



Guidelines for Safe Use of the X-Ray Diffractometer

This manual describes the correct use of the product as well the usage precautions to be observed. To obtain full-expected performance from the product, please read this manual thoroughly.

Also, store this manual at an easily accessible place so that you can promptly refer to it whenever it is necessary.

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Important Information on Safety

Before using the X-ray diffractometer and auxiliary equipment

Read and make sure you fully understand these “Important Points Concerning Safety” as well as the “Safety Precautions” provided in a separate chapter. Observe all instructions given in this guideline. The important points concerning safety and safety precautions given in this guideline are essential for preventing harm or injury to those involved in the management, operation, maintenance, and servicing of the X-ray diffractometer, as well as others who may come into contact with the equipment.

The X-ray diffractometer¹⁾ generates strong X-rays. X-ray is harmful to the human body, and X-ray exposure can cause significant damage (radiation damage²⁾). Additionally, the X-ray tube window³⁾ incorporates metallic beryllium, a substance harmful to the human body if inhaled its powder or touched by a part of the body. The high-voltage unit inside the X-ray diffractometer can cause electric shock. Improper handling or use of the X-ray diffractometer may result in fatal accident.

To maintain safety in the use, installation and maintenance of the X-ray diffractometer, you must keep in mind potential hazards at all times. Despite the difficulty of foreseeing all potential hazards, we at Rigaku Corporation have done our utmost to address potential dangers in this guideline. Warnings related to various hazards are ranked in the three categories shown in Table 1. These warnings are provided on the warning indication labels affixed to the X-ray diffractometer and are also given in this guideline.

Keep this guideline in an easily accessible location for ready reference.

Table 1 Hazard definitions

Symbol	Hazard level	Definitions
DANGER 	DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.
WARNING 	WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
CAUTION 	CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

The term “serious injury” refers to radiation damage, loss of eyesight, injuries, burns (high-temperature or low-temperature), electric shock, bone fractures, poisoning, or other conditions with sequelae or conditions requiring hospitalization or long-term outpatient care.

The term “minor injury” refers to injuries, burns, electric shock, or other conditions that do not require hospitalization or long-term outpatient treatment.

The term “physical damage” refers to damage to the X-ray diffractometer, damage to related equipment, or damage to acquired data.

¹⁾⁻²⁾ See the Glossary at the end of this manual.

³⁾ See “X-ray tube” (Page 15, Fig. 1) in this manual.

Table 2 Meanings of graphical symbols

	The  symbol indicates a prohibited action (cannot do).		The  symbol indicates a mandatory action . (must be followed)		The  symbol indicates information that requires careful attention (including danger and warnings).
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WARNING



Do not modify the X-ray diffractometer without written consent from Rigaku Corporation. In addition, do not perform any repairs not specifically described in this guideline or mount or remove any components not authorized by Rigaku Corporation.

Such unauthorized modification or replacement of parts may seriously affect safety and must be avoided.

WARNING



The X-ray diffractometer is an equipment that applies the X-ray diffraction method¹⁾ to perform analysis. Do not use this equipment for any purpose other than this analysis.

Warning labels

The followings show the meaning of each safety label.

Table3 Warning labels

Warning on radiation exposure	Caution on electric shock
	
Caution on radiation exposure	Forbidding disassembly
	

¹ See the Glossary at the end of this manual.

Legal Regulations

Be sure to observe all laws and regulations

Use of X-ray diffractometers is subject to varying laws, and regulations in the country or region in which the X-ray diffractometer is installed. Be sure to observe all applicable laws and regulations to ensure the safety of work procedures, operations, and management.

The equipment supervisor¹⁾ and the radiation safety officer²⁾ are responsible for training the operator³⁾ and maintenance engineer⁴⁾ with respect to items required to maintain the safety of X-ray operations.

X-ray diffractometer must only be operated, maintained and serviced by qualified personnel who are trained with the X-ray safety procedures.

¹⁾⁻⁴⁾ See the Glossary at the end of this manual.

Safety Precautions

WARNING



Conditions under which incorrect handling may result in death or serious injury to the operator



- Do not attempt to modify or remodel the X-ray diffractometer
Modifying the X-ray diffractometer without written consent from Rigaku Corporation can significantly affect its safety. Never attempt to modify the X-ray diffractometer. Doing so without consent from Rigaku Corporation will void coverage under the warranty.



- Do not attempt to remove, disassemble or modify the X-ray shutter
Actions such as removing or disassembling the X-ray shutter main-body, modifying its functions, replacing or adding components, or mounting the X-ray shutter incorrectly may result in exposure to X-rays and radiation damage.
Never attempt to modify or remove the X-ray shutter main-body.
Contact the sales representative who you purchased the instrument from for all X-ray shutter main-body repairs or maintenance work.
- Do not attempt to remove, disassemble, or modify the radiation enclosure
Actions such as removing or disassembling the radiation enclosure, modifying its functions, replacing or adding components, or mounting the radiation enclosure incorrectly may result in exposure to X-rays and radiation damage.
Never attempt to modify, remove, or mount the radiation enclosure.
Contact the sales representative who you purchased the instrument from for all radiation enclosure repairs or maintenance work.
- Do not attempt to disassemble the X-ray shutter warning lamp or X-RAYS ON indicator.
Do not attempt to disassemble the X-ray shutter warning lamp or X-RAYS ON indicator, or mount a lamp other than the dedicated lamp. Such actions may lead to incorrect indication of the X-ray generation status, resulting in radiation exposure that can cause radiation damage.
- Do not attempt to disassemble, repair, or modify the X-ray optics connection sensor
Disassembling the X-ray optics connection sensor or modifying its functions may result in the X-ray shutter opening or exposure to X-rays when an X-ray optical system such as a goniometer has not been connected. Such exposure may result in radiation damage.

