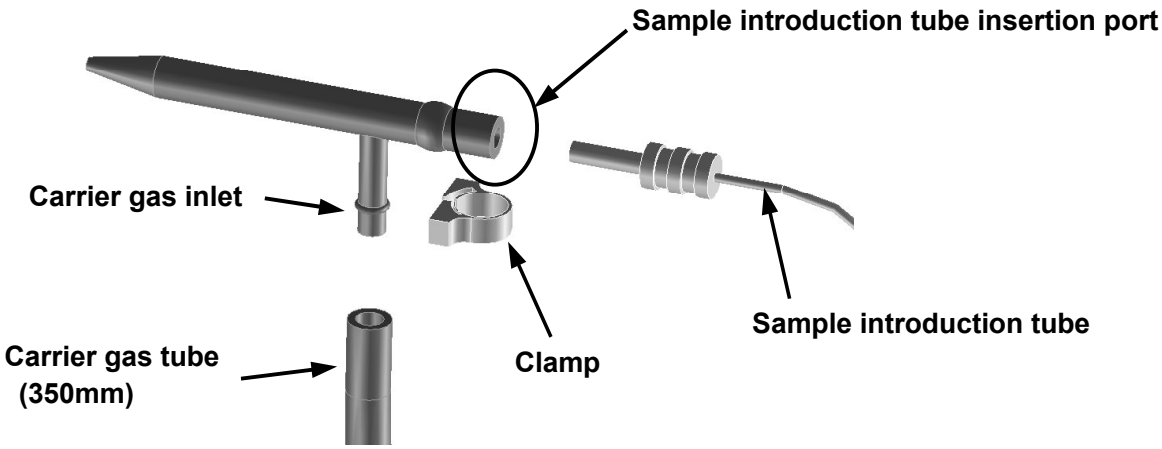


Fig. 8-10 Attaching the Nebulizer, Sample Introduction Tube, and Carrier Gas Tube

8.3.4 Attaching the Nebulizer to the Chamber

* Hold the chamber's nebulizer inlet with one hand and, with the other had, insert the nebulizer into the chamber. Check that the straight section of the nebulizer is securely inserted in the chamber's O-ring section.

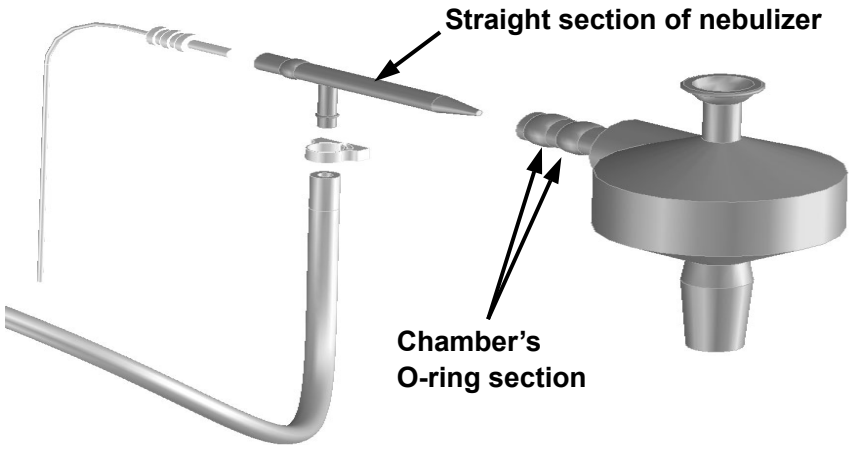


Fig. 8-11 Attaching the Nebulizer to the Chamber

8.3.5 Attaching the Chamber

(1) Join the ball joint of the torch and the extension pipe, and secure the connection with the ball joint clip.

(2) Join the ball joint of the extension pipe and the chamber, and secure the connection with the ball joint clip.

(3) Set the torch, extension pipe, and chamber so that they form a straight line.

(4) Fill the leveler with water.

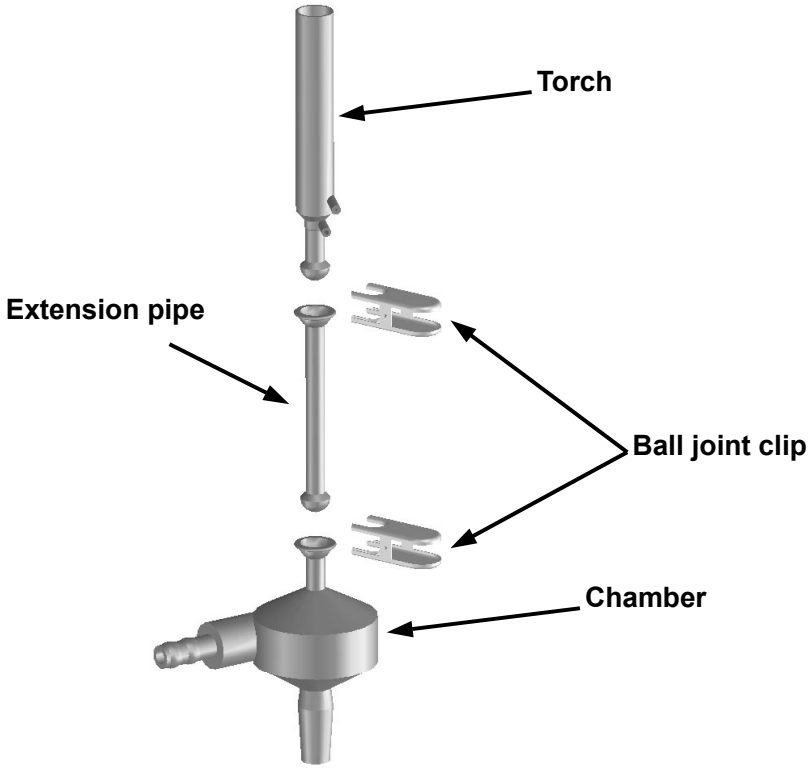


Fig. 8-12 Attaching the Chamber

8.4 Replacing the Sample Introduction Tube

The sample introduction tube, the sample introduction tube's nebulizer insertion port, and the drain tube are affected by sample solvents. This may cause liquid leakage or instability in sample suction. In this case, replace the sample introduction tube. Insert the new sample introduction tube up to the end of the nebulizer's sample introduction tube insertion port.

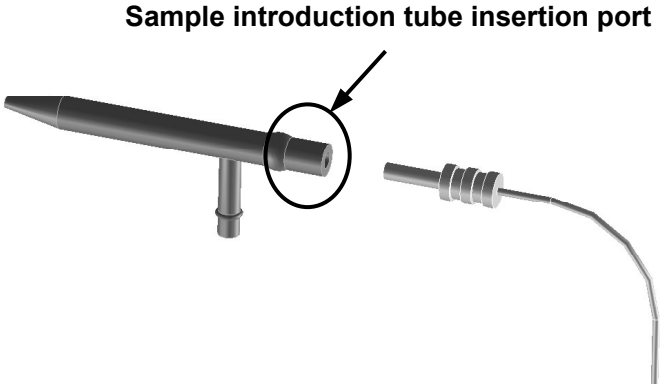


Fig. 8-13 Replacing the Sample Introduction Tube

8.5 Replacing the Drain Tube

(1) Remove the drain tube as described in "8.2.3 Removing the Leveler".

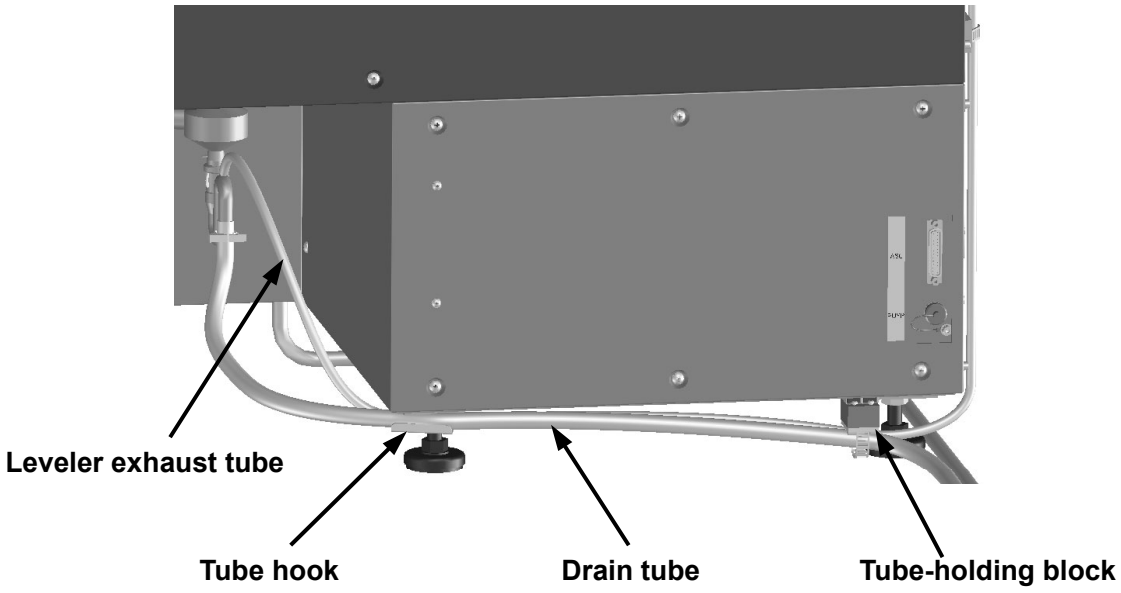


Fig. 8-14 Tube Arrangement on Right Side

(2) Remove the tube-holding block's band and take out the drain tube.

