# High pressure gas safety training

Cryogenic Laboratory,
Kanazawa University

# 1. High Pressure Gas Law

High-pressure gas is regulated by the " High Pressure Gas Safety Act" (enforced in April 1997, former "High-pressure Gas Control Law"). Further detailed rules are stipulated by government or ministerial orders such as "High Pressure Gas Safety Act Enforcement Ordinance" and "General High Pressure Gas Safety Regulations".

## 1.1 Purpose of law

《Article 1》 This law regulates the production, storage, sale, transportation and other handling and consumption of high-pressure gas, and the production and handling of containers in order to prevent accidents caused by high-pressure gas, and... The purpose is to promote activities and thus ensure public safety.

[Commentary]
The purpose of the law is to prevent accidents caused by high-pressure gas and to ensure the public safety of not only the employees of business establishments but also local residents. For this reason, certain regulations are imposed on high-pressure gas, and voluntary activities are in place to prevent disasters.

## 1.2 What is "high pressure gas"?

《Article 2》 The term "high pressure gas" means any gas that falls under any of the following items [Partially omitted]:

· Compressed gas, the pressure (meaning gauge; the same shall apply hereinafter) of which is not less than 1 MPa at its normal operating temperature and which is currently not less than 1 MPa, or compressed gas, the pressure of which is not less than 1 MPa at a temperature of 35°C;

· Liquefied gas, the pressure of which is not less than 0.2 megapascal at its normal operating temperature and which is currently not less than 0.2 megapascal, or liquefied gas, the temperature of which is 35 degrees Celsius or less in the case that the pressure is 0.2 megapascal

[Commentary]
- Normal operating temperature does not mean room temperature, but the temperature at which the device is operating steadily.
-A compressed gas with a pressure of 1MPa or less will be a high-pressure gas if the pressure when converted to a temperature of 35°C may be 1MPa or more.
-Liquefied gas refers to what is present as a gas at room temperature and pressure, but is made liquid under the temperature or pressure of a certain condition. If liquid and its vapor coexist, both should be handled as liquefied gas.
- Even if the liquefied gas has a pressure of 0.2MPa or less, it will be a high-pressure gas if the temperature at which the saturated vapor pressure becomes 0.2MPa is 35°C or less.
-Acetylene gas, liquefied hydrogen cyanide, liquefied brommethyl, and liquefied ethylene oxide are handled as high-pressure gas under more severe conditions.

## 1.3 About permission to manufacture high-pressure gas

《Article 5》 Any person who falls under the following shall obtain the permission of the prefectural governor for each business establishment.

-The volume of gas that can be processed by compression, liquefaction, or any other method (meaning the volume converted to a state where the temperature is 0°C and the pressure is 0Pa) is 100 ㎥ per day (the gas corresponds to the type of gas specified by a Cabinet Order). In some cases, a person who intends to manufacture high-pressure gas using equipment that has a value of 100 ㎥ or more for each type of gas specified by the Cabinet Order and is more than the value specified by the Cabinet Order.

[Commentary]

The term "high-pressure gas" is a definition of a state. Therefore, even if a substance is the same, whether it is a "high pressure gas" or not depends on its state. When the product made by some kind of processing is “high-pressure gas”, it is referred to as “manufacture of high-pressure gas”. A typical example of "manufacturing of high- pressure gas" includes:

- low-pressure gas is compressed to produce "high-pressure gas";
- low-pressure gas is cooled or liquefied to produce "high-pressure gas";
- "high-pressure gas" is pressurized, depressurized or vaporized to produce "high-pressure gas".

On the other hand,, when “high-pressure gas” Is used to become a state where it is not “high-pressure gas”, it is referred to as "consumption".

The cryogenic laboratory of Kanazawa University is licensed as a first-class manufacturer, and conducts "production of high-pressure gas" and "storage of high-pressure gas" for liquid nitrogen and liquid helium.

## 1.4 Safety Training

《Article 27》 A Class 1 Producer shall prepare a Safety Training Program for his/her employees.

