

Safe Handling of

Hydrochloric Acid

Japan Soda Industry Association

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Introduction

Hydrochloric acid (excluding solutions containing not more than 10% hydrogen chloride) is designated as a deleterious substance under Japanese laws, and is a strongly corrosive substance. Persons who handle hydrochloric acid should learn about the related laws and regulations (such as the Poisonous and Deleterious Substances Control Law), its properties, and precautions on handling, and should observe them to ensure safety.

This leaflet compiles the information that dealers, transporters, and consumers handling hydrochloric acid need to know as a guideline for the routine prevention of accidents.

I. Information about Hydrochloric Acid

1. Commercial Hydrochloric Acid

- Commercial hydrochloric acid normally contains 35% hydrogen chloride (38% in special cases), and is classified into industrial, reagent, food additive, and Japanese Pharmacopoeia grades according to its uses. The qualities of these grades are specified in JSIA (Japan Soda Industry Association) Standards, JIS (Japanese Industrial Standards), and JSFA (Japanese Standards for Food Additives) as shown in the following tables.

Quality of industrial synthetic hydrochloric acid (JSIA 04-1998)

Component	Type 1	Type 2
Hydrochloric acid (%)	≥ 37	≥ 35
Iron (Fe) (%)	≤ 0.0005	≤ 0.002
Residue on ignition (%)	≤ 0.005	≤ 0.01

Quality of reagent grade hydrochloric acid (JIS K 8180-1975)

	Special grade	Arsenic analysis grade
Residue on evaporation (%)	≤ 0.001	≤ 0.001
Residue on ignition (sulfate) (%)	≤ 0.0005	≤ 0.0005
Sulfate content (SO_4^{2-}) (%)	≤ 0.0001	≤ 0.0001
Free chlorine	within limits (Cl \leq approx. 0.00001%)	within limits (Cl \leq approx. 0.00001%)
Iodine-reducing substances	within limits (\leq approx. 0.0001% as SO_3)	within limits (\leq approx. 0.0001% as SO_3)
Heavy metals (as Pb) (%)	≤ 0.00005	≤ 0.00005
Iron (Fe) (%)	≤ 0.00002	≤ 0.00002
Arsenic (As) (%)	≤ 0.000001	≤ 0.0000005
Content (%)	35.0 ~ 37.0	35.0 ~ 37.0

Quality of hydrochloric acid for food additives (JSFA-III, 1973)

Appearance	Colorless to light yellow
Content	90 ~ 120% of indicated content
Sulfates	≤ 0.012 w/v% as SO_4^{2-}
Arsenic	≤ 0.0002 w/v% as As_2O_3
Heavy metals	≤ 0.001 w/v%
Iron	≤ 0.003 w/v%
Residue on ignition	≤ 200 ppm

- Hydrochloric acid includes by-product hydrochloric acid of various concentrations and accompanying components as a by-product of various chemical reaction processes. It is important to use by-product hydrochloric acid after obtaining sufficient information about the components other than hydrogen chloride or other information from the manufacturer.

2. General Characteristics of Hydrochloric Acid

- Hydrochloric acid is a non-flammable, transparent and colorless or light yellow liquid. When it has a concentration of 25% or more, it is a fuming (hydrogen chloride gas, hydrochloric acid gas) strong acid.
- Hydrochloric acid reacts with a chromate, permanganate, or persulfate to generate chlorine; and reacts with a metal peroxide to form its chloride and chlorine.
- Hydrochloric acid gas has a strong pungent odor, and is highly corrosive.
- Hydrochloric acid is harmful to humans and animals. The inhalation of a large quantity of hydrochloric acid will cause intoxication and result in death.
- When hydrochloric acid is heated, it generates a large quantity of hydrochloric acid fumes.
- Although hydrochloric acid itself is non-explosive or non-flammable, it corrodes various metals to generate hydrogen. If the hydrogen is mixed with the air, an explosion may occur.

- Examples of materials resistant to corrosion by hydrochloric acid include acid-resistant glass, acid-resistant ceramics, acid-resistant rubber linings, rigid vinyl chloride, polyethylene, and acid-resistant FRP.

3. Effects of Hydrochloric Acid on the Human Body

- If a skin or mucous membrane is exposed to hydrochloric acid, the site becomes inflamed.
- If the treatment of eyes after exposure to hydrochloric acid is delayed or improperly performed, the patient's sight may be weakened, or even lost.
- Working in an environment thick mist or gas of hydrochloric acid mist or gas may result in corrosion of the teeth.
- If hydrochloric acid is erroneously swallowed, it causes vomiting or a stomach ache, a dry mouth and a burning sensation, as well as a decrease in the heart pulse rate. The lethal dose from oral intake of concentrated hydrochloric acid is said to be 15 to 20 g for adults and 5 g for children; however, this may vary considerably from individual to individual.
- The inhalation of concentrated hydrochloric acid gas or mist irritates the throat, causes coughing, and irritates the eyes and the nose. If the concentration of hydrochloric acid gas in the air is 0.035%, humans will have a pain in the throat and chest, and have difficulty in breathing within 10 minutes. The inhalation of a large quantity of hydrochloric acid gas or mist may result in death.
- The following table shows the symptoms caused by hydrochloric acid gas (hydrogen chloride) in the air according to the concentration.