(3) Take the drain tube out of the tube hook and, if there is still some solvent in the drain tube, drain

it into the waste tank.

(4) Connect the new drain tube to the leveler as described in "8.2.3 Removing the Leveler".

(5) Insert the drain tube into the tube hook. Ensure that there is no slack in the drain tube between the leveler and the tube hook.

(6) Secure the drain tube and the leveler exhaust tube with the tube-holding block. Ensure that there is no slack in the drain tube between the tube hook and the tube-holding block.

(7) Insert the drain tube into the waste tank. Ensure that the end of the drain tube is not immersed in waste.

(8) Fill the leveler with water.

8.6 Replacing the Leveler Exhaust Tube

(1) Pull the leveler exhaust tube out of the leveler. (See "Fig. 8-14".)

(2) Remove the exhaust tube from the tube hook and the tube-holding block.

(3) Remove the leveler exhaust tube from the holding bands on the duct.

(4) Remove the leveler exhaust tube from the holding bands on the rear side.

(5) Insert the new leveler exhaust tube in the holding bands on the duct. Ensure that the end of the leveler exhaust tube does not protrude above the top end of the plasma stand exhaust guide.

(6) Secure the leveler exhaust tube with the holding bands on the rear side.

(7) Secure the leveler exhaust tube and the drain tube with the tube-holding block and the tube hook. Ensure that there is no slack in the drain tube. (See "Fig. 8-14".)

(8) Attach the leveler exhaust tube to the leveler.

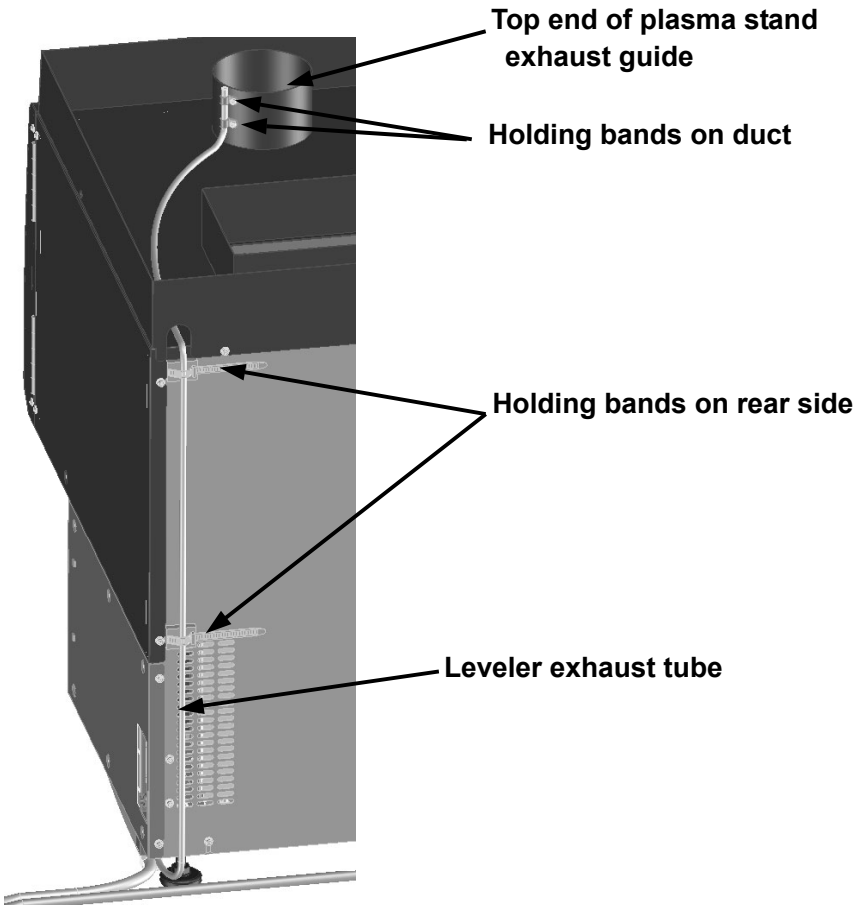


Fig. 8-15 Tube Arrangement on Right Rear Side

8.7 Cleaning and Replacement of Reflect Mirror in Cooling Jacket

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

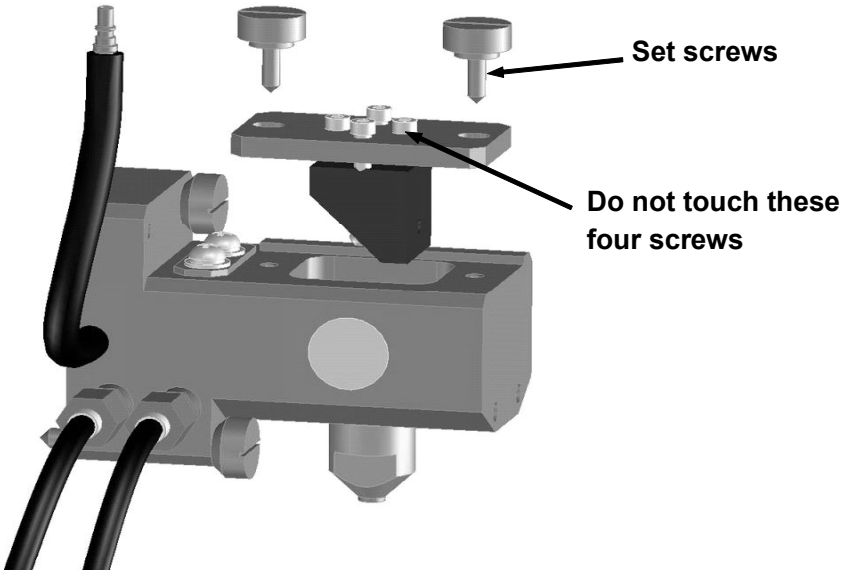


Fig. 8-16 Removing the Mirror Holder

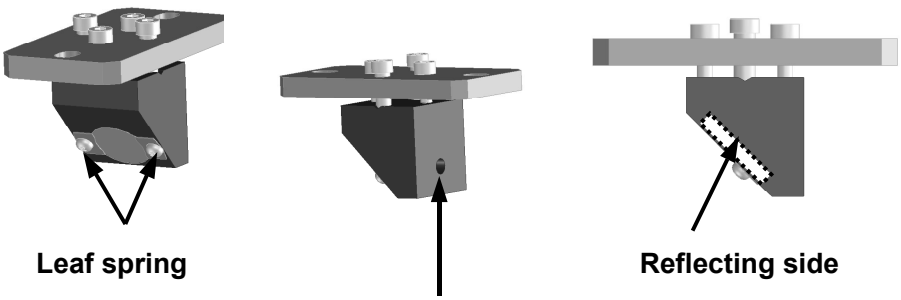


Fig. 8-17 Replacing Back-Reflect Mirror

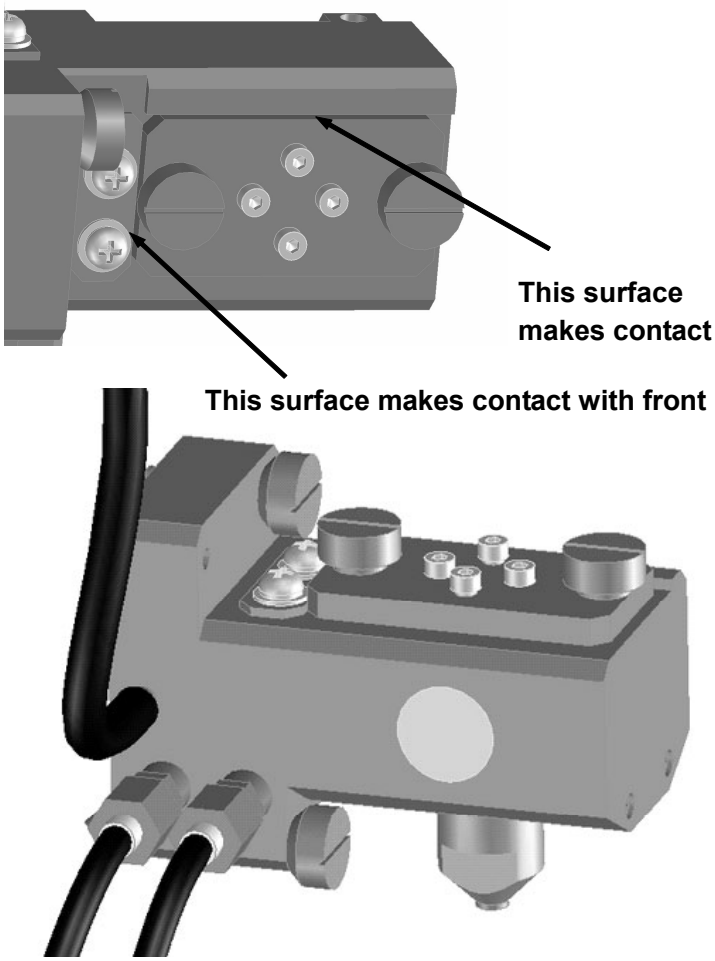


Fig. 8-18 Attaching Mirror Holder

(1) Loosen the mirror holder's set screws and remove the mirror holder from the jacket. Do not remove the mirror from the mirror holder when cleaning it.