[Commentary]

- As mentioned above, the cryogenic laboratory at Kanazawa University is authorized as a Class 1 Producer and undergoes a safety inspection once a year by Ishikawa Prefecture.

-Those who use cryogens such as liquefied nitrogen and liquefied helium through the cryogenic laboratory are considered to be the employees. Those who use cryogens should be aware of this point and be careful not to violate the law and to prevent accidents. This course is carried out as a safety training to raise the safety awareness of employees and prevent accidents.

# 2 Properties and Hazards of High-pressure Gas

## 2.1 Properties of gases

Various types of gases are used as high-pressure gas, and their properties shall be properly understood and handled accordingly. Table 1 shows the properties of frequently used gases.

| Name | Gas density in standard reference condition (g/l) and specific gravity against air | Boiling point (K) | Liquid density at boiling point (g/l) | Volume ratio of gas in standard reference condition and liquid at boiling point | Gas classification | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | Inflammable gas (Explosion limit) | Toxic gas (Permissible level) | |
| Nitrogen ($N_2$) | 1.251 (0.967) | 77.4 | 808 | 646 | x | x | |
| Helium ($^4He$) | 0.1785 (0.138) | 4.2 | 125 | 700 | x | x | |
| Oxygen ($O_2$) | 1.429 (1.105) | 90.2 | 1142 | 799 | x (See the note.) | x | Note: Burnable |
| Hydrogen ($H_2$) | 0.0899 (0.0695) | 20.3 | 808 | 646 | o (4 to 75 vol%) | x | |
| Carbon dioxide ($CO_2$) | 1.977 (1.529) | 195 (Sublimation) | | | x | x (See the note.) | Allowable quantity: 5000 vol ppm |
| Carbon monoxide (CO) | 1.250 (0.967) | 81.6 | | | o (12.5 to 74 vol%) | o (25 vol ppm) | |
| Ammonium ($NH_4$) | 0.771 (0.597) | 239.7 | | | o (15 to 28 vol%) | o (25 vol ppm) | |

Table 1: Properties of major gases

## 2.2 Hazards of high-pressure gas

### 2.2.1 Flammable gas

The explosion limit specified in Table 1 is the condition at ambient temperature and ordinary pressure in air and varies depending on temperature and pressure. The majority of explosion limits are detonation limits, and even a small quantity of flammable gas may pose an extreme danger when leakage occurs during handling (Detonation: Violent explosion where combustion velocity exceeds the speed of sound).

### 2.2.2 Toxic gas

The permissible level specified in Table 1 is the 'time-weighted average concentration of toxic gas in the working environment that does not affect the health of a healthy adult male after exposure to the gas every day while working 8 hours per day.' The ceiling value is established for some types of gases that cause acute poisoning and are thus prohibited from exceeding the specified concentration even for a short period of time. Among hazardous gases, those with lower permissible levels are specified as 'toxic gas' according to the High-pressure Gas Safety Law.

> [Handling precautions for flammable gases and toxic gases]
> When using flammable or toxic gas, make sure to adequately ventilate the area continuously. A concentration alarm or the like shall be installed. When using a toxic gas, gas masks shall be prepared.

### 2.2.3 Burnability of oxygen

Oxygen gas is not inherently flammable, while many substances readily ignite in a gas atmosphere containing a high concentration of oxygen. When oxygen is supplied from oxygen gas cylinders in particular, gas compression or friction may pose a risk of unintended ignition. Therefore, never use gas packing made of flammable materials.

### 2.2.4 Oxygen deficiency

If a large quantity of gas other than oxygen leaks into the air, relative oxygen concentration in the air will drop, possibly leading to a risk of oxygen deficiency. Since a liquefied gas expands its volume by approx. 700 times when it evaporates, due care should be exercised against oxygen deficiency. Table 2 shows the influence of lowering oxygen concentration on the human body.