	Symptom	Concentrations (ppm)
Allowable concentrations	Long-term sustainable limit	5
Mild symptoms	Production of tears, coughing, sneezing and a runny nose	10 ~ 50
Moderate symptoms	Difficulty in breathing, difficulty in opening the eyes, chest pain, life threatening in 30 minutes to one hour	50 ~ 100
Serious symptoms	Impossible to breathe, unconsciousness, death in 30 minutes to one hour	1,000 ~ 1,300
	Lethal dose	1,300 ~ 2,000 (0.13 ~ 0.2%)

(Note) 1 ppm = one millionth = $1 \text{ cm}^3/\text{m}^3 = 0.0001\%$

Since hydrochloric acid gas has a strong pungent odor, its presence can be detected even when the concentration is as low as 0.13 to 0.26 ppm.

II. Containers for Hydrochloric Acid

1. Types of Containers

The shipping containers used for hydrochloric acid are those rail tanks be tightly sealed, such as acid-resistant bottles (including polyethylene containers, etc.), and steel drums tank trucks, tank cars, and tankers with corrosion resistant linings,.

2. Displays on the Containers

- The “Poisonous and Deleterious Substances Control Law” requires the following to be displayed on the containers:

Container (outside) : “Non Medical Use” and “Deleterious Substance”
(red characters on a white background)
Name, grade, net weight of the contents

Tank truck: Name and address of the manufacturer or importer
"Poison" (white characters on a black background)
(On the front and back of the truck)

- On both sides of rail tanks, "Exclusive Use for Hydrochloric acid" is displayed.
- Care must also be taken to the display requirements of other related laws and regulations.

III. Handling of Containers

1. Transportation

(1) General precautions

- The shipping containers must be tightly sealed so that hydrochloric acid does not leak, and must be handled with great care so as not to break them.
- Transport hydrochloric acid with great care, and be sure to wear protective goggles and rubber gloves, and wear rubber boots or rubber clothing as required.
- In the case of consolidated transport, keep alkalis and metals away from hydrochloric acid, and do not place the containers on top of other containers containing organic chemicals.

(2) Transportation of hydrochloric acid in acid-resistant bottles

- When acid-resistant bottles containing hydrochloric acid are to be transported, check them thoroughly beforehand for damage and condition of the seals of the bottles.
- When the acid-resistant bottles are to be moved, use a cart regardless of the presence or absence of any contents. Do not use chain, hoists, pulleys, or makeshift lifts. Do not carry the bottles by holding them by their caps or necks.

(3) Transportation of hydrochloric acid by tank truck

- The laws require that each tank truck should be provided with a document describing the name, components and grade of the contents, the first aid measures to be taken in case of an accident, protective equipment, tools and so on. In the case of long periods of transportation, a standby driver is required to ride in the truck.
- The driver must be certain to close the manholes or valves so that the liquid does not leak.

(4) Transportation of hydrochloric acid by ship

- When acid-resistant bottles or steel drums containing hydrochloric acid are to be transported by ship, refer to the “Ship Safety Law.”

2. Precautions for Storage

- Place containers containing hydrochloric acid outdoors. If they are placed indoors, it is desirable that acid-resistant paints and acid-resistant mortar be used, and the floor should be coated with asphalt, acid-resistant blocks, or sodium-silicate-treated concrete, because the buildings will be corroded by hydrochloric acid mist. It is necessary for the storage place to be equipped with a drainage, and any spilt hydrochloric acid should be flushed away using a large quantity of water. For this, a water supply that can provide a large quantity of water should be located near the drain. It is not recommended to store hydrochloric acid in any basement area.
- To prevent health hazards caused by hydrochloric acid mist, and to avoid the danger that the room will be filled with hydrogen generated by the corrosion of metals, the building should be of an open structure and well ventilated.
- Use electrical facilities that are as airtight and corrosion resistant as possible. For the wiring, use plastic-coated wire, or use airtight metal conduits protected by acid-resistant paint or plastic conduits.
- Store hydrochloric acid apart from oxidants (in particular, nitric acid or chlorates) and combustibles, as well as cyanides or sulfides.

- Avoid direct sunlight and close proximity to a heat source. In addition, avoid passageways and places where there is a risk of something falling.
- The containers must be mechanically strong and corrosion resistant, and should not allow the contents to leak out.
- The containers must be tightly sealed, and an appropriate head space (5% by volume or greater) must be left when the container is filled with hydrochloric acid.
- When hydrochloric acid is stored in a tank, always check the quantity of the remaining hydrochloric acid to prevent any danger of its overflowing. Install a ventilation hole in the tank and connect the hole to a hazard prevention facility.

IV. Tank Trucks, Rail Tanks, and Tankers

- The capacity of a tank truck is normally 5 to 8 m³.
- The capacity of rail tank is normally 10 to 30 m³.
- The capacity of some tankers is 50 to 200 m³.

1. Structure

When hydrochloric acid is transported, shipped, or received using a tank truck, tank car, or tanker, it is important to have an accurate knowledge of the structure and materials of the valves and pipes, as well as the interior and exterior of the storage tanks related to the transport, receiving, and shipping operations on the basis of correct and accurate drawings; and to keep everyone informed about these.