WARNING



Potentially hazardous conditions under which incorrect handling may result in death or serious injury to the operator

- Do not remove the high-voltage cable from the X-ray diffractometer



When X-rays are being generated, high voltage is supplied from the high-voltage transformer to the X-ray tube via a high-voltage cable. Even after X-ray generation has been halted, the high-voltage transformer and high-voltage cable will retain a powerful charge.

Removing the high-voltage cable from the X-ray diffractometer may result in electric shock.

When performing maintenance work, contact the sales representative who you purchased the instrument from before removing the high-voltage cable from the X-ray diffractometer.



- Avoid contact with the high-voltage cable head

The high-voltage cable head may retain an electric charge even after power supply to the X-ray diffractometer has been shut down. Avoid direct contact with the high-voltage cable when replacing the X-ray tube or performing similar tasks. Doing so may result in electric shock.



- Avoid contact with beryllium

Beryllium is used in the X-ray path windows in components such as the X-ray tube, X-ray detector, and high-temperature attachment. Inhaling of beryllium powder or vapor or contacting of beryllium powder may lead to serious illness or death. In addition, a beryllium window of X-ray tube is very thin, and will be easily damaged when the vacuum state is released, which may scatter airborne particles of beryllium.

Avoid contact with beryllium.

Dispose of beryllium in accordance with applicable laws and ordinances.



- Fire hazard (Turn the power key to the OFF position, or press the EMO button(optional).)

If the device emits smoke or an unusual odor, immediately shut off the power supply to the X-ray diffractometer. (Turn the power key to the OFF position or press the EMO button (optional) on the front side of the X-ray diffractometer.)

CAUTION

Potentially hazardous conditions under which incorrect handling may result in minor injury to the operator or physical damage to the X-ray diffractometer

- Do not replace the sealed-off X-ray tube immediately after X-ray generation has stopped
The X-ray tube will remain hot for a short time after you have finished using the X-ray generator and X-ray generation has stopped. Contact with the X-ray tube during this time may result in burns. Wait at least 30 minutes after X-ray generation has stopped to allow the X-ray tube to cool and reach room temperature before undertaking replacement.
- Do not replace the rotating anode or electron gun immediately after X-ray generation has stopped
Components inside the X-ray tube will remain hot for a short time after you have finished using an X-ray generator equipped with a demountable X-ray tube¹⁾ and X-ray generation has stopped. Touching the rotating anode or electron gun during this time may result in burns. Wait at least one hour after X-ray generation has stopped to allow the X-ray tube components to cool and reach room temperature before undertaking replacement.



- Avoid contact with the high-temperature furnace
- Avoid contact with high-temperature gases or liquids
When using attachments equipped with a heating furnace to raise sample temperatures, avoid contact with the furnace and the components in its vicinity, which may become very hot. Doing so may result in burns.
When using attachments that rely on high-temperature gases or liquids to increase the temperature of the samples, avoid contact with high-temperature gases or fluids and components while they are still hot.
Wait until the furnace and components have cooled to room temperature before performing any required tasks.
- Avoid contact with the low-temperature furnace
- Avoid contact with low-temperature gases or liquids
When using an attachment to reduce the temperature of the samples to a low temperature, touching the low-temperature parts will cause low-temperature hazards.²⁾
Touching dry ice, liquid nitrogen, liquid helium or other coolants used to reduce the temperature of the samples to a low temperature will cause low-temperature hazards.
Wait until the samples and the area in the vicinity of the samples have returned to room temperature before performing any work that is required.



- Measure the amount of leakage radiation at regular intervals
If the amount of leakage radiation exceeds the permissible radiation level stipulated by law, immediately shut off power supply to the X-ray generator, affix a “Do not use” label to the X-ray diffractometer, and contact the sales representative who you purchased the instrument from.

^{1) 2)} See the Glossary at the end of this manual.

CAUTION



Potentially hazardous conditions under which incorrect handling may result in minor injury to the operator or physical damage to the X-ray diffractometer

- Do not suddenly open the valve on the gas cylinder
Suddenly feeding gas to attachments (container) that is used to substitute the gas in the sample atmosphere may result in damage to the detector or to the attachment. In addition, there is a risk of injury from broken fragments. Open and close the cylinder valve gently. Be sure to observe all laws and regulations that are related to the handling of high-pressure gases.¹⁾



- Do not suddenly open the leak valve of attachment
Do not suddenly open the leak valve when changing the pressure inside a sample chamber or vacuum path from a vacuum to atmospheric pressure. The sudden difference in pressure may result in damage to the sample chamber or vacuum path. Besides, fragments of the damaged parts can cause injury. Be sure to open or close the leak valve gradually.

- Do not suddenly open the vacuum leak valve (leak knob) of demountable X-ray tube
Do not suddenly open the vacuum leak valve (leak knob) when changing the pressure inside a demountable X-ray tube from a vacuum to atmospheric pressure. The sudden difference in pressure may result in damage to the X-ray tube. Be sure to open or close the leak valve gradually. In addition, periodic vacuum evacuation must be carried out on demountable X-ray tubes.

- Observe the installation conditions/requirements for the X-ray diffractometer
Observe the installation conditions/requirements stipulated in the user's manual when installing this X-ray diffractometer. Rigaku Corporation does not guarantee normal operation of the X-ray diffractometer if the installation conditions/requirements are not observed.



- Storage
If you will not be using the X-ray diffractometer for an extended period of time, store it in an environment that is free of dust particles and corrosive gases, at a room temperature of between 5 and 40°C, and with a relative humidity of 75% or less. Periodically evacuate the demountable X-ray tube.

- Do not move or relocate the X-ray diffractometer
Consult the sales representative who you purchased the instrument from if you wish to move or relocate the X-ray diffractometer. Rigaku Corporation will not guarantee operations at the relocated site if the X-ray diffractometer is moved or relocated without prior consultation. Moreover, if the X-ray diffractometer is moved or relocated, a "Notification of Plans" must be submitted to the jurisdiction's Labor Standards Office.