(2) Clean the mirror attached to the mirror holder using a piece of gauze moistened with alcohol. If the dirt cannot be removed, replace the mirror with a new one. Loosen the leaf springs to replace the mirror. Position the mirror so that the reflecting side is facing downward. After cleaning or replacing the mirror, insert the mirror holder into the jacket.

(3) Check that the front and one side of the mirror holder are making contact with the jacket before tightening the set screws to secure the mirror holder.

NOTE

Do NOT remove the mirror from the mirror holder when cleaning it. When replacing the mirror, attach the new mirror so that the reflecting side is facing downward. Be careful not to scratch the mirror.

8.8 Cleaning the Axial-View Observation Orifice Assembly L

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

NOTE

Cleaning the orifice assembly L helps prevent sample contamination and abnormal electric discharge. If such phenomena are observed, clean the orifice assembly L. The frequency of cleaning will differ depending on the samples being analyzed and the period of use.

(1) Remove the orifice assembly L.

1) Turn the orifice assembly L with a spanner.

2) When the orifice assembly L becomes looser, turn it manually to remove it.

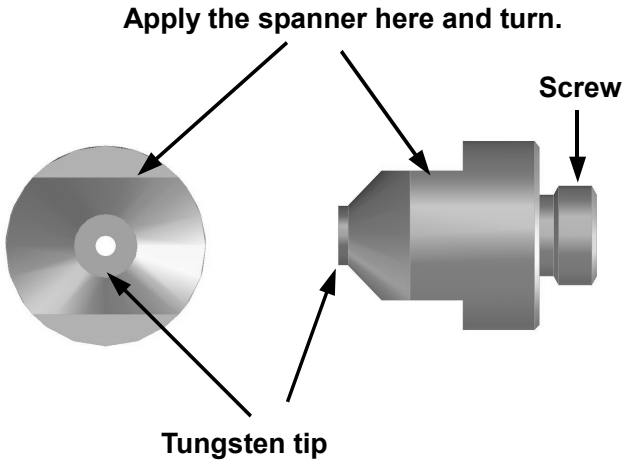


Fig. 8-19 Removing the Orifice Assembly L

(2) Clean the orifice assembly L.

1) Immerse the assembly in hydrochloric acid (HCl) 2 standard solution for two minutes.

2) Remove the assembly from the hydrochloric acid and rinse it with purified water.

3) Wipe the surface (in particular, the surface of the tungsten tip) with gauze.

NOTE

Do NOT perform ultrasonic cleaning on the orifice assembly L.

(3) Attach the orifice assembly L.

1) Attach the orifice assembly L to the cooling jacket by turning it manually.

2) Tighten the assembly with a spanner. Be careful not to tighten with excessive force.

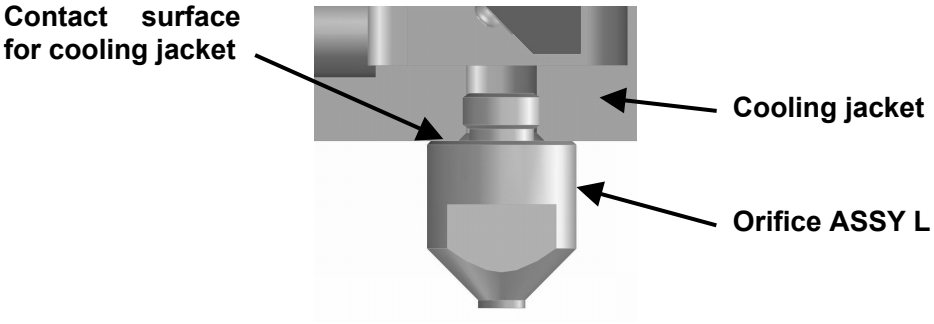


Fig. 8-20 Orifice Assembly L Attachment

NOTE

The contact surface with the cooling jacket will become rough due to wear of the orifice assembly L. This will decrease the orifice assembly L cooling efficiency, leading to significant deterioration of the orifice assembly L surface. In this case, replace with a new orifice assembly L.

8.9 Attaching and Removing the Cooling Jacket

There is a possibility that the mirror inside the cooling jacket may be contaminated when analyzing organic solvents or hydrofluoric acid samples. In this case, then, remove the cooling jacket.

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

Remove the cooling jacket using the following procedure.

(1) Remove the two water-cooled tubes.

(2) Remove the argon gas purge tube.

(3) Remove the two attachment screws.