2. Unloading from Tank Trucks, Rail Tanks, and Tankers

- On receiving, make sure that the person in charge of the factory continually observes the checking of pipes, opening and closing of valves, checking of the commencement and termination of receiving, and the checking of the quanti-

ties received.

- When loading and unloading using a tank truck, make sure that the manual brakes and a vehicle lock are applied so that the truck cannot move during the operations. Under no circumstances should the truck be left unobserved.
- When unloading from a tank truck, rail tank, or tanker, use a pump or compressed air. If a gas other than air (nitrogen or carbon dioxide) is used, immediately inform the loading operator or indicate this fact on the tank so that there is no fear of suffocation when an operator needs to enter the tank. (Refer to V. Use of Hydrochloric Acid, 1. General Precautions, p. 10.)
- The supervisor of the unloading should make sure that the operators have sufficient knowledge of the properties of hydrochloric acid, the joints and the pipelines; and allow them to operate these only after checking the contents of the tank and testing the vents and the safety valves.
- When unloading using a pump (or siphon), remove the vent flange of the tank in the tank truck, rail tank, or tanker to allow air to enter. Remove the blanking plate of the delivery pipe, connect the pipeline of the storage tank to the flange of the delivery pipe, and start up the pump (or siphon) to start delivery. When the tank has been emptied, stop the pump (or siphon), remove the pipeline from the delivery pipe, and close the vent and the flange of the tank. During this operation, care should be taken so that the hydrochloric acid does not come into contact with metal parts, or it is not spilt. However, if it is spilt, flush it away with a large quantity of water.
- When hydrochloric acid is delivered by air injection, make sure in advance that there are no defects in the lid of the tank, the flange connected to the pipeline, the valves and so on. Should there be any defects, hydrochloric acid might be ejected from that part to cause an accident. Open the block valve slowly and properly adjust the flow rate to the tank. Although the internal pressure of the tank is rapidly lowered after delivery has been completed, continue air injection until the pipeline is emptied before closing the valve. The mist discharged when the internal pressure returns to normal pressure must be absorbed in water and neutralized using an alkali before disposal.
- The facility for pressure-pumping hydrochloric acid through a flexible pipe such as a rubber hose must be equipped with a pressure gauge, and an anti-

corrosive pressure-resistant hose must be used. Before pressure-pumping, inspect the hose, pressure gauge, and the connection of the hose, and take sufficient care as to the limit of the working pressure of the hose.

V. Use of Hydrochloric Acid

1. General Precautions

- Since hydrochloric acid is highly corrosive, operators must always wear protective gear when handling hydrochloric acid. Take a shower or bath after the operations, and wash their face and hands, and gargle immediately before taking a meal.
- If the place where the hydrochloric acid mist is produced, and the place cannot be naturally ventilated, discharge the contaminated air using an exhaust system.
- When a sealed acid-resistant bottle is opened, the slightly higher pressure in the bottle than the ambient pressure may eject the contents; therefore, keep the face or hands away from the cap of the bottle.
- When hydrochloric acid is being taken out of an acid-resistant bottle, do not use air pressure, but use a bottle holder that can be safely tilted, and a siphon.
- When hydrochloric acid is sampled by suction, use a safe pipette, vacuum pipe, or the equivalent.
- If an operator needs to enter a storage tank, tank car, tanker, tank truck or equipment using hydrochloric acid, fill the tank with water to clean it beforehand, and sufficiently ventilate the tank after flushing. Disconnect any hydrochloric acid pipes connected to the storage tank, or insert a blanking plate to prevent any hydrochloric acid from flowing in, and the operator must enter the tank wearing a ventilation mask (air aspirator) and safety rope and have an observer standing outside the tank.
- Care must be taken so that the hydrochloric acid to be used does not mix and

react with an oxide (especially nitric acid and chlorate), cyanide, or sulfide which generates toxic gases.

2. Fire Precautions

- Although hydrochloric acid itself is not combustible, it corrodes various metals to generate hydrogen. Therefore, isolate any flames during the operation of the pipelines and the tank.
- If the pipes or the tank must be welded or cut using a torch or any tool using a flame, it is necessary to check whether the hydrochloric acid has been discharged and whether the pipes and the tank have been sufficiently cleaned and ventilated by introducing air before starting the operations.

3. Treatment of Empty Containers and Waste

- As a rule, sufficiently clean up empty containers with water to remove any remaining hydrochloric acid after emptying the contents. However, when the containers are to be exclusively used for hydrochloric acid, and the remaining mist or acid cannot leak out, cleaning with water is not required.
- When hydrochloric acid is being disposed of, neutralize it by adding lime milk or a soda ash solution while slowly stirring it, and then dilute it with a large quantity of water.

4. Accident Prevention Measures

The laws require that various measures be taken for the prevention of accidents.

(1) Operating rules

It is important to establish rules for the proper use of facilities for handling hydrochloric acid or any associated facilities, and to operate them in accordance with these rules.

(2) Voluntary inspection

Hydrochloric acid is a highly corrosive substance. It is important to periodically inspect equipment that is used for handling hydrochloric acid and to retain the

inspection records.

(3) Supervision by qualified persons

When laws stipulate certain requirements, operations must be carried out in accordance with these requirements.