¹⁾ See the Glossary at the end of this manual.

- Deterioration of cooling water hose

The cooling water hose may become damaged due to hardening from aged deterioration and usage environment. If the hose becomes damaged, water may flood the floor. In some cases, it may lead to serious water leakage to the floor below and cause extensive damage and loss.

- Periodic replacement of cooling water hose

It is suggested that the cooling water hose be replaced periodically. It is recommended to be replaced every five years. To prevent serious water leakage and to maintain the performance, a periodic replacement is necessary. To replace the cooling water hose, contact the sales representative from whom you purchased the instrument.



- Disposal

Please separate the metallic beryllium used in the window of the X-ray tube and the lead used in the X-ray screen from general waste and ask a waste-processing company authorized to handle these items to dispose of them. Be sure to dispose of beryllium in accordance with all applicable laws and regulations. Please ask a company authorized to handle cylinders to dispose of gas cylinders.

X-ray safety features

X-ray shield

The X-diffractometer contains an X-ray shielding tube and radiation enclosure that shield X-rays.

1. The sealed-off X-ray tube is installed in a metal tube shield. The X-rays are shielded by this tube shield.
2. The demountable X-ray tube housing is made of metal. The X-rays are shielded by this tube housing and the X-ray shutters. (See Fig. 2)
3. An X-ray shutter has been mounted at the position at which the X-rays are taking out from the X-ray tube. The X-rays are shielded by the X-ray shutter when the shutter is closed.
4. The interlock mechanism of X-ray shutter contains three sensors (one for Open and two for Close) and the main shutter. Signals from the Open and Close sensors are always monitored by the safety circuits. The two Close sensors function as individual safety circuits (double safety mechanisms), which prevents unexpected radiation exposure caused by incorrect operations.
5. If the X-ray shutter lamp and/or the X-ray ON indicator is disconnected or short-circuited, X-ray generation will stop.
6. The radiation enclosure is equipped with an interlock mechanism. When X-rays are emitting (the X-ray shutter is open), the door of the radiation enclosure cannot be opened. When the door is opened, the X-ray shutter closes to stop the X-ray emission.
7. The X-rays on lamps of the radiation enclosure turn on while X-rays are generated.
8. The radiation enclosure contains an observation window which is made of a material capable of shielding X-rays. If the observation window becomes damaged, immediately turn off the X-ray diffractometer's power supply to stop using the X-ray diffractometer.

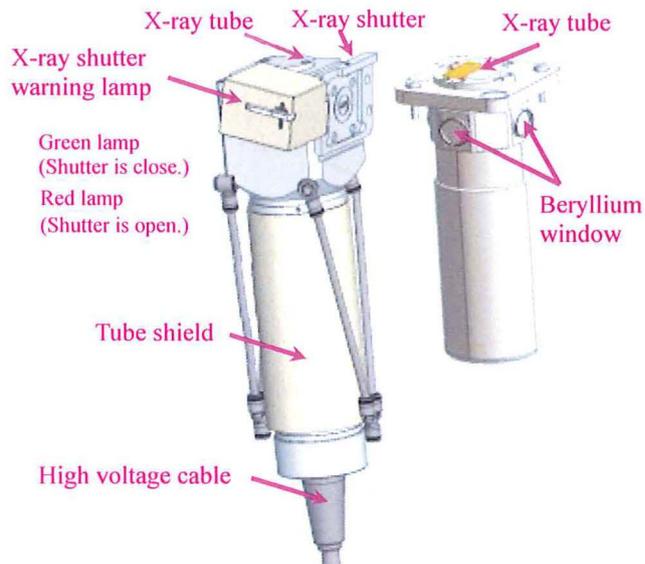


Fig. 1

Sealed-off X-ray tube assembly and sealed-off X-ray tube

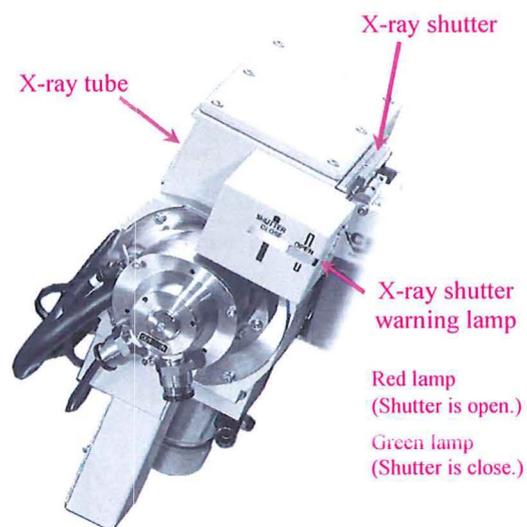
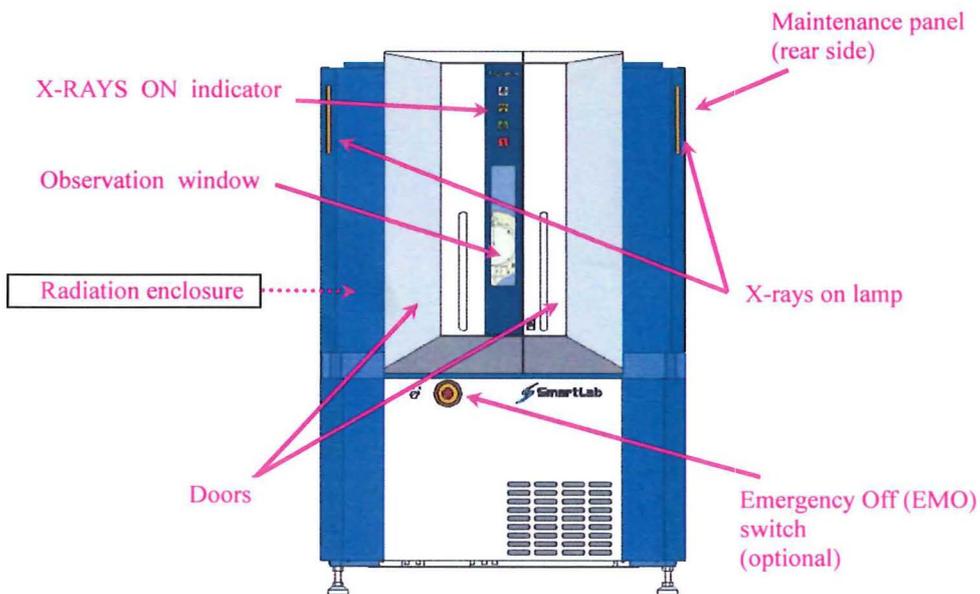