| Oxygen concentration (%) | Symptom |
|---|---|
| 21 | Ordinary concentration |
| 16 to 12 | Pulse rate and respiration rate increase, and effort is required to concentrate.<br>Minute muscular work becomes difficult.<br>Headache, nausea, and/or ear noise ensues. |
| 14 to 9 | Judgment impairment, elation, unstable mental condition, and/or no recognition of stimuli.<br>Inebriation, no memory of certain past events, temperature rise, general feeling of weakness, and/or cyanosis. |
| 10 to 6 | Loss of consciousness, central nervous system disorder, convulsions, Cheyne-Stokes respiration, and/or cyanosis. |
| Less than 6 | Coma → Bradypnea, respiratory arrest, and cardiac arrest after 6-8 minutes. |

Table 2 Symptoms caused by oxygen deficiency

### 2.2.5 High pressure

When handling high-pressure gases, pay careful attention to the physical force of gas pressure. In particular, force, not pressure, is hazardous for the human body. Pressure may lead to various accidents such as detachment of a cover/lid, movement of pipes, or rupture of containers, possibly leading to an unexpected disaster.

# 3 High-pressure Gas (Compressed Gas)

## 3.1 Inspection of high-pressure gas containers (cylinders)

High-pressure gas containers are subject to a pressure test at an interval specified by applicable laws and regulations (once every three years for compressed gases). If the content (gas) alone is purchased from contractors and cylinders are borrowed, owners of the cylinders shall conduct pressure tests, while users are not obliged to do so. When borrowing cylinders for a long period of time, users shall periodically check that they do not exceed the specified pressure test interval.

Data including gas type, container weight, pressure resistance, and inspection date are embossed on each container as shown below:

| | |
|---|---|
| (1) Name or code of container manufacturer: | D001 |
| (2) Name of gas filled in the container (katakana or chemical symbol) | He |
| (3) Container No. and serial No. | CBCL-4-6035 |
| (4) Inner volume (actually measured value) [liters] | V47.7 |
| (5) Container weight (main body excluding the valve) [kg] | W68.4 |
| (6) Date of pressure test (Month and year) | 8.1991;7-94 |
| (7) Test pressure [kg/cm2] | TP250 |
| (8) Maximum filling pressure (only for compressed gas) [kg/cm2] | FP150 |

In general, new cylinders are filled with gas until the maximum filling pressure at 35ºC is reached.

## 3.2 Handling of cylinders

### 3.2.1 Transportation and storage

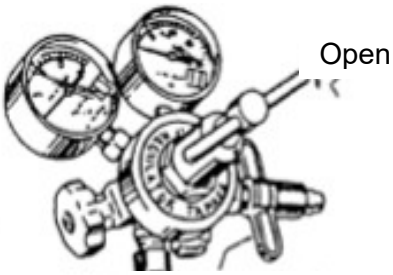
- Make sure to attach caps to protect valves when transporting cylinders, and use dedicated transport equipment such as carriers.
- Containers are heavy (approx. 70 kg for ordinary cylinders) and have a high center of gravity; therefore, it is extremely dangerous if they stand independently without fixation while in use. Make sure to fix them to cylinder stands or a wall with a chain or the like to prevent falls.
- Store containers in a well-ventilated location away from direct sunlight. Since cylinders are filled with gas with the filling pressure at 35ºC, they may exceed the maximum filling pressure after exposure to direct sunlight in the summer for a long period of time.

### 3.2.2 Confirmation of containers

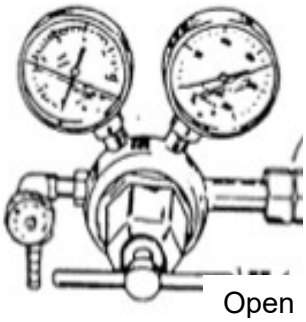
- Containers are color-coded according to the gases to be filled, and embossed accordingly. Make sure to confirm the type of content gas before use. It is preferable to indicate the type and pressure of the content gas on the pipe.