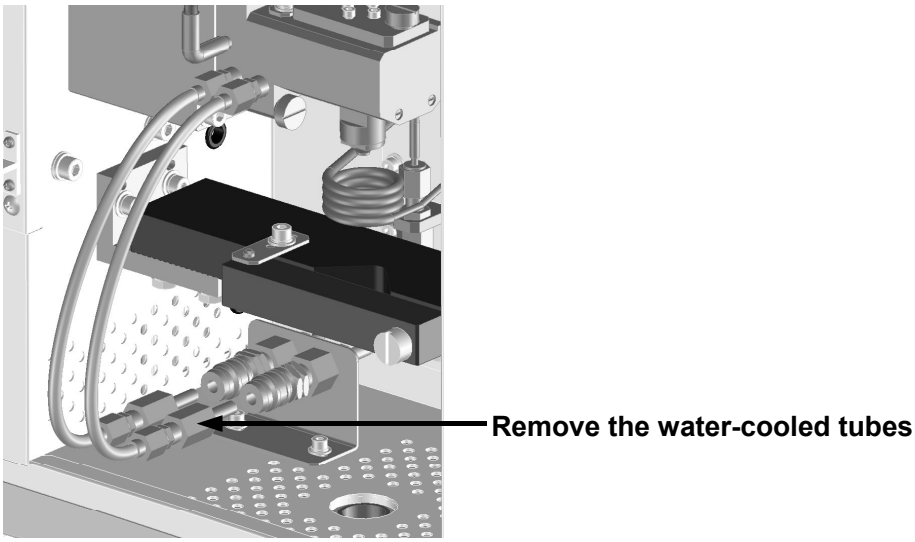


Fig. 8-21 Removing the Water-Cooled Tubes

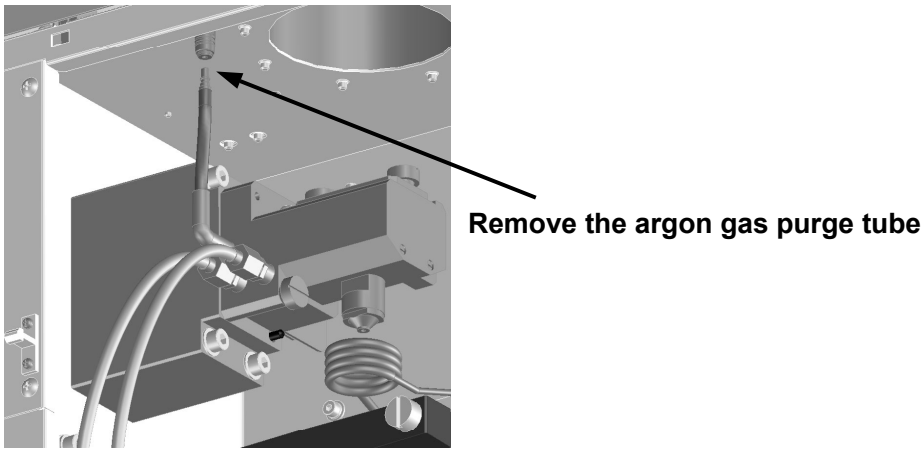


Fig. 8-22 Removing the Argon Gas Purge Tube

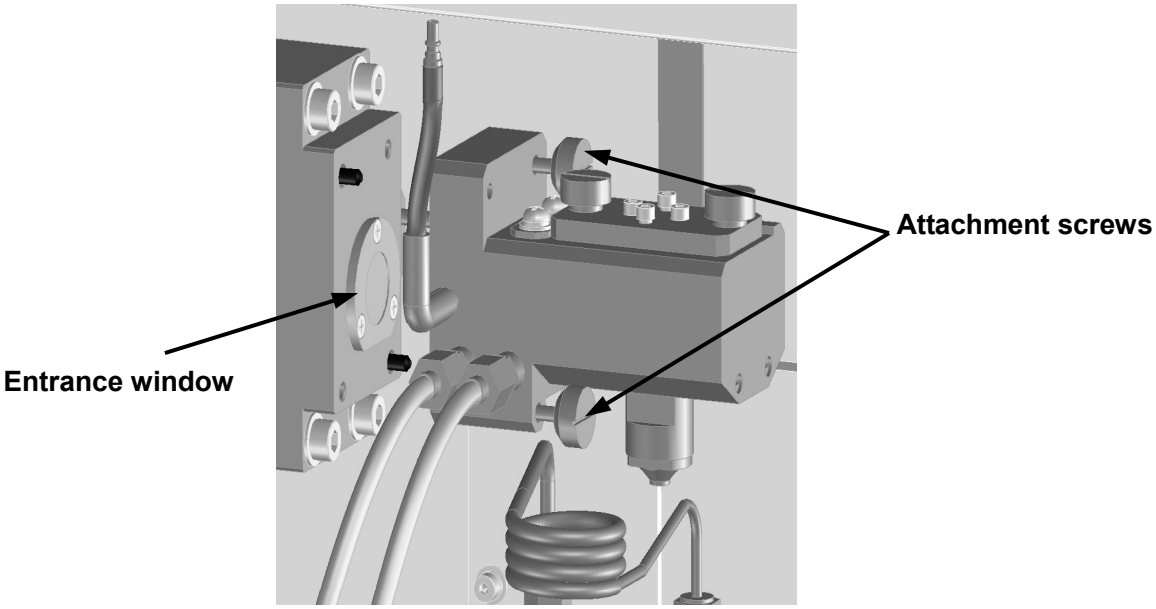


Fig. 8-23 Removing the Cooling Jacket

Attach the cooling jacket using the following procedure.

(1) Insert the upper positioning pin in the cooling jacket's pin hole and turn the jacket slightly in a clockwise direction until the lower positioning pin makes contact with the bottom of the cooling jacket. Secure the cooling jacket in this position using the two attachment screws.

(2) Connect the two water-cooled tubes.

(3) Connect the argon gas purge tube.

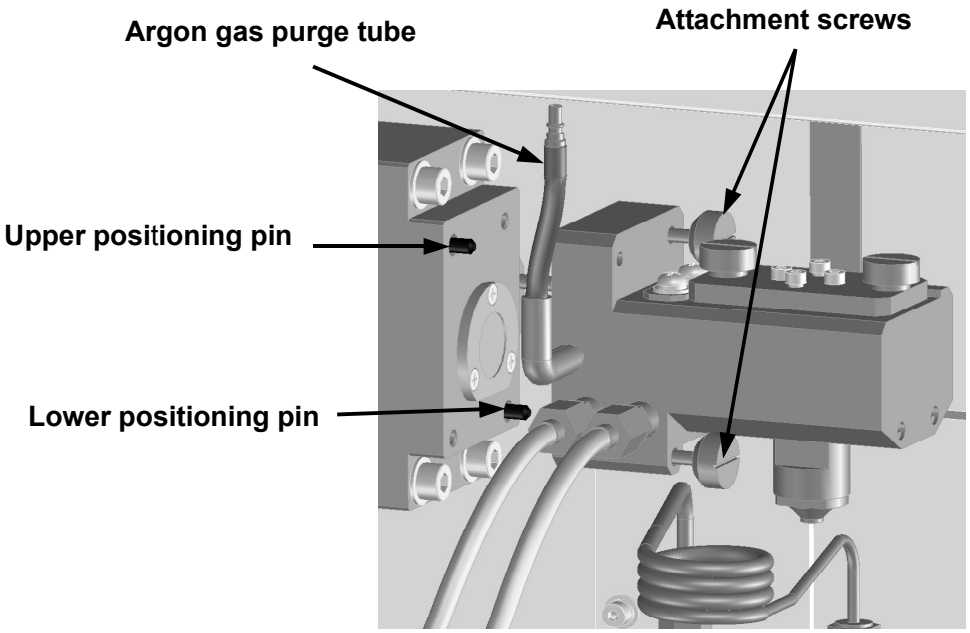


Fig. 8-24 Attaching the Cooling Jacket

8.10 Cleaning the Entrance Window

If the ICPE-9000 is used for a long time, the surface of the entrance window becomes dirty and the transmittance decreases. Although the appropriate frequency varies with the types of sample analyzed and the frequency of use, cleaning is required at least once every one to two weeks.

(1) Remove the cooling jacket.

(2) Remove dirt from the window surface with absorbent cotton that has been dipped in alcohol or benzol and then wipe the surface with dry gauze.

(3) Attach the cooling jacket.

NOTE

The area on the spectrometer side of the entrance window is maintained in a vacuum state. Do NOT remove the entrance window.

NOTE

Touching the glass part of the entrance window may cause the transmittance to decrease due to dirt. Be careful NOT to touch the glass part when resetting the cooling jacket.

8.11 Cleaning the Radial-View Observation (Option) Entrance Window

WARNING

Risk of Burn Injury

There is a risk of burn injury. Do NOT touch the plasma stand interior for 3 minutes after the plasma is extinguished.

(1) Loosen the screws securing the radial-axis purge tube to remove it.

(2) Remove dirt from the glass surface of the entrance surface with absorbent cotton that has been dipped in alcohol or benzol and then wipe the surface with dry gauze.

(3) Reattach the radial-axis purge tube.

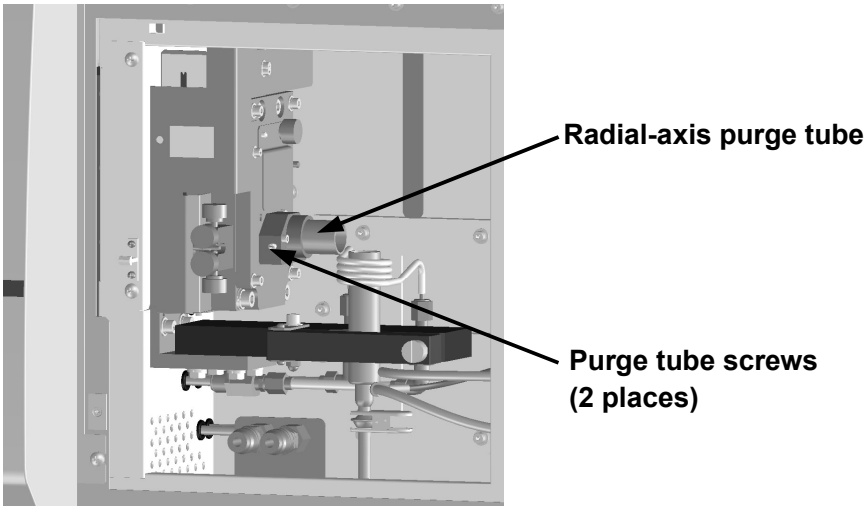


Fig. 8-25 Cleaning the Entrance Window

NOTE

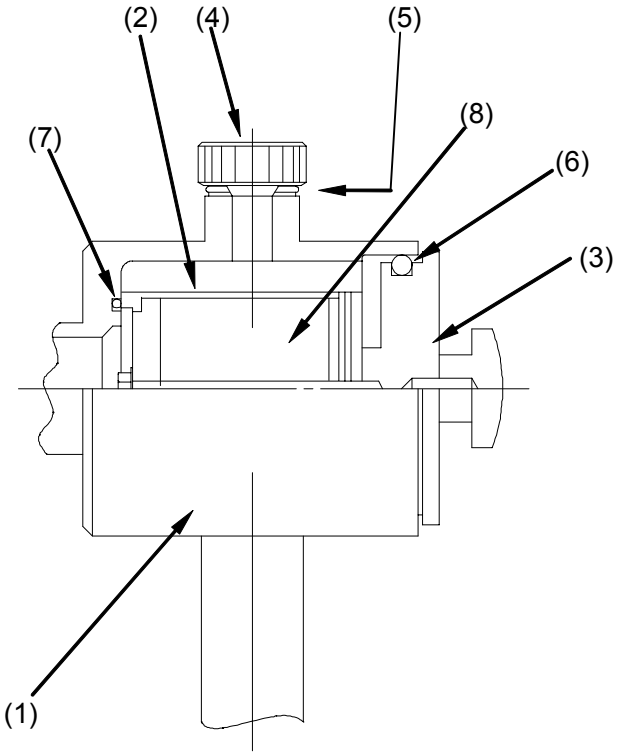
The area on the spectrometer side of the entrance window is maintained in a vacuum state. Do NOT remove the entrance window.