Fig. 2

Demountable X-ray tube

Radiation enclosure – SmartLab SE



Radiation enclosure – SmartLab

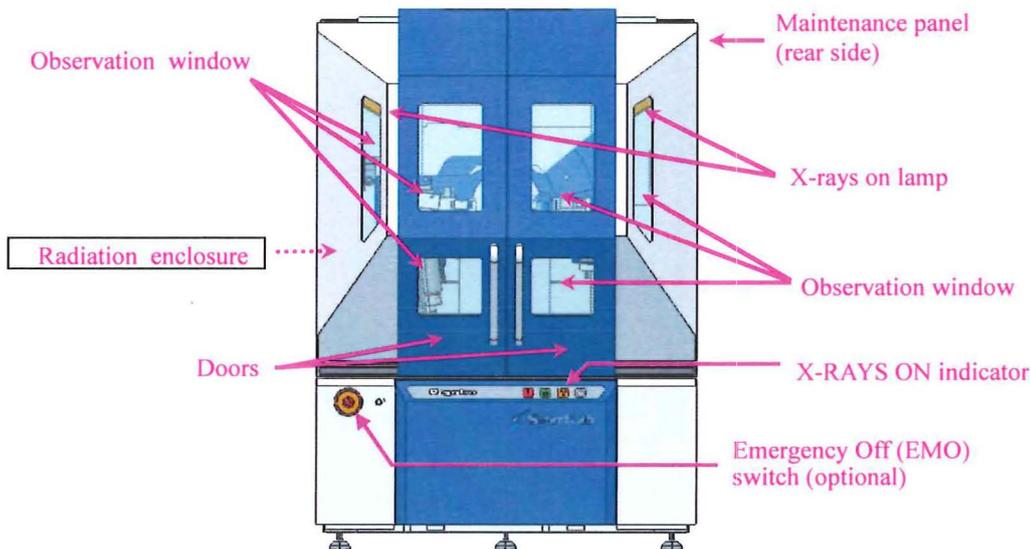


Fig.3 Radiation enclosure

Safety features for safe use of X-rays

Mechanisms, designed to protect the operator from accidental radiation exposure that is caused by failures of radiation protective components, are called fail-safe mechanisms.¹⁾ The following two fail-safe mechanisms are provided for X-ray diffractometers equipped with a radiation enclosure.

1. Fail-safe mechanism for X-ray generation
2. Fail-safe mechanism for X-ray shutter

Fail-safe mechanism for X-ray generation

This mechanism allows X-ray generation only when the X-ray shutter has been mounted correctly,²⁾ when the X-ray shutter warning lamp is functioning normally, and when the radiation enclosure doors are closed. See Fig. 4. Details of the mechanism are as follows.

- An X-RAYS ON indicator to indicate the X-ray generation status is provided on the radiation enclosure (see Fig. 3). X-rays cannot be generated if disconnection or short circuit occurs in the X-RAYS ON indicator cable. The X-rays on lamp turns on in yellow while the X-rays are being generated. When X-ray generation has stopped, the X-rays on lamp turns off.
- X-rays cannot be generated if the maintenance panel on the rear surface of the radiation enclosure is fitted incorrectly. X-ray generation will stop if the maintenance panel is opened while X-rays are being generated.

Fail-safe mechanism for X-ray shutter

This mechanism allows the X-ray shutter to be opened only when a condition that prevents X-ray leakage outside the radiation enclosure has been ensured, even when X-rays are being radiated. See Fig. 4. Details of the mechanisms are as follows.

- An X-ray shutter warning lamp is provided on the X-ray tube (see Fig. 1 and 2). X-rays cannot be generated if disconnection or short circuit occurs in the X-ray shutter warning lamp cable.
- The X-ray shutter can open only when X-rays are being generated, and when the radiation enclosure door is closed.
When the X-ray shutter is open, the door of the radiation enclosure cannot be opened. Also, when the door is opened, the X-ray shutter cannot be opened.

Precautions related to sample mounting and replacement

Of the daily operations required by the X-ray diffractometer, sample mounting and replacement are the tasks that bring you closest to the X-ray path. Be sure to observe the following precautions to prevent X-ray exposure.

1. Look into the observation window on the radiation enclosure and confirm that the left side of the X-ray shutter lamp is lighting in green (indicating that the X-ray shutter is close), before mounting or replacing samples.

¹⁾ See the Glossary at the end of this manual.

- If the right side of the X-ray shutter lamp is lighting in red, the X-ray shutter is open and X-rays are emitting. Do not attempt to mount or replace any samples at this time.