### 3.2.3 Handling of pressure regulators (pressure reducers)

- Make sure to attach pressure regulators when using compressed gases. Since usable gas types are specified for respective pressure regulators, make sure to confirm the gas type before use.
- Connection between regulators and cylinders, for example, tightening by hand or using a spanner, varies depending on the type of regulator. If damage is observed on the valve seat, ask the contractor to replace the cylinder.
- Before use, check that no gas leaks are observed from the connection between the cylinder and pressure reducer.
- The ordinary pressure regulator increases pressure when the pressure regulating valve on the outlet side is pressed and turned clockwise and opens. Before opening the cylinder valve on the inlet side in particular, confirm that the outlet-side pressure regulating valve is closed (or that the pressure is set to 0).
- Always close the master cylinder valve and pressure regulator after use.




(a) Convex screw connection type




(b) Concave screw connection type

3.2.4 Serviceability limit

Containers shall be returned with a pressure that is greater than the atmospheric pressure that still remains. This is to ensure that purity is maintained in re-filling and to prevent corrosion of the container due to moisture from the air entering.

# 4 Cryogenic liquefied gas

## 4.1 General handling precautions

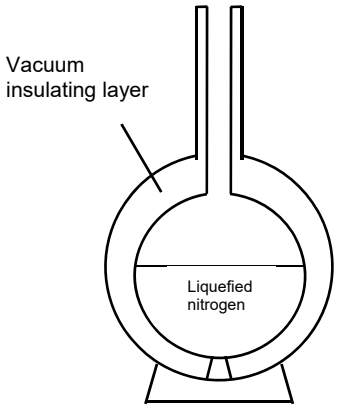
- Since liquefied gas or evaporative gas will cause frostbite, exercise due care not to allow it to contact directly with the skin or eye. Do not directly touch containers and piping cooled by liquefied gas.
- Even if you directly touch liquefied gas, you will not get frostbite if the contact occurs over a short period of time. This is because evaporative gas exists between liquefied gas and the skin. However, liquefied gas that soaks into the clothes is dangerous because it may cause direct contact with the skin. Do not allow it to overflow from the container and splash over your shoes. Use of cotton work gloves is also dangerous when handling liquefied gas.
- If you must use cotton work gloves or a cotton waste rag, make sure that you can remove it immediately. It is recommended to use leather gloves dedicated for handling cryogenic materials.
- When liquefied gas evaporates, its volume expands by approx. 700 times. Therefore, never seal openable containers.
- For sealed containers such as self-pressurized containers, check the safety valve for proper operation.
- If a large quantity of liquefied gas evaporates, oxygen concentration decreases proportionally. When using liquefied gas indoors, ensure adequate ventilation. Using liquefied gas, in particular liquefied nitrogen to cool a room or make ice is inefficient and dangerous.
- Transportation of liquefied gas by elevator may cause oxygen deficiency. Make sure to use the stairways, or station two persons outside the elevator on the 1st floor as well as the destination floor.

> [Handling precautions for liquefied nitrogen and liquefied helium]
>
> - Liquefied gas is high-pressure gas.
> - Such gases pose a low temperature and oxygen deficiency risk.

## 4.2 Liquefied nitrogen containers

### 4.2.1 Openable container

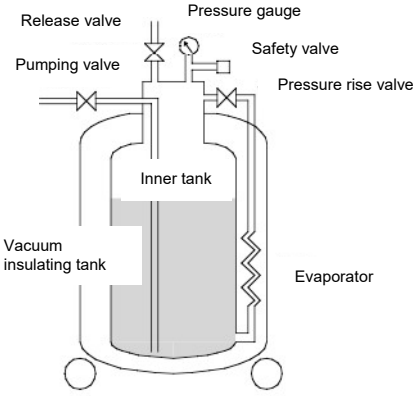
- Containers have a single- or double-layer Dewar structure and are closed (or placed on top) using a cork or metal cap container cover. Most small containers of 20 liters or less are of this type.
- Since the cover cannot be sealed to allow evaporating gas to leak from the mouth, this type of container is called an openable container.
- Exercise due caution to prevent containers from accidentally becoming sealed by using covers other than the dedicated cover. When containers are left without a cover, water may condense and block the mouth, or oxygen in the air may enter and become liquefied.