(4) Prevent of erroneous operations

For the piping of facilities for handling hydrochloric acid, it is important to take measures such as the indication of the name and the direction of flow of the liquid, as well as color coding and indication of the opening and closing direction of major valves and cocks. Furthermore, for the inspection of the operating procedures or facilities, the utilization of a checklist is effective.

(5) Education and training

First of all, make sure that the operators handling hydrochloric acid observe the operating standards for safe operations. For this, it is necessary to provide education and training concerning:

- The location of protectors, showers, eye washers, sodium bicarbonate solution for gargling, water taps, cleaning hoses, and first aid facilities
- Proper methods for the use of protectors and first aid facilities
- First aid measures to be taken in case of an emergency
- For operators filling tanks, measures for preventing a lack of oxygen deficiency.

It is also important to train supervisors concerning the following, and regularly carry out training drills for dealing with disasters:

- Proper usage of the first aid facilities
- Measures to be taken in case of chemical injury

5. Prevention Measures for Hygiene

If operators handling hydrochloric acid are trained in proper handling methods, and are sufficiently supervised, serious damage can be avoided. However, chemical injury caused by hydrochloric acid is a relatively neglected aspect of handling chemicals, and since the disregard of thorough training and supervision can have serious results, prevention and management related to safety and hygiene must be reaffirmed.

(1) General precautions

- The most important aspect of the prevention of accidents involving hydrochloric acid is to make sure that the hydrochloric acid does not come into contact with the eyes, teeth, or skin, or infiltrate the respiratory organs, stomach or

intestines.

- Ventilate the work place so that the concentration of hydrochloric acid fumes in the air does not exceed the maximum permissible limit of exposure.
- Install water taps or safety showers that can supply a large quantity of water, and prepare eye-washing facilities that use flowing water in the suitable locations around the site for operations involving hydrochloric acid. Indicate these in a conspicuous manner, and always inspect them.
- Operators handling hydrochloric acid must gargle with a sodium bicarbonate solution at the end of the work to prevent acid corrosion of the teeth.
- Perform physical examinations periodically or as needed, and if acid corrosion of the teeth, chronic skin injury, chronic tracheal disorders, or visual disorders are detected, promptly provide medical treatment.

(2) Protective wear and devices

- Maintain protective wear and devices in good condition so that they can be used immediately. The major protective wear and devices are protective goggles, protective clothing (JIS T 8115-1979), protective gloves (JIS T 8116-1979), protective boots (JIS T 8117-1979), and gas masks (JIS T 8152-1975). In addition, prepare oxygen masks, safety ropes and so on as required.

VI. Actions to be Taken in Case of a Leakage

- Always take care of the hydrochloric acid spilt, and wash the place where any hydrochloric acid has been spilt with a large quantity of water. Flush away hydrochloric acid that has been spilt on concrete, wood, or other corrosion-sensitive materials with water, and promptly neutralize it with soda ash or lime. Since carbon dioxide gas is generated when soda ash is used, ventilate the site well so that the gas cannot remain.
- Take care to prevent leakage due to ejection from valves, cocks, flanges, or other joints in machinery and equipment. Never repair the equipment, pipes and so on during handling operations.

- When the piping or other items need to be repaired, make sure that the internal pressure has been equalized to the ambient pressure and that any remaining liquid has been removed.
- Provide the rooms for using or storing hydrochloric acid with hoses, water taps and drain outlets so that a large quantity of water can be supplied.
- From containers of highly concentrated hydrochloric acid or heated hydrochloric acid, hydrochloric acid gas that is a little heavier than air will be generated. While hydrochloric acid gas is easily dissolved in water, a water spray must be used to eliminate any leaked hydrochloric acid gas.
- Accidents during transportation must be reported to the health center, the police station and the fire station, and the measures described above must be carried out.

VII. Maintenance of the Facilities (Cleaning and Repairing)

The cleaning or repair of a facility after the use of hydrochloric acid must be directed by an experienced supervisor who knows the dangers well. In addition to general precautions, take care of the following:

- Make sure that the hydrochloric acid is completely blocked off at the inlet port of the tank.
- When an operator enters the tank or the facility, remove the contents by pumping or flowing out as much as possible, and thoroughly clean it with water.
- Dismantle all the pipes connected to the tank or the facility. If possible, remove them by sorting them into groups.
- Supply fresh air with a small air blower. Do not use compressed air since this is dangerous.
- Display a warning sign when an operator is inside the tank or other facilities.

- When the piping is being repaired, remove any hydrochloric acid in the pipe beforehand, and clean the pipe sufficiently with warm or cold water.

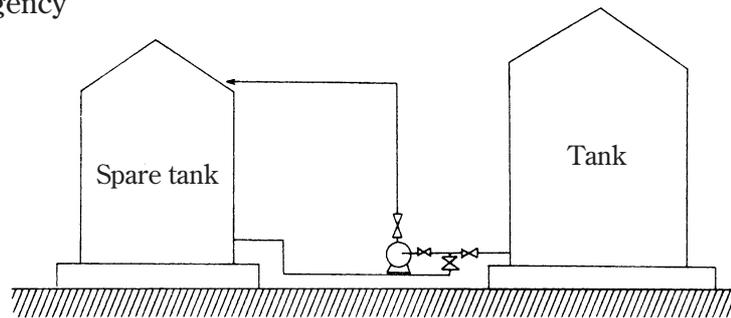
VIII. Safety Facilities

In order to prevent leaked hydrochloric acid from flowing out of the area of the storage facilities, it is preferable to install facilities for the safe storage of hydrochloric acid or facilities for recovering it and preventing it from causing harm.