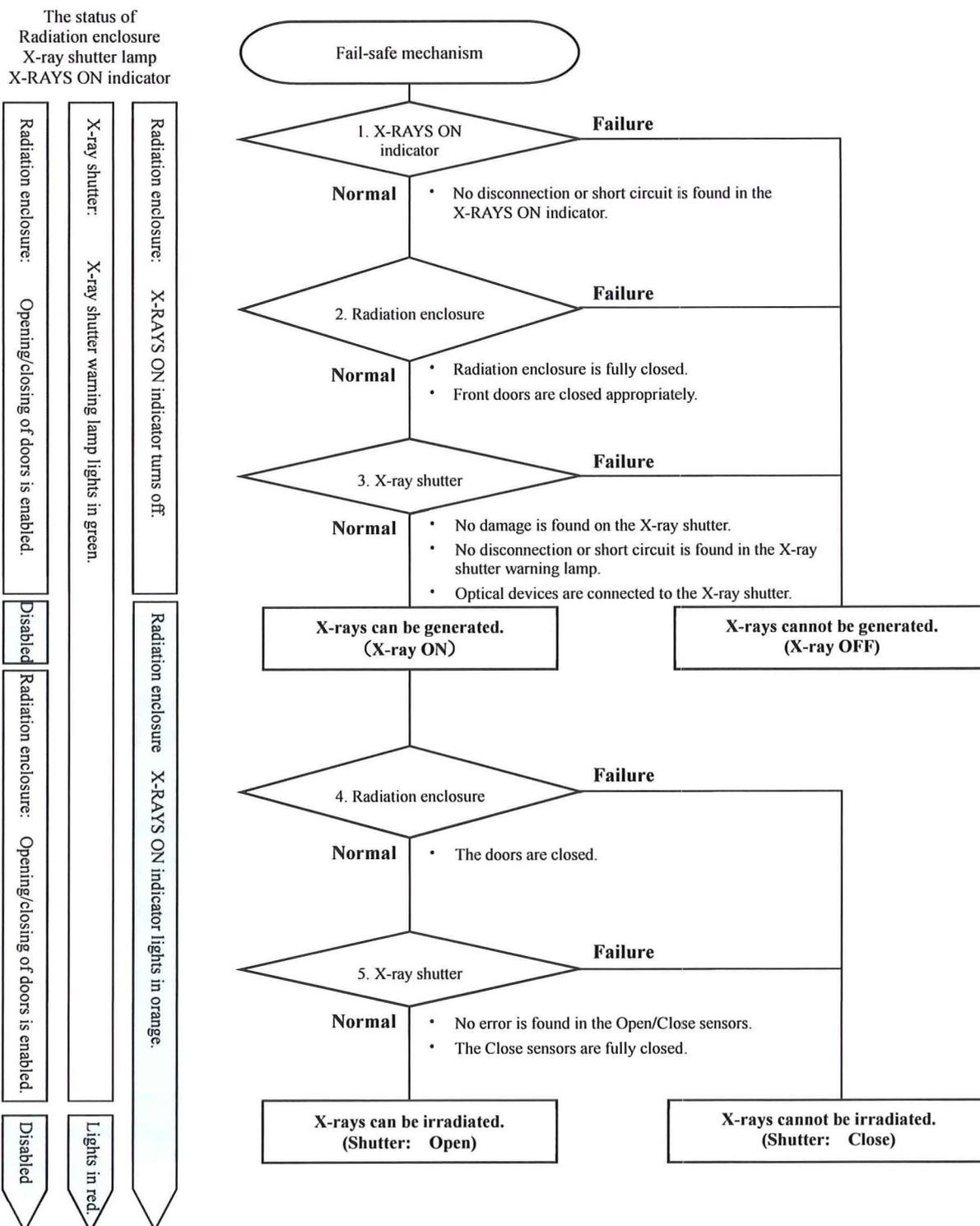


Fig. 4 Fail-safe mechanism

X-ray safety management

Leakage radiation measurement

The measurement of leakage radiation in the vicinity of an X-ray diffractometer is a basic requirement for preventing radiation damage. Be sure to perform leakage radiation measurements at regular intervals and to save the results recorded.

If leakage radiation exceeds the permissible amount stipulated by applicable laws and regulations, immediately shut off power supply to the X-ray diffractometer, affix a “Do not use” label to the X-ray diffractometer, and contact the sales representative who you purchased the instrument from.

Perform leakage radiation measurement at maximum load when the X-ray tube is at its maximum tube voltage.

Always wear protective clothing when performing leakage radiation measurements.

In addition to periodic measurements, perform leakage radiation measurement in the following cases.

- When the X-ray diffractometer is installed
- When the X-ray diffractometer is relocated
- When the radiation enclosure has been repaired or reinstalled
- When the X-ray tube has been repaired or replaced
- When the X-ray shutter has been repaired or replaced
- When the optical system has been replaced, modified, or repaired
- When there has been exposure or possible exposure to X-rays

Personal dosimeter

A personal dosimeter can be used to evaluate the absorbed dose in the case of a discovery of radiation exposure, radiation leakage or scattered radiation. When using the X-ray diffractometer, be sure to wear a personal dosimeter ¹⁾ as directed by the equipment supervisor or other supervisory personnel.

¹⁾ See the Glossary at the end of this manual.

Precautions related to electrical hazards

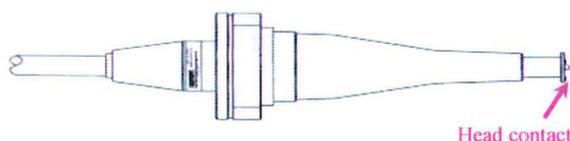
Precautions related to high voltage

While X-rays are being generated, a high voltage ranging from several negative kV to -60 kV is supplied from the high-voltage transformer to the X-ray tube via the high-voltage cable. Even after X-ray generation has been halted, the high-voltage transformer and high-voltage cable will retain a high-voltage electric charge. Removing the high-voltage cable from the X-ray diffractometer may result in electric shock.

To prevent electric shock, contact the sales representative who you purchased the instrument from, for performing operations such as connecting or removing the high-voltage cable, cleaning the high-voltage cable head, and replacing the insulating grease.

These operations must be performed only by a Rigaku service engineer or other qualified personnel¹⁾.