8.12 Replacing the Molecular Sieve (Oil Absorbent) in the Vacuum Pump

The molecular sieve in the vacuum pump at the back of the ICPE-9000 can be replaced while maintaining a vacuum state in the spectrometer.

Replace the molecular sieve using the following procedure.

1) Push the vacuum pump stop switch to stop the vacuum pump.
2) Loosen the leak valve (4) to allow leakage.
3) Remove the filter lid (3) and take out the absorbent container (2).
4) Replace the absorbent.
5) Reattach the absorbent container (2) and the filter lid (3).
6) Close the leak valve (4).



(1) Oil filter
(2) Absorbent container
(3) Oil filter lid
(4) Leak valve
(5) Fastener seal
(6) O-ring
(7) O-ring
(8) Absorbent (molecular sieve)

Fig. 8-26 Replacing the Molecular Sieve

8.13 Replacing the Vacuum Pump Oil

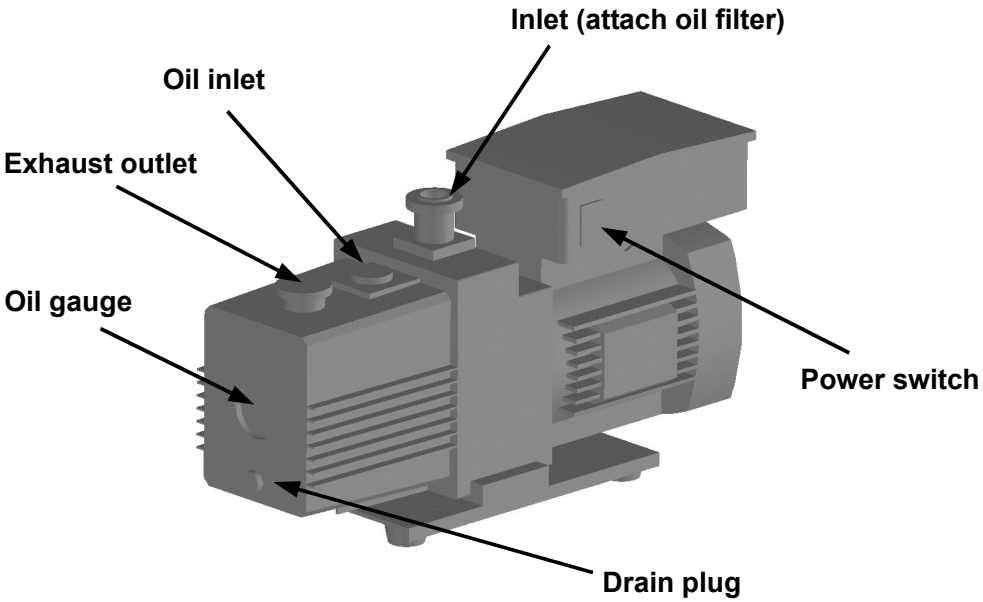


Fig. 8-27 Replacing the Vacuum Pump Oil

Replace the pump oil once every six months.

Before taking out the oil, warm it up by running the pump for a short while.

CAUTION

The rotary pump weighs approx. 16kg. Do NOT perform maintenance work with an inappropriate posture.

1) Remove the drain plug to let the oil out. Collect the oil in a container that can hold at least 1 L.

2) If the collected oil is suspended or dirty, flush out the inside with clean oil before adding more oil.

3) Close the drain plug and add oil via the oil inlet. Normally, add oil until the surface is in the center of the oil gauge.

8.14 Waste Tank

Check the waste tank on a regular basis and ensure that it does not overflow with waste.

Ensure that liquid flows smoothly through the drain tube and that the end of the drain tube is in the waste tank but not immersed in waste.

NOTE

Dispose of waste in accordance with your country's laws and regulations.

8.15 Cleaning the Fan Filters

The filters on the left side and the bottom of the ICPE-9000 must be cleaned on a regular basis. Clean the filters once every three months. The cleaning methods are described below.

8.15.1 Cleaning the Side Filter

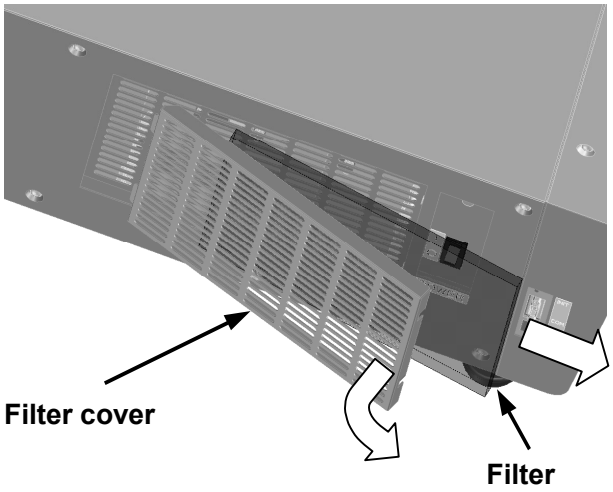


Fig. 8-28 Cleaning the Side Filter

(1) Turn OFF the computer power supply and the power switch.

(2) Pull the front end of the side filter cover to the left and then forward to remove it.

(3) Remove the filter.

(4) Remove dust from the filter with a vacuum cleaner.

(5) Clean the filter cover in the same way.

(6) Attach the filter onto the filter cover, engage the catches at the back end of the cover onto the ICPE-9000, and close the front end of the cover.

(7) Turn ON the power switch.

NOTE

If the power switch is turned OFF, the spectrometer temperature-control circuit stops operating. The time required for the spectrometer to stabilize varies with the external temperature but, if it has been OFF for 1 to 2 hours, 6 hours is required. It soon recovers, however, after a momentary power interruption.

8.15.2 Cleaning the Bottom Filter

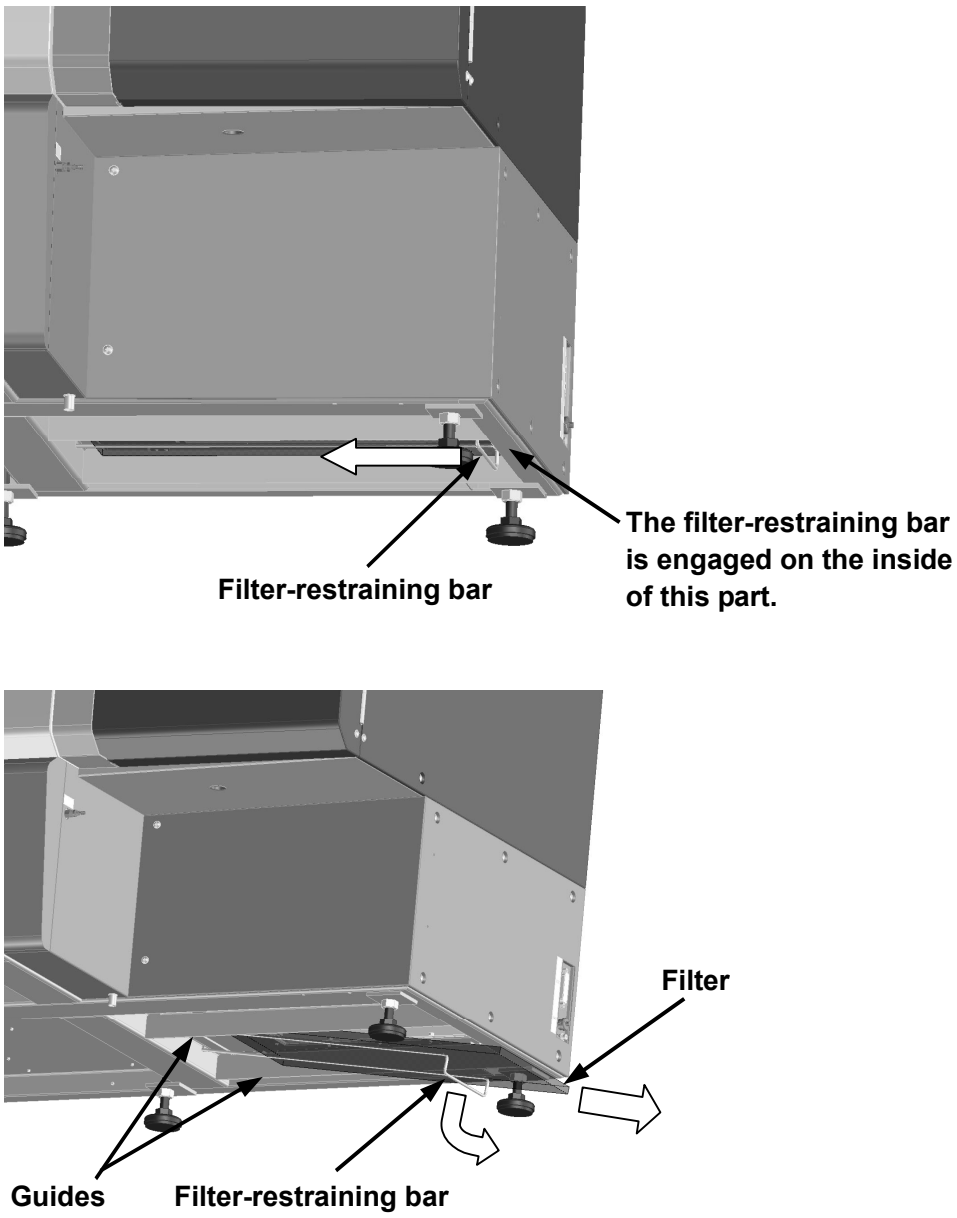


Fig. 8-29 Cleaning the Bottom Filter

(1) Turn OFF the computer power supply and the power switch.