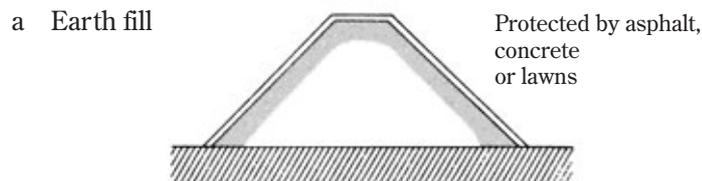
- Provide protection using banks to contain liquids, tank beds, and pit-like structures using acid-resistant paint, acid-resistant mortar, concrete lined with asphalt, acid-resistant blocks, or facilities treated with sodium silicate.

The examples of such facilities are as follows:

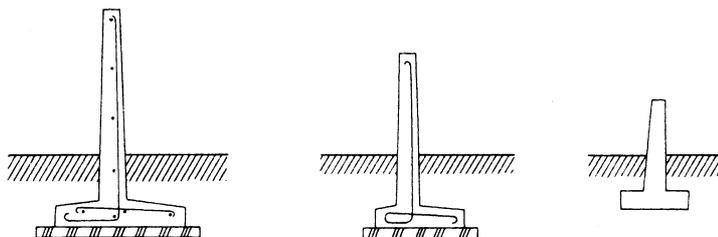
- Spare tanks that can receive hydrochloric acid in a short time in an emergency



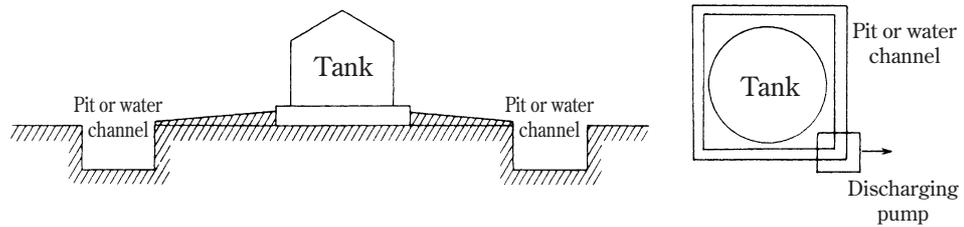
- Liquid bank around the tank or group of tanks



- b Concrete



- Pit-like structure and pond, depression, etc.



The leaked hydrochloric acid is recovered or disposed of. For the disposal of, neutralize it with an alkali, and flush it away with a large quantity of water.

IX. Emergency Measures

1. General Guidelines

- Since the description below only covers first aid measures, diagnosis and treatment by a physician are required after carrying out these measures. If there is no hospital or clinic in the factory, display the urgent means of making contact in an emergency with the nearest physician, hospital, and ambulance in a conspicuous place.
- In case of chemical injury caused by hydrochloric acid, the acid must be promptly removed from the skin or eyes. The sooner the hydrochloric acid is removed, the more effective the subsequent treatment.
- Always have tweezers, scissors, writing brushes, tourniquets, disinfected gauze, oiled paper, absorbent cotton, splints, bandages, slings, and adhesive bandages ready as first aid equipment; moreover, have alcohol, iodine tincture, a 2~3% mercurochrome solution, a hydrogen peroxide solution, ammonia water, a 1~2% boric acid solution, a 2~5% sodium bicarbonate solution, boric acid ointment, refined vegetable oil, and wine as first aid medication. In addition, have milk of magnesia ready for cases where hydrochloric acid has been swallowed, and have 0.5% pontocaine as a local anesthetic agent for cases where hydrochloric acid has entered the eyes.

2. Skin Exposure

- Firstly, wash the skin with a large quantity of flowing water for a long time until the hydrochloric acid has been completely removed. Clothing must be immediately removed. Never try to neutralize the acid with an alkali.
- Always keep in mind that shock symptoms, such as tachycardia, excessive sweating and collapse, can suddenly occur in cases of serious chemical injury or chemical injury covering a large area of the body, and if such symptoms occur, lay the patient quietly on his/her back, and warm him/her to a degree that is not excessively hot until a physician comes.
- Do not apply oil or other ointments to the affected site unless under the direction of a physician.

3. Eye Exposure

- If hydrochloric acid gets into the eyes, immediately rinse it out with a large quantity of flowing water for at least 15 minutes.
- In this case, keep the eyelids open wide so that water can reach every part of the eyeball and eyelids.
- After washing, administer a few drops of 0.5% pontocaine solution or equivalent local anesthetic agent as first aid treatment.
- Do not use oil or other ointments unless under the direction of a physician.
- Immediately have the patient receive medical treatment by a physician, if possible, by an ophthalmologist.