When replacing the X-ray tube, avoid direct contact with the high-voltage cable head contact.



High-voltage cable head (X-ray tube end)

Precautions related to the power supply in the internal section

The X-ray generator contains charged and live parts. Touching these parts may result in electric shock. Contact the sales representative who you purchased the instrument from before touching the interior of the X-ray generator in the course of maintenance or other operations.

Precautions related to the ground wire

Make sure that the X-ray generator's ground wire is connected to a protective conductor²⁾ before using the X-ray diffractometer.

1. The X-ray diffractometer will be in a dangerous condition if its internal and external grounding terminals are not connected to a protective conductor (protective grounding terminal).
2. Never remove the ground wire while the X-ray diffractometer is receiving an electric current.

¹⁾ An individual who has received a radiation safety officer's license or individual using the X-ray diffractometer who under the direction and control of a radiation safety officer has received training from the equipment supervisor regarding items essential for maintaining the safety of X-ray operations.

²⁾ See the Glossary at the end of this manual.

Fire hazard

If the X-ray diffractometer emits smoke or an unusual odor, Turn the power key to the OFF position, or press the EMO button(optional) to shut off the power supply to the X-ray diffractometer.

Vacuum hazard

When using attachments that contain a sample chamber depressurized or evacuated for a vacuum state, observe the following precautions. Inappropriate handling may release the vacuum, resulting in damage to the attachment or diffractometer with physical injuries.

1. When releasing the vacuum state of the attachment, stop the vacuum pump, and then immediately open the leak valve gradually to return the state to the ambient.
2. When using a vacuum pump, use a backflow valve to prevent backflows.
3. Be careful to handle sealed-off X-ray tubes. The inside of X-ray tubes is maintained in a vacuum state. Damage to the X-ray tubes may result in releasing the vacuum state if you drop or fall it. In addition, a beryllium window of X-ray tube is very thin, and will be easily damaged when the vacuum state is released, which may scatter airborne particles of the beryllium.
4. Do not suddenly open the vacuum leak valve (leak knob) when changing the pressure inside a demountable X-ray tube from a vacuum to atmospheric pressure. The sudden difference in pressure may result in damage to the X-ray tube.

Precautions related to hazards caused by materials or substances

Precautions related to beryllium

Metallic beryllium is used in the X-ray tube window, in the window of the attachment (for instance, high or low temperature attachment) used for substitution of the sample atmosphere, and in the X-ray detector window. Beryllium and the powder and/or vapor from its corrosive products and chemical compounds are harmful to the human body if they are touched, ingested or inhaled. Such actions may cause serious illness or death. Be sure to observe the following.

1. Avoid contact with the beryllium with any part of your body. If you accidentally touch the beryllium with your bare hands or get it on your skin immediately wash it off with soap and water and then consult a doctor.
2. Beryllium window used in X-ray tubes, X-ray detectors, and attachments is very thin, and will be easily damaged when the vacuum state is released, which may scatter airborne particles of beryllium. The airborne particles of beryllium are harmful. If you accidentally touch them with your bare hands or get it on your skin, immediately wash them off with soap and water, and then consult a doctor. If you inhale them, consult a doctor immediately.
3. Do not perform any of the following actions with regard to parts that contain metallic beryllium.
 - Moisten with water (if water is spilled on the part while it is being handled, soak up the water with absorbent paper or similar)
 - Polish, sharpen, cut, or destroy, etc. to produce airborne particles of beryllium
 - Apply agent, wipe with chemicals, etc., which converts beryllium into soluble chemical compound
 - Incinerate, vapor, etc., which converts beryllium into fume
4. If you accidentally damage the part, please observe the following.
 - Avoid contact with the part with your bare hands.
 - Do not inhale the particles of beryllium.
 - Recover all the fragments, place them in an airtight container to prevent their dispersal, and ask a company that specializes in the handling of such materials to dispose of the damaged part. If you cannot locate a suitable company, please consult the sales representative who you purchased the instrument from.

Precautions related to the measurement of toxic samples

This X-ray diffractometer is not equipped with a safety mechanism for the handling of toxic samples. Measurement of toxic samples must be performed only by responsible individuals with specialized knowledge regarding their handling. Be sure to observe the following precautions.

1. Do not measure radioactive substances. Such actions may result in exposure to radiation. Moreover, the X-ray detector may calculate the radiation from radioactive substance.
2. Do not measure substances that are likely to ignite or explode.
3. Use special containers to prevent burns caused by inhalation or spillage of volatile samples or samples liquefied at low temperatures.
4. Do not inhale asbestos, free silicic acid or their dust.
5. Do not inhale the dust, vapor, or mist from toxic substances, or allow them to come into contact with your body or clothing.
6. Do not allow toxic samples to become scattered.

Precautions when using gas for the sample atmosphere

See “Precautions related to gas” later in this chapter and observe the precautions given.

Precautions related to thermal hazards

Inappropriate handling when replacing the X-ray tube immediately after it has been used or using an attachment to maintain the temperature of the samples at a high or low temperature may result in burns or low-temperature hazards. Be sure to observe the following handling precautions.

Precautions related to burn hazards

Precautions related to the sealed-off X-ray tube replacement operation

Replacing a sealed-off X-ray tube immediately after the X-ray generator has been used may result in burns due to the high temperature of the X-ray tube. Before undertaking replacement operations, stop the X-ray generation, turn off both the power switch and breaker of the X-ray diffractometer, and wait at least 30 minutes.

Precautions related to the demountable X-ray tube replacement operation

Replacing a demountable X-ray tube immediately after the X-ray generator has been used may result in burns due to the high temperature of the X-ray tube. Before undertaking replacement operations, stop the X-ray generation, cool down the X-ray tube for an hour and then stop the vacuum pump.