(2) Slide the filter-restraining bar at the bottom of the right side of the ICPE-9000 to the left. (The bar is in the pouch at the bottom of the ICPE-9000. Hook a finger onto the bar and slide it.)

(3) Remove the filter.

(4) Remove dust from the filter with a vacuum cleaner.

(5) Mount the filter onto the bar in the original position (between the two guides) and push it to the left, into the ICPE-9000.

(6) Re-engage the bar onto the pouch-like section at the bottom of the right side of the ICPE-9000.

(7) Turn ON the power switch.

NOTE

If the power switch is turned OFF, the spectrometer temperature-control circuit stops operating. The time required for the spectrometer to stabilize varies with the external temperature but, if it has been OFF for 1 to 2 hours, 6 hours is required. It soon recovers, however, after a momentary power interruption.

8.16 Checking Operation of Safety Devices

The operation of the safety devices used with the ICPE-9000 can be checked as described below. Check the operation of the safety devices on a regular basis (every one month).

(1) Argon gas pressure sensor:

1) Ignite the plasma.
2) Stop the supply of argon gas and check that the plasma is extinguished.

(2) Plasma stand door switch:

1) Ignite the plasma.
2) Open the plasma stand door and check that the plasma is extinguished.

(3) Coolant flow switch for RF coil, RF power supply, and orifice assembly:

1) Ignite the plasma.
2) Stop the supply of coolant and check that the plasma is extinguished

8.17 Inspecting the Argon Gas and Coolant Piping

Inspect the argon gas and coolant piping on a regular basis to ensure that there are no leaks. Also, if condensation occurs on the utility connections, place the condensation dish (provided) at the position shown in the figure. If the dish fills up with water, throw the water away.

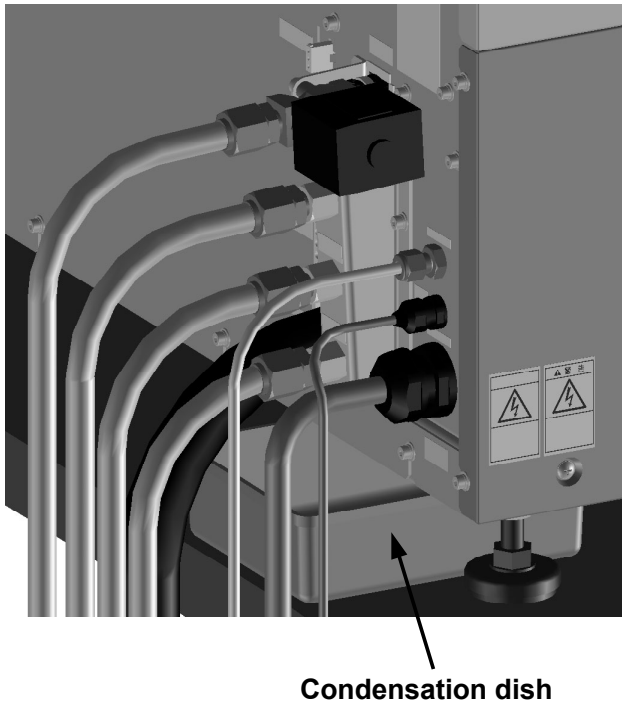


Fig. 8-30 Condensation dish

8.18 Cleaning the Filter for the Mains Water Supply Connection Kit (Option)

NOTE

If the filter case (one-touch joint) is opened while the main valve for the mains water supply is open, mains water will spurt out. Be sure to close the main valve for the mains water supply before performing maintenance work. When the filter case is opened, the water in the hose may flow out. Perform maintenance work in a sink.

(1) Close the main valve for the mains water supply.

(2) Open the [Instrument Control] window in the software, set the [Coolant Water Valve] to [ON], and click [Apply]. The residual pressure in the piping is removed.

(3) Open the filter case, loosen the filter to remove it, and then clean the filter with a brush.

(4) Return the filter to the filter case and reconnect the filter case. Check that the filter case is securely connected.

(5) Open the main valve for the mains water supply.

(6) In the [Instrument Control] window, set the [Coolant Water Valve] to [OFF], and click [Apply].

(7) Check that there are no water leaks.

(8) Close the main valve for the mains water supply.

9. Maintenance Parts and Consumable Items

9.1 Maintenance Parts List

P/N	Part name	Unit	Notes
211-86285	SEAL, LINE	Exterior part	Front panel
211-86282	SEAL, DOOR	Exterior part	Plasma stand front panel
211-81444	TORCH ADAPTER	Accessory	Made of Teflon
211-86093-91	TORCH POSITIN JIG ASSY	Accessory	To adjust torch point
210-14037	INLINE FILTER B-4F-7	Accessory for gas piping part	Ar gas filter
035-69703-01	INSERT B-405-170	Accessory for gas piping part	Piping of inline filter
016-31404	PVC TUBE 3.17X1.58	Accessory	Torch and nebulizer (*1)
016-31428	PVC TUBE 4.76X1.58	Accessory	Leveler exhaust tube (*1)
200-30864-24	TYGON TUBE, 7/16X1/16	Accessory	Leveler (glass) tube (*1)
046-00426-05	CASE, POLYSTYRENE, 45-066-05	Accessory	For molecular sieve Inside spectrometer
228-49750-02	POLYSTYRENE CASE, SQUARE TYPE	Accessory	Condensation dish on rear side of main body
016-31409	PVC TUBE 9.52X1.58	Accessory	Leveler to drain tank (*1)
016-43505	PP TUBE 44-PP WH	Accessory, plasma stand	Ar gas piping outside of main body and coil coolant (*1)
035-65503	HALF UNION, C1N1/4XPT1/4	Accessory	Ar gas piping outside of main body
206-52224-03	LABEL, VOLTAGE, 200V	Accessory	Sticker for voltage
206-52224-04	LABEL, VOLTAGE, 230V	Accessory	Sticker for voltage
206-52224-05	LABEL, VOLTAGE, 240V	Accessory	Sticker for voltage
206-52224-06	LABEL, VOLTAGE, 220V	Accessory	Sticker for voltage
016-46021-05	POLYURETHANE TUBE, U2-4-6X4GN	Gas piping part	For carrier gas (*1)
016-43285-23	POLYOLEFIN TUBE, TPS0604BU-20	Gas/water piping part	Ar gas /CCD coolant outlet (*1)
016-43285-13	POLYOLEFIN TUBE, TPS0604BU-20	Gas piping part	For purge gas (*1)
016-43285-33	POLYOLEFIN TUBE, TPS0604BU-20	Gas piping part	For CCD purge (*1)
016-43285-43	POLYOLEFIN TUBE, TPS0604BU-20	Gas piping part	Radial-view observation kit, cooling jacket purge (*1)
016-43285-53	POLYOLEFIN TUBE, TPS0604BU-20	Water piping part	For CCD coolant inlet (*1)
035-60903-01	COUPLER, MC-04PH	Gas piping part	Plug
035-60903-15	COUPLER, MC-04SHB	Gas piping part	Socket, panel mount type
035-60461-03	REDUCER, B-6MO-R-4	Gas piping part	Ar gas inlet inner side
035-69706-01	INSERT, B-6M5-4M	Gas piping part	Outside diameter, 6 mm Ar gas inlet inner side