4. Swallowing

- Immediately call a physician.
- If the patient is clearly conscious, do not force the patient to vomit. (There is no problem with natural vomiting.) Immediately give the patient milk of magnesia repeatedly after short intervals. If this is impossible, have the patient drink a large quantity of water. Never give sodium bicarbonate to the patient.
- If the patient is unconscious, do not give anything to the patient.

5. Poisoning caused by Concentrated Hydrochloric Acid Mist or Hydrogen Chloride

- Mild poisoning causes inflammation of the trachea. Coughing is generally relieved by oxygen inhalation.
- Move an unconscious patient suffering from acute poisoning to a place with fresh air and that is not cold. If breathing has stopped, give mouth to mouth resuscitation. When oxygen can be used, and there is a person who is accustomed in handling oxygen, perform oxygen inhalation. Since time is often wasted if a person accustomed to handling oxygen is not available, first call a physician. Rub the chest of the patient toward the heart in a comfortably warm but not excessively hot place to try to recover of the circulatory organs. No stimulants are required if oxygen inhalation is adequately performed. Do not give medicines for shock unless under the instructions of a physician.

X. Reference Items

1. Properties of Hydrochloric Acid

- Molecular formula : HCl
- Molecular weight : 36.46
- Specific gravity : 1.18 (15 °C, 35% concentration)
- Melting point : – 66 °C (35% concentration)
- Boiling point : 108.6 °C (constant boiling mixture of 20.2% concentration)
- Vapor pressure : 10.6 mmHg (20 °C, 30% concentration)
322.0 mmHg (40 °C, 36% concentration)

2. Relationship between the Concentration of the Formed Hydrochloric Acid, Absorption Temperature, and the Concentration of Equilibrium Hydrochloric Acid

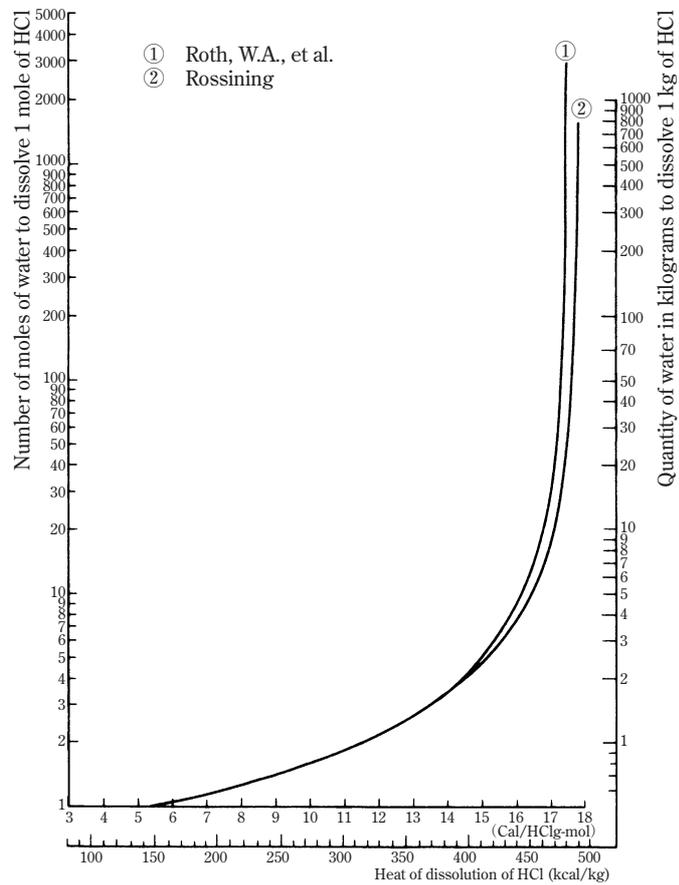
Absorption tempera- ture (°C)	Concentration of gas-phase hydrogen chloride gas (%)						
	5	10	20	30	50	70	90
	Concentration of equilibrium hydrochloric acid (%)						
5	33.8	36.1	38.6	40.0	41.9	43.2	44.1
10	33.2	35.5	38.0	39.4	41.3	42.5	43.4
15	32.6	34.9	37.3	38.7	40.6	41.8	42.7
20	32.0	34.2	36.6	38.0	39.9	41.1	42.0
25	31.3	33.6	35.9	37.4	39.2	40.4	41.3
30	30.4	32.9	35.2	36.5	38.4	39.6	40.6
40	29.2	31.6	33.8	36.1	37.0	38.1	39.0
50	28.0	30.0	28.2	33.6	35.4	36.5	37.4