- Containers can suffer structural mechanical weakness in the neck. Note that containers containing a large quantity of liquefied nitrogen will become highly loaded if they are inclined when discharging the liquid. Use of a syphon or the like is recommended to discharge liquefied gas from containers with a capacity of 20 liters or more.
- Exercise due care to prevent impact power during transportation.
- When the degree of vacuum from the vacuum section of the Dewar condenser deteriorate over time, evaporation increases, the outer wall becomes cool, or condensation accumulates. Ask the vendor for re-vacuuming in order to make it usable again, or you may conduct re-vacuuming by yourself.

4.2.2 Self-pressurized containers

- A self-pressurized container is a container with a capacity of 50 liters or more that can increase inner pressure through the use of a pressure rise device to pump out the content.
- Such large containers are usually transported by using casters or dedicated transport carriers. The center of gravity of such containers is located significantly high and the total weight including the container and liquefied nitrogen (specific gravity: approx. 0.8) exceeds 100 kg; therefore, they must be transported carefully. To ensure safety, each self-pressurized container must be transported by several people.
- A safety valve is always installed to release gas in case the inner pressure rises above the specified level. Check the safety valve for proper operation. Containers also require periodic inspection at specified intervals.




Structure of a self-pressurized container
(cross-sectional schematic)

4.2.3 C.E.

- After receiving liquefied nitrogen from tankers, the Cryogenic Laboratory stores it in a reservoir (capacity: approx. 8,000 liters) called the C.E. (Cold Evaporator). The C.E. is kept constantly pressurized at 2 to 3 atm.
- An automatic feeder is used to pump out from the C.E. to each user.
- An automatic feeder with a barcode container management system can pump out contents of the required quantity with automatic pumping to maximum capacity or to a manual stop.

If you have any questions about operation of the automatic feeder, please contact Nunomura from the Monitoring Office, Cryogenic Experiment Section (ex. 5873).

[Measures in case of an emergency]
- The automatic liquefied nitrogen feeder does not stop even if the stop button is pressed, and liquefied nitrogen will continue to overflow.
→ Close needle valve B to stop the liquefied nitrogen and immediately report to the emergency contact.

- If you find other abnormalities. → Immediately report to the emergency contact.

[Emergency contact]

Koichi Nunomura (in charge of security) Ex. 5873 or 090-7081-8268

Satoshi Abe (Director of the Cryogenic Laboratory ) Ex. 5665 or 090-9444-4856

# 5 Transportation by elevator

Transportation of gases by elevator may cause oxygen deficiency. Make sure to use stairways, or station two persons outside the elevator on the 1st floor as well as the destination floor.

An example of transportation in Natural Science Hall 5 (College of Science Building) is shown below:

(1) Use of an elevator

To transport high-pressure and liquefied gases, of the two elevators in the laboratory building, use the east-side elevator (on the workshop side).

(2) Transportation method

Do not go into the elevator during transportation of high-pressure or liquefied gases.
Two or more persons shall stay outside the elevator on the loading floor as well as the destination floor, to load and receive the gases, respectively.
During transportation, post a sign (as shown in the photo below) to be originally placed in the elevator between the handrails near the elevator entrance to clearly indicate that the elevator cannot be used.


(3) Specific transportation procedure

Example: Two persons, A and B, transport a container from the 1st floor to the 7th floor.

(a) Person A goes to the 7th floor in advance and waits for the container in front of the elevator.

(b) Person B loads the container on the 1st floor, removes the sign from the handrail in the elevator, posts it between the handrails near the elevator entrance, presses the 7th-floor button, and sends off the container by itself. (Person B does not accompany the container.)
* If the container poses a risk of fall or movement, it must be secured.

(c) When the container arrives at the 7th floor, Person A removes the sign (and hangs it on the right handrail), returns the fixture to the original position, and unloads the container.