Precautions related to the handling of high-temperature attachments

Inappropriate handling of the high-temperature attachment¹⁾ that is used to increase the temperature of the samples and retain it at a high temperature may result in burns. Be sure to observe the following precautions.

1. Wait until the furnace and the temperature inside the furnace have returned to room temperature before mounting or replacing any samples.
2. Wait until the furnace and the temperature inside the furnace have returned to room temperature before removing the airtight cover of the high-temperature attachment. Removing the cover when the temperature is high will damage the furnace and components.
3. When using a high-temperature attachment that increases the temperature of high-temperature gases or fluids, take care to prevent the high-temperature gases or fluids from coming into direct contact with your body or clothing.
4. Wear appropriate protective clothing.

Precautions related to low-temperature hazards

Inappropriate handling of the low-temperature attachment²⁾ that is used to reduce the temperature of the

¹⁾ High-temperature attachment, infrared heating high-temperature attachment, sample direct heating high-temperature attachment, ultra-high-temperature attachment, liquid crystal high-temperature attachment, medium and low temperature attachment, steam high-temperature attachment, simultaneous measuring instrument for X-ray diffraction and differential scanning calorimetry, etc.

²⁾ Medium and low temperature attachment, ultra-low temperature X-ray diffractometer attachment, low temperature attachment, etc.

samples and maintain it at a low temperature may result in low-temperature hazards. Be sure to observe the following precautions.

1. Avoid cryogen or coolant, which is, used to reduce the temperature of the samples to a low temperature (such as dry ice, ethylene glycol, liquid nitrogen, and liquid helium), from coming into direct contact with your body or clothing.
2. If a large quantity of liquid nitrogen is used in a small room, provide adequate ventilation to prevent lack of oxygen.

Precautions related to gas

Incorrect handling of gas may lead to serious accidents. Be sure to observe applicable laws and regulations pertaining to the installation, conveyance, storage, return and handling of gas cylinders. Handle all gas cylinders with great care, and be sure to observe the following precautions.

Precautions related to high-pressure gas

1. Fix gas cylinders to their dedicated stands so that they do not topple over and fall to the ground.
2. Maintain gas cylinders at a temperature of 40°C or lower, and place them in a well-ventilated location away from direct sunlight.
3. Close the gas cylinder valves when the cylinders are not being used.
4. Avoid handling the gas cylinders with oil-stained hands or gloves.
5. Handle the gas cylinders with great care. Inappropriate handling that causes the cylinders to topple over and fall to the ground may result in explosions or ruptures to the cylinders, facilities, or piping.
6. Before use, use soapy water or leak detection fluid to confirm that there is no leakage of gas from the piping or valves.
7. Do not open the gas cylinder valve suddenly. The rapid difference in pressure may result in damage to the containers connected to the cylinder and to the piping.
8. Avoid using gas cylinders for any purpose other than the purpose for which it was designed.
9. Make sure the workplace and the installation location are adequately ventilated.
10. Be sure to observe all laws and ordinances related to the handling of high-pressure gas (The High-pressure Gas Safety Law and related laws and ordinances).
11. For refilling or disposal of gas cylinders, either contact a company authorized to handle such requirements or the sales representative who you purchased the instrument from

Precautions related to flammable, corrosive, or toxic gases

When handling flammable, corrosive, or toxic gases, be sure to observe the above precautions related to high-pressure gas as well as the following precautions.

1. Gas leakage or inappropriate handling of flammable gas may cause a fire or explosion. Make sure that there are no gas leaks and handle gas in an appropriate manner.

2. When using a flammable gas, prohibit smoking and the use of fire within a 5-meter radius of the workplace, and do not place any flammable or combustible items in its vicinity.
3. A corrosive gas may corrode the X-ray diffractometer, its components and the surrounding facility. Corrosive gas must not be handled by anyone other than a responsible individual with specialized knowledge regarding its handling.
4. Even a small amount of toxic gas leakage may lead to serious accidents involving human life. Toxic gas must not be handled by anyone other than a responsible individual with specialized knowledge regarding its handling.
5. Be sure to handle gas ventilation and emission in accordance with all applicable laws and regulations.

Precautions related to non-toxic gas

A build-up of even non-toxic gas may cause suffocation. Ensure adequate ventilation to prevent gas build-up.

Precautions on SF₆ (sulfur hexafluoride)

For high-voltage insulation of the demountable X-ray tube, SF₆ gas is used. Arbitrary release of this gas is prohibited and appropriate collection is required by laws. For the disposal of this gas, contact the sales representative who you purchased the instrument from.

Glossary

Term	Description
X-ray diffractometer	An X-ray diffractometer is an equipment which records the diffracted angle and intensity of the diffracted X-ray generated when a sample is irradiated by an X-ray. An X-ray diffractometer comprises the following four units: an X-ray generator which generates X-rays; a goniometer which measures the diffracted angle of the diffracted X-ray beam; a counter to calculate the intensity of the diffracted X-ray beam; and a control and data processing unit to control the X-ray generator, the control unit, and the goniometer and to gather the diffraction data. In addition, there are various attachments.
Radiation damage	Radiation damage refers to direct or indirect physical damage caused by the biological action of ionizing radiation which triggers phenomena such as alteration of the cells or tissue of living organisms, mutation or destruction of cells, or destruction of tissue. Symptoms of radiation damage include nausea, total-body fatigue, an increase in leukocytes, skin pigmentation, loss of hair, premature aging, carcinogenesis, shortening of the life span, pernicious anemia, and leukemia.
Ionizing radiation	Particles or electromagnetic waves that ionize atoms are called ionizing radiation. Ionizing radiation includes X-rays, α rays, β rays, γ rays, electron rays and neutron rays.
X-ray diffraction method	When a crystal is irradiated by X-rays, that crystal exhibits a unique diffraction profile (a diffraction pattern consisting of a lattice of multiple diffraction lines). X-ray diffraction is used to analyze the diffraction profile and the structure of crystals to obtain information related to the crystal phase. Either of two X-ray diffraction methods – powder or single crystal – can be used, depending on the form of the sample.
Equipment supervisor	The term equipment supervisor (management organization) refers to the individual or organization responsible for equipment use and maintenance. That person or organization is responsible for ensuring both that the equipment performs correctly within the specified operating range and that the operator and maintenance engineer receive the suitable training.
Operator	The operator uses the equipment and products to realize the functions for which they are intended. He/she is required to receive training with respect to the maintenance of safety and suitable operation of the equipment.
Maintenance engineer	The maintenance engineer performs tasks specified as necessary to ensure the correct operation of the equipment and products. Please refer to the user's manual for detailed instructions on maintenance procedures. The user's manual clearly states which procedures can be performed by the maintenance engineer. Please refer all other procedures to the sales representative who you purchased the instrument from. The maintenance engineer is required to receive training in safety maintenance and equipment operations.
Controlled area (X-ray controlled area)	The boundaries of a controlled area must be indicated by a sign. Persons who do not need to enter the controlled area must be prohibited from entering. If the X-ray diffractometer is correctly equipped with a radiation enclosure, the outside of that radiation enclosure shall be the boundary of the X-ray controlled area.

Term	Description
Radiation safety officer license	The radiation safety officer license is a national certification in Japan that authorizes engineers to use X-ray equipment to perform quality inspections of industrial goods and non-destructive structural inspections in Japan. As the requirements for the radiation safety officer is subject to varying laws, and regulations in the country or region in which the X-ray diffractometer is installed.
Demountable X-ray tube	A demountable X-ray tube is an X-ray tube that uses a vacuum pump to evacuate the tube. Available products include rotating anode X-ray tubes (the general term is rotor) and microfocus X-ray tubes (Microflex is an example of this product type). X-ray tubes with a sealed vacuum are called sealed-off X-ray tubes. X-ray tube is the general term for both demountable and sealed-off X-ray tubes.
Low-temperature hazards	Low-temperature hazards include injuries such as frostbite and chilblains.
High-pressure Gas Safety Law	The purpose of the High-pressure Gas Safety Law is to prevent disasters caused by high-pressure gas by regulating the production, sale, storage, transportation, and other handling and consumption of high-pressure gas, along with the production and handling of the cylinders for high-pressure gas.
Safety features	The term safety features refers both to mechanisms required to prevent accidents and to maintain normal operations when the equipment happens to behave erratically or when an operator handles the equipment carelessly and mechanisms required to protect individuals from exposure to X-rays or from other hazards such as burns. A fail-safe mechanism is also one of the safety features.
Fail-safe mechanism	A fail-safe mechanism refers to a mechanism that acts to protect individuals from X-ray exposure when a component or other device mounted to prevent exposure to X-rays malfunctions. When this mechanism operates, X-rays cannot be generated, X-rays being generated are stopped, X-ray shutters cannot be opened, and open shutters are closed. This safety feature is only effective when a Rigaku Corporation made radiation enclosure is properly incorporated with Rigaku Corporation made X-ray equipment.
Personal dosimeter	A personal dosimeter is a small dosimeter that can be worn by each individual to enable measurement of the dose equivalent received by that individual. Various types are available, including glass badges, optically-stimulated luminescent dosimeter, thermoluminescent dosimeters and pocket dosimeters.
Protective conductor	A protective conductor is a conductor electrically connected to exposed conductive parts, extraneous conductive parts, and the main grounding terminal to protect against electric shock.

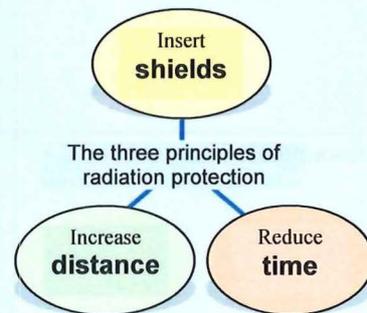
The three principles of radiation protection

The following three methods are ways to minimize the amount of ionizing radiation to which an operator is exposed. These are called the Three Principles of Radiation Protection.

1. Insert shields between the radiation source and the human body
Shielding materials attenuate X-ray strength. The higher the atomic number and the thicker the material, the greater the attenuation. Lead is often used for shielding.

2. Increase the distance between the radiation source and the human body
The attenuation of X-rays is inversely proportional to the square of the distance between the radiation source and the human body. In the face of exposure risk, immediately move away from the area.

3. Reduce the time of radiation exposure
When handling radiation, protect yourself from radiation to the extent possible by the methods described in 1. and 2. above. In unavoidable situations, reduce the amount of time for which you are exposed to radiation to minimize exposure. Smaller exposures are always preferable. X-ray management is essential to ensure that exposures do not exceed the dose limits specified by law.



Rigaku Corporation

3-9-12, Matsubara-cho, Akishima-shi, Tokyo 196-8666, Japan

Phone: 81-42-545-8111 Fax: 81-42-544-9795 www.rigaku.com

Rigaku Corporation

Sales Office

4-14-4, Sendagaya, Shibuya-ku,
Tokyo 151-0051, Japan

Rigaku Beijing Corporation

2601A, Tengda Plaza, No.168,
Xizhimenwai Avenue, Haidian District,
Beijing 100044, P.R. China

Rigaku Americas Corporation

9009 New Trails Drive,
The Woodlands, Texas 77381-5209,
U.S.A.

Rigaku Asia Pacific Pte. Ltd.

10 Anson Road, #15-14 International
Plaza, Singapore 079903

Rigaku Europe SE

Hugenottenallee 167,
63263 Neu Isenburg, Germany

Rigaku Latin America Ltda.

Avenida Doutor Arnaldo, 1980, sala 10,
bairro Sumaré, na Cidade e Estado de
São Paulo, CEP 01255-000, Brasil