P/N	Part name	Unit	Notes
035-57503-11	UNION, TIGHTENING, B-400-61	Gas piping part	Ar gas inlet
260-13500-04	HOSE CONNECTOR, AMC-04 B409	Water piping part	Coolant inlet /outlet
035-65348-04	TEE, UNION, UT4N6X4	Water piping part	Flow switch part
016-35757-02	TUBE, N2-4-6X4, RED	Water piping part	Coil/cooling jacket outlet (*1)
016-35757-04	TUBE, N2-4-6X4, YELLOW	Water piping part	Coli/cooling jacket inlet (*1)
018-15021-03	NBR FOAM TUBE, ST9X10	Water piping part	Thermally insulator tube for coolant (2m unit)
035-65505-10	HALF UNION, C4N6X4-PT1/8	Water piping part	CCD/cooling jacket main body side CCD coolant inlet/outlet Cooling jacket/coil coolant outlet
035-65506-10	HALF UNION, C4N6X4-PT1/4	Water piping part	Cooling jacket coupler side Cooling jacket /coil Coolant inlet
016-35757	TUBE, N2-4-6X4, BLACK	Water piping part	Coil/cooling jacket piping
072-60304	CABLE TIE, TY-28M	For securing piping	In controller unit
072-60303	CABLE TIE, TY-25M	For securing thermally insulated tube	In controller unit
211-86100-91	GAS CONTROL ASSY	Gas controller	Gas controller with PCB
211-84516-91	PCB, GASCON ASSY	Gas controller	Gas controller PCB
016-46027-12	POLYURETHANE TUBE, TIUB05G-X4	Gas controller	For carrier gas (*1)
016-46027-17	POLYURETHANE TUBE, TIUB05C-X4	Gas controller	For plasma gas (cooling gas) (*1)
016-46027-22	POLYURETHANE TUBE, TIUB05YR-X4	Gas controller	For auxiliary gas (*1)
035-60208-08	PLUG, FPL-M5	Gas controller	For inlet assembly
035-60725-50	ELBOW, KQ2L05-U01	Gas controller	Piping connector
035-60726-48	HALF UNION, KQ2H06-U01	Gas controller	Piping connector
035-65028-05	HALF UNION, EC6-M5	Gas controller	For inlet assembly
036-10201	O-RING, 1A P3	Gas controller	For pressure sensor seals
211-86033-91	STOP VALVE ASSY, CARRIER GAS	Gas controller	For preventing reverse-flow for nebulizer
211-86034-91	STOP VALVE ASSY, PURGE GAS 1	Gas controller	For flow of purge gas at standard flow rate
211-86037-91	STOP VALVE ASSY, PURGE GAS 2	Gas controller	For flow of purge gas at high flow rate
211-86038-91	CAPILLARY ASSY, PURGE S	Gas controller	For flow of purge gas at standard flow rate
211-86038-92	CAPILLARY ASSY, PURGE L	Gas controller	For flow of purge gas at high flow rate
211-88153-91	VALVE, VSO ASSY 8	Gas controller	Proportional solenoid valve for carrier gas

P/N	Part name	Unit	Notes
211-88153-92	VALVE, VSO ASSY 9	Gas controller	Proportional solenoid valve for plasma gas (cooling gas)
211-88153-93	VALVE, VSO ASSY 10	Gas controller	Proportional solenoid valve for auxiliary gas
211-86162-91	MAINTENANCE PART, SENSOR FOR GAUGE	Gas controller	Sensor for gauge
211-86163-91	MAINTENANCE PART, SENSOR AND CAPILLARY FOR CARRIER GAS	Gas controller	Sensor and capillary for carrier gas
211-86164-91	MAINTENANCE PART, SENSOR AND CAPILLARY FOR PLASMA GAS	Gas controller	Sensor and capillary for plasma (coolant) gas
211-86165-91	MAINTENANCE PART, SENSOR AND CAPILLARY FOR AUXILIARY GAS	Gas controller	Sensor and capillary for auxiliary gas
211-86166-91	MAINTENANCE PART, SENSOR FOR PURGE GAS	Gas controller	Sensor for purge gas
211-86167-91	MAINTENANCE PART, SENSOR AND CAPILLARY FOR PURGE GAS	Gas controller	Sensor and capillary for purge gas
211-86168-91	MAINTENANCE PART, SENSOR AND CAPILLARY FOR SLOW LEAK	Gas controller	Sensor and capillary for slow leak
211-86125-91	MAINTENANCE PART, ECHELLE COIL	Plasma stand	RF-coil
016-31425	TYGON TUBE,3/32X5/32 1M	Plasma stand	For protection of photoelectric switch (*1)
631-41200-02	VITON TUBE, 5×8	Plasma stand	For purge gas (cooling jacket - joint)
036-10218	O-RING, 1A P18	Plasma stand	For window
036-12002	O-RING, 1A G30	Plasma stand	Connection plate light-guiding spacer
211-88275-91	REFLECT MIRROR IN COOLING JACKET	Plasma stand	In cooling jacket
211-82309-04	IGNITER ASSY	Plasma stand	Outside on the right side
211-88113-91	NOISE FILTER ASSY	Plasma stand	For igniter
211-88122-91	DOOR SWITCH ASSY	Plasma stand	Switch (outer)
211-88122-92	DOOR SWITCH ASSY	Plasma stand	Switch (inner)
211-88123-91	COOLING JACKET SWITCH ASSY	Plasma stand	Outside on the left side
211-88124-91	TEMPERATURE SWITCH 55°C ASSY	Plasma stand	Outside on the right side
211-88124-92	TEMPERATURE SWITCH 65°CASSY	Plasma stand	Left outside on the upper side
211-88124-93	TEMPERATURE SWITCH 75°C ASSY	Plasma stand	Center outside on the upper side
211-86114-95	ENTRANCE WINDOW WITH HOLDER,	Plasma stand	Window between vacuum spectrometer and light-guide

P/N	Part name	Unit	Notes
018-17101-15	SHIELD, FINGER, 97-611-02	Plasma stand	Shield on inner door (406mm unit)
072-60381-02	CLAMP, ULM-18MSG	Plasma stand	For securing back of leveler exhaust tube
072-60342-04	CLAMP, KCA-64	Plasma stand	For securing leveler exhaust tube duct
211-86136-91	TUBE BAND ASSY	Plasma stand	Block for securing tube on right side of main body
211-86547	PLATE, TUBE HOLDER	Plasma stand	Tube hook on right side of main body
211-88066	LABEL, TORCH CONNECTION	Plasma stand	Attached to inner door, inner surface, on the right
211-85114	LABEL, IGNITER CABLE 2	Plasma stand	Attached to inner door, inner surface, on the left
211-86083-91	EXHAUST VALVE ASSY	Vacuum system part	With oil filter
211-88096-91	VACUUM PUMP ASSY	Vacuum system part	Vacuum pump wit power cable
035-02402-02	CLAMP, 20/25KF, 18342	Vacuum system part	For connection oil-filter with vacuum pump
018-30148-01	HOSE, DS-2, OIL 25	Vacuum system part	Vacuum hose (for 3MT need) (*1)
037-61028	HOSE BAND WIRE 36	Vacuum system part	For vacuum hose
211-86074-91	SLOW LEAK VALVE ASSY	Vacuum system part	Slow-leak valve
036-10217	O-RING, 1A P16	Vacuum system part	Between Light-guide and Spectrometer
036-10233	O-RING, 1A P30	Vacuum system part	Spectrometer exhaust pipe
036-15501-53	O-RING, AS568A-153 1A	Vacuum system part	Between Spectrometer and CCD
036-22401	FASTENERSEAL, DT-1-4M4	Vacuum system part	Seal for spectrometer leak screw
200-47686-02	PB-1, PIRANI TUBE FILAMENT	Vacuum system part	Pirani gauge
211-84634	O-RING, W5*ID727	Vacuum system part	For spectrometer lid
211-86032-91	HOLDER, SENSOR ASSY2	Vacuum system part	Slow-leak resistance tube assembly
630-02639	FILTER UNIT, DFU	Vacuum system part	Slow-leak filter
211-86043-95	ADHERED ASSY TOROIDAL	Optical part	In spectrometer
211-86045-95	ADHERED ASSY PLANE	Optical part	In spectrometer
211-86047-95	ADHERED ASSY COLLIMATOR	Optical part	In spectrometer
211-86049-95	ADHERED ASSY SCHMIDT	Optical part	In spectrometer
211-86051-95	ADHERED ASSY TELEMETER	Optical part	In spectrometer
211-86053-95	ECHELLE G ASSY	Optical part	In spectrometer