# Notice from the Cryogenic Laboratory

As an on-campus joint-use facility, the Cryogenic Laboratory provides liquefied nitrogen, conducts liquefication and supply of helium, supports implementation of cryogenic experiment techniques, and provides joint-use equipment.
The devices as listed below can be shared and used:

- SQUID magnetometer (2 to 300 K, 0 to 5T)
- Helium leak detector
- Sniffer leak detector

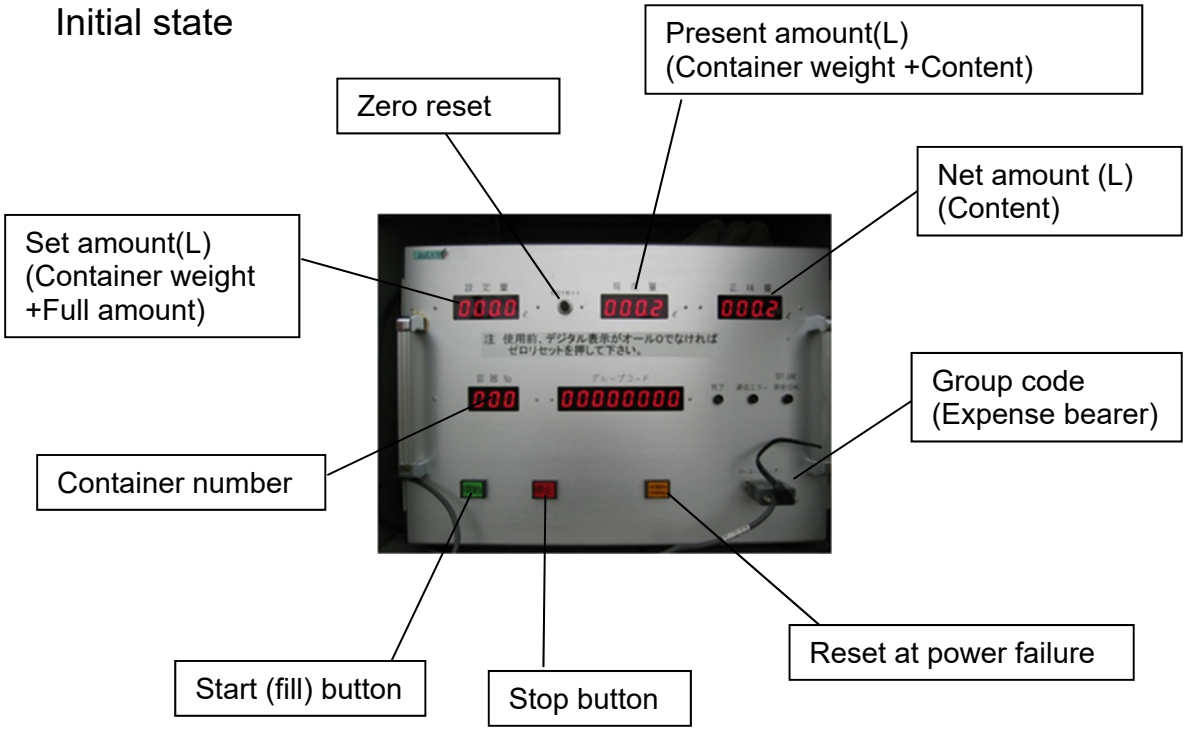
We are planning to secure shared space to use liquefied helium, improve containers for liquefied nitrogen and liquefied helium for loaning out, and improve joint-use equipment qualitatively and quantitatively.

For requests regarding the first use of liquefied helium, consultation about cryogenic technology, and utilization of joint-use equipment, do not hesitate to consult with us.

Contact:
Satoshi Abe, Director of the Cryogenic Laboratory (Ex. 5665 or abesi@staff.kanazawa-u.ac.jp)
Koichi Nunomura, in charge of security (Ex. 5873 or n2683@adm.kanazawa-u.ac.jp)

# How to pump out liquid nitrogen with an automatic feeder

Initial state





# How to pump out liquid nitrogen with an automatic feeder


Read the two barcodes on the container

Check that the set amount, container number,
and group code have been read correctly.


# How to pump out liquid nitrogen with an automatic feeder

Put the container on the load cell,
Check that the start button is flashing,
Insert the pumping port and press the start button.

If the barcode is not read correctly, the start button will not flash. In that case, remove the container from the load cell,
Please read the barcode again.


# How to pump out liquid nitrogen with an automatic feeder

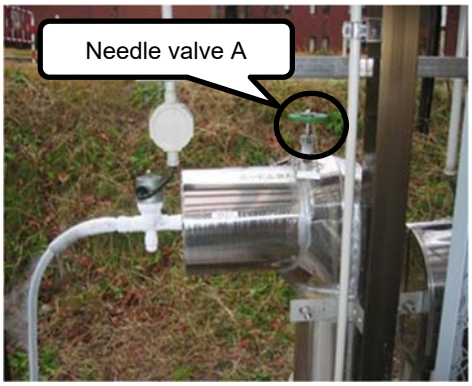
When started, the net amount displays the net amount pumped or filled in.

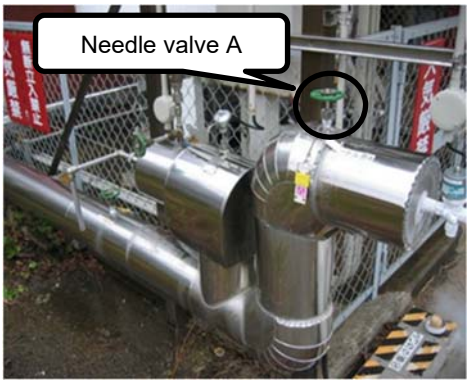
When the piping returns to room temperature, gas is released from the middle of the piping until it cools.
When the pipe is cold, liquid  nitoropgen starts to be filled from the pumping port.


# How to pump out liquid nitrogen with an automatic feeder

## Pumping (Filling)

Needle valve A (flow control valve) is fully closed and set to an appropriate opening for the 5L container.
In a large container, opening the needle valve A leads to faster filling (make sure that the needle valve A is fully closed when finished).




# How to pump out liquid nitrogen with an automatic feeder

## End of pumping (filling)

To stop the pumping before the container is full, press the stop button. Or
When the current amount reaches the set amount, the pumping ends automatically. (Chime sounds)
When the container is removed from the load cell, the chime stops, the display is reset to its initial state.


Data such as container number, group code and pumping amount are automatically recorded.

## How to pump out liquid nitrogen with an automatic feeder

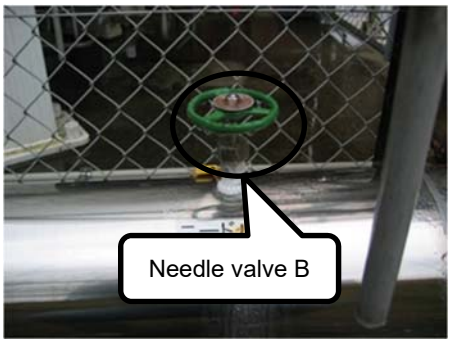
When a new user uses the automatic feeder, or a new container is used,
We will prepare a barcode on the spot, so enter the door and drop by Nunomura (technical staff) in the Monitoring Office on the left side.

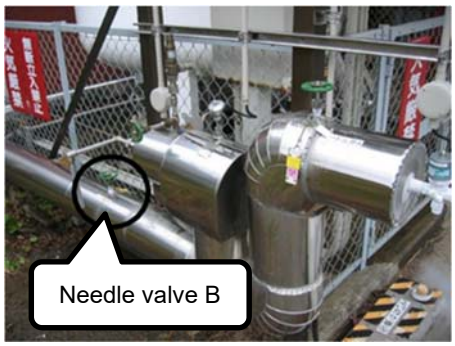
If you have any questions about how to pump,
please ask Nunomura (technical staff) or staff/graduate students in the laboratory.

If the container is full before the set amount is reached and liquefied nitrogen overflows,
Manually stop it by pressing the stop button.
If this happens often, please contact Nunomura as the set amount is inappropriate.

## How to stop automatic feeder in an emergency

Liquefied nitrogen continues to overflow even if the stop button is pressed.
→ Close needle valve B to stop the liquefied nitrogen and immediately report to the emergency contact.



# 寒剤利用登録(修正)申込用紙

年　　月　　日

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| 教員氏名 | | |
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