3. Heat of Dilution of Hydrochloric Acid

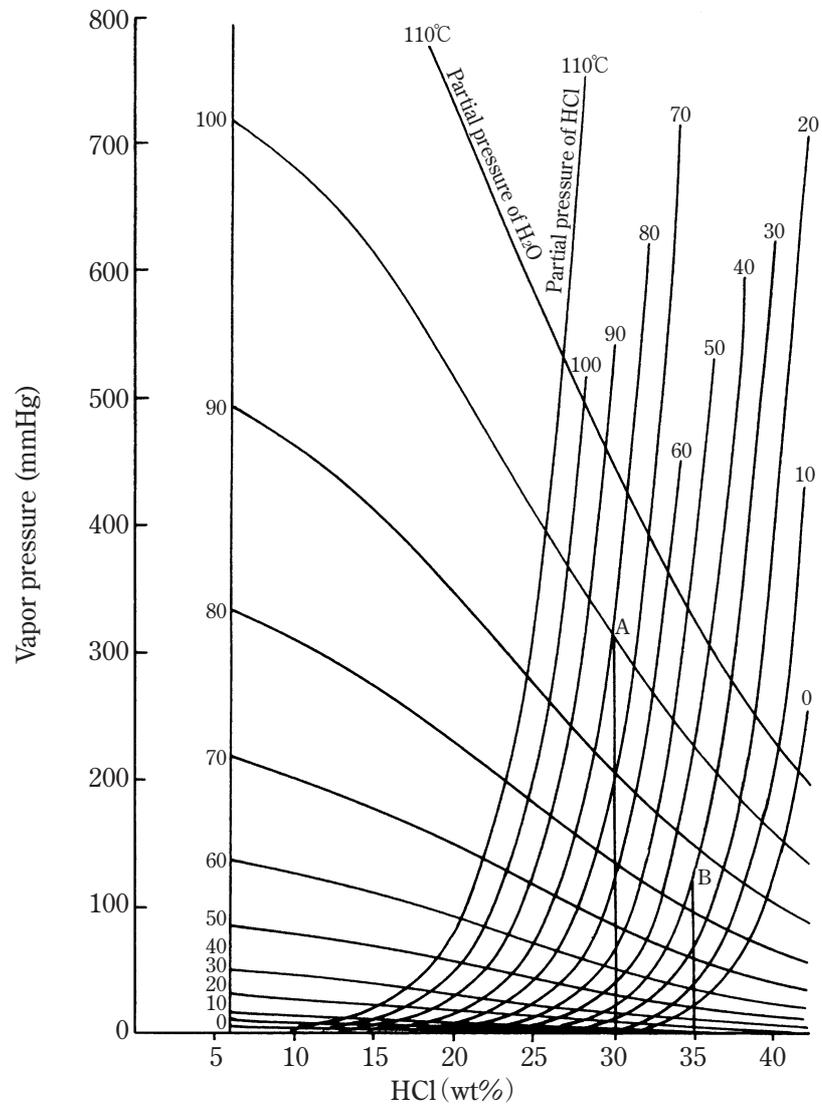
Infinite heat of dilution of hydrochloric acid (25°C)

Molar ratio H ₂ O/HCl	3	5	10	12	15	20	25	50	100	200	400	1,600
HCl wt%	40.3	28.9	16.9	14.5	11.9	9.2	7.5	3.89	1.96	1.00	0.507	0.127
kcal /g·mol HCl	4.47	2.76	1.46	1.25	1.05	0.85	0.73	0.433	0.343	0.249	0.181	0.090

Heat of the dissolution of hydrochloric acid in water



4. Partial Pressures of HCl and H₂O on Hydrochloric Acid



XI. Related Laws and Regulations

Although hydrochloric acid is mainly regulated by the Poisonous and Deleterious Substances Control Law, since it is also covered by the Pharmaceutical Law, the Food Sanitation Law, the Ship Safety Law, the Water Pollution control Law, the Air Pollution control Law, and Waste Disposal and Public Cleaning Law, Occupational Health and Safety Law, Fire Defense Law, and High Pressure Gas Control Law, great care should be taken when handling hydrochloric acid.

(1) Poisonous and Deleterious Substances Control Law

Hydrochloric acid (excluding solutions of 10% or less) is specified as a deleterious substance, and is subject to regulation as to its marketing, storage, consumption, transportation, etc.

- (a) Dealers in hydrochloric acid, and carriers using motor vehicles whose loading capacity for hydrochloric acid is 5 tons or more, or motor vehicles on which containers of a capacity of 1,000 liters or more are loaded must appoint a person in charge of handling poisonous and deleterious substances at each establishment to prevent health hazards. All the persons who handle hydrochloric acid on the job have managerial responsibility under the law regarding loss and leakage prevention, displays, measures to be taken in case of accidents, and so on.
- (b) When a dealer sells or provides hydrochloric acid, the required items must be recorded, and the record must be retained.
- (c) When 5 tons or more of hydrochloric acid is transported at a time using a motor vehicle, the required signs must be displayed, and the required protective equipment for at least two persons must be carried. If a specified time (4 hours of continuous driving, or 9 hours of driving in one day) is to be exceeded, a standby driver must accompany the driver.
- (d) The standards related to first aid measures in case of a driving accident must be established, and the drivers must carry a document in which these measures are described. Education and training in first aid measures are also required.

(e) When hydrochloric acid is discarded, the neutralization method is stipulated (after stirring in a solution such as milk of lime to neutralize it, it must be diluted with a large quantity of water and flushed away).

(f) For the tank storage (outdoors, indoors, and underground) of hydrochloric acid, the standards for the structure and facilities have been established.

(2) Pharmaceutical Affairs Law

Hydrochloric acid (excluding solutions of 10% or less) is specified as a deleterious substance under the Pharmaceutical Affairs Law, and is subjected to the regulation of its handling.

(a) On the containers or packages, the name and the characters “Deleterious” must be written in red within a red frame on a white background.

(b) Marketing, provision, storage, and displays are also regulated.

(3) Food Sanitation Law

Hydrochloric acid is specified as a chemically-synthesized compound when it is intended for use as a food additive, and is subject to restrictions when it is marketed, displayed, manufactured, and processed.

(4) Ship Safety Law

Hydrochloric acid is specified as a hazardous material (corrosive material) in the regulations for shipping and storing hazardous materials under this Law, and the shipper must observe the preparation of hazardous material specifications, the rules for packaging, the notification of hazardous materials when shipping by motor vehicle ferry, etc.

(5) Water Pollution Control Law

Since hydrochloric acid affects the hydrogen ion concentration specified by regulations and standards related to water discharged from establishments, care should be taken.

(6) Air Pollution Control Law

Hydrochloric acid is specified as a harmful material under the law, and the concentration of hydrochloric acid emitted from smoke and soot generating facilities into the atmosphere is regulated to be 80 to 700 mg/Nm³ depending on the types of facilities. Since certain local governments have more stringent emission standards by regulations, care should be taken.

(7) Waste Disposal and Public Cleaning Law

Waste acid is specified as industrial waste, and its collection, transfer, and disposal must be carried out by corporation and companies themselves in accordance with specified standards, or entrusted to industrial waste disposal services approved by the Governor that exercises jurisdiction over the district.

(8) Occupational Health and Safety Law

Since hydrochloric acid (excluding solutions of less than 1% concentration) is specified as a specified chemical substance under the “Rules for Preventing Hazards Caused by Specified Chemical Substances or the Like” of the law, the operating environment must be cleaned, and care must be taken to prevent health hazards.

(9) Fire Defense Law

When 200 kg or more of hydrochloric acid (excluding solutions of less than 36% concentration) is stored or handled, this must be notified to the fire chief (superintendent of the fire station) who exercises jurisdiction over the area.

(10) High Pressure Gas Control Law

Liquefied hydrogen chloride in a cylinder is subject to regulation under the High Pressure Gas Control Law (toxic gases).

XII. Cases of Disasters

- (1) When an operator carried sample bottles of hydrochloric acid, one under the left arm, and two more with one in each hand, since he was holding the cap of one bottle that was insufficiently screwed on, the screw of the cap became

loose and the bottle fell to the ground. At this time, concentrated hydrochloric acid left in the bottle splashed out and entered in his left eye to cause chemical injury.

- (2) When an operator transferred hydrochloric acid from a rail tank into a 20 ℓ bottle using a hose, the hydrochloric acid overflowed from the bottle and got onto his face to cause chemical injury.
- (3) When an operator transferred hydrochloric acid from a 25ton tank into an acid-resistant tank under a pressure of 1 kg/cm², since the 2inch PVC pipe of the inlet for a hydrochloric acid measuring instrument was incompletely joined to a rubber tube, the rubber tube came off due to the liquid pressure of the instrument, and hydrochloric acid was ejected causing inflammation in both eyes and on the neck of the operator.
- (4) When hydrochloric acid was transferred from a tank truck to a 7ton receiving tank, the rubber hose came off and hydrochloric acid flowed out. At that time, droplets of hydrochloric acid flew onto the face of an assistant of the truck to cause chemical injury.
- (5) At the moment when an operator turned the spindle of a Y-valve to switch the No. 1 3HP pump that was used to transfer hydrochloric acid from a 5m³ receiving tank to a large 100ton tank to the No.2 3HP pump due to a malfunction, hydrochloric acid was ejected and the droplets entered both eyes causing chemical injury, and at the same time, a mild acute poisoning. It was found as a result of disassembling and inspecting the Y-valve that the cause of the hazard was corrosion and breakage of the valve due to the use of poor materials.
- (6) After transferring hydrochloric acid from a 50ton storage tank for shipping, an operator tried to open the compressed air valve using a handle turning tool to drain the liquid left in the liquid pipe, the rubber tube connected to the nipple came off due to the remaining pressure, and hydrochloric acid was ejected and entered his left eye to cause chemical injury.
- (7) In a synthetic hydrochloric acid factory, when an operator opened the valve of the separator and went down, the bottom of his trousers became caught by the valve installed in the V-shaped PVC pipe, and the valve broke. Since hydrochloric acid flowed out of the broken valve, he bent down to block it with the right hand, but his face and hands were exposed to hydrochloric acid.

- (8) When an operator removed a burner inserted in the bottom of a hydrochloric acid incineration column, and replaced the nozzle cap, drops of dilute hydrochloric acid fell from the bottom of the column and scattered around, then entered his left eye to cause chemical injury.
- (9) In a pulp plant, when 10% hydrochloric acid was being flushed out to clean the inner surface of stainless steel pipes, a part of the hydrochloric acid entered a black solution containing sodium sulfide through a valve that was erroneously opened, and hydrogen sulfide was generated. Subsequently, an operator working nearby died due to gas poisoning.
- (10) When an operator was carrying a narrow-neck glass sampling bottle (500 ml) filled with hydrochloric acid by holding the neck of the bottle, the base of the neck broke, and his legs were exposed to hydrochloric acid to cause chemical injury.
- (11) Lightning struck a hydrochloric acid tank, the roof of the tank was blown off, the tank bottom was cracked, and hydrochloric acid leaked out.

Safe Handling of Hydrochloric Acid

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