P/N	Part name	Unit	Notes
211-86131-95	ADHERED ASSY PRISM	Optical part	In spectrometer
210-21018	VARIABLE CAPACITOR	Matching box/RF Power supply	Air variable capacitor
055-87826-17	CAPACITOR,HT50V500KA	Matching box/RF Power supply	500-pF fixed capacitor
055-87826-21	CAPACITOR ,HT57V250KA	Matching box/RF Power supply	250-pF fixed capacitor
078-60016	PHOTO SENSOR, EE-SV3	Matching box/RF Power supply	Photo-sensor
055-88896-03	CAPACITOR, CV1C100G-16.7KV	Matching box/RF Power supply	Vacuum variable capacitor
228-36446-01	STEPPING MOTOR 5PV	Matching box/RF Power supply	Stepping motor
239-33011	RF POWER SUPPLY TSP2716A	Matching box/RF Power supply	RF power supply
211-84521-91	PCB ASSY RFG-CONT	Matching box/RF Power supply	Control PCB
211-88201-91	PCB ASSY PHASEDETECT	Matching box/RF Power supply	Phase detector PCB
032-47901	COUPLING, TIGHT D-530A	Matching box/RF Power supply	Coupling for air variable capacitor
204-19620	A.M COUPLING	Matching box/RF Power supply	Coupling for vacuum variable capacitor
065-43580-01	SW, FW-0/G1.7, COIL, DC24*	Electrical part	For vacuum pump
065-89706-01	BREAKER, NF30CS2P30AF	Electrical part	30A breaker (power switch)
074-80624-32	POWER SUPPLY, EWS1500-48	Electrical part	48V/32A(RF unit)
074-80654-51	POWER SUPPLY, VS50B-24	Electrical part	24V/2.5A(Matching box)
074-80654-77	POWER SUPPLY, VS100B-24	Electrical part	24V/4.3A (power unit)
074-80707-14	POWER SUPPLY, VS15C-15	Electrical part	15V/1A (Matching box)
074-80707-22	POWER SUPPLY, VS30C-5	Electrical part	5V/6A (power unit)
075-00162-05	FILTER, ZRAC2230-11	Electrical part	Line-filter 250V/30A
211-84511-91	PCB ASSY,ECHELLE-C	Electrical part	Left side in controller
211-88013-91	PCB ASSY,ICPE POWER	Electrical part	Center in controller
211-88090-91	TRANSFORMER ASSY	Electrical part	Right side in controller
211-88091-91	STOP VALVE ASSY	Electrical part	For coolant
211-88095-91	SOLENOID ASSY	Electrical part	For shutter in spectrometer
211-88122-91	DOOR SWITCH ASSY	Electrical part	Plasma stand in/out door
211-88125-91	FLOW SWITCH ASSY (0.2LM)	Electrical part	For RF coil
211-88125-92	FLOW SWITCH ASSY (0.5LM)	Electrical part	For cooling jacket
211-88148-91	INDICATOR ASSY	Electrical part	For power supply
036-15501-44	O-RING, AS568A-144 1A	CCD peripheral part	For cooling block
072-60304	CABLE TIE, TY-28M	CCD peripheral part	For securing purge tube
072-60320-02	CABLE TIE, T30R	CCD peripheral part	For thermally insulated hose
211-86059-91	PURGE BLOCK ASSY	CCD peripheral part	Between spectrometer and CCD

P/N	Part name	Unit	Notes
211-86090-92	CCD SEALING ASSY	CCD peripheral part	CCD main body
211-86513	INSULATOR, CCD, BANK OF WATER	CCD peripheral part	On the spectrometer under CCD
211-88027-01	TUBE, CCD, PURGE, 66X1	CCD peripheral part	Purge gas shield tube in front of CCD
211-88186-91	CABLE, CTRL PCB-CCD_1M (CCD signal cable)	CCD peripheral part	Signal cable
211-88172-91	CABLE, CONDENSATION SENSOR (Condensation sensor cable)	CCD peripheral part	For condensation sensor
211-88179-91	CONDENSATION SENSOR ASSY (Condensation sensor assembly)	CCD peripheral part	Condensation sensor ASSY
211-88181-91	CONDENSATION SENSOR CONNECTOR ASSY (Connector for condensation sensor assembly)	CCD peripheral part	Connector ASSY for condensation sensor
211-88166-91	CABLE, CCD-POWER (CCD power cable)	CCD peripheral part	Power cable
078-29152	HEATER, STF1002	Temperature-control batch	Heater at rear side of spectrometer
211-88135-91	CABLE, FAN J22	Temperature-control batch	Cable for fan
211-88151-91	HEATER OVERHEAT SENSOR ASSY	Temperature-control batch	Switch ASSY for over-heat
228-34618-91	TEMPERATURE SENSOR ASSY	Temperature-control batch	Temperature sensor ASSY for control
211-88136-91	CABLE, THERMISTOR J6 (Temperature sensor relay cable)	Temperature-control batch	Cable for thermistor J6
211-88150-91	CABLE, HEATER CN13 (Heater cable)	Temperature-control batch	Power cable for heater
037-60177-01	CLAMP, WIRE S-703	Temperature-control batch	Clamp for sensor ASSY cable
211-86070-91	FAN ASSY	Temperature-control batch, back of main body, gas controller periphery	DC 24V Fan Repair every Approx. 3 years

*1: Please order it by a meter unit

9.2 Consumable Items List

P/N	Part name	Approximate replacement period	Unit
211-86308	FILTER, BOTTOM	1 year (*1)	Main unit
211-86287	FILTER, LEFT	1 year (*1)	Main unit
211-81448	MINI-TORCH 7500	3 months (*2)	Plasma stand
211-86533	EXTENSION PIPE, L	1 year (*2)	Plasma stand
210-15508-01	BALL JOINT CLIP, FOR 12	1 year (*2)	Plasma stand
037-61113-04	CLAMP, SNP-10	1 year (*2)	Plasma stand
046-00993-01	CLIP, FOR TS-15, D-310-1	6 months (*2)	Plasma stand
046-00092-02	NEBULIZER, AR30-1-FC1S	2 months (*2)	Plasma stand
046-00093-02	SPRAY CHAMBER, 808-8881	1 year (*2)	Plasma stand
046-00093-01	DRAIN TUBE, 808-8214	1 year (*2)	Plasma stand
016-31404	VINYL TUBE, R3603 1/8X1/16	1 month	Plasma stand (*3) (Auxiliary gas and carrier gas tubes)
211-85118-91	PLASMA GAS TUBE ASSY	1 month	Plasma stand (plasma gas tube)
200-30864-24	DRAIN TUBE, TYGON T 7/16X1/16	3 months (*2)	Plasma stand (*3)
211-84352-91	ORIFICE ASSY L	1 month (*2)	Plasma stand
211-43740	ORIFICE ASSY	1 month (*2)	Plasma stand (for optional plasma torch)
046-00092-06	SAMPLE INTRODUCTION TUBE EZT-075X1	2 months (*2)	Plasma stand
016-31428	LEVELER EXHAUST TUBE	3 months (*2)	Plasma stand (*3)
210-14037	INLINE FILTER	1 year	Piping part
035-69703-01	INSERT, B-405-170	1 year	Two used when replacing inline filter
035-62974-01	SLEEVE SET, B400SET	1 year	Two used when replacing inline filter
017-30166-01	PUMP OIL, R-2 1L	6 months	Vacuum system
210-07003-04	MOLECULAR SIEVE	6 months	Vacuum system
017-30813-01	SI GREASE, HIVAC-G 50G	6 months	Vacuum system
211-83697	CONNECTION TUBE	1 month (*2)	For connecting autosampler suction tube

*1: Varies with the ICPE-9000 installation environment.

*2: Varies with the analysis samples.

*3: Please order it by a meter unit.

10. Troubleshooting

No	Problem	Possible cause and solution
1	The spectral intensity dropped significantly.	Possible causes are given below. Identify and remove the cause of the problem. ・ Deposits adhered to the tip of the nebulizer. ・ Deterioration of nebulizer ・ Deterioration of sample introduction tube ・ Bubbles entered the sample introduction tube and the sample suction volume decreased. ・ The sample introduction tube is not properly inserted in the nebulizer. ・ The tip of the torch's center orifice is dirty. ・ The tip of the torch's center orifice melted. ・ The internal diameter of the torch's center orifice changed. ・ The reflective mirror inside the cooling jacket is dirty (in axial-view observation). ・ The entrance window is dirty. ・ Foreign matter adhered to the center of the orifice assembly (in axial-view observation). ・ The entrance window of the radial-view observation kit is dirty (in radial-view observation). ・ The leveler was damaged and drain liquid does not accumulate.
2	The spectral intensity is unstable.	・ The ICPE-9000 installation location does not meet requirements related to installation location or facilities. ・ One of the causes listed for problem 1 ・ A large amount of exhaust is discharged from the exhaust duct.
3	Condensation occurs on the RF coil.	・ Wipe off the water droplets with gauze or some other appropriate material and ignite the plasma. ・ Increase the coolant temperature.

No	Problem	Possible cause and solution
4	The spectral intensity for elements is high even with a blank.	• The blank liquid is dirty. • The torch is dirty. • The chamber is dirty. • The rinse time is short.

If the problem is not resolved by performing the appropriate countermeasures, make a note of the problem and contact your Shimadzu